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CONTENTS OF VOLUME XXVI

January–February, No. 1

March–April, No. 2

May–June, No. 3

July–August, No. 4

September-October, No. 5

November–December, No. 6

Vol. XXVI JANUARY-FEBRUARY, 1926 No. 1

NATURAL HISTORY

PRESENT RACES OF MAN

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EXPLORATION · RESEARCH · EDUCATION

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NATURAL HISTORY

THE JOURNAL OF THE AMERICAN MUSEUM

DEVOTED TO NATURAL HISTORY, EXPLORATION, AND THE DEVELOPMENT OF PUBLIC EDUCATION THROUGH THE MUSEUM

PRESENT RACES OF MAN

CLARK WISSLER, EDITOR

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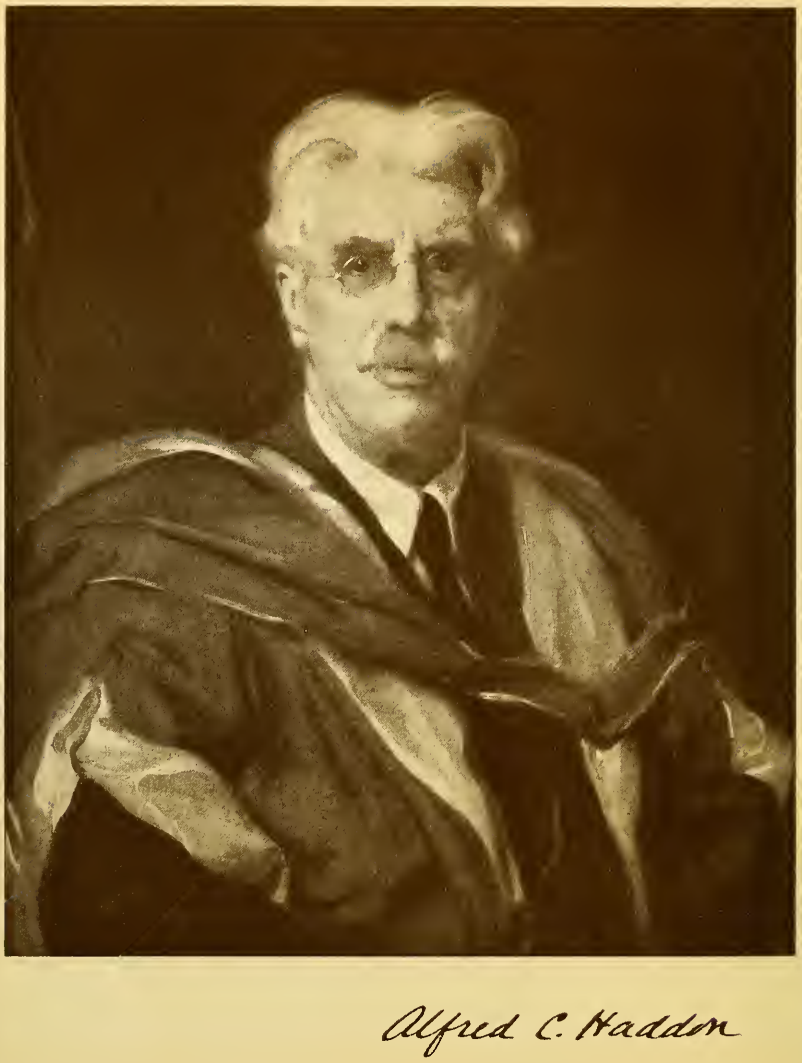


THE DEAN OF ENGLISH ANTHROPOLOGISTS

Alfred C. Haddon, University Reader in Ethnology, and Fellow of Christ College, Cambridge, England, a widely traveled, versatile scientist, recognized as a zoölogist and an authority on all phases of anthropology. Doctor Haddon, who has a long list of publications to his credit, is perhaps best known for his contribution to the Torres Strait Expedition, and for his book *The Races of Man*. A new and revised edition of the latter was issued last year

NATURAL HISTORY

VOLUME XXVI JANUARY-FEBRUARY, 1926 NUMBER 1

The Evolution of Human Races

BY HENRY FAIRFIELD OSBORN

Honorary Curator of Vertebrate Palæontology

COMMENTS and observations on the probable causes of the origin of Races and Species in man, on the gradual divergence of races into subspecies, and on the grouping of species into primary human genera as distinct as the genera of the plant and animal world. Secular Natural Selection or Darwinism and secular Inheritance of Acquired Adaptations or Lamarckism, illustrated by theoretic origin of Arboreal, of Amphibious, and of Sartorial races of Man.

FRANCE, from the close of the eighteenth century, was the leader in Anthropology, the science of man. In 1875, Armand de Quatrefages, professor in the Museum of Natural History, Paris, delivered a course of elementary lectures on "The Natural History of Man"[1] to audiences of working people in Vincennes. These delightful lectures represent the pre-Darwinian point of view and dwell with emphasis upon the *unity* of human species and upon the intellectual, moral, and spiritual distinctness of man.

THE PRE-DARWINIAN PERIOD

In support of his opinion that all the greater and lesser divisions of the human race belong to a single species, namely, *Homo sapiens*, Quatrefages devotes Chapter I to the discussion of fertility. He observes: "*Fertility is the law of union between animals belonging to different races* (mixed breeding)," whereas "*infertility is the law when animals of different species unite* (hybridization)." This argument is now known to be invalid; we know that, both in nature and in experiment, many distinct species and even distinct genera of plants and animals occupying over-lapping geographic areas interbreed freely and may leave a long series of hybrid descendants, some of which are highly useful both in plant culture and in animal culture.

If an unbiased zoölogist were to descend upon the earth from Mars and study the races of man with the same impartiality as the races of fishes, birds, and mammals, he would undoubtedly divide the existing races of man into several genera and into a very large number of species and subspecies. We recall the fact that in 1875 Quatrefages was profoundly influenced not only by the then prevailing ideas of the special creation of man as a distinct species but also by the classification of the great Swede, Linnæus (Carl Linné), father of systematic botany and zoölogy.

During the eighteenth century, in the course of developing his monumental "Systema Naturæ," Linnæus rendered an immortal service to science when he introduced the terms *Homo sapiens* to express the fact that man stands apart from other Primates as the substantive genus *Homo*, and that the first species of man we know is entitled to the adjective *sapiens*. He also defines the variety *Homo sapiens europæus* as white, sanguine, and muscular, with fair, wavy hair and blue eyes. We may take this as a starting

[1]de Quatrefages de Breau, Jean Louis Armand: The Natural History of Man: A Course of Elementary Lectures. Translated from the French by Eliza A. Youmans. D. Appleton & Company, New York.

point for our review of the relation of terminology to our present knowledge and theory of human evolution.

THE POST-DARWINIAN PERIOD

Two centuries elapse, and we discover another genus supposedly related to man's ancestors, i.e.:

Pithecanthropus erectus

the ape-like man	of erect stature
(Greek-Latin: Pithecus-anthropos)	(Latin: *erectus*, straight)

We also discover that the European variety of man which Linnæus had in mind is not all Scandinavian, but that it includes three very distinct subtypes, races, or stocks, namely, the Scandinavian or Nordic, the Alpine or Ostro-Slavic, and the Mediterranean, each distinguished by racial characters so profound and ancient that if we encountered them among birds or mammals we should certainly call them *species* rather than *races*. Since, however, they coincide with racial distinctions, we adopt for three secondary races of man the subspecific terms:

Homo sapiens europæus nordicus—the tall, fair-haired, blue-eyed, narrow-headed, narrow-faced race.

Homo sapiens europæus alpinus—the medium-statured, dark-haired, gray- or brown-eyed, broad-headed, broad-faced race.

Homo sapiens europæus mediterraneus—the medium-statured, black-haired, black-eyed, narrow-headed, narrow-faced race.

Each of these races of men is distinguished by innumerable differences of character and predispositions, spiritual, intellectual, moral, and physical. For example, the Nordic and Alpine races have a hairy covering over the greater part of the body. The men are heavily bearded, in adaptation to the severe climate of the cold northern regions from which the Nordics sprang, or to the cold mountain and plateau region from which the Alpine-Slavs sprang. The members of the Mediterranean race, on the other hand, have relatively smooth and hairless bodies, in adaptation to the warm southern coast regions of Eurasia from which they sprang.

There has been another still more profound change both in our knowledge of facts and in our theories and conceptions since the time of Linnæus and even of Quatrefages, through anatomical researches among the Asiatics and Africans. This is the recognition that the genus *Homo* is subdivided into three absolutely distinct stocks, which in zoölogy would be given the rank of species, if not of genera, stocks popularly known as the Caucasian, the Mongolian, and the Negroid:

Homo sapiens europæus—North and south Eurasiatic stock, wavy hair (cymotrichous) with intermediate cross section. Broad- or long-headed. Tall to medium stature. (= CAUCASIAN.)

Homo sapiens asiaticus—Extreme East Asiatic stock. Straight hair (lissotrichous) with round cross section. Broad-headed. Medium to tall stature (American Indian). (= MONGOLIAN.)

Homo sapiens afer—African stock. Closely curled hair (ulotrichous), flattened cross section. Narrow-headed. Short to tall stature. (= NEGROID.)

The spiritual, intellectual, moral, and physical characters which separate these three great human stocks are far more profound and ancient than those which divide the Nordic, Alpine, and Mediterranean races. In my opinion these three primary stocks diverged from each other before the beginning of the Pleistocene or Ice Age. The Negroid stock is even more ancient than the Caucasian and Mongolian, as may be proved by an examination not only of the brain, of the hair, of the bodily characters, such as the teeth, the genitalia, the sense organs, but of the instincts, the intelligence. The standard of intelligence of the average adult Negro is similar to that of the eleven-year-old youth of the species *Homo sapiens*. The wisdom teeth of the Negro are erupted at the age of thirteen; the wisdom teeth of *Homo sapiens* are erupted between the ages of twenty-one and thirty, if at all. The young Negress may in extreme cases produce her offspring at the age of eleven; the early maturing Hindoo woman of Caucasian stock may produce offspring at the age of twelve. Hundreds of other differences might be cited. This is not said in disparagement of the Negroid race, which displays many noble qualities of spiritual and moral character, as observed by sympathetic and unprejudiced travelers like Herbert Ward, whose sculpture[1] has also revealed the superb physical development of the native Negro.

The Mongolian is somewhat less profoundly different from the Caucasian than is the Negro. The intelligence and morale of the Mongolian may fully reach the high Caucasian level, as shown in great periods of Chinese history, but his physical development seldom equals that of either the Negroid or the Caucasian, which give rise to the tallest races in the world.

The hair happens to be one of the most conspicuously distinctive and constant features of these three species of man. Skin color is less uniformly distinctive. The Mongolians are yellow to dark brown or bronzed in skin color. The Negroids are generally dark brown to full black. The Caucasians are extremely fair-skinned in the North, light-brown-skinned in the South, very dark-brown-skinned in subtropical Polynesian hybrid branches, like the Hawaiians.

Each of these human species interbreeds with the other and produces a great variety of half and quarter breeds. Thus *inter-fertility is not a bar to specific distinction or even to generic distinction in mammals*. In the family of Bovidæ, for a parallel, several genera and species freely interbreed, e.g., our domestic cattle (*Bos taurus*) and the bison (*Bison americanus*).

CAUSES OF THE DIVERGENCE OF RACES, SPECIES, AND STOCKS

The color divergence in the Caucasian and Mongolian species is only the most conspicuous of thousands of divergent characters which have been brought about through the long influences of mate selection, of indirect adaptation to climate, of the direct influence of climate, of the influence of habit, and of 'organic' or coincident selection. I am inclined at present to regard the prolonged or secular influence of habit and of organic selection as among the prime causes of the divergence of human characteristics. The opening of the Lord's Prayer, "Give us this day our daily bread," is a recognition of the world-wide fact that the

[1]The superb collection of Herbert Ward's sculptures is to be seen in the U. S. National Museum.

primitive man must first think of the food supply for himself and his family. Exactly like an animal, he is compelled to work for his food supply, to seek it where the environment offers it, whether in the chase of animals or birds, in fishing, or in the earth. The search for food has led man into various habits and habitats to which he was more or less fitted by intellectual, moral, and physical predispositions.

These predispositions are hereditary and therefore subject to organic selection. By heredity men may be predisposed to arboreal, to cursorial, to terrestrial, or to amphibious life. The born climbers take to the trees, the born swimmers take to the water, the born runners take to the chase. But in turn these very habits of tree life, of aquatic life, of cursorial or running life, through the process of individual modification and self-adaptation, are self-perfecting. Those who attain the greatest skill and facility are naturally the most successful members of the tribe. They are the best climbers, the best fishermen, the best hunters. They are rewarded by the first choice of wives and blessed with the first crop of offspring. This is the essence of the principle of *organic selection*, a subsidiary principle of Natural Selection, which was independently formulated by Baldwin, Morgan, and Osborn.[1] The illustration which Osborn used is cited on page 11 in 'How to Produce an Arboreal Type of Man.'

Have we wandered far from our subject, the evolution and terminology of human races? Not at all. We have, on the contrary, come to the very heart and philosophy of it, because the genesis of human races was exactly like the genesis of animal races prior to the era of civilization. Following alike the principle of adaptive radiation, man goes forth to seek and labor for food. He may go to the temperate regions, to the North Pole, or to the Equator. If he chooses the Equator the quest for food is very easy and requires relatively little intelligence; the environment is not conducive to rapid or varied organic selection; the struggle for mere existence is not very keen; the social and tribal evolution is very slow; intellectual and spiritual development is at a standstill. Here we have the environmental conditions which have kept many branches of the Negroid race in a state of arrested development.

The food supply is primarily from the chase, secondarily from agriculture or the quest of natural fruits. The Mongoloid races at a very early stage exhausted their animal food supply and were compelled to turn to agriculture. This explains the extraordinary industry, vitality, and working powers of this people, which are the result of ages of organic selection. A Chinese or Mongoloid workman has far greater endurance and is capable of more continued effort on less food and a lower energy (calorie) diet than the Caucasian, who, until the game supply began to be exhausted in the forests and plains of northern Eurasia, was chiefly a hunter and fisherman.

It is, then, the varied quest for food which is the prime cause of the evolution of the specific and subspecific characters of man. This quest leads him into certain new environments, the new environments compel him to adopt new habits and modes of motion, and the new habits and modes of locomotion produce new modifications and changes of form which are accumulated through organic selection and pre-

[1]H. F. Osborn: A Mode of Evolution Requiring neither Natural Selection nor the Inheritance of Acquired Characters. *Trans. N. Y. Acad. Sci.*, Vol. XV, March 9 and April 13, 1896, pp. 141–42, 148.

disposition. This is not the Lamarckian theory of the direct inheritance of acquired characters; it is a theory of prolonged or *secular* inheritance of *predispositions* which happen to *coincide* with the new demands and habits of life. This process of organic or coincident selection operates over very long periods of time.

The new environments also throw all the old adaptations out of balance and put new survival values on certain characters. The heavy beard is a distinct advantage to the Nordic and to the Alpine hunter. The hairy covering of the body is of benefit to the Alpine Slav of the cold plateau regions. On the contrary, the Mediterranean subspecies and the Negroid species develop hairless bodies, partly because hair is unnecessary with a very dark skin, partly because hair and clothing harbor insect carriers of infectious diseases, from which it is easy to protect the nude and hairless body. The Mongoloid races, although partly migrating into the coldest regions of the earth, have never acquired a hairy covering and are as hairless as the Negroids; the same is true of the American Indian.

Individual choice of habit and of habitat, with men as with animals, has by these means been the polestar of evolution. Lamarck in a secular or geologic sense was right when he said that organs were acquired when animals *strove for them;* they are first acquired as non-heritable *modifications;* in the course of ages they are acquired as true hereditary characters. This choice of habit or of habitat has sometimes been optional, a matter of pleasure in choosing between two or more alternatives, and sometimes enforced. Alden Sampson has shown that the white-tailed deer (*Odocoileus macrourus*) of the western states seeks no less than seventy-three kinds of food during the course of the year. Among the antelopes of Africa there is a great seasonal range of diet for certain species; others, like the *Oribi*, are said to browse only

Photograph by Underwood and Underwood

RUNNING TYPE

Paavo Nurmi, Finnish runner. Observe the feeble arms and strong legs

on a single kind of plant to which the animal is exclusively adapted. Man, like the bear, is naturally omnivorous, but he may be forced to an exclusively frugivorous diet, as among the plantain eaters; to a strictly graminivorous diet, as among the rice eaters; or to an exclusively flesh and fat diet, as in the case of the most northerly Eskimo. An exclusive diet tends to the organic selection of a modified type of dentition, to a modified musculature of the jaws, and to modification of the digestive tract, all of which organs are extremely modified in the Eskimo.

The choice, however, leads to a readjustment of all the internal and external reactions of man as a mechanism, to a change in all survival values, and to a new series of actions, reactions, and interactions between the developing and race-begetting man and his lifeless and living environment, to use Osborn's tetraplastic and tetrakinetic conceptions of evolution.

HOW A RACE OF TAILORS MIGHT BE PRODUCED

The anatomy and physiology of a tailor as studied by the British anatomist, Sir Arbuthnot Lane, in the year 1888, show that the lifelong habits of a tailor engaged in his confining and laborious trade actually produce a distinct type of man. Such a type, if it became heritable and thus established, might be described humorously as a new variety, *Homo sapiens sartorius*. In the old days the tailor sat with bent form, with crossed legs, jerking his head sharply to the side in drawing the needle and thread with his thumb and forefinger through the resistant cloth—sartorial habits which, if prolonged through a lifetime, produce many new characters. The type is now extinct, for the modern tailor works only at machines.

The following are only a few of the modifications of muscles, tendons, and bones produced in individuals by hundreds of repetitions of similar motion which might conceivably result in the evolution of a hypothetic new variety—*Homo sapiens sartorius*—in which these modifications would be heritable: The muscles tend to shorten and recede into tendons; the tendons grow relatively longer and the bony surfaces into which they are inserted tend to grow in the direction of the pull which the muscles exert upon them; the articulation between the breastbone (sternum) and the collar bone (clavicle), normally a close junction, is modified into a very complex movable joint almost of the character of a typical hinge joint, like that of the elbow. Owing to the prolonged squatting posture, which compresses the chest and prevents the free rise and fall of the ribs and chest breathing, the six pairs of ribs become firmly coössified with the respective vertebræ of the back, indicating that they had ceased to rise and fall with sternal breathing and that by way of compensation respiration is almost exclusively by means of the diaphragm, which, in the normal human being, supplements the rise and fall of the chest. To accommodate the side jerk of the head which the tailor pursuing his trade for a period of twenty or thirty years repeats thousands of times, the right side of the skull forms a new joint with the broad transverse flange on the right side of the first vertebra of the neck (the atlas). This joint is adaptive; it relieves friction between the side of the skull and the side of the vertebra. A small synovial cavity containing the fluid surrounds this newly acquired sartorial joint. This provision for freedom of movement on the right side of the neck is balanced by a rigid fixation on the left side of the neck because the left half of the second vertebra (the axis) is firmly united by bone to the left side of the third vertebra. Thus the second and third vertebræ tend to form a single bone. This fixation is also adaptive, fitting the tailor to his peculiar mode of living. But Nature does not stop here. Doctor Lane finds that the peglike process (the odontoid) of the axis is prolonged in its socket of the atlas and that a new transverse ligament is formed to keep this peg from slipping out of place and pressing on the spinal cord. (It is pressure of the axis upon the spinal nerve and rupture of the transverse ligament that produce instantaneous death in hanging.) In brief, the anatomy of the tailor is full of *new anatomical characters*, caused partly by fixation of motion, partly by exaggeration of motion.

These anatomical changes, effected during the lifetime of the individual, serve to emphasize the great contrast between the rapidity of individual adaptation or modification and the slowness of race adaptation or evolution. All these marvelous adapative modifications die with the individual; none of them is inherited. The son of this tailor will not exhibit any of these newly acquired characters—his ribs and vertebræ will move freely upon each other. It is only through the slow process of the *coincident selection of predispositions toward the sartorial form of body that a new sartorial race could be produced* in which these sartorial modifications would be *inherited characters*. Again, this sartorial race, like the amphibious or the arboreal race spoken of above, would finally emerge after the selection of hundreds or perhaps thousands of generations of those individuals in which the body is peculiarly adapted by predisposition to the sartorial habit. All the evidence we have, like that of the fossil horse, for example, shows that modifications produced by peculiar habits, if transmitted at all, would be imperceptible in one generation. The horse has not yet lost its lateral fingers and toes which began to be useless two million years ago, at the beginning of the Oligocene period.

Photograph by Herbert Lang

SQUATTING TYPE

Belgian Congo blacksmith. Observe the feeble legs

THE INFLUENCE OF HUMAN POSTURE ON THE SKELETON

In a most valuable essay by Arthur Thomson in 1889 upon 'The Influence of Posture on the Form of the Articular Surfaces of the Tibia and Astragalus in the Different Races of Man and the Higher Apes,' we find clearly brought out the distinction between *congenital* variations and those which may be *acquired* by prolonged habits of life. It is perfectly clear from this investigation that certain racial characters, such as 'platycnemism' or flattened tibia, which have been considered of great importance in anthropology, may prove to be merely individual modifications due to certain local and temporary customs. Thomson's conclusions are that the tibia or shin is the most variable in length and form of any long bone in the body. Platycnemia, i.e., flattened tibia, is most frequent in tribes living by hunting and climbing in hilly countries, and is associated with the strong development of the *tibialis* *posticus* muscle. The great convexity of the external condyloid surface of the tibia in savage races appears to be developed during life by the frequent or habitual knee flexure in squatting; it is less developed where the tibia has a backward curve and is independent of platycnemia. Another product of the squatting habit is a facet formed upon the neck of the astragalus (heel-joint bone) by the tibia. This facet is very rare in European man; it is found in the gorilla and orang, but rarely in the chimpanzee. We must therefore be on our guard to distinguish between congenital or hereditary skeletal characters which are fundamental, and 'acquired' skeletal modifications which may not be hereditary.

Photograph by Underwood and Underwood

SWIMMING TYPE

Duke Kahonomoku, the world-famed swimmer from Hawaii. Observe the strong arms and strong legs

THE AMPHIBIOUS LIFE OF THE PRIMITIVE HAWAIIANS

The early explorers were all impressed with the amphibious life of the natives of the 'Sandwich Islands' and with their fearlessness and dexterity. On Vancouver's second journey, in the years 1793–4, he was accompanied by the botanist Archibald Menzie, in whose journal,[1] February 5, 1794, we find the following observations:

After the whole party had breakfasted we left Honomazino in our canoes about nine in the morning and soon after passed the western part of the Island which is a dreary tract of the most rugged rocks of lava scattered here and there with some fishermen's huts. About noon we came to a small village named Manaka where we found our Chief Rookea's residence and where we landed before his house at a small gape between rugged precipices against which the surges dashed and broke with such violence and agitation and with such horrific appearance, that even the idea of attempting it chilled us with the utmost dread. We, however, quietly submitted ourselves to their guidance and were highly pleased to see the extraordinary dexterity with which they managed this landing. Having placed their canoe in readiness before the gape they watched attentively for a particular surge which they knew would spend itself or be overcome in the recoil of the preceding surges before it could reach the rocks, and with this surge they dashed in, landed us upon a rock from which we scrambled up the precipice and in an instant about 50 or 60 of the natives at the word of command shouldered the canoe with everything in her, and clambering up the rugged steep, lodged her safely in a large Canoe-House upon the brink of the precipice, to our utmost astonishment.

. . . .

In the afternoon our attention was at one time directed to a number of young women who stripped themselves quite naked upon the summit of a pending cliff, and taking a short run vaulted one after another from the brink of it headlong into the sea, regardless of the foamed and agitated appearance of that element, and as it were setting its wildest commotions at defiance, for at this time the surf ran very high and dashed with furious

[1]See Hitchcock: *Hawaii and Its Volcanoes*, p. 65.

force against the cliff, yet they dexterously disentangled themselves, and clambering up the rock again, repeated their leaps several times with seeming satisfaction till they were quite fatigued. The cliff was at least thirty feet high and so very rugged with packed rocks which were now and then deluged with a boisterous surf, that to look down the precipice was enough to intimidate any one not accustomed to such extraordinary feats of activity.

More recently so trustworthy an observer as Frank Bullen[1] describes a feat of which he was eye-witness. Half a mile from the towering mass of Sunday Island, exposed to the full force of the gigantic swell of the South Pacific, a young Kanaka sailor left the boat, landed in a weltering whirl of rock-torn sea, climbed the steep sides of the cliff and seized a wild goat, the object of his quest. In the struggle both lost their footing and tumbled down the cliff in a small avalanche of stones and dust. Although badly battered—not by his swim but by the fall—the man lashed the goat to his naked body, ignoring its struggles, crawled out on the rocks and dove once more into the turmoil of breakers, returning to the boat in triumph with the goat none the worse for the experience.

HOW TO PRODUCE AN ARBOREAL TYPE OF MAN

As the swimming habit will produce through individual preference an amphibious type, which might be perfected in successive generations through organic selection of the most apt swimmers, so an *arboreal* type might be produced. Thus Osborn observed in 1896,[2] in first defining the principle of organic and coincident selection:

> If the human infant were brought up in the branches of a tree as an arboreal type instead of as a terrestrial, bipedal type, there is little doubt that some of the well-known early adaptations to arboreal habit (such as the turning in of the soles of the feet and the grasping of the hands) might be retained and cultivated; thus a profoundly different type of man would be produced. . . . During the enormously long period of time in which habits induce ontogenic variations, it is possible for natural selection to work very slowly and gradually upon predispositions to useful correlated variations, and thus what are primarily *ontogenic variations* become slowly apparent as *phylogenic variations* or congenital characters of the race. Man, i.e., *Homo sapiens*, for instance, has been upon the earth perhaps seventy thousand years; natural selection has been slowly operating upon certain of these predispositions, but has not yet eliminated those traces of the human arboreal habits, nor completely adapted the human frame to the upright position. This is as much an expression of habit and ontogenic variation as it is a constitutional character.

At the time the above passage was written, Osborn adopted the widespread current faith in the direct arboreal ancestry of man. Robinson's well-known photograph of the baby clinging to a broom handle, with its feet turned in, had just been published, and no fossil human skeletons were known at the time to rebut the prevailing arboreal hypothesis. Since then the complete skeleton of the Neanderthal man has been discovered, and the balanced proportions of the upper and lower limbs lend no support to the arboreal hypothesis. The Neanderthal man is descended from many hundreds of thousands of generations of *walkers,* not of tree climbers. Another line of evidence *against* the arboreal theory has recently come to mind. It is that when man does take to the trees it is never in the manner of the chimpanzee or of the gorilla, but in the manner of the bear, i.e., of "shinning the tree," by embracing the trunk with the arms and shins. No anthropoid ape displays this power, which is among the early instincts of

[1] Bullen, Frank T. *The Cruise of the "Cachalot,"* pp. 299, 305–307.
[2] Trans. N. Y. Acad. Sci., March 9, 1896.

Photograph by Herbert Lang

CLIMBING TYPE

Climbing pygmies of the Belgian Congo. No monkey or ape climbs in this manner

every boy. The ape must rise into the tree not by the trunk route but by the branches. Once started, the swinging action resembles that of a man on a trapeze. The grasping is done with all five fingers, including the rudimentary thumb *placed around the branch.* The thumb is not used either by the ape or by the trapeze expert, because the hand must instantly hook itself over the branch. Consequently the thumb is not developed and all arboreal mammals are practically thumbless.

As a boy of ten the writer watched the Spanish lads near Murcia, Spain, climbing the date palms. They placed a fibre girdle around the slender trunk and, swaying backward and forward, arose by slipping the girdle higher and higher, turning the soles of the feet inward on the outer sides of the trunk. This method of tree climbing, with all its variations, is purely a human achievement. As tree climbing is observed among the Hawaiian boys, no girdle is used. The slender trunk of the cocoanut palm is seized by the hands and, where possible, the body leans backward and the feet are placed sole downward against the trunk.

DISTINCTION BETWEEN HUMAN AND ANIMAL EVOLUTION

The great distinction between these sartorial, amphibious, and arboreal adaptations in man is that they are relatively temporary—matters which may endure for a few years, or at most for a few centuries—whereas corresponding adaptations in animals are *secular;* they certainly extend through enormous periods of time corresponding with the great secular changes in the earth's surface. If we could imagine all mankind forced into a sartorial or an amphibious mode of life for thousands or hundreds of thousands of years, then we should have a real parallel between human and animal evolution.

Among animals, however, we observe a parallel to man evolving under the 'adaptive radiation' and 'organic selection' principles in the comparison between the psychology and the mechanical evolution of the various races of the horse. The horse and the elephant both resemble man in the resourceful and intelligent selection of habit and habitat. They are the only mammals that rival man in seeking food and in overcoming all natural difficulties in every region of every continent except Australia. Horses would swarm in Australia if once they had a footing there. The greatest enemy of the horse, as well as of man, has been insect-borne infectious diseases. This debars the horse, as it does the white and yellow races of man, from the insect-laden tropics.

There is, however, one very fundamental difference between the mechanical evolution of man and of the horse, namely, that the latter has been mainly a *single-track* adaptive evolution from the very beginning, whereas man evolved in three phases, each of which has left some traces in his anatomy:

(1) a quadrupedal terrestrial phase, extremely remote.

(2) a quadrumanous arboreal phase, still very remote.

(3) a bipedal and bimanous terrestrial phase.

Opinions differ as to the length of these phases and their relative antiquity in geologic time. The matter will be settled positively only by palæontologic discovery. In the writer's opinion, which differs radically from that of many of his colleagues, *the quadrumanous arboreal phase in man was never a very profound or exclusive mode of life*. The anatomical evidence does not point to a prolonged period of arboreal existence, but rather to a prolonged period of terrestrio-arboreal habit, during which our very remote ancestors lived and fed chiefly upon the ground but sought protection from their enemies in the trees. In brief, we do not believe the case has been proved for arboreal man, chiefly because neither the human leg and foot nor the human arm and hand retains proofs of prolonged arboreal adaptation; on the contrary, the human hand is of a non-arboreal type, as far as possible from the thumbless, trapeze-motion hand of the gibbon. Secondly, the human foot retains no traces of the grasping foot and big toe of the higher apes. In brief, the better we understand the human anatomy and mechanism and the more we learn of the fossil ancestors of man, the less close appears our relationship to the great anthropoid apes, the gorilla, the chimpanzee, the orang, and the gibbon, which pass from the terrestrio-arboreal to the super-arboreal phase in an ascending scale of structure.

CONCLUSION

Our conclusion from the world-wide studies and observation of the post-Darwinian period is quite contrary to that of Quatrefages quoted at the beginning of this article. We have discovered that 'species' and 'genera' of man arise in the same manner that races, species, and genera arise among other mammals. This is for the reason that the creative evolution of primitive and of uncivilized man is subject to the same laws as those which prevail throughout the animal kingdom, until human Civilization steps in and interferes with the natural orders of things. Thus when man begins to specialize and races begin to intermingle, Nature loses control. It appears that the finest races of man, like the finest races of animals, arose when Nature had full control, and that man is upsetting the divine order of human progress.

Courtesy of the Field Museum of Natural History

BAGOBO (MALAY) OF THE SOUTHERN PHILIPPINES, CUTTING TEETH TO POINTS

Courtesy of the Field Museum of Natural History

Pygmy women of the Malay Peninsula

Peoples of Malaysia[1]

By FAY COOPER COLE
Professor of Anthropology, University of Chicago

THE region known as Malaysia extends from the Malay Peninsula on the west to the borders of New Guinea on the east; and from the line of islands which fringe the southern coast of Sumatra and Java to the northern extremity of Formosa.

It derives its name from the principal ethnic group which inhabits it—the Malayu or Malay, but this does not imply that all its inhabitants are of one race, of a uniform stage of advancement, or under one political control; neither does it mean that all people closely affiliated with the Malay reside in it, for racially, a considerable part of the inhabitants of Siam, French Indo-China, and Burma belong to this division of mankind.

Politically, Malaysia falls under the control of Great Britain, Holland, France, Portugal, the United States, and Japan, while the former rule of Spain in the Philippines and of China in Formosa has left a deep impression on those islands.

PYGMIES

The first inhabitants of Malaysia were doubtless pygmy blacks, a remnant of whom still exists in the Malay Peninsula, the Philippines, and the Andaman Islands in the Bay of Bengal. No pygmy groups are now to be found in Sumatra, Java, or Borneo, but the frequent occurrence of individuals exhibiting Negroid characteristics leads us to the belief that they once inhabited practically all of this island world.

Culturally these people are among the lowest known today. Their garments are strips of beaten bark; they build no permanent dwellings, and have no domesticated animals, other than an occasional dog or a wild rooster used as a decoy in trapping; and they practise no agriculture, except in regions where they are much influenced by their neighbors.

How such a primitive people could have reached isolated islands over such great distances has long been a puzzle. Since they are not seafarers such a feat seems quite impossible for them today, yet it is unlikely that they ever possessed a higher culture than at present.

It has been suggested that their dispersal over this region was at a time when Malaysia formed a part of the

[1]The material presented in this article, as well as the photographs, were gathered by Doctor Cole during three expeditions into Malaysia made for the Field Museum of Natural History.

Asiatic mainland,—a contention which is strengthened by the distribution of certain plants and animals over the islands as well as in China in the north and the Malay Peninsula in the south.

Courtesy of the Field Museum of Natural History

Pygmies of Malay Peninsula with Captain Berkeley, governor of Perak

Many theories have been advanced to account for the origin and dispersal of the pygmies. Some consider them as the little modified descendants of a very ancient race, ancestral to all other Negroids and hence our nearest approach to primitive man. Others regard them as a recent, degenerate branch of the Negro, the result of long continued malnutrition, lack of functioning of certain glands, and other causes which the length of this paper will not allow us to discuss.

For our present purposes it is enough to say that the pygmies at one time occupied all the archipelago; that they have left a trace of their blood among the invading groups and hence must be considered in any discussion of the physical types found in Malaysia.

In height the men average about 146.5 cm., the women a little less. Their heads are short, broad and low, with an average cephalic index of 82. The forehead is low and receding; nose broad, often with such spreading wings that the width exceeds the length; the lips are thick and protruding; the chin feebly developed. In general, they appear well proportioned, although actual measurements show the arms to be somewhat longer, when compared with the legs, than is the case with the Malays and whites. The hair is closely curled or woolly, while the skin color varies from a chocolate brown to very dark sepia. Thus they appear much like the African Negro, except for their stature and their brachycephalic or round heads.

They were never a powerful people, but from the earliest times have been broken up into small nomadic bands which waged a never ceasing struggle for existence against the jungle and its inhabitants, a struggle so keen that only the strongest children survive and an aged person seldom is seen. Yet the contest is staged in a land of plenty, where jungle fruit and tubers are to be had for the taking, where deer, pigs, monkeys and squirrels abound, and the streams are stocked with fish and snails. Nets and traps, and bows and arrows make it possible to supply most of their needs, but the most deadly weapon was and is the blowgun, through which tiny darts tipped with poison are blown. When game is plentiful the pygmies feast, but if the hunt has been unsuccessful or if bad weather keeps them at home, they fast. Except in a few regions where they are much influenced by their neighbors, they have no fields; they store no food against a

Courtesy of the Field Museum of Natural History

Group of pygmies on the Island of Palawan, Philippine Islands

Courtesy of the Field Museum of Natural History

Typical pygmy men of the Malay Peninsula time of need, and so real periods of privation are frequent and the weaker members of the community suffer.

Their houses, for the most part, are mere windbreaks of leaves; and the best is nothing more than a framework of sticks covered with leaves beneath which is a raised floor serving as a bed, table, and reception room. If the night is cool or the mosquitoes troublesome, a fire or smudge is built below so that the inhabitants can sleep in peace; but, more often, when bedtime comes, they pull the burning embers from the bonfire and curl up in the hot ashes. This does not make for cleanliness, but this troubles the pygmies not at all. They seldom bathe. At times they rub the body over with grease until it shines, but the next sleep in the ashes turns them a dull gray. Their neighbors tattoo their flesh, but the pygmy skin is so dark that this ornamentation would not show, and to make up for this they scarify their backs and arms. Gashes are cut and dirt and soot rubbed in so that the wounds will become infected and large raised scars will be assured. They further beautify themselves by cutting, filing, or breaking their front teeth into points. And so they live happy, carefree lives, quite unconcerned by the change and progress of the neighboring lowlands; but they are rapidly vanishing and another fifty years may find them gone.

THE SAKAI

Another group which must be mentioned is the Sakai, a pagan people of the Malay Peninsula, now found only in the mountain forests and in a few valleys not yet appropriated by the Malay. Here we seem to have a situation quite the reverse from that encountered with the pygmies. The latter appear today, as they have always been, an exceedingly primitive people, but the Sakai give evidence of having had a much higher culture which has broken down through contact with invaders. As the Malay pressed in from the coast they drove the pagan tribesmen before them, seized their lands, enslaved them, and always despised them. The Sakai apparently lacked the organization to resist, and, little by little, retired toward the interior where they came into close contact with the pygmies who, in turn, were driven deeper into the jungle. This process has been going on for generations and still is in progress, so that we find the Sakai in all stages of transition. The first groups met by the investigator are those which have worked out a satisfactory relationship with the Malay. They make their clearings near to the invaders, and provide them with game, rattan, gums, and other jungle products, in return for which they receive some tawdry products of civilization. Their homes are poor imitations of those of their neighbors, while the furnishings are the scantiest. They are entirely under the control of the higher group, with which there has been considerable intermixture.

Far in the interior are the bands which have followed the line of least resistance; have almost entirely given up agriculture; and now lead a life not far removed from that of the pygmy. They have, in fact, freely intermarried with the latter until in many cases it is difficult to say in which division they should be placed. Between these two extremes we have the remnants of an older culture. Often the whole group lives in a rectangular house raised high above the ground on piles. Along one side of the building runs a corridor, in which the cooking is done, and back of this are the family compartments.

A head man, usually one of the oldest of the group, has nominal control over this house and perhaps two or three neighboring dwellings of similar type.

Surrounding the settlement are the fields—clearings made in the forest. Small trees and underbrush are slashed, then the larger trees are deeply cut on one side, so that when a certain tree is cut, it will fall on another, and this on still another, until a wide path is made across the clearing. Later, these are fired and then the men go through the fields with sharpened sticks, punching holes in the ground. The women follow, drop seed corn or rice into the holes, push back the dirt with their feet, and the planting is complete. Rude fences and traps are built around the fields to keep out deer, wild pig and other intruders, and during the time the grain is ripening it is constantly guarded by members of the family. Logs left after the burning are seldom removed, since the white ants eat the dead wood in one or two seasons and leave the fields clear. The owner does some weeding, but soon after the jungle is removed, a rank grass invades the land and within one or two seasons the planter finds it easier to cut a new opening in the forest rather than to combat the grass with the primitive implements at his command. Work in the fields is largely communal, the whole group going from one plot to another until all are prepared. The owner of the land has first claim to the crop, but should disaster come to a neighboring field, or should any be in want, he readily shares his wealth. For one to have a surplus while another is in need is in true Sakai society unthinkable. Chickens and pigs are found in every settlement and are highly prized as food, but no one would think of eating an animal raised in the same house or settlement as himself. Pressed for an explanation the Sakai will shrug his shoulders and reply, "Just like eating your own family." He does not hesitate, however, to trade his birds or animals with another settlement and then eat his new possessions.

All Sakai make use of the blowgun. The principal poison is secured from the *upas* tree (*Antiaris toxicaria*). Deep cuts are made in the bark and as the sap flows out it is caught in bamboo tubes. It is then boiled down until of the thickness and color of tar, when it is spread on a bamboo spatula and allowed to dry. When needed it is dampened and the end of the dart is rolled in it until a thin layer adheres. At the other end of the dart a cone of pith is attached and the missile is complete. With his blowgun ready, the Sakai slips quietly through the jungle, never breaking a twig nor making a sound until he sights his prey. A dart is inserted into the tube, and slowly the hunter raises it to his lips. A single puff into the tube sends the missile flying noiselessly toward its victim. The animal is seldom frightened even if struck, but soon the poison gets in its work. The Sakai cuts a bit of flesh away from the wound and the game can then be eaten without any ill effects.

Some traps are used for game, and funnel-shaped basket traps are placed in streams in such a way that all fish passing down with the current must enter. Then the stream above is beaten and rocks are overturned so as to drive the fish down and into the trap. Snails, jungle fruits, and tubers likewise furnish foodstuffs, so that under ordinary circumstances the people have plenty.

When near to the Malay the men

Courtesy of the Field Museum of Natural History

Group of Sakai hunters with blowguns

wear clouts of cloth, while the women employ a wrap-around skirt of similar material; but in the mountains, beaten bark takes the place of cloth, and a fringe or kilt of shredded leaves serves as a skirt. The upper portion of the body is seldom covered and is never tattooed, but the faces are painted in red, yellow, and white designs. The septum of the nose is pierced and porcupine quills or tapering rods are worn cross-wise of the face. The women also wear bamboo combs, not for use, but for ornament and protection, for each bears a magical symbol which wards off danger and evil spirits.

We have already seen that the Sakai have mixed with the Malay on the one hand and the pygmy on the other, so that they frequently present characteristics of each. This accounts for the theory often advanced that the Sakai are the result of a fusion of these two. Such a solution does not take account of the fact that the majority of the group have rather long, narrow heads, while both Malay and pygmies have short heads. In general, also, the nose is thinner and higher than in the other groups. The average stature is about 150 cm., but individuals are found who are below the average of the pygmy, while others tower above the Malay. The hair is likewise variable, some is long and straight, some hangs in ringlets, while in some cases it is short and woolly as in the negro. Pygmy blood is also evident in the dark skin of some individuals, but the majority are a yellowish or reddish brown with a distinct gray undertone.

The language seems to belong to the Mon-Khmer group and thus, together with other anthropological data, seems to justify us in believing that they show closer affinity to the Mon-Khmer than to any of the neighboring peoples.

THE MALAY

The last people we shall consider is the Malay—the most numerous and most advanced in Malaysia. They are

Above: A fifty-year old Sakai woman, one of the wild pagans of the Malay States.

Left: Sakai women of the Malay Peninsula. *Photographs by courtesy of the Field Museum of Natural History*

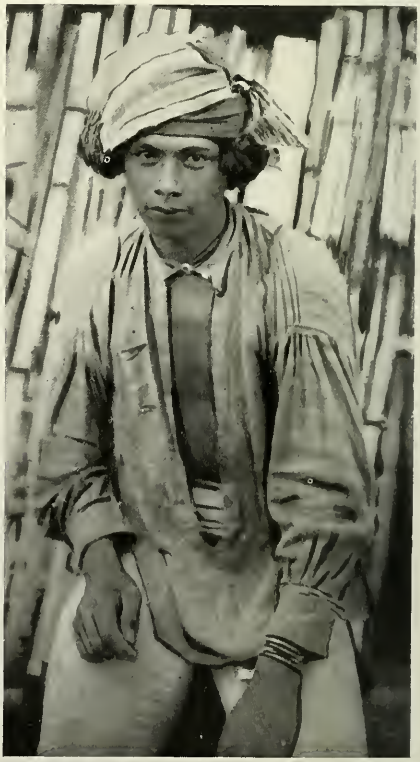
generally described as being short in stature—about 160 cm. —of slight build, with round heads, rather narrow but low noses, and thick lips, straight black hair and yellowish brown skin. Such a description would fit most of the coast people, and a considerable proportion of the interior tribesmen, but it would need to be considerably modified to include all the Malay. In some groups

A Tinguian gentleman—a typical pagan Malay. *Photographs by courtesy of the Field Museum of Natural History*

many of the people are of stocky build, have longer and narrower heads, longer and broader noses, thicker lips, and the hair is distinctly wavy. Some investigators have applied the name Indonesian to this type, but this must not be interpreted to mean that there are any true Indonesian groups or tribes in Malaysia, for the type is found in every part of the archipelago thoroughly fused with the typical Malay.

To the writer the evidence seems to indicate an early movement into Sumatra, Java, and adjacent islands of a people closely related to the Polynesians. From time to time they were joined by groups of southern Mongoloids, some of whom came in by way of the Irawadi, some by the Salween, Mekong, and other rivers. The newcomers brought in some new elements of culture, and also modified the physical type, but apparently were not strong enough to impress their language. The speech of the earlier settlers remained dominant and gave rise to the language now called Malayo-Polynesian.

The movement of southern Mongoloids into Malaysia appears to have been slow but continued until there was a thorough mixture of the two groups in the main islands, but in the more remote regions the Polynesian element was still dominant. Finally, the pressure of population carried a part of these marginal groups out into the islands toward the east, while the



Courtesy of the Field Museum of Natural History

One of the so-called Indonesian men of the Southern Philippines mixed people we now call Malay pushed their way north through the Philippines to Formosa. There has been intermixture with other peoples in the new homes, and conditions of life have doubtless left their impress on physical type, but if this theory is correct the chief difference between Polynesian and Malay is the greater amount of Mongoloid blood in the latter. However, there are many groups in Malaysia in which individuals closely approximating the Polynesians are still to be found.

It appears that the various groups coming into Malaysia not only entered by somewhat different routes, but that in their homeland they had developed customs often quite radically different from those of their neighbors, customs which they have preserved with surprisingly little change up to the present. In some regions the people are divided into clans or gens, yet the vast majority of the Malay have neither. The bachelor's house, trial marriage, and even polyandry appear in very primitive groups, yet others equally primitive have no such institutions. Terraced rice fields and a highly developed economic life are found within a few miles of a region where hoe or dibble culture is of about equal importance with hunting and fishing.

Courtesy of the Field Museum of Natural History

A Tinguian family of Northern Luzon, showing the influence of their civilized neighbors in dress

In historic times the coast Malay has been profoundly modified by contact with India, China, and the colonizing powers of Europe, but in the interior of many islands are still to be found groups living the life of former times. One of the most interesting of these is the Tinguian—a powerful pagan tribe of northern Luzon. The rugged mountains of their homeland are but little wooded and the streams are uncertain, so that hunting and fishing are of minor importance and the people are forced to agriculture. Lacking level ground, they have terraced the mountain-sides so as to provide fields. Rice is their chief crop and on its cultivation they will labor unceasingly, but when the harvest is over they indulge in many festivals and ceremonies.

Some of these are purely social, but most have as their object the gaining of favor with superior beings. A whole host of spirits, some good, some bad, are known to the Tinguian; in fact, he

Courtesy of the Field Museum of Natural History

Tinguian women seeding and bushing cotton

is on very intimate terms with the spirit world, for he talks to its members through mediums. At times of ceremony the superior beings enter the bodies of chosen men or women who are no longer considered human but as the spirits themselves; and under their guidance the people do many things to bring health and happiness to the group. A birth, marriage, sickness, or death, or any event of importance calls for a ceremony, but it is likewise a social event to which people will come from all neighboring villages.

During the dry season fires are built in various parts of the village and around these the women gather to spin, the men to make fish nets, while some good story-teller chants the tales of long ago or tells of the fighting prowess of the fathers. The Tinguian are not far removed from the days of head-hunting and it is still the proud boast of many a man that he has fought in the villages of their enemies.

Child betrothal is common and marriage usually takes place before either of the couple has reached puberty. A price is paid for the girl, but she is in no sense a slave; she holds property in her own name and passes it on to her children. She takes care of the house, looks after the children, brings water from the village spring, assists her husband in the fields, and in her spare time makes pottery, spins, or weaves. Her husband, for his part, is no laggard, but does the heavy work in the fields, cares for the water buffalo, makes knives and head axes on his primitive forge, and until recently was an enthusiastic head-hunter. Occasionally he fishes and hunts, but this is a sport, not a necessity.

The government is purely local, each village selecting one of its old men to act as its head, but he has little actual power and can be replaced at the will of the group. Custom is law and violation of custom results in ostracism of the offender until such a time as he is ready to conform.

Of his own volition the Malay has never developed a strong government. He has shown himself to be very adaptable and has progressed far toward civilization under the leadership of more advanced groups. The culture of the Tinguian is probably much the same as that of the more advanced Philippine tribes at the time of the Spanish occupation and a comparison of their life with that of the Christianized Filipino throws much light on the possibility for advancement in the Malay race.

Courtesy of the Field Museum of Natural History

Tinguian playing the nose flute

Span of Life and Average Duration of Life

By RAYMOND PEARL
Institute for Biological Research, Johns Hopkins University

FREQUENTLY in newspapers, magazines, and other forms of popular literature where precise accuracy cannot be expected, and only a little less often in technical journals, one meets the following statement or its equivalent: "In the last quarter century, the span of life has been lengthened."[1] There is not the slightest evidence that the *span* of human life has been lengthened in the last two thousand years, let alone the last twenty-five. What the ignorant or careless users of phrases like that quoted really intend to convey, of course, is that the mean or average duration of life has lengthened in the last quarter century. It is probably hopeless to expect that workers in the biological sciences will in the near future, at any rate, use words with that precision, and with that careful regard for their rigorously defined meanings, which students of mathematics and of physics have for a long time been accustomed, and indeed compelled, to exercise. But it so happens that the one field of biology in which prevails the same standards of precision in the definition of concepts that we are accustomed to in physics, is that field which has to do with duration of life, and is commonly called actuarial science. Hence the medical or other writer who misuses terms in this field cannot attempt the alibi that, there being no definitions recognized as standard, his are as good as another's.

In the actuarial universe of discourse "span of life" has no status whatever. When it is desired to discuss what the writer of the quoted editorial note wanted to talk about, the expression "expectation of life at birth," or "mean after-lifetime, at birth" is used. "Mean (or average) duration of life" has the same significance and is an entirely acceptable substitute even in technical writing, provided it is made clear that the writer is not confusing "mean duration of life" and "mean age at death" in his thinking. These two things are the same in a stationary life-table population, but may be distinctly different in actual general populations, as Farr long ago pointed out.

"Span of life" denotes a concept impossible to define precisely. It is correctly used when one says: "The span of life of horses is roughly 20 to 25 or perhaps even 30 years, while that of man is somewhere about 100 years." The *span* of life, in short, is its total extension between its biological lower and upper *limits*. Limiting values of any thing are extremely difficult to determine precisely. In the present state of knowledge it is impossible to define the span of either equine or human life any more exactly than is done in the second sentence of this paragraph. Furthermore, there is no such thing as an absolutely fixed and determinate biological upper limit to the life span. The upper limit of human longevity is quite certainly a variable matter, for which an average value may be determined if one has sufficient data, but there is no particular single age at which the ax inevitably descends. Individuals alive

[1] *Journ. Amer. Med. Assoc.* July 18, 1925, p. 197.

at any particular age, no matter how high, still have an expectation of life after that age. This expectation may be difficult to measure, because of lack of data, and it may be minute in magnitude to the point of seconds of time, but always an average after-lifetime is theoretically calculable. This is even true of the cohort composed of the one person who has lived longer than any other one ever did. Theoretically he has a calculable expectation, but practically it cannot be determined merely because of lack of statistical data.

But if it is difficult to measure the biological upper limit of life, it is even more trying to extend it. On the other hand the mean duration of life not only has a precise significance, but as events have shown, can be greatly extended, so far as human beings are concerned, by proper attention to sanitation and the application of curative and preventive medicine. The accomplishments in this direction are notable and redound enormously to the credit of the medical profession. They have so far been made chiefly by lowering steadily the death rates in infancy and the early portion of the human life span. When the death rates from say age 75 to 100 have been equally lowered, we may perhaps then appropriately begin to speak about "lengthening the life span."

While every one knows that the expectation of life at birth is increasing, it is surprisingly difficult to get data to measure the extent of the accomplishments in this direction with anything like really scientific accuracy. Life table studies made in the Department of Biometry and Vital Statistics of the School of Hygiene and Public Health of this University show that for Baltimore City in 1870 and 1920 the expectations of life at birth were respectively 33.7 years and 51.5 years. These figures relate to the whole population (male and female, white and colored) and are approximate only. The 1870 figure is probably a little too low, owing to defective statistics for that year, but the discrepancy probably does not amount to as much as two years, and the 1920 figure is probably not in error from the unknown true value by as much as a half year. We see here the very substantial gain of 17.8 years in mean duration of life in this community in a half century, taking the figures at their face value, and it may be regarded as certain that the gain has been as much as 15 years. For the larger and more heterogeneous population of the original registration states (which include the New England States, New York, New Jersey, District of Columbia, Indiana, and Michigan) we have the following data[1] enabling a comparison over roughly the last fifth of a century.

EXPECTATION OF LIFE AT BIRTH. ORIGINAL REGISTRATION STATES

	1901	1910	1919–1920	Gain 1901–1910	Gain 1910–1920	Gain 1901–1920
White males	48.23 yrs	50.23 yrs	54.05 yrs	+2.00 yrs	+3.82 yrs	+5.82 yrs
White females	51.08 yrs	53.62 yrs	56.41 yrs	+2.54 yrs	+2.79 yrs	+5.33 yrs
Negro males	32.54 yrs	34.05 yrs	40.45 yrs	+1.51 yrs	+6.40 yrs	+7.91 yrs
Negro females	35.04 yrs	37.67 yrs	42.35 yrs	+2.63 yrs	+4.68 yrs	+7.31 yrs

[1]Data for 1901 and 1910 from Glover, J. W., *United States Life Tables*, Washington, Government Printing Office, 1921. Data for 1919–1920 from Foudray, E., *United States Abridged Life Tables*, 1919–1920. Washington, Government Printing Office, 1923. Both of these are official publications of the Bureau of the Census.

For London it is possible to make reasonably accurate comparisons of the expectations of life at birth over a longer period. The following table is quoted from a recent paper by Sir George Newman.[1]

LONDON LIFE TABLE, 1841–1922

Period	Expectation of life (years)		Period	Expectation of life (years)	
	Males	Females		Males	Females
1841–50	34.6	38.3	1891–1900	41.2	45.4
1851–60	36.4	40.4	1901–10	47.2	51.9
1861–70	35.7	39.9	1911–12	49.5	54.5
1871–80	38.0	42.4	1920–22	53.8	59.1
1881–90	40.1	44.5			

From these figures the following differences appear:

GAIN IN EXPECTATION OF LIFE AT BIRTH, LONDON	MALES	FEMALES
From 1901–10 period to 1911–12	+2.3	+2.6
From 1911–12 period to 1920–22	+4.3	+4.6
From 1901–1910 period to 1920–22	+6.6	+7.2

It is apparent from these figures that the gains in expectation of life at birth have been somewhat higher, over the nearest comparable time period, in the population of London than in the population of the Original Registration States.

The explanation of the generally greater gains of the negroes as compared with the whites, especially since 1910, is not entirely clear. It can scarcely be seriously maintained that more, and more effective, public health efforts have been directed during these years to the improvement of the negro mortality than have been applied to the white population. Perhaps the most probable explanation is that when the general level of mortality is as high as it is among the negroes in cities, any improvement in sanitary conditions will produce a more marked effect than it will in a population already enjoying a low mortality rate.

Now while all these gains in expectation of life at birth are extremely impressive, the case wears a wholly different aspect when expectation of life (= mean after life time) at age 77 is considered. This odd age is taken rather than 75 or 80, in order to compare Miss Foudray's figures directly with those of the earlier years, without interpolation. From the same sources as before, we have for the Original Registration States the following data:

EXPECTATION OF LIFE AT AGE 77. ORIGINAL REGISTRATION STATES

	1901	1910	1919–1920	Gain 1901–1910	Gain 1910–1920	Gain 1901–1920
White males	6.09 yrs	6.04 yrs	6.17 yrs	—.05 yrs	+.13 yrs	+.08 yrs
White females	6.54 yrs	6.41 yrs	6.61 yrs	—.13 yrs	+.20 yrs	+.07 yrs
Negro males	5.96 yrs	6.15 yrs	5.92 yrs	+.19 yrs	—.23 yrs	—.04 yrs
Negro females	7.32 yrs	6.91 yrs	6.88 yrs	—.41 yrs	—.03 yrs	—.44 yrs

[1]*Lancet* July 25, 2925, p. 165

The irregular gains (+ sign) or losses (—sign) of a few hundredths of a year shown by these figures are without significance. It is to be hoped that any person who is suddenly seized with an urge to write about the lengthening of the *span* of human life will call to mind in time that its upper limiting values are in fact staying about where they presumably have been for a very long time.

But the question as to the *possibility* of lengthening the human life span at some future time must not be unfavorably prejudged because the evidence is that it has not yet been discernibly altered in this sense. There arises here a consideration which I do not recall having seen discussed, but which obviously has an important bearing upon the case. I can illustrate it best by a form of diagram much used in actuarial work. Suppose the passage of time as measured by years of the Christian era be plotted as abscissa, and age be plotted as ordinate. Then a straight line inclined at an angle of 45 degrees (provided a year has the same value on both scales) drawn between the dates of an individual's birth and death, will represent the passage of his life.

In the present case let us apply this principle of graphic representation to the data regarding the expectation of life of white males in the original registration states at age 77. The resulting diagram is shown as Figure 1.

The persons aged 77 in 1901 were born in 1824, so the uppermost or 1901 line starts from the base (0 age) at the date 1824. Those aged 77 in 1910

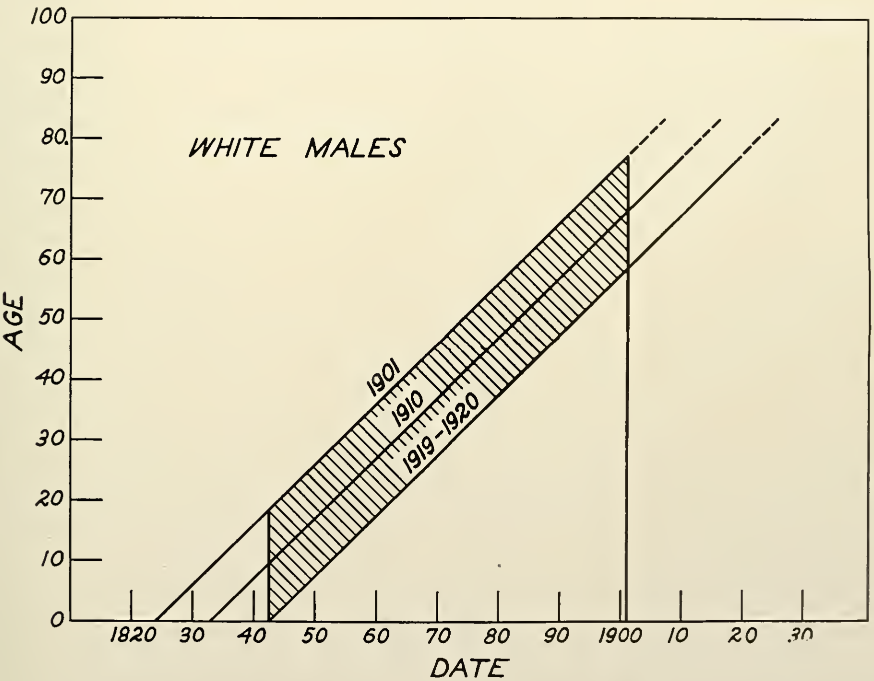


Fig. 1. Showing the expectation of life of white males in the original registration states reaching the age 77 in the years 1901, 1910, and 1919–1920. The dotted lines are the expectations of life and the solid lines the years lived prior to attaining age 77. For further explanation see text

were born in 1833, and the second or 1910 line starts from 0 age on that date. Now if a perpendicular be erected from 1842-1843 to cut the 1901 and 1910 life lines, and another perpendicular be dropped from the 1901 line to cut the base at that date, a parallelogram will be included by these two perpendiculars and the 1901 and 1919-1920 life lines. This parallelogram is crosshatched in Fig. 1. This shaded parallelogram defines the overlapping portions of the lives of persons in the three cohorts under discussion. During the 58.5 years from 1842-1843 to 1901 all of the persons in these three cohorts were alive together. Whatever environmental stresses, whatever improvements in sanitation, whatever discoveries in medicine, acted upon the men in one of these cohorts, acted also during this period of nearly 60 years upon those in the other two cohorts. But this period is a major portion of their whole lives. If it were true, as it may well be, that improved environment, better sanitation, better preventive medical service are just as effective in reducing mortality rates at the upper end of life as they are at the lower end, one would not expect to see from them any but a slight effect in cohorts not more than 20 years apart at birth. Too great a portion of the whole life of both cohorts would have been spent under the same environmental conditions.

Summarized the situation is this: The evidence available does not indicate that any increase is occurring now, or has occurred in the recorded expectation of life of persons who live to the age of 75 or more. Still less is there any evidence that the biological upper limit of the human life span has been raised. Whether in the future, as a result of what is being done now in public health and preventive medicine, the expectation of life at advanced ages will be raised, is a question impossible of answer at the present time. But in the meantime the expectation of life at birth, or the mean duration of life, has been and is being notably increased.

Above the sea of clouds in the Sierra Nevada de Santa Marta, Colombia, the land of the Arhuaco Indians

Coast and Crest in Colombia[1]

AN EXAMPLE OF CONTRAST IN AMERICAN INDIAN CULTURE

By J. ALDEN MASON
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TO the ordinary layman reader the term "Indian" calls to mind a vision of a tall, high-cheeked, red-skinned man, decorated with feathers and gaudy beads, taciturn in disposition, his character a curious melange of nobility and treachery. The Scot may differ radically from the Welshman, the German have little in common with the Frenchman, but the Indian is still an Indian, whether he till his patches of sun-burnt corn on the arid flats of Arizona or spear fish by the humid marge of a lethargic Brazilian river. Even those persons of wider reading who recognize the great variations in physique, in psychology, in language, and in culture, which obtain among the many hundreds of tribes and nations of American Indians, seldom realize the full extent of these differences or how sharp the division between groups which may be close neighbors.

Differences in language, in physical type, in religion, social organization, and similar respects, more or less transcend the boundaries of geographical and ecological areas, but differences in material culture are to a large extent dependent on the natural environment upon which the tribe must subsist and to which it must adapt itself. In the United States, variations in these environmental conditions, though great, are never sudden and abrupt, with the result that the boundaries of material culture areas are never sharp-cut and variations from group to group are slight. In other parts of America, however, and especially in western South America, abrupt changes in altitude produce natural environmental areas of the

[1]Photographs taken by the author while on an expedition to Colombia for the Field Museum of Natural History.

greatest divergence within the space of relatively few miles, and these in turn have produced, or at any rate support, native populations of widely different character.

Such a region of diverse natural environmental conditions is found on the northern or Caribbean coast of Colombia between the Magdalena River and the Lake of Maracaibo. Here is a little-known and seldom-visited region, dominated by the little seaport of Santa Marta, the oldest city on the South American mainland, which last year celebrated its four-hundredth anniversary, having been founded in 1525. For the first few years of its history it enjoyed a slight meed of prosperity as the seaport of Colombia, from which sailed the galleons laden with the treasures of the land of El Dorado to enrich the insatiable coffers of Castile and Leon, if peradventure they escaped the even greedier clutches of the English gentlemen-pirates of the Spanish Main. Then it lapsed into centuries of somnolence from which it is only just awakening by virtue of the new golden harvest, the banana, which today leaves its portals in the immaculate steamers of the United Fruit Company. Behind Santa Marta the majestic mountains of the Sierra Nevada, whose summits have never known the foot of man, rear their peaks to heights of eternal snow. In the cool valleys near the foot of the chill treeless *paramo* dwells a nation, or group of tribes, of peaceful, sedentary, inoffensive Indians, practically untouched by civilization, the Arhuacos. Occasionally, to carry down the blocks of brown sugar or *panela* which they trade for steel implements and other civilized products, a few of them descend to the hot seacoast at Dibulla, a little settlement largely inhabited by negroes. Here they may meet a few members of another absolutely different Indian nation, also wanderers from their native heath, the Goajiros. But they avoid each other like lepers, pass with averted eyes on opposite sides of the street, and ignore each other's presence. The Arhuaco fears the reputed ferocity and physical strength of the Goajiro and the latter dreads the magical power and "strong medicine" imputed to the Arhuaco. Though their territories impinge so closely, it is difficult to imagine two beings of the same race more different in all respects.

Approximately one hundred miles east of Santa Marta one comes to the open roadstead of Rio Hacha, the seaport for the Goajira Peninsula which extends a hundred miles farther east. Here the lofty wooded mountains have disappeared with their humid verdure, and instead the peninsula is low, arid and torrid. In place of the majestic *caracolí*, mahogany, and other tropical trees, cacti, and thorny bush cover the ground. Herds of stock,—cattle, sheep, goats and horses,—browse on the scanty vegetation, and their hides, together with the *divi-divi*, *brazilete*, and logwood which are gathered by the Indians, form the principal exports of Rio Hacha.

In 1922 and 1923 I spent upward of a year in the region of Santa Marta for the principal purpose of pursuing archæological investigations for the Field Museum of Natural History of Chicago, with which I was then connected and to which I am indebted for the use of the notes and photographs herein used. During this time I was enabled to spend several months with the Arhuacos and to make a short visit to the Goajiros.

As examples of diverse and contrasted

cultures a slightly more detailed exposition of the life of these two neighboring tribes may perhaps be of interest.

The Arhuacos are an undersized folk, the men averaging little more than five feet in height, and the effect given by this shortness is intensified by their childlike natures. Bashful, reticent, suspicious of all strangers, especially civilized persons, the unannounced visitor is nearly certain to find their villages suddenly abandoned at his approach. But he who, like ourselves, comes accompanied by their friends and preceded by a good repute, finds them friendly and affable. Never boisterous and seldom demonstrative, quietness seems to be the keynote of their natures. Only under the influence of their home-brewed *chicha*, made of cane syrup, or the stronger imported rum, do they expand, and even then the usual effect is a maudlin lugubriousness, and the rare disagreements result only in wrestling and hair-pulling. The women are especially bashful and are seldom in evidence.

A group of Arhuaco Indians in a neighboring "civilized" village. Their slight stature is striking in comparison with a tall negro. A woman stands at the right

Living as they do in the fastnesses of the mountains, separated from the civilized settlements on the coast by great stretches of virgin forest, they are unbelievably ignorant of modern business and are exploited in a pitiful fashion by the few *civilizados* who live on the outskirts of their country and trade them machetes and other needed modern tools in return for loads of *panela*, the blocks of unrefined sugar which are their sole object of export. Money is nearly unknown to them and they accept it in pay for services and products only on the advice and instructions of the village head, always a man who has had some dealings with civilization and who does his best to protect his charges from exploitation. Any offer of pay is referred to him who passes upon the fairness of the offer and the value of the proffered coin. "We do not like your practice of trade," said one Indian. "We prefer that you should make me a gift, and then I will counter by making you one." It was a most difficult matter to secure any specimens from them. Never once was an article voluntarily offered for sale or barter and only by dint of continued pleading was a small representative collection of their goods secured by listing desired objects and soliciting the aid of the village heads in obtaining them.

Dressed in long tunics which fall to the knees, under which are worn loose baggy trousers— the latter probably a civilized adaptation,— with their long unkempt hair falling over their shoulders and frequently with rather thick beards, the men present a patriarchal appearance such as the imagination ascribes to the Judean shepherds of old. These garments are made of cotton grown, spun, and woven by the men, rather heavy and frequently decorated with violet stripes. But they are generally frayed, worn, and dirty, and the ensemble is unkempt, notwithstanding the fact that the people bathe frequently in the cold mountain streams. The women wear blouses, generally with one arm bare, and short skirts of the same cotton fabric. Their sole ornaments are necklaces which are largely composed of the beads of roseate carnelian found in the graves of the ancient Taironas near the coast. They fear to molest these graves themselves, but eagerly purchase from local treasure-hunters beads of second quality, those without high polish known as *muertos*, being unable to compete with the wealthier Goajiros for the polished beads known as *vivos*.

While the men spin and weave the cloth worn by both sexes, the women knit the bags carried by the men. Every man or boy bears one or more of these knitted bags in which he carries his flint and steel for making fire,—the modern substitute for the ancient fire-making sticks,—his *poporo* and *tami*, and his coca leaves. The *poporo* is the ubiquitous companion and constant solace of every man, and its acquisition marks the boy's attainment of man's status. It is a pear-shaped gourd in which he carries the powdered lime obtained by burning shells and which is mixed with the coca leaves for chewing. This chewing of coca leaves is one of the characteristics which connect the Arhuacos with the people of the highlands of southern Colombia, Ecuador, and Peru, where the custom has persisted since time immemorial, as is attested by the finds of dried coca leaves and gourds of lime in the ancient graves. This coca, *Erythroxylon coca*, is the plant from which our medicinal cocaine is obtained, and the chewing of its leaves has, in a minor degree, the same anæsthetic effect as the administration of cocaine; it deadens the sensibilities to hunger, fatigue, and pain and enables the hardships of primitive life to be better endured. His tiny plantation of coca is a man's most valued possession; the failure of his crops or the burning of his house he can endure with resignation and fortitude, but the destruction of his *hayal* is a calamity of catastrophic magnitude. Such is the insatiable demand for the leaves that the plants are never allowed to reach a state of efficient production, but the leaves of immature size are gathered by the women, toasted over a slow fire, and emptied into the coca bag. An exchange of a handful of coca leaves is the customary prelude to every meeting or conversation. After a pinch of leaves has been put in the mouth, the stick is stirred around in the *poporo* until it is covered with lime and then licked off, the mixture of coca and lime providing the desired elements. The remainder of the lime adhering to the stick is then scraped off against the neck of the gourd until a great collar of lime concretion is formed, the size of the collar and the blackness of the owner's teeth being more or less an index of his importance in the community. The rattle of the stick in the *poporo* is the one constant sound in an Arhuaco village, as typical as the "pat-pat" of the tortilla-maker in a Mexican pueblo.

Mama Miguel, Arhuaco native priest, and his wife and child. He bears a burden band across his forehead and in his hand the ubiquitous *poporo* or gourd of lime and stick

A small boy neophyte, training for the priesthood, dancing with mask and rattle, while other boys supply the organ accompaniment on gourd trumpets

The villages are permanent groups of houses, so close together as almost to touch, in a cleared mountain valley, by a turbulent icy stream. In the more conservative towns the houses are conical and built of thatch of palm or grass on a foundation of poles, but in the more civilized villages rectangular houses with walls of wattle and mud are coming into vogue. They are small and one-roomed, the conical ones being without any smoke-hole, and as the fire in the center burns constantly in these cool heights, long fronds of soot hang from every straw. Upon marriage, the happy groom builds his bride a house into which he never enters and here she and the children sleep on mats. The wife prepares her husband's meals in the house and they eat them outside or he carries his to the men's house. Only in their distant *rozas* or farms do husband and wife associate intimately. But in the center of every village are one or more larger houses, their walls made of a plaited cane. These are at once temples and men's clubhouses, where all the adult men, married or unmarried, sleep in their hammocks and pursue their sedentary occupations. Here the *mama* or native priest holds full sway and here most of the native rites and religious ceremonies are performed. The *mama* enjoys great power and reputation for healing the sick, for legendary knowledge, and for magical practices, and the chief *mama* of the tribe is visited even by white patients from the civilized towns on the coast. The attainment of the rank, however, is preceded by years of novitiate during which abstinence from the use of salt, and all imported food products, and many other restrictions are observed. Apparently there is

The house of the native priest's wife. Like the temple which it adjoins, its walls are built of plaited cane

A typical Arhuaco Indian. The long unkempt hair, occasional thick beard, and long simple garment lend a patriarchal air to the native

Knitting a bag while bringing home vegetables. The Arhuaco women are very bashful and only with difficulty can they be induced to face the camera

Men twisting *pita* (agave) fiber for rope and braiding selvages on cloth at the door of a guesthouse in an Arhuaco village

Above.—*Mama* Miguel, native priest of Palomino, weaving cloth outside the door of the temple. All the weaving is done by the men. This priest carries two unusually fine knitted bags and wears the old knitted cap worn today by only the conservative elders

Right.—*Mama* Miguel plaiting a fire-fan of reeds. The plaited fire-fan is one of the most constant features of South American Indian cultures. Each tribe has its special type

A

C

B

D

A.—San' Miguel, the largest village of the Kagaba-Arhuaco. The larger conical huts are the native temples; the large rectangular houses are the church, guesthouse, and other municipal edifices constructed under the orders of the clergy and civil authorities.

B.—A native Arhuaco Indian bridge. These are built high to avoid freshets and are made without a bit of metal in their construction.

C.—Bringing specimens and equipment down from the mountains. The women bear burdens equal to those of the men.

D.—Arhuaco men (and dogs) eating outside the maternal door. The husband never sets foot inside the door of the house he has built for his bride little distinction of wealth or social position.

Agriculture is the sole method of subsistence of the Arhuacos, and every family possesses several isolated cultivated plots separated by as much as a day's journey. Due to the abrupt changes in altitude, an Arhuaco will have one plot in the hot lowlands where he raises bananas, yucca, yams, and such tropical foods; another near his village where plantains, corn, beans, coca, and tobacco are grown; and a third near the cool paramo where he cultivates potatoes and *arracacha*, most of these being native pre-Columbian food-products. Practically no hunting is done, firearms are almost unknown and the bow and arrow today is hardly more than a boy's toy. Every Indian of means owns a dog and an ox or two on whose patient long back all transportation is done over the precipitous mountain trails. A few chickens and pigs complete the list of domestic animals, for horses, donkeys, sheep, and goats are unknown.

The larger mountain streams, which become raging torrents in the rainy season, are crossed by means of ingenious bridges built high above the water. These are made entirely of wood tied together with withes and without a piece of metal in their construction. The approach is made of slanting poles resting on forked posts and the main span is of a single log upon which hand rails are erected.

Today the mountainous territory of the Arhuacos has been set apart by the government of Colombia as an Indian reservation, governed directly from Bogotá, but for the greater part they are unvisited and unmolested. The clergy have compelled them to build a large house in the center of each village to be used as a church, but this is opened hardly more than once a year when a *cura* may come to say mass. So, content in their isolation, they follow in the footsteps of their fathers and forefathers the age-old customs of pre-Columbian America. But life is harsh and children are few, and apparently the nation of the Arhuacos is slowly but surely diminishing and following the dim trail of many another tribe of aboriginal Americans to extinction and almost unrecorded oblivion.

The low, sandy, torrid, arid peninsula which forms the home of the Goajiro Indians is also set apart by the Colombian government as an Indian territory, but the authority of the government is practically nil. For the Goajiros are a fine, vigorous, independent, and upstanding nation, and the little seaport of Rio Hacha has in times past frequently suffered from their depredations in Indian wars. Even today it is dangerous to cross the Goajira to the towns of the Venezuela frontier and one is safe only in company with an Indian or half-blood of standing. Tall, well-formed, rather forward and aggressive of nature, the Goajiro is a magnificent specimen of the American Indian, resembling somewhat our Navajo or Sioux. When under the influence of liquor he is inclined to be quarrelsome and dangerous. Though living in a relatively aboriginal state, he is well acquainted with the practices of modern business, since he gains his entire livelihood by stock-raising, and is a keen bargainer and trader. I secured more specimens from them in a week than in two months among the Arhuacos. The natives for miles around brought in objects of all kinds for sale and only the constant assistance of my companion enabled me to keep up with the brisk business. The women, too, are magnificent specimens, not only of phys'cal womanhood, but of quiet and self-possessed capability and efficiency. Some of them are married, practically sold, to merchants of Rio Hacha, for whom they carry on business with the natives in their camps.

The men normally wear nothing but a breech-cloth, necklace, and beadband, but possess gorgeous and expensive robes and trappings which are worn on ceremonial occasions. These beautiful robes are woven of cotton by the women and sell only for high prices. The gaudy horse-trappings are made by the men. The hair of the men is worn relatively short.

The women wear a great voluminous enveloping Mother Hubbard wrapper of purchased cloth. Though naturally comely, to the stranger their beauty is marred by the uniform custom of painting the cheeks. On dress occasions beautiful and highly prized necklaces of beads and gold ornaments are worn which come from the graves of the now extinct Tairona Indians and bring to the lucky treasure-hunter a price beyond the competition of the archæologist. For the Goajiro, living a simple aboriginal life requiring few necessities, uses his wealth only for prestige and display. His herds of stock can purchase him little but power and social standing in his community and he does not hesitate to sacrifice possessions of great value if thereby he can increase his reputation for wealth and generosity.

A Goajiro Indian. In every respect the contrast with the Arhuacos is striking

This condition has led to an interesting development of social custom based on wealth. All intercourse is hedged about by restrictions the violation of which may be atoned for only by the payment of heavy damages. For instance, the man who cuts or otherwise injures himself must recompense his mother's relations—to whose clan he belongs—for the offense of having shed the clan's blood, as well as all spectators for their sorrow and tears. The lender of any object by means of which any injury is suffered is liable to heavy claims, while he who mentions the name of a deceased person, even quite inadvertently, is guilty of the gravest offense, and may suffer great financial losses if he escape death at the hands of the outraged relatives. Since these payments are exacted in the form of considerable quantities of live stock, it will be deduced that the visitor to the Goajira must comport himself with the greatest circumspection if he is to return with a sound body and exchequer.

Prestige and social position, however, are as much more dependent upon

A Goajiro hut with its easily portable equipment. The Goajiros are a pastoral people and need to change camps frequently

birth than upon wealth as among our most aristocratic civilizations. Acquired wealth merely may permit a low-born man to marry a girl of better class, in which case his children, belonging to the clan or caste of the mother, inherit her social position. But he still remains of plebian blood, unfit for association with the aristocracy. For all descent is figured in the maternal line and, consequently, a man's sister's children are considered as more closely related to him than his own children, and to them his wealth descends, while his wife's brothers exercise considerable control over his children. The maternal uncles arrange the terms of a girl's marriage and, as she is practically sold to the prospective husband, the payment is made to them. Every man is permitted as many wives as he can purchase and support, but these, naturally, preside over different households in different camps.

Agriculture is as despised as it is difficult on the Goajira, the native living almost exclusively on meat, together with corn and such other vegetable products as may be imported. Cattle, sheep, and goats range the peninsula in great herds, and the Goajira horses and mules are famous all along the coast. In the rainless season, all the streams are dry and the stock must be watered at great wells dug in the stream bed, an operation which consumes a large part of every day.

Needless to say, nearly every Indian is mounted. Though a good rifle and quantities of ammunition are the prized possessions of almost every man, yet the bow and arrow is in constant use and the accuracy of the natives in its use is admirable. The hunting arrows bear beautiful steel blades, but the war arrows are pointed with the poisoned tip of the ray which is always kept under a cap of hollow reed. The use of coca is unknown at present.

Since the Goajiro must follow his stock to suitable grazing, and especially watering conditions, his camps are temporary and his life nomadic. These camps consist of small houses, lean-to's

A native funeral on the Goajira. The corpse is in the hammock under the arbor, surrounded by the women mourners

and arbors made of poles and thatch, frequently open at one end, and full of a jumble of hammocks, in which all members of the family sleep, gourds, bags, and pottery vessels containing all the possessions of the family. One of the vessels is sure to contain a brew of *chicha mascada*, a large bowl of which is the first hospitality offered the visitor. He will not find this unpalatable, provided he be ignorant of the process of manufacture. This is done by the women of the band, who chew mouthfuls of corn and expectorate the mass into a large bowl which is then mixed with water and allowed to ferment.

The greatest opportunity for display of ornament, wealth, and generosity is afforded the Goajiro on the occasion of a funeral, one of which we were fortunate enough to witness. The chief of a small band having died, the news spread rapidly through the Goa-

The burial at a Goajiro cemetery. The grave is being dug with pointed hardened sticks jira and every native of any degree of kinship or acquaintance donned his best regalia and proceeded with his family to the camp of the deceased. Here the near relations had hung the corpse in a hammock under an arbor, rounded up all his live stock, and sent to Rio Hacha for a large supply of rum. On arrival, each man made camp and was immediately presented with meat in accord with his importance and the size of his entourage, a kid to the lesser, a goat, a lamb, a sheep, even an ox to the stars of greatest magnitude. These gifts were continued as long as the mourner cared to remain. At the funeral of one famous chief it is reported that 120 fat oxen were killed and that the hides did not pay for the rum consumed. After each newcomer had satisfied his hunger and chatted awhile with friends, he approached the corpse, threw his robe over his head and for a long time voiced his sorrow in loud and apparently sincere lamentations. His duty thus performed, he felt at leave to depart, being given meat sufficient for the return journey.

The late lamented, who had departed this life on Friday afternoon, lay in state in his hammock until Monday morning, by which time, the weather being stifling, his demise was palpable even to the most distant mourner, yet the women of the near family remained bent over the corpse, wailing continually. On Monday morning, however, he was taken down, sewed in a hide, tied on the back of a horse, and the entire gaily caparisoned cavalcade set out at a rapid pace, amid shouts and clouds of dust, for the cemetery. This was at a considerable distance, and for over an hour the procession raced across the burning sands. The thirst was unbearable and when an abandoned well was passed, filled with water compared with which Gunga Din's must have been the veriest ambrosia, I followed the example of several Indians in drinking a mouthful (with the natural consequence of ten feverish days in the Santa Marta Hospital). Finally the party halted at a little enclosure, and a grave was tediously dug. The slowness of this operation was caused not by the depth or size, which were slight, nor by the ground, which was not stony, but because, in accord with the inevitable conservatism of religious rites everywhere, the grave was dug with pointed sticks. This task accomplished, the corpse was finally consigned to Mother Earth together with some of his prized personal possessions. We were then warned that, the funeral and the consequent truce between hostile persons and factions being over, it was the part of discretion for non-combatants to retire, so we bade farewell to the Goajiros and their arid land. The bones of the deceased would, in accord with Goajiro custom, be exhumed in a year or two, and be given a second burial in a large urn under a pile of stones.

Thus these two nations of American Indians, though occupying adjoining regions, differ from each other in every important respect, the Arhuacos small, reticent, sedentary, and agricultural, inveterate coca-chewers, with no distinction of wealth and practically ignorant of civilized methods: the Goajiros tall, vigorous, and independent, nomadic and pastoral, with social customs and distinctions largely based on wealth, not addicted to the vice of coca-chewing, and withal good business men, apparently able to cope with the demands of modern civilization.

The Skin Colors of the Races of Mankind

By CHAS. B. DAVENPORT
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As one travels over the earth he is struck by the great variety in skin color of the different peoples, ranging from the fair, almost pigmentless, skin of the typical Swedes to the almost ebony-like blackness of the aborigines of parts of Africa and Australia. This variation in color struck the attention of early explorers. It is so obvious that it has been taken as a basis for dividing mankind into several distinct varieties, and to-day one of the most generally accepted classifications of mankind is based on skin color, so that we recognize the white, black, brown, yellow and red races. Our problem is: precisely what kinds of skin color may be recognized? what was the original color? how did the different types evolve?

In considering the different kinds of skin color it is first of all desirable to be able to measure it. Two main types of measuring apparatus have been used; first, a set of tinted standards, each bearing a name or number, to which any skin color can be referred. To this type belongs the well-known Broca scale consisting of patches of different colored inks printed on paper. Ridgeway's "Color Standards" (1912) give additional colors, far more numerous than are required for human skin color determination. Unfortunately, the standard colors change during the process of repeated exposures to light; also in the different printings of the scale the colors are not always the same. Another kind of standards has been devised by Professor von Luschan, consisting of 36 rectangular masses of opaque glass tinted in a graduated series to match different skin colors, but the trouble with this scale is that the surface is too shiny to match any skin.

Still another method of measuring skin color does away with some of these disadvantages, while introducing new difficulties. This is the method of the color mixer or the color top. Such a top is made by the Milton Bradley Co., for use in schools. When using this top to record skin color, one must select the paper color discs according to the known color elements in the skin.

The color of the skin proper, without pigment, may be regarded as white. This is nearly the color of the skin of the cadaver, especially if viewed from the inner surface. The color is not chalky white, but more or less creamy, due to the presence of a yellow pigment. The color of the "white" skin may be reproduced by using, in the color top, discs of white and lemon yellow (pure spectrum yellow). This yellow pigment is widespread in the skin of vertebrates (as well as many invertebrates). One may identify it with Krukenberg's (1882) lipochrome, including ether-soluble fatty pigments. The amount of this yellow pigment in the skin varies in different persons and in the different races of mankind. It is most obvious in many of the peoples of Eastern Asia (whence the yellow race). It is abundant in the negro race also, but here it is largely obscured by black pigment. It shows in many mulattoes who are sometimes referred to as yellow negroes (colloquially, "yaller niggers").

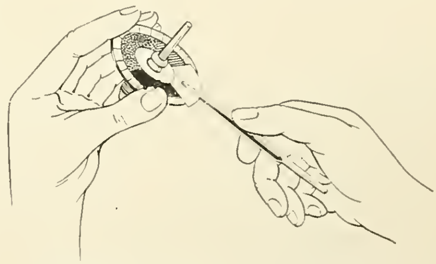
The third constant color constituent of the healthy skin is a red color due to the blood circulating in the skin capillaries. This is represented fairly by the "red" of the Bradley color top. As has been pointed out, this is not a spectral red; it lies near to Ridgeway's "ox-blood red" and, according to Todd and van Gorder's determination contains 41 per cent of Ridgeway's spectral red, true j, together with 59 per cent black. Apparently, human arterial blood is not of a spectrum red color but contains much black. In using the Bradley ox-blood red we are using a color close to that of the human capillaries.

The color top and the color discs

The fourth constituent of skin color is black. This is due to melanic pigment, which, when viewed under the microscope one granule at a time, is seen to be not really black but of a sepia color. In masses, however, light is so completely absorbed by it that melanic pigment appears completely black.

By combining 4 discs, white (W), black (N, nigrum), yellow (Y), and red (R), in sectors of varying sizes and then spinning the top, one can match any skin color closely and express the result in a formula that gives the percentage that each element, or color sector, is of the whole, e.g., N 72, R 14, W 6, Y 8.

The skin color differs on the various parts of the human body, just as it does on the body of the pig, hippopotamus, and other relatively hairless mammals. The "color of the skin" of a given person, is, therefore, not very significant unless we know the location of the skin that was measured. It is desirable, therefore, that all skin measurements should be made at corresponding points on the surface of the body. Areas to be excluded are those that are excessively exposed to the sunlight and wind, so that they are "tanned."


Adjusting the color discs on the top

Areas thus affected change their color in the same person with the seasons. On this account face and hands are especially to be avoided. Areas that are naturally especially highly pigmented are also to be avoided. This excludes (what would naturally be excluded for other reasons) the region of the perineum, the areolæ, and the mid-ventral line of the abdomen. Areas that are naturally especially little pigmented must also be excluded. Thus the palms of the hands and the soles of the feet and, to a less marked degree, the axillary region of the upper arm are relatively devoid of pigment, even when constantly exposed. The spot on the skin to be selected should be convenient and easily accessible and, at the same time, ordinarily not too much exposed to sunlight. The part of the upper arm, over the lower portion of the deltoid muscle, between the biceps and triceps, is recommended. This part of the arm can be placed upon a table, close to the spinning color top, to facilitate comparison.

Examples of color discs set to match skin colors of various races

With the aid of the color top it is now possible to describe in exact quantitative terms the skin color of the different races of mankind and hybrids between them, and to reproduce those colors in the laboratory. For example, three imperfect albinos of the San Blas tribe of Indians were measured by me in December, 1924. Results were as follows:

Olo, juvenile male, N O, R 37, Y 5, W 58.
Chico, juvenile male, N O, R 57, Y 7, W 36.
Marguerite, juvenile female, N O, R 62, Y 2, W 36.

It appears that in albinos the black pigment (N) is unrepresented and red (R) and white (W) are in nearly equal amount.

The amount of black pigment in the skin of Europeans varies with the amount of exposure to the sun, and with strain or race. Thus the skin of the upper arm of the writer shows a proportion of N and R which, during the earlier summer, stands at 8 and 15 respectively (total 23%), while toward the end of the summer these elements stand at 20 and 36 (total 56%).

As examples of skin color of Caucasians of different racial stocks may be given the results of measuring the skin color of the upper arm of children at Letchworth Village, toward the end of the summer (August 15, 1925) when the skin was generally deeply tanned. They are as follows:

Initials	Sex	Age, years	Skin Color N	R	Y	W
ENGLISH AND MIXED STOCK						
W. C.	M	11	17	27	15	41
L. W.	M	11	17	33	17	33
E. B.	F	8	12	38	13	37
M. B.	F	13	13	33	17	37
R. P.	F	14	11	35	12	42
E. B.	F	17	12	22	12	54
SOUTH EUROPEAN STOCK						
J. M.	F	10 Italian	25	32	18	25
S. K.	F	13 Jewish	23	27	14	36

Considering the above table it appears that in the children of English or mixed stock the boys are darker than the girls, doubtless because of greater exposure to the sun. The girls differ among themselves. Thus R. P. was distinctly of a florid type, much freckled (unfreckled skin was measured); while E. B., at 17 years, had a more pasty complexion. This difference is expressed quantitatively in the relative amount of red in the two children. The boys of South European stock are much darker than the boys of English stock—the amount of N increasing from 11-17 per cent to 23 and 25 per cent respectively while white diminishes from 33-54 to 25 and 36 per cent. A much tanned boy of about 11 years, of unknown racial stock, had the formula N 27, R 43, Y 15, W 15.

The color of the living negro skin is quite different from that of European stocks. Thus, Miss Danielson obtained in Bermuda from a probably full-blooded negress of about 30 years the following percentages: N 77, R 15, Y 3, W 5, and from a Jamaican negress the percentages: N 60, R 29, Y 6, W 5. In Louisiana from a full-blooded negress was obtained the percentage N 70, R 28.5, Y 1, W 0.5. First generation hybrids (of known pedigree) between negroes and whites have such formulæ as 43, 27, 12, 18; 37, 32, 11, 20; and 30, 28, 18, 24. It thus appears that the mulatto has a skin color that is, on the average, intermediate between that of a negro and a Caucasian.

In the children of two mulattoes (the genetical F_2 generation), there is an extraordinary variability in skin color. Thus in one individual of the F_2 generation the skin color formula is N 10, R 30, Y 12, W 48. This person is quite white. In another case: N 56, R 31, Y 6, W 7. This person is fully as dark as many full-blooded negroes. These measurements show quantitatively that two mulatto parents may produce "white" children and full-black children; and these may even occur in the same fraternity. A prettier case of Mendelian segregation it would be hard to find. The evidence leads to the conclusion that two pairs of black-producing factors are present in full-black negroes, and only one pair in mulattoes, while the children of mulattoes may have 0, 1, 2, 3 or 4 factors for black.

Few quantitative studies have been made on the elements of skin color in Orientals. As I write, I have turned to a Japanese collaborator and have measured the skin color of his upper arm. It is N 20, R 33, Y 14, W 33. The Y element is not exceptionally great, and the proportions are not so very different from the Letchworth Village lad: L. W.

Some other observations the writer has made suggest that Eastern Chinese show a large per cent of yellow in their skins.

In some studies of the Shinnecock Indians of Long Island, I have, myself, taken a series of measurements of skin color of several of the men, who probably have no negro blood. Living largely out of doors on the edge of the ocean they acquire a very dark color. The skin color of these men is as follows:

	N	R	Y	W
C. L. B.	28	37	14	21
E. C.	37	40	10	13
D. N.	48	32	8	12

In these cases the visible yellow element is not high; probably largely because obscured by the high percentage of N+R, 65 to 80 per cent.

Of three San Blas Indians (brought by Mr. R. O. Marsh to the United States) the skin color was measured by me in December, 1924. The area measured was over the biceps of the upper arm. These people had been fully clothed for some months. The percentages are as follows:

		N	R	Y	W
Pipi	M	46	37	8	9
Philip Tomson	M	33	47	11	9
Jim Berry	M	35	44	14	7
Alfred Robinson	M	37	42	8	13
Mrs. Berry	F	31	45	13	11

Here again the high proportion of N+R (up to 83 per cent) obscures the yellow.

The skin color of a number of full-blooded Australian aborigines was measured by the author. An average reading of the women is N 64, R 23, Y 5, W 8. An average reading of the men is N 67, R 23, Y 5, W 5. It thus appears that the skin of Australian aborigines has fully as much black pigment as that of full-blooded negroes found in North America.

The skin color of a number of hybrids between Australians and whites was also measured and found to vary in the different cases, depending upon the amount of white blood. In a typical case of a half-blood male the proportions were N 34, R 40, Y 14, W 12. A woman whose father was a half-blood with the preceding formula and whose mother was a full-blood had the proportions N 60, R 26, Y 9, W 5. This is a return from an intermediate condition of the first generation hybrid toward the full-blood condition. In the second generation of Australian-white hybrids, as in the second generation of negro-white hybrids, there is a great range and variation of the skin color. Thus in one fraternity (McHugh) the proportion of N varies from 32 to 53%.

Using the Milton Bradley colors—black, white, yellow and red—in a color top which is spun to match the skin, it appears that albinos have no black in the skin and about equal proportions of red and white, and that even in the Indian albinos the proportion of yellow (outside of the huge freckles) is small, around 5%.

In Caucasians the proportion of N varies from 5 to 25 or more, according to the racial stock and to the degree of tanning, by which process the black pigment is developed in excess. The white element is generally in excess of the red and the proportion of yellow is close to that of black. In the full-blooded negro the percentage of black rises to 60 or 70 or even more. The amount of red is correspondingly reduced and the yellow and white elements are at a minimum. In the first generation hybrids (F_1) between negroes and whites the proportion of black is about halved and yellow becomes a much more prominent element of the skin color. In the later generation the black segregates.

In eastern Asiatics and the American Indians the proportion of N approaches that of tanned South Europeans and red is about equally abundant with black. Yellow and white are correspondingly reduced. Even in Indians the proportion of black becomes very greatly reduced when the skin has been long protected from exposure to the sun and wind, and under these circumstances the yellow element becomes very large. The eastern Asiatics were formerly classified as the yellow race—a terminology justified by the large size of the yellow factor. This factor is large, also, in Indians, although much covered over by, and possibly in part converted into, black pigment.

The skin color of Australian aborigines of Brewarrina, New South Wales, is extremely dark; in hybrids between them and whites the skin color follows the same laws as in the case of negro-white crosses.

Thus it appears that the several types of mankind differ from each other in the proportion of black and yellow pigment. The blackest pigment is found on the borders of the Indian Ocean from Australia through certain parts of India, to the whole of central Africa. Europe is characterized by a comparatively small amount of the black pigment which, however, may be much developed in certain races by exposure to the sunlight. In Eastern Asia we find certain races which on exposure to the sunlight develop a considerable amount of black but which have, also, a large amount of yellow pigment that appears when the black pigment is diluted through hybridization. This yellow pigment also seems to be present in negroes in a greater degree than in Europeans, though ordinarily covered by the black pigment.

It is impossible to state definitely what was the original color of the skin in the immediate ancestors of man. Possibly just as different species of anthropoid apes differ in skin color (the gorilla having a black skin and the chimpanzee having a light one) so a certain section of mankind may have arisen from light-skinned and another from dark-skinned ancestors. There is no theoretical reason for believing that there was a single pair to which we could point, if only we knew enough, as the progenitors of all human beings; but just as there are different kinds of gorillas today so there may well have been a variation inside the species which constituted the primitive man—a variation which had been inherited from still earlier prehuman ancestors.

If we adopt the hypothesis that the ancestor of mankind was black-skinned (and apparently a black skin was very widespread, even over Europe in prehistoric days) then the semi-albinic condition characteristic of Europeans and most of the inhabitants of Asia must have arisen through a mutation unfavorable to the production of black pigment. If, on the other hand, we assume that the ancestors of mankind had a chimpanzee-like, creamy-colored skin, then the deep pigmentation found in the negroes, negroids, and Australians must have arisen by a special mutation in the direction of melanism. There does not seem to be any satisfactory evidence that the differentiation of mankind into light and dark races was due to the direct action of the sunlight. It is true that the aborigines of Central and Southern Africa are deeply pigmented, as are the natives of Ceylon, Papua, and Australia. On the other hand, the Southern Australians live entirely outside of the tropics, and the Tasmanians, who were very dark, lived at a latitude of 42 to 43°, about the same as that of Boston. Contrariwise the Indians of Equatorial Brazil and Ecuador seem never to have attained the dark color of the negroes; while the Eskimo are characterized by dark pigmentation, about like that of the Equatorial Indians, but not so extreme as that of the Australians.

Melanic sports are known in many species of mammals and it seems *a priori* probable that melanism in man is of the nature of a mutation. It is clear that such mutation occurring in equatorial regions would serve to protect the underlying tissues and viscera from the effect of the powerful sun's rays. Indeed, the negro basks in the sunlight which the white man finds it necessary to avoid. The concentration of black-skinned races especially in the equatorial regions may very well be ascribed to the fact that their pigmentation permits them to enjoy just this region and tends to keep out their unpigmented enemies. The blacks who once apparently inhabited Europe were not able to hold their own there against a lighter-skinned people and were either annihilated, in whole or in part, or migrated to a climate that was grateful for them but malignant for their white enemies. This is, admittedly, speculation; but speculation based upon the best available genetical evidence.

A MOHAVE

The Mohave, Yuma, and Cocopa, three tall tribes on the lower Colorado River, were the only Californians who were notably warlike

A Western Mono woman with a carrying net, a Southern and Central Californian device

Californian Indian Types[1]

By E. W. GIFFORD
Curator of the Museum of Anthropology, University of California

THERE are more families of languages spoken in California by the Indian tribes than in any other region of equal size. In habits and customs also, these Indians differ greatly among themselves. The tribes in the northwestern part of California have a mode of life reminding one of the totem-pole makers of British Columbia and Alaska: again, the tribes of southern California are much like the Indians of Arizona and New Mexico; but when one turns to central California, he notes that the native culture is unique, thus justifying the notion that central California is one of the primary aboriginal culture areas of North America.

With such variety in language and culture it is not surprising to find that California is quite as diverse in the matter of racial types. In the living Indian population of today (totalling about 16,000 souls) five types and subtypes are distinguishable. Although it is customary to regard the American Indian race as quite homogeneous, as indeed it is when compared with the Caucasian race, we find that in California there are distinctive types in stature, and in the form of the head, face, and nose, to name only four principal characteristics.

As the Indians in the more thickly settled parts of California became extinct before anthropologists had opportunity to gather data from them, it is necessary to rely upon skeletal material to determine the physical type of the aborigines in these parts. There seems to be no clear and indisputable evidence. however, even in those regions where Indians still dwell, that the physical type has changed during the long course of the Indian occupation of California. Generally speaking, in those regions where narrow-headed people live today, crania of similar type are forthcoming; and in other

[1]The illustrations in this article are all from unpublished photographs and specimens in the collection of the University of California Museumof Anthropology, excepting the diagram on p. 53 and the photographs on p. 57.

MODOC $\frac{1}{4}$ MODOC $\frac{3}{4}$ KLAMATH LAKE

The man shows a trace of artificial flattening of the forehead, a custom practised more extensively by the tribes to the northward. The flattening is done in infancy

regions inhabited by broad-headed peoples, the cranial evidence reveals ancient peoples of the same type. This stability of population has its parallel in material culture, for the evidence of the shellmounds reveals no change in culture from the remote past down to the time of Caucasian settlement.

California has among its living tribes examples of the shortest and tallest peoples of the whole American continent. The Yuki Indians, of Mendocino County, have an average stature, for men, of 157 centimeters. The Mohave, of the Colorado River region in southeastern California, have an average stature, for men, of 171 centimeters, making a difference between the averages of more than five inches. The difference is about equivalent to that between the average statures of the Nordic and Mediterranean branches of the white race. The stature of the greater number of Californians lies between the two extremes.

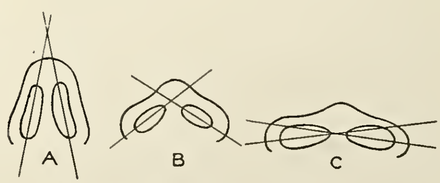
The head form likewise shows a considerable range. Some groups, have narrow heads like the short Yuki, with a cephalic index averaging 76, or like the extinct Santa Catalina islanders with an average index of 74. Others like the tall Mohave have a cephalic index averaging 89, which is however due in part to deformation. It is not to be doubted, however, that the

Range of head form shown by two skulls. At the left a narrow skull of the Western Mono type from Santa Catalina Island, with a cephalic index of 70.4; at the right a broad skull from the San Joaquin Valley, with a cephalic index of 90.6

Mohave are normally broad headed. Again we may compare the Californian Indians with certain of the European races in this matter of head form, the difference between the averages being comparable to the difference between the averages of the Alpine and Nordic branches of the white race in Europe.

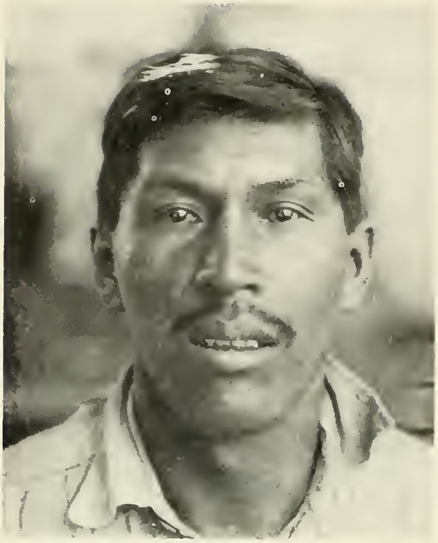
Nose form in California also reveals a considerable range, some groups having noses which are not very much broader than those of Europeans, other groups having noses that are almost negroid in their breadth. The short-statured Yuki, already referred to, belong to the latter class, and have an average nasal index of 87. In other words, the breadth of the nose is 87 per cent of the length. At the other extreme are such peoples as the Achomawi of Shasta County and the Karok of Humboldt County with average nasal indices of 73 and 72, respectively.

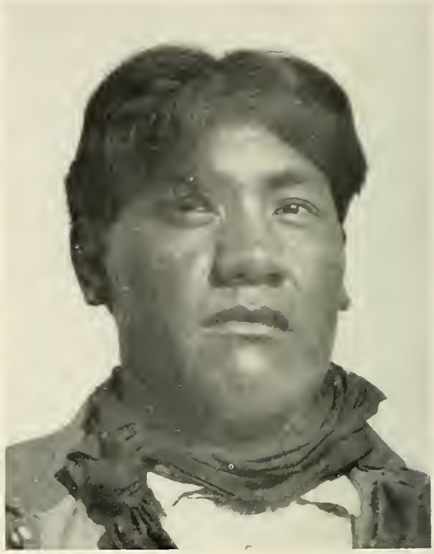
One feature of narrow noses is that the longer axis of the opening of the nostril usually runs from front to back. Very broad noses like those of many negro peoples have nostrils with the long axis running transversely. Most Californians fall into the intermediate class in this regard, having the axis of the nostrils oblique, that is to



Diagrammatic representation of nostril forms; A, antero-posterior; B, oblique; C, transverse

say, intermediate between the two extremes just described. The narrowest-nosed groups tend toward the anterior-posterior long axis; the broad-nosed groups toward the transverse long axis.





NARROW AND BROAD NOSE FORMS

½ Achomawi, ½ Atsugewi (Shasta County), illustrating narrow nose

A Northern Pomo young man, illustrating the broad nose type

NOSES APPROACHING THE EUROPEAN TYPE

¾ Achomawi, ¼ Atsugewi (Shasta County)

A Central Miwok (Tuolumne County)

NARROW NOSES

An Atsugewi chief (Shasta County)

½ Achomawi, ½ Modoc (Shasta County)

OBLIQUE NOSTRILS

A Northern Paiute girl (Modoc County)

A Southern Miwok (Madera County)

ILLUSTRATING TWO TYPES OF FACE FORM

Buena Vista type, with high face and narrow nose

San Joaquin type, with low face and broad nose

The profile of the nose in the majority of Californians may be characterized as straight, though there are a certain number of convex or aquiline noses and a certain number of concave noses. Concave noses seem to be particularly prevalent among the Yuki. The nose bridge is usually intermediate in height between that of Caucasians and Mongolians, that is to say, it is not as low as the bridges which are frequent with Mongolians, nor as high as the bridges which are frequent with Caucasians.

The glabella, the lower part of the forehead above the bridge of the nose, is frequently fairly prominent among Californian Indians, although not nearly so prominent as it is among the Australian aborigines. It is more marked though, than in average Caucasians and Mongolians. This character has its most pronounced development in males, and serves often as a means of distinguishing the skulls of adult males from those of females.

An important character that divides the Californian Indians into two distinct classes is face form. The Yuki and certain of their neighbors have low faces, as expressed by the average facial index of about 76, while the majority of the Californian tribes have high faces with an average index of about 85.

Although it is possible to distinguish the different types by stature, head form, nose form, and face form, it is not possible to separate them upon the basis of complexion, eye color, hair color, and hair texture. All are uniformly pale brown in complexion on the unexposed parts of the body. All have straight, coarse, lank, black hair. Face and body hair is scanty, as in all Mongoloid peoples. The eye color is dark brown. With exposure to the sun the Californian Indian becomes dark brown in complexion, matching some of the paler negroes in this respect. When the clothes are removed, the contrast between the dark brown face and the pale brown body is very striking.

Although the characters of the hair are among the most prominent of those suggesting relationship to the Mongolian peoples of Asia, the complete epicanthic eyefold (so conspicuous in Chinese and Japanese) is absent in adults, so far as observations go, although there are among adults occasional instances of partial or medium epicanthus. Another Mongolian trait, that of the shovel-shaped upper incisors, is very common, however.

The degrees of development of the Mongoloid or epicanthic eyefold. Sometimes the degree of development varies in the two eyes of a single individual. A swollen or beveled lower lid frequently accompanies the epicanthic eyefold, but very often this occurs independently

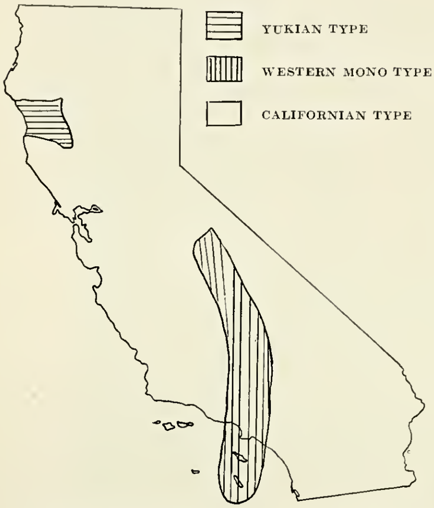
Chins on the whole are less prominent than Caucasian chins, though their true character is often partly concealed under a heavy pad of flesh. The lips of the Californian Indians may be characterized as medium in thickness, occupying in this respect a position halfway between the lips of whites and of negroes. In the matter of facial projection or prognathism they represent the opposite extreme to the negroes, there being practically no facial projection in aboriginal Californians.

The foreheads of the Californian Indians are either vertical or very slightly sloped, but true low foreheads are lacking. A curious feature of hair growth frequently gives the impression of a low forehead. The feature consists of the hair growing exceptionally low on the forehead, and quite close to the outer ends of the eyebrows.

The slight protuberance on the upper edge of the ear, known as Darwin's point, is far less prevalent among Californian Indians than among whites, in fact its occurrence may be characterized as very rare. The ear lobe is generally medium in size, though a certain number of examples have been recorded as small, and a certain number as large. Only two individuals out of several hundred examined were without ear lobes, thus approaching in this regard the characteristic condition of the Bushmen of South Africa.

The fact has been mentioned that

the Californians fall into five types and subtypes. The three main types are the Yuki type, the Western Mono type, and the Californian type, the range of which is shown on the map. The Yuki type centers in Mendocino County in north-central California,



Probable distribution of California physical types

while the Western Mono type is represented by living peoples in the southern Sierra Nevada and probably by the extinct inhabitants of the Los Angeles coast and of Santa Catalina and San Clemente islands. The Californian type may be regarded as the one truly typical of the state, for in its three subtypes it occurs throughout the length and breadth of the state, except for the relatively small regions occupied by the Yuki and Western Mono types.

The Yuki type embraces not only the Yuki and their linguistic relatives, the Huchnom, but also the Athabascan Wailaki and Kato, all of Mendocino County. It is of interest to note that the Athabascan Hupa are quite different in type from their linguistic relatives, the Wailaki. Here we have an excellent example of the fundamental distinctness of language and physical type. The Wailaki and Hupa tongues are but dialects of a single language, yet physically the Wailaki and Hupa peoples are very different, the short-statured, low-faced, narrow-headed, broad-nosed Wailaki contrasting with the medium-statured, high-faced, broad-headed, narrow-nosed Hupa. The Hupa are of the Californian type. This is a case in which either language or physical type would seem to have traveled, leaving the other behind; i.e., either a people of Yuki type adopted an Athabascan language from neighbors, or an Athabascan-speaking people in contact with people of Yuki type had their physical type swamped and obliterated through marriage and replacement by their Yuki-type neighbors. The case

A Hupa and his half-Hupa, half-Yurok wife (Humboldt County)

Upper Left.—An aged and blind Yuki—an excellent example of the sparseness of beard, characteristic of the Yuki type and of Californians in general (Mendocino County). He also illustrates the broad low face of the Yuki type.

Upper Right—A good example of the narrow-headed, narrow-nosed Western Mono type (Madera County)

Lower Right—A woman of half-Yuki, half-Huchnom parentage. She illustrates nicely the Yuki type with its low face and broad nose (Mendocino County)

perhaps parallels that of the Burgundians, in whom original blondness and blue eyes have been replaced through intermarriage by brunetness and brown eyes.

Apparently similar to the Wailaki case is that of the Eastern Mono who live on the east side of the Sierra Nevada in Inyo County. Although speaking a language only slightly different from that of the physically distinctive Western Mono, the Eastern Mono are unlike them in physical type and belong instead to the widespread Californian type to which their other neighbors, the Washo and Miwok, also belong.

The Yuki type is characterized primarily by short stature (average for men 157 cm.) and low face: and secondarily by a relatively narrow head and broad nose.

The Western Mono type is medium in stature (average for men 165 cm.), high-faced, relatively narrow-headed, and medium-nosed. Although similar to the Yuki type in head form, it differs in the other characters.

The widespread Californian type is at once recognizable by its broad head and high face. The stature of men varies from medium (161 cm.) to tall (172 cm.). The nose form is variable, too, ranging from relatively narrow to relatively broad. The three subtypes distinguished are designated as Narrow-nosed, Broad-nosed, and Tall.

As to the physical relationships of the Californians to other North American Indians little can be said at present. The Yuki type suggests one of the types described by Boas from the coast of British Columbia, while the broad-headed Californian type seems to resemble the broad-headed type of the Northwest, as represented by the Kwakiutl and the Shuswap. In the south, the Californian type appears to have relatives in Mexico. Hrdlicka writes:

> Ancient crania from the California Peninsula are also of a different type. Arizona and Sonora show no population, recent or ancient, allied physically to the Californians. In Mexico, however, are several great Indian peoples who in many features approach the Californians to such a degree that an original identity must be held as probable. One of these is the Otomi, of the States of Hidalgo and Mexico. A large group of peoples in the States of Puebla, Michoacan, and farther south, even including the Aztecs, and finally the Tarahumare, in Chihuahua, are all physically related to the Otomi as well as to the Californians.[1]

It seems clear then that two of the three outstanding Californian types are not peculiar to the state. The third type, the Western Mono type, will probably be found to have relatives elsewhere also.[2]

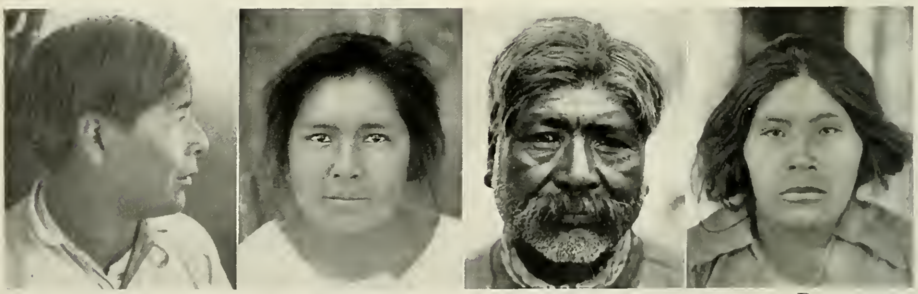
[1]Ales Hrdlicka, Contribution to the Physical Anthropology of California, *Univ. Calif. Publ. Am. Arch. Ethn.*, IV, 64, 1906.

[2]The principal published works on the physical anthropology of the Indians of California are as follows:

Franz Boas, "Anthropometrical Observations on the Mission Indians of Southern California," *Proceedings of the American Association for the Advancement of Science*, Vol. XLIV, pp. 261–69, 1895. "Anthropometry of Central California," *Bulletin of the American Museum of Natural History*, Vol. XVII, pp. 347–80, 1905.

Ales Hrdlicka, "Contribution to the Physical Anthropology of California," *Univ. Calif. Publ. Am. Arch. Ethn.*, Vol. IV, pp. 49–64, 1906.

Heinrich Matiegka, "Ueber Schädel und Skelette von Santa Rosa (Santa Barbara-Archipel bei Californien)", *Sitzungsberichte der Königlichen Böhmischen Gesellschaft der Wissenschaften in Prag*, 1904.



A B C D

A.—A Washo of the vicinity of Lake Tahoe, a good example of narrow-nosed variety of the California type.

B.—¼ Western Mono, ¾ Gashowu Yokuts (Fresno County)

C.—¼ Western Mono, ¾ Gashowu Yokuts (Fresno County). Shows tanning from sun quite markedly.

D.—½ Eastern Mono, ½ Miwok, an unusually broad-faced individual

Tsibish decided to turn away from the lake trail, because it was so cold

An Incident in Montagnais Winter Life

PRIMITIVE MAN'S SHELTER

By FRANK G. SPECK
Professor of Anthropology, University of Pennsylvania

I CAN review in my mind's eye the scene of our departure some years ago from the comfortable settlement at Lake St. John, near the southern base of the Labrador Peninsula, where the Montagnais hunters come in the summer months to secure the necessities of life in exchange for their furs. My companion was a seasoned nomad named Tsibish, who drives two big sled-dogs, Blacky and Broken-leg. The scenic setting and the details of our experience rise in the form of a quiet panorama of the semi-arctic. It is as vivid as the immediate present.

We have turned our backs upon the low buildings of the Hudson's Bay Post nestling upon the shore now banked high with snow reaching to the eaves on the side toward the lake. Tsibish has decided to push his way through the small timber and take a land route to reach a point convenient for his purpose, rather than to follow the shore and avail himself of the smooth going over the lake, because the latter is so much colder. For the intense cold lies like a pall over these frozen bodies of water. After rising some thirty or forty feet in passing through the fields and clearings about the Post we welcome the more comfortable temperature, despite a slight increase in the breeze, and the sight of the sun, though it is dimmed from its usual winter brightness by a drive of sifting snow.

Our course leads toward the northwest following the usual dog-trail, broken and beaten by the sled runners and the feet of several parties which have passed this way since the last heavy snowfall. Not content with the easy passage of the beaten trail, the perverse dogs hardly run fifty feet without floundering in the soft snow at one side, and with great fuss are pulled back to the track. Bad behavior we say, but evidently good normal sled-dog progress. A snag has caught the trace.

A breathing spell

"Back up! Pull off your mittens, Tsibish. Hold them in your teeth to choke your grumbling. Untwist the traces and start again."

No order to the going, all snags, branches, soft powdery places, but still the Montagnais finds occasion to grin, for to his well-adapted arctic humor there is something funny in the gawky postures of the dogs, their sheepish, helpless looks, and especially in the fact that the whole foolish performance will have to be repeated in all probability by the time we have covered the next fifty yards.

Ekwesʰà! Kakwshtèoshet, "Now then! Blacky."

And so progress is slow, but before long the dark line of the evergreen forest looms nearer. That is what we want, for not far within the embrace of its thickset, closely-grown, snow-laden branches we are going to make our bed, as open to the stars this cold night as the bed of the wolf. And we are going to try what to the Montagnais and Naskapi of this barren plateau is the very culmination of severity; a night in the *ktabakwèndzwap* "open-top camp." To many a starving hunter in the Labrador *taiga* this term connotes not only the misery of cold, but the pangs of hunger, since it is most often that the open-top camp becomes the night's bivouac when the game has failed. And then the able-bodied men as a last resort launch themselves abroad without the usual camp impediments in a final endeavor to find food. In this case, however, such an extremity does not have to be considered, because tucked away in the fur bags tightly strapped on our sled are a frozen northern hare, a quarter of beaver, some frozen moose-meat, a fat beaver tail, about half a pound of tea, and some little cotton sacks of sugar and salt, providing altogether a source of mental satisfaction that again brings the friendly grin to Tsibish's broad face.

Our little run of a couple of hours on the open stretch has brought out the perspiration on our bodies, so we open our fur coats and push back our warm caps from steaming brows, to look about, now that we are within the silent balsams. No wind in here. And I can see by the focus of my companion's eyes that his glance is ranging both sides of the track for the proper place, one sheltered by living evergreens but within reach of enough standing dead trees to supply the eight or ten logs which we are going to burn in the course of the long January night. The place is found. We plunge from the path into snow almost hip deep and pass a couple of rods to the right with the dogs in still worse plight, wallowing with their sleds in a spray of dry snow. Everything comes to a stop and out comes the light steel bush-ax which every Labrador Indian keeps within reach while on the trail. A tender touch to its keen edge, a glance from it to a small balsam,—whack, and Tsibish's work is begun. Blacky and Broken-leg are lying just where they stopped and are guzzling in the snow as though they had never seen it before. This is their habit, for the Montagnais teaches his dogs to nose into the snow at a signal to smell for beaver, when he is hunting near a lake, until nosing the snow becomes habitual with them.

Tsibish has dropped the tops of three or four balsams now, slanting down to the snow, by cutting them only partly through on the same side. This is to be the wind-screen of our night's shelter. Lopping off some branches, he intertwines them vertically, forming a fence about four feet high above the snow and ten feet long. It has a sufficient curve to make almost a quarter circle. By this time we have tramped down the snow within the arc, and a little packing of more snow around the sides is sufficient to keep out the direct wind and the flank drafts. The litter of twigs and small branches resulting from our operations is now gathered and laid about a foot deep under our feet for a flooring. And behold the "open-top camp" for a winter night in the Labradorean plateau is ready for occupancy by the hardy Montagnais hunter and his white comrade.

On a stick near the back of the enclosure, the frozen hare is impaled, while still one more serious task has to be performed. With a glance at the gathering dusk of the afternoon twilight, Tsibish sinks the keen blade of his ax into the nearest dead balsam tree. And the veteran of many winter blasts and summer droughts, killed by the consuming tongue of flame of a bush fire some ten or twelve years ago, now falls prostrate in the soft snow. In a few minutes six or seven others follow and we are soon dragging ten- or twelve-foot lengths of the doughty spars to the front of our shelter.

Guzzling in the snow

It is now too dark to wield the ax in safety, so the fire is started with dry cedar twigs in the hands of the leader, lighted by a match, the "little fires" which have now become so indispensable to these Indians who, only a generation ago, had to rely on flint and steel. The cheerful flames leap into being,

The "open-top" camp. (Negative exposed 1 hour, 30 minutes at midnight)

spread, and eat their way upward into fresh bundles of faggots and downward into the sizzling snow. They catch into the dry surface of the trees hauled from the *brulè*, and by the time complete darkness has engulfed our white-floored cañon amid the evergreens, there is warmth enough and light enough to illuminate a scene which would strike the fancy of the most apathetic beholder. The Labrador hunters of today, reduced to the straits of elementary human existence, construct their open winter bivouac in a form reminiscent of some remote period of culture before man had taught himself the device of complete overhead shelter. We can see ourselves reproducing now the experience of boreal hunters in early Neolithic times, and the thrill of the experience, even though it be for only a passing glimpse backward into those hoary ages, is the reward. We are living for a while in a primeval atmosphere. These thoughts, however, are passing through the mind of only the white man. A look or two at Tsibish betrays the fact that to him this is part of life. For I learned that he and his companions have resorted winter after winter to this procedure when, through the necessity of seeking new hunting districts, they betake themselves with minimum of food, axes, and weapons, to distant barrens, in the hope of locating a fresh abundance of meat. *Mishte alimàn!* "great hardship," as they term starvation, is the normal lot of Tsibish and his kind during the long hard winters of the interior. Not only he but his wife and children know it, and generations of ancestors as well. More than half of them have fallen victims, and almost half still do succumb to that fate.

Back to the immediate present my thoughts leap with the bounding flames of the now furnace-like cavern eating their way through the forest snow downward to the forest floor. We kneel on the boughs of our enclosure and empty the caribou-skin sack of its frozen contents to prepare our evening meal. Out come the viands. Portions of meat hewn off with the ax are affixed to green twigs and inclined toward the heat to thaw and roast. On a piece of rag stretched on the boughs, is poured a handful of tea. This goes into the kettle and on top of it several handfuls of snow from the dirty but willing hands of "Little-Tea-Water," for this, I am now ready to announce, is the meaning of my

Descendants of the Maya Indians

FAMOUS FOR THEIR ARCHITECTURAL ACHIEVEMENT

PHOTOGRAPHS REPRODUCED THROUGH THE COURTESY OF THE CARNEGIE INSTITUTION OF WASHINGTON AND E. L. CRANDALL

A SUNNY LITTLE MAYA MAID

The children of Yucatan are happy and cheerful. Their playthings are simple and their wants few. The days slip by in playing out-of-doors, bathed in the brilliant sunshine of the subtropics, health-, strength-, and life-giving. This little miss of eight or ten will mother a whole brood of younger sisters and brothers, taking care of them all day long, piloting them carefully through the village streets, and marshaling them home again, safe and sound, at eventide

TEMPLE OF THE FOUR LINTELS AT OLD CHICHEN ITZÁ

A Mestizo boy standing beside the western doorway of the Temple of the Four Lintels at Old Chichen Itzá. This is a typical Maya ruin, standing roofless and dismantled, buried in the dense tropical forest

A PRIMITIVE SUGAR PRESS

Stalks of sugar cane going through a primitive sugar mill. The juice is made into sugar for local consumption and home-brew

YUCATAN TODAY AND YESTERDAY

A Mestiza standing by one of the Plumed Serpent columns in the Temple of the Jaguars at Chichen Itzá, Yucatan

INDIAN GIRL IN THE TEMPLE OF THE JAGUARS

Both Indian and Mestiza girls wear the same kind of garment—the embroidered huipil, and their costume is considered incomplete without the gold filigree chain and cross

THE CHURCH AT THE VILLAGE OF DZITAS

Every village in Yucatan has its church of stone, often of enormous size. The church at Dzitas faces the village plaza and has a picturesque belfry, a machicolated roof, and flanking buttresses. It serves the religious needs of about two thousand people. The group in the left foreground includes both Indians and Mestizas

STREET IN A YUCATECAN VILLAGE

The streets in the villages of Yucatan are rocky and rough, great patches of native limestone cropping out everywhere and anywhere. Dry-laid rough stone walls line these simple highways, and the houses of stone or plaster-covered wattlework are built flush with the street line

CHANGING CUSTOMS AND COSTUMES

The picturesque huipil of the Yucatecan women is gradually being replaced by cheap European clothing in the younger generation. Girls wearing modern dresses like the one in this picture are called Catarinas to distinguish them from the Mestizas or Indians who wear the old-fashioned huipiles

A SHRINE BY THE ROADSIDE

Roadside shrines with wooden crosses are found throughout Yucatan. The devout, in passing, offer a candle, a bunch of flowers, a bit of colored ribbon or paper, and a prayer

A YUCATECAN REBEKAH

The water-carriers of Yucatan are the women and girls. Almost no houses outside of Merida, the capital, are equipped with running water, its source being wells in which the country abounds, and its service of supply—the Yucatecan women

MESTIZA GIRLS DRAWING WATER

Yucatan is a dry limestone plain with practically no surface water. Every village has one or more wells, and here all day long the women gather to gossip and fill their large earthenware jars, hauling the water up by hand

A MAYA INDIAN GIRL

A Maya girl in her embroidered huipil, standing in one of the winding stony roads of a Yucatecan village, with its rough-laid stone walls

A MESTIZA GIRL

This girl is wearing the typical women's garment of Yucatan, a white cotton single-piece sleeveless slip embroidered around the neck and the bottom of the skirt with flowers in cross-stitch

TYPICAL YUCATECAN HOUSE

A thatched wattlework hut with rounded ends, and front and back doorways, is the typical home of the Maya Indian family, the same today as it was a thousand years ago

THE VILLAGE MARKET

Small booths where local produce is sold in diminutive quantities, a *medio* (3 cents) of sugar, a *cuartillo* ($1\frac{1}{2}$ cents) of coffee, are features of every village market

A ROADSIDE WELL

In the parched and waterless landscape of Yucatan the traveler hails with delight the wayside well, the vivid green leaves of the banana tree arching over it offering a grateful island of shade along the sun-baked and dusty road.

Modern galvanized iron buckets and even five-gallon gasoline cans have replaced the old wooden containers at these wayside wells, somewhat destroying their picturesqueness, but the water still remains the same—cool and refreshing as of old companion's native name. Tsibish is, indeed, "king of the tea," and he smiles at the flavor of his joke as a few minutes later the odor of his brew fills his nostrils. The same tawny hands are now wiped free of grease in his thick hair.

The labor of the day is finished. The genial warmth in front of us thaws out tongue as well as face, and the tradition of taciturnity with which the northern Indian is accredited is everlastingly shattered by the flow of conversation and exchange of jokes lasting through most of the night. Food consumed, washed down with several pints of tea, blankets out, dogs fed and snuggled down on their crisp couches of snow while still attached to their harness, and we are ready for the night.

My own thoughts now turn to the Eskimo this cold night, sheltered beneath the thick roofs of their snow-huts some hundreds of miles to the north and east of us. The full force of the contrast between their almost comfortable existence and the Indians' comfortless one is borne out in reality, viewed from the debit side. Even though we are enclosed in hareskin robes over our fur and woolen garments, the biting cold descends from the altitudes above and is drawn with violent suction against our backs and sides by the volume of heat ascending from the cavern of embers. It is no paradox to declare that it is colder near the fire than it is at a distance of fifty feet. It is this violent draft of in-drawn cold that makes the bough-screen at our backs an absolute necessity. No

As the afternoon darkens, the smoke rises, and our *Ktabakswèndzwap*, "balsam camp," beside the trail is complete matter how cold the night is without, its all the same! To add to it Tsibish says in his low voice, "*Kispashnanò*," "Let's melt some snow for a drink." Several quarts of crisp snow are forthwith heaped into our kettle for drinking-water and for the tea-drinking which will amount to dissipation this long night. Tsibish wishes it would snow hard during the night to raise a drift against the rear screen, the better to turn the wind. Wind is deadly! It cuts through every covering but leather. Hence, our feet enveloped in moccasins over five pairs of woolen socks, and our hands in caribou-skin mittens over woolen gauntlets beneath, are now our most comfortable parts. And where, in this congealing night, are the pair of cross-bills and the Hudsonian chickadee, the only birds seen during the day's march? And how does the tiny body of the Labrador red squirrel that alarmed us with his rattling call this afternoon withstand the intensity of this polar chill?

"I am satisfied to be in here now where it is calm," remarks Tsibish, "for indeed on the lake now it is blowing hard."

Need I say that our conversation soon turns to that topic of eternal interest—the comparison of racial values? He is as eager to know the habits of my people, the *Bastonèuts*, "Bostonians," as the Labrador Indians call all Americans, as I have been, throughout our twelve years of friendship, to comprehend the life of the *Ilnùits*, "The people," as these Indians call themselves. And I tell him as he listens with rapt attention. Many grins and some surprise, show in his wide eyes as I unravel the mysteries of home-life, domestic appliances, and social relationships of the *Otcimàwuts*, "Gentlemen-Chiefs," by which name these simple natives also designate the occasional Americans whom they encounter on their sojourns to the post. But let us turn from this portion of our dialogue to that which concerns the lore of the savage.

"*Opitcipwiàn Otcimàu*," "Gentleman-Chief-of-the-Rags," (for such is my honorable title among these people,—one derived from the habit of buying their cast-off objects), "this night is one like that during which *Atikwabèo* "Caribou Man," had his dream which called him to leave the company of mankind and become chief of the caribou. Maybe you know the story how he, with the men of his family, were on the tracks of the herd. How they left their families with all the food to save them and set forth, with nothing to eat themselves, in search of relief. How they were hoping for a dream to tell them where to go to find the caribou. How after several nights in the open-top camp, just as we are tonight, they received no dream at all and began really to starve. How on this night Caribou Man received a vision. How he saw a female caribou appear and call him forth to join her companions, to go with her as a mate and become the chief of the caribou. And how he told his dream to his father that night when they awoke to throw more wood on the fire as we shall soon do. Ha! ha! And then sure enough when morning came did it not come true? The caribou were there and a female came forth. And did he not lay down his weapons in the snow and walk to where the female caribou was standing? And did he not disappear with her and carry out her wish? And at last did he not send his relatives some big bulls for them to kill and thus save them and their little ones from the great starvation? Ah! It was a night like this that he left them for their sake and still lives with the caribou herd, riding the back of a bull when they travel, and sleeping among their bodies for warmth, these many winters. They say he eats moss like his caribou and even that he has had offspring by them. You know that story, Gentleman-Chief.

"I have indeed often wished, for the contentment of my soul-spirit, to journey to those mountains somewhere far north of the land of the Barren Ground People to see from a safe distance the Caribou-House where Caribou-Man dwells, that is so often spoken of. Ah! to behold such a mountain of caribou-hair and to see the great caribou-herds that gather within it at the summons of Caribou-Man. Even the *Ayestcimèuts,* 'the Raw-Meat-eaters,' the 'Bad People' (Labrador Eskimo), know that the caribou are sent forth from there by Caribou-Man for us to kill.

"But we shall never see that region, *Otcimàu,* for I know that neither you nor I could journey so far, and you, like us Indians, would not disregard the tradition which forbids us to approach it.

"At any rate let us take another drink of tea and rub grease on our foreheads that we may fall asleep for a while before the fire needs wood again, and dream of the great food."

"Yes," I solemnly reply, "I know the story, my comrade, and I doubt whether I shall ever try to reach that land, as I know that no one who reaches it ever returns again. We will try to sleep for a while to learn what our souls will tell us in the 'great dream,' for the drink of tea and the grease rubbing we have given them."

Tsibish takes out his moose-skin tobacco pouch and fills his pipe, "to give his soul-spirit a drink of smoke," as is the custom of these nomads. The fire getting low, we drag three more great logs on the embers and settle down in our "sets" beneath the arctic sky. As the frigid scene dancing through the leaping flames grows hazy and finally melts into blackness, I lose myself in drowsiness. I do not know what Tsibish did, nor can I recall now if I dreamed that night. I only recall that, for the fourteen hours or more we occupied our position, there were awakenings, tea-drinkings, and some narrations, more than a dozen times to replenish the gigantic fire and turn our cold parts toward its heat. And at last the gray of dawn and the shine of the cold moon brought us to the consciousness of coming day. With the dogs kicked out of their snowy beds and a good meal on the remaining beaver and hare meat, we soon left the "open-top camp," that memorable relic of winter life, and continued our journey northwestward through the endless balsams along the narrow sled trail that led to Tsibish's solitary tent miles away, where his wife and six children were anxiously waiting for him.

Some Changes in the Human Face as Influenced by the Teeth

By MILO HELLMAN
Research Associate in Physical Anthropology

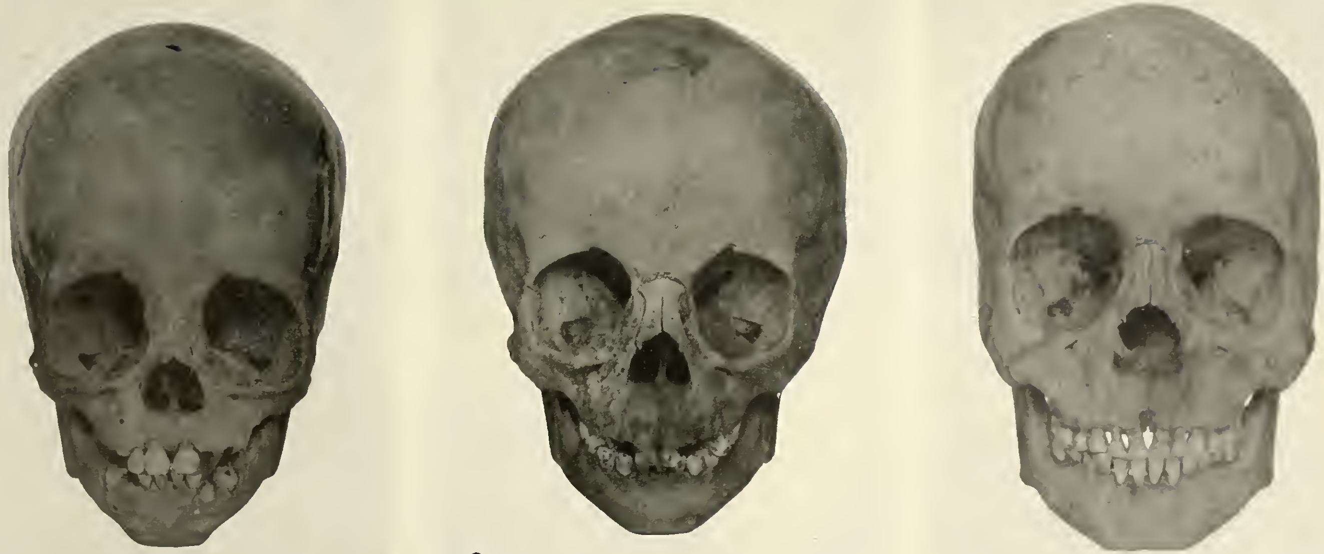
THERE are few parts in the make-up of the individual that portray so well the effect of development[1] as does the face. From the beginning to the end of life, the face undergoes a continuous series of changes. The gradations of these changes are, to be sure, imperceptible, and definite border lines do not exist; but certain stages, once reached, become well defined and are easily recognized. For example, anyone is able to notice the change of the infant face to that of the pubescent boy or girl, or to that of the adolescent man or woman. The transition from middle life to senility is also easily recognized by the facial change.

While such changes are obvious, some of the factors concerned in bringing them about are not so widely known. It is, for instance, not generally known how much the teeth contribute to the modification of the face. As a matter of fact, on account of their position in the jaws, the teeth constitute an important factor in this process. This becomes quite evident when it is shown that certain stages in the development of the dentition are coincident with and perhaps causally related to certain changes of the face.

It must be stated that these stages in development are not necessarily related to age, but rather to certain conditions, since a certain stage in development may be reached by one individual much earlier in life than by another. As a consequence, the age at which a stage in development is reached varies when a number of individuals are concerned, but the stage attained is, nevertheless, the same in all. For example, all children in the course of development go through the stage of puberty, before they become adults, but some go through it earlier, others later. This depends on hereditary tendencies, on environmental influences, and on many other known and unknown conditions.

In the development of the dentition too, certain easily recognizable stages are reached, but the age at which these stages are reached is variable. Studies of a large number of New York children illustrate this point quite clearly. For instance, it is found that the stage of the fully developed deciduous dentition in these children may persist until the seventh year. But the succeeding stage, when the first permanent molar tooth has been added to the deciduous dentition, may be observed between the ages of seven and eleven years. Coincident with the eruption of the first permanent molar tooth in these children, one or all of the deciduous incisor teeth may be lost and replaced by their permanent successors. The stage following, when all the deciduous teeth have been replaced by the permanent successors, extends from nine to fourteen years of age, and the establishment of the permanent dentition, less the wisdom teeth, occurs from eleven to seventeen years of age. The variability in age is thus quite evident. But the whole matter becomes more

[1]Development is used here in the sense of embodying both growth (increase in size) and differentiation (increase in complexity).



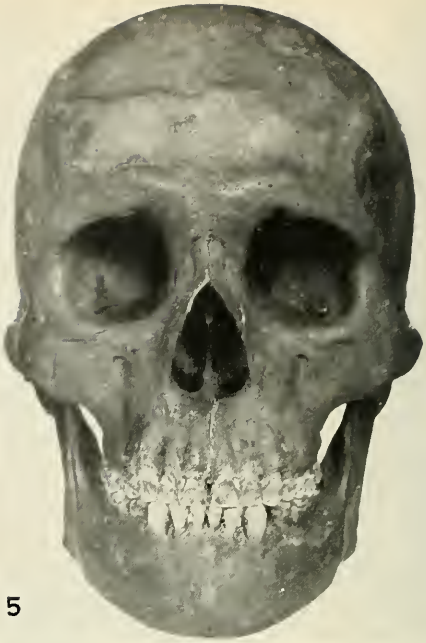
1 2 3

1. Infancy:—The deciduous dentition is not fully developed. The incisors are completey erupted and in position; the first molars are not quite fully erupted, while the canines are just beginning to erupt. The second deciduous molars are absent as yet.

2. Early childhood:—The deciduous dentition is fully developed. The upper lateral incisors and canines were lost in transportation.

3. Late childhood:—The first permanent molars have erupted and are in position. The lower deciduous incisors have been lost and are replaced by the permanent incisors. The upper deciduous teeth are still all present

4



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6

7

4. About puberty.—The permanent dentition is fully developed. The third molars (wisdom teeth) are still absent.

5. Adult.—The permanent dentition is completely developed, including the third molars (wisdom teeth).

6. Old age.—The permanent dentition is still complete. The teeth show extensive wear. The lower right second premolar was lost in handling.

7. Senility.—Most of the teeth have been lost; those remaining show much wear. The alveolar process is considerably atrophied

complicated when groups of children of different economic levels or when the sexual differences in the same group are studied. It is therefore simpler and more satisfactory, when development is discussed, to refer to the stages and not to the ages. The stages of dentition to be discussed in this paper are the following:

1. When the deciduous or temporary teeth are in the process of eruption.
2. When the deciduous dentition has been completed.
3. When the first permanent molars have been added and some or all of the deciduous incisor teeth are lost and are being replaced by the permanent incisor teeth.
4. When the permanent dentition—less the wisdom teeth—is completed.
5. When the wisdom teeth are in position.
6. When the teeth show extensive wear from use in old age.
7. When the teeth are lost during senility.

These stages, numbered from 1 to 7, give an adequate illustration of the development of the dentition.

That the growth of the face is, in a large measure, influenced by the development of the dentition, can be demonstrated by certain measurements. The height of the face, for instance, is determined by measurements taken between the point where the bones forming the bridge of the nose are joined to the lower border of the bone constituting the forehead and the middle of the lower border of the lower jaw. This dimension is called the total height of the face.[1] In the infant, before the teeth have appeared, and in the senile, after they have been lost, this measurement indicates the dimension of the bony structure of the face alone, for the jaws in these instances are in contact with each other. But when the teeth begin to erupt in the toothless infant's mouth, the jaws are pushed apart, as it were, by the teeth, because additional room is necessary for their accommodation. As a result, there is an increase in the height of the face to the extent of the area occupied by the teeth, in addition to the actual growth of the jaw bones themselves. The teeth thus form a separate and distinct item in the increase in height of the face.

The fact then becomes quite obvious that the changes in height of the face are due to two processes occurring simultaneously. One, of the growth of the jaw bones, and the other, the development of the dentition. Their relation can be determined by a comparison of relative measurements.

Of course, the proper and ideal way of obtaining such measurements would be to follow up one or many individuals by repeatedly measuring their faces, from early infancy to senility. This is being done and will be reported when the records are more complete. It will, however, take a long time before it can be done satisfactorily. Another method is to take a group of individuals of all ages and make comparative measurements. This also has been done, but measuring the living is more or less subject to inaccuracies because of various difficulties. For instance, the skin and the subcutaneous tissue (the meshwork of various tissue fibers, the fat, and the delicate muscles under the skin) are sources of a considerable degree of error. It is therefore easier and more satisfactory to measure skulls. Furthermore, when skulls are

[1]Attention is called to the fact that the growth of the face occurs in three dimensions, in height, in width, and in depth. For the present purpose, the discussion is confined to the height alone.

measured, a more desirable group can be chosen to make the procedure more effective.

A collection of skulls recently acacquired by the American Museum of Natural History has been found eminently suitable for this purpose. This collection consists of a large number of American Indian skulls excavated by Earl H. Morris in Cañon del Muerto, Arizona. They date back an extensive period in time, certainly more than two thousand years, and appear to have belonged to a very homogeneous group, as shown by the various characters studied. The collection also recommends itself for this purpose, because there is a remarkable range of ages from infancy to senility; also their dentitions are far superior to and more uniform than the dentitions of modern civilized people.[1]

The measurements of the faces of these skulls revealed a very interesting fact. They show not only that the face grows in the course of development, but also that when it grows, it follows certain characteristics inherent to all growth phenomena; i.e., its growth varies in intensity at different stages of development. It grows, for instance, more rapidly at first, slows down, and then speeds up again. But while it continues to grow until old age, the rate of growth becomes slower and slower as age advances. The greatest amount of growth takes place during adolescence. In senility, there is a reversal of this process, a kind of involution, since the height of the face is actually reduced. A glance at the figures in the first column of the accompanying table (p. 73) will convey a better idea of what actually happens. These figures are based on the arithmetic averages for the measurements. The periods of facial growth are approximated by the stages in dental development. The second column gives the percentile increase of the facial height at the stages mentioned.

Referring to the dental development, it is quite clear that the first marked increase in facial height is coincident with the completion of the deciduous dentition; the second, and the most significant one, during the completion of the permanent dentition. The first slowing up in growth occurs during the period preceding the loss of the deciduous teeth, and the second, after the completion of the permanent dentition. But while the first retardation is temporary, the second retardation continues until old age sets in, terminating with an involution of the facial skeleton, when there is an actual decrease in height. This, as has been mentioned above, is coincident with the loss of the permanent teeth.

With this point in mind, the measurements of the dentition also assume an interesting aspect. As has been mentioned above, the teeth form a distinct item in the dimension of the facial height, for the dental height[1] is not the same at all stages of development. It, too, changes during the course of development. There is an increase in the dental height, beginning with the eruption of the deciduous teeth, and continuing to the completion of the permanent dentition; then begins a decrease, at first slight, then more marked, until senility brings on the loss of the teeth. The figures in the third column of the table will illustrate

[1]The choice of this skull collection was made in full recognition of the fact that it does not represent mankind in detail. It does, however, represent a human type. The study of this group, therefore, furnished only a rough outline of the problem. The color and relief, so to speak, needed to make this into a complete picture, will be furnished in the future.

[1]The dental height was obtained by measuring the distance between the lower borders of the upper alveolar process and the upper border of the lower alveolar process at the median line.

RELATIONSHIP BETWEEN HEIGHT OF FACE AND DENTAL HEIGHT

	Facial Height		Dental Height		Relative Dental Height
	Average in mm.	Increase in percent	Average in mm.	Increase in percent	Percentages of facial skeleton
INFANCY Before completion of deciduous dentition	60.43		6.14		9.23
EARLY CHILDHOOD At completion of deciduous dentition................	69.20	14.20	8.20	25.12	10.59
LATE CHILDHOOD First permanent molars in place; some or all permament incisors erupted.....	75.50	9.1	11.20	26.78	12.92
PUBESCENCE Permanent dentition (less wisdom teeth) complete.	100.00	32.45	11.60	3.5	10.39
ADULT AGE Permanent dentition, including wisdom teeth,complete	106.20	6.2	11.00	— 5.17	9.38
OLD AGE Teeth show considerable wear.....................	110.33	3.89	9.1	—17.27	8.46
SENILITY Permanent teeth are being lost and alveolar process atrophying................	101.80	—7.73	5.7	—37.40	5.39

NOTE: The minus sign (—) means decrease. Facial height represents height of facial skeleton, without the teeth; dental height is the height of the dentition.

this. The figures in the fourth column show the percentile increase and decrease at the different stages.

Another outstanding feature brought out by these measurements is the relationship between the development of the dentition and the growth of the face. The importance of the part played by the dentition in the process of the vertical growth of the face will be apparent when a few figures are cited. Thus, before its completion, the deciduous dentition represents 9.23% of the total height of the face. With the completion of the deciduous dentition, the percentage rises to 10.59. When, in addition to the deciduous series the first permanent molars have erupted and some or all of the permanent incisors have taken the place of their deciduous predecessors, the dental height is 13% of that of the face. After the remaining deciduous teeth (canines and molars) have been lost and are replaced by the succeeding permanent teeth (canines and premolars) and the second permanent molars are in place, the percentage decreases to 10.39. This decrease then continues during adult and middle age to 9.35%;

in old age to 8.46%, and, when senility brings about the loss of most of the teeth, to 5.3%.

The interesting facts brought out by these figures may be stated in a different way, namely, the height of the dentition bears approximately the same percentile relation to the height of the face during early infancy as during adult life, and during early childhood as during pubescence. But in late childhood, when the face shows the least increment, the dentition is developing at its highest rate and shows the highest relative proportions. This is just at the period when the face remains infantile, while the dentition assumes its adult character by changing the deciduous for the permanent series. The lowest relative proportion to that of the face then appears in senility. But, despite the fact that the face is actually decreasing in height during senility, the loss of the teeth actually shows a lower relative dental height than at any of the other stages noted. One curious thing should be mentioned: when the dental height reaches its highest dimension, it shows a decrease in its relation to the facial height. This is explainable by the fact that just when the permanent dentition is completed, there is the greatest increment in the facial skeleton; i.e., the face undergoes those changes which transform it from that of the boy or girl to that of the man or woman.

There are, then, three fundamental facts to be recognized:

1. The growing face continues increasing in height from infancy to old age, and the greatest increase occurs at the time when the adult stage is reached. There is, however, also a decrease to be noticed. But that occurs in senility.

2. The dentition, too, follows a certain course during its development. The dental height increases from the time the deciduous teeth begin to erupt in early infancy to the completion of the permanent dentition, lacking, as yet, the wisdom teeth (third molars). But as soon as full growth is attained (the third molars completing the permanent dentition) a decrease in the dental height begins.

3. The relationship between phases 1 and 2 brings an interesting fact into relief, i.e., it shows that the stage presenting the greatest increase in the dental height, precedes that of greatest increment in the growth of the face. This is very interesting for it demonstrates that even the adult reminds one of some phylogenetic (group development) facts concerned with the mouth and face. The mouth, being the oldest part of the face, develops first; the face then grows around it.

The Hair

By C. H. DANFORTH
Department of Anatomy, Stanford University

MAN differs from all other mammals in the complete lack of tactile hairs, and from all other anthropoids in the total loss of hair from the terminal segments of the fingers and toes. The specialized "feelers," whose absence has been cited as one of the most distinctively human traits, may, according to both Broman and Schultz have a fleeting representation in the early fœtus, but these transient rudiments never produce real hair. On the distal segments of the digits no trace of follicles has been found at any stage.

As compared with many, but not all, of the lower mammals, man also shows a marked reduction in the total amount of hair, and a deficiency of several types besides the true tactile forms. Hairs which could properly be classified as spines, awns, wool or fur, fail to appear in the human pellage, which consists essentially of only two forms: the down, or vellus, and terminal hair which belongs to the category of bristles or mane and corresponds to similar hair in the anthropoids.

The vellus, which is one of the most characteristic features of the human pilary system, covers almost the entire body and is composed of numerous, minute, unpigmented hairs with relatively large cuticular scales and no medulla. In contrast to the vellus are unevenly distributed hairs which have relatively smaller scales and well developed medullas. These latter are called terminal hairs, in the sense that they represent the ultimate grade of morphological differentiation of hair (in man). The outstanding differences between these extremes are shown in Fig. 1. Between the two forms may be found transitions representing all intermediate phases.

The presence of transitional hairs suggests that we may have to do with only one fundamental type. Hausman has recently shown that the dimensions of the scales and the development of the medulla is primarily a function of the size of the hair rather than a regional or racial characteristic. To this it might be added that within any circumscribed area of the body the life span of a hair—the time between its first appearance and the appearance of its successor in the same follicle—is roughly proportional to its size. Thus in the course of 31 months a single follicle on the finger produced in succession nine hairs of moderate size, while during the same period another follicle less than a millimeter distant produced twelve small hairs. Although individual follicles usually produce practically identical hairs at each successive cycle, the output occasionally changes so that down may be replaced first by

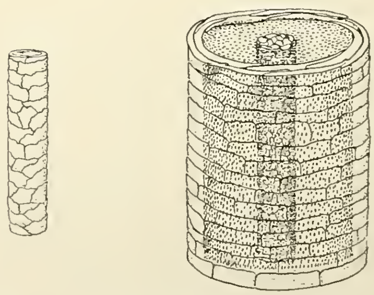


Fig. 1.—Slightly schematic sketch of a vellus, or down hair, and a terminal hair from the chest of a white man

transitional and later by terminal hair. Trotter found that the latter tend to become coarser as age increases.

Racial differences in the vellus and fine transitional hairs have not been adequately studied. On the middle segments of the fingers all hair is usually absent in the negroes, usually present in white races, and variable in yellow races. Trotter was unable to find any significant difference in the actual number of fine hairs on the faces of white and negro subjects.

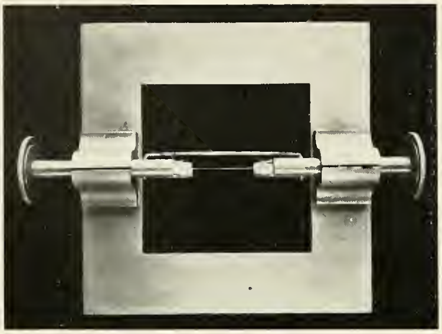


Fig. 2.—A convenient form of hair rotator. The hair (white line in the photograph) whose index it is desired to ascertain, is secured in the axis of the crosspieces by means of the clips and the rotator placed on the stage of a microseope where the greatest and least diameters may be measured by means of an ocular micrometer or by projection. The amount of rotation may be read from scales on the milled heads. The distance of the two rotating crosspieces from each other may be adjusted by means of the excentric connecting piece, or may be made to act separately by its removal

In the development of terminal hair there are well known racial, as well as age, sex, and individual differences. Many of these differences appear very gradually and not promptly at puberty, as is often supposed. For example, terminal hair on the ears, and "wild" hairs in the eyebrows usually appear relatively late and increase over a period of many years. While there is a certain degree of what might be called regional autonomy in the production of terminal hair, there is also a strong tendency for hair to follow a definite sequence in its appearance in different parts of the body. That is, if one subject has hair in region *a*, another subject with more hair will usually have it in regions *a* and *b*, not *b* and *c*.

This progressive tendency in the production of terminal hair may be illustrated by reference to a limited area, the face. Children, most women, and possibly a few men have nothing but vellus on the cheeks, upper lip, and chin. The boy of a heavily bearded race begins at about puberty to show a few terminal hairs at the corners of the upper lip. Then these grow longer and others appear over the rest of the lip. This is followed by a few coarse hairs at the side of the chin and in front of the ears. Gradually these hair-covered areas extend and ultimately become continuous. The "full beard" is not attained for a number of years, and at no time do all the follicles reach the stage of producing terminal hair. In passing through these successive degrees of beardedness the young man parallels, one by one, the final stages

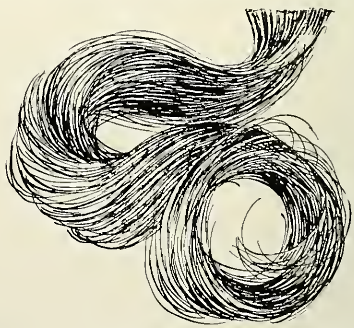


Fig. 3.—A lock of hair from D, showing the appearance of strands in their usual relations

reached by occasional women of his own race and by the adult men (e.g. Indian, Japanese, negro) of certain other races. This phenomenon, which is also manifested by hair in other parts of the body, is very suggestive of what the morphologist calls recapitulation but it is doubtful if any phylogenetic significance should be attached to it.

The hair of the head, capillus, is most readily available and generally utilized for anthropological studies. Since the time of Peter Browne and Pruner Bey, both of whom attempted to classify the races of man on the basis of their hair form, it has been popularly supposed that the Indian's hair is straight because it is circular in cross section, the white man's wavy because it is oval, and the negro's curly because it is flat. But the case is not quite so simple as this. Negro hair is indeed flattened, but so, too, is much Chinese and Japanese hair that is perfectly straight. Hair that is really oval in cross section is uncommon. The degree of flattening in a hair may be indicated by a "hair index" obtained by multiplying the shortest transverse diameter of the shaft by 100 and dividing by the greatest diameter. Hair indices usually range between 50 and 98, and are best obtained by means of some form of hair rotator such, for example, as that shown in Fig. 2. In general, curly hairs have low indices (cf. Fig. 7) but occasionally straight hairs are found with indices lower than those of other hairs which are curly.

Studies of the follicles which produce different types of hair as well as observations on the shafts themselves indicate that the primary curl is due to a slight inequality between the two sides of the more or less flattened shaft. Another significant factor in producing the characteristic appearance of the capillus, as a whole, is the twist of the shaft on its own axis. Since in each hair of the head the lesser curvature remains consistently on the same side, a quarter or half turn of the shaft will change the direction of the curve and greatly modify the appearance of the hair. This important feature, which is usually ignored, is shown in one of the hairs in Fig. 4, and the two in Figs. 5 and 6.

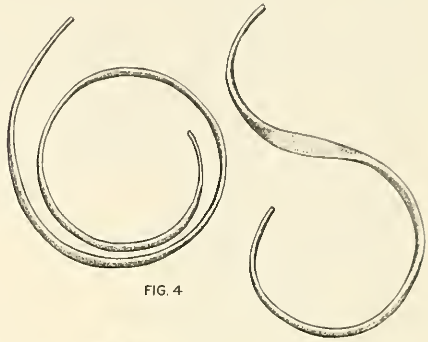


FIG. 4

FIG. 5

FIG. 6

Fig. 4.—Two of D's hairs freed from the deformation effects of neighboring hairs. The one on the left is the more typical.

Fig. 5.—A hair from C. This is a characteristic negro hair which shows not only a coiling but a marked twisting of the shaft. The direction of the twist is reversed at the middle of the figure, changing the direction of the coil from clockwise to counter-clockwise.

Fig. 6.—Hair from a boy, E, with some negro blood, showing the negro type of twisting associating with a rather open coiling

In order to illustrate some of these points from sources close at hand the writer, having equipped himself with a kodak, a pair of scissors, and some envelopes, spent a holiday in search of representative types. Interesting subjects were photographed and samples of hair secured from the side of the head about half way between the vertex and the ear. The hair and photographs of five children were selected for the present purpose. After the pictures were printed, the backgrounds of trees and buildings were blocked out with India ink. The hairs selected were measured, sectioned, and sketched. Comparison of the sketches and photographs may help to show the relation between the form of individual hairs and the effects which they produce when growing in masses.

The first subject, A, is a boy of about twelve, born in Canton, China. His hairs are black, straight, of variable diameter and high index. Only a few are flattened, and these but slightly. (Samples from Chinese and Japanese subjects showing many hairs of rather low index were also procured).

B is a boy of three, "old American," of English and Scotch descent. His hair shows a rather wide range of individual forms but gives the impression of being perfectly straight. It may be noted that one hair is oval in section.

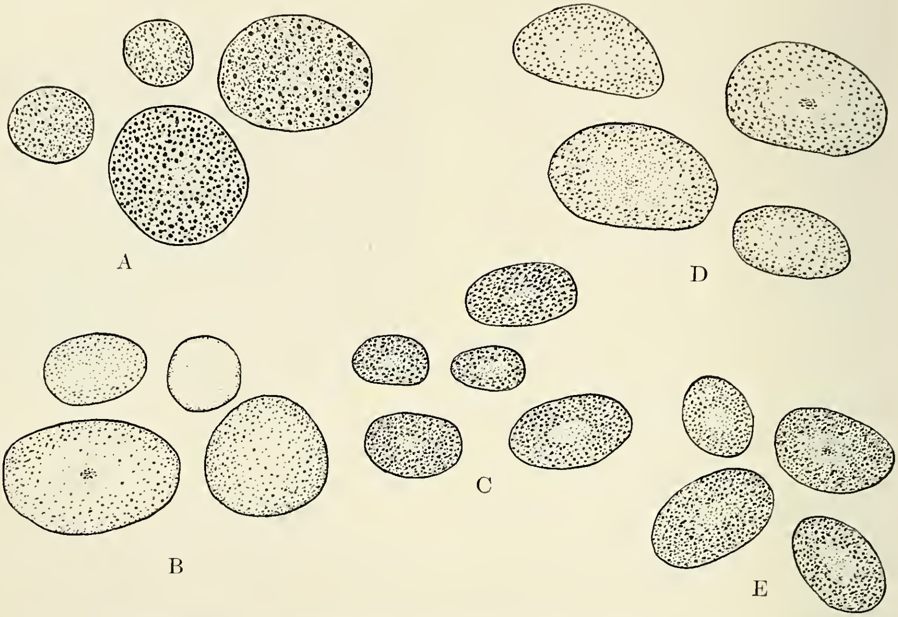


Fig. 7.—Cross sections of representative hairs of the five subjects A, B, C, D, and E

C is a negro girl of about five, apparently with no white blood, at least in her immediate ancestry. The hair is typical of her race. Its distinctive appearance is dependent upon two factors; the tendency to curl in rings of small diameter, and a persistent twisting of the shaft now one way, now the other, so that the direction of the spiral is in some places clockwise and in others counter-clockwise. It is the effect produced by masses of such hair that has led to its popular characterization as "wool." When cut rather short individual shafts tend to assume the form of an S with a twist in the middle.

D, a girl of ten, presumably largely German in ancestry, has hair which at

A

B

C

A.—A Chinese boy, with characteristic straight hair.

B.—A white boy, with straight hair.

C.—A young negro girl, showing the "woolly" hair characteristic of her race.

D.—A white girl, with exceptionally tightly curling hair which, however, differs very greatly from that of C.

E.—A boy, of mixed white and negro ancestry. His hair is negroid in some respects, but not in others

D

E

first sight might seem to resemble that of C or E. In the curled locks these hairs are in fact forced, by gravity and combing, into S-shaped curves as shown in Fig. 3, but individual hairs, isolated, dipped first in sodium hydroxide, then in water, and finally dried to restore their normal form, coil with a few exceptions in a single plane, like a watch spring. Negro hair when similarly treated behaves very differently. A few of D's hairs show an abrupt twist giving a true S-curve, but one with a wide diameter.

E, seven years old, would seem to be of mulatto and French ancestry. His hair is interesting in that it is of an intermediate type. The pigment is rather moderate in amount but distributed as in C. The twist in the shaft is such as is usual in negro hair, but the curvature is much less, giving an uncommonly wide loop.

From characteristics such as these, much information of anthropological value may be obtained, but the student of hair very readily becomes a skeptic when he attempts to make observations on the heads of subjects he sees about him.

In the negro section of any large city one may see very black women whose hair has been coerced into a state of relative straightness, and in Chinatown many of the girls have hair that has been curled so tightly that lines of scalp show through as in the conventional pickaninny. Between such obviously artificial effects as these and the purely unintentional and relatively slight modification found in the hair of D, one meets a wide range of conditions and soon learns to record his "field observations" with caution.

The Relationship of Races as Shown by Blood Characteristics

By REUBEN OTTENBERG

IT has been known for years that the blood of many individuals does not mix perfectly with that of many others. In some cases the mixture of blood from two persons results in a kind of clotting of the red corpuscles; *agglutination* it is called by the scientists. It looks like the curdling of milk. It is on account of this that blood tests have to be carefully made before a blood transfusion, for if this agglutination were to occur in a person's veins it might have serious consequences.

This phenomenon does not occur at random but follows a remarkably regular rule discovered in 1901 by a Viennese scientist, Karl Landsteiner, now in the Rockefeller Institute in New York. Landsteiner found that there are four kinds of human blood, that the blood of all persons can be classified in one of these four groups, and that the blood of everyone belonging to the same group is compatible, while agglutination always occurs when mixing the blood of persons belonging to different groups.

Blood, as everyone knows, is composed of two chief ingredients, a watery part called serum and solid floating particles called the corpuscles. When the blood of one person agglutinates the corpuscles of another it is because the serum of the one person has in it a substance which has agglutinative action on something in the corpuscles of the other person. Landsteiner found that there were two such agglutinable substances in the corpuscles. The one known as substance A is characteristic of the cells of persons belonging to Group II; the other, known as substance B is found in the corpuscles of persons belonging to Group III. Both A and B are found in the cells of persons belonging to Group IV (this is the rare group which comprises less than 5% of our population) while both A and B are entirely absent from the cells of persons belonging to Group I (which is the common group, comprising about 45% of our population).

In each case the serum of the person possesses the power of agglutinating that one of these two substances, A or B, which his cells do not contain. If this were not so we should all die, or rather, should never have been born. This is not as complicated as it sounds as will be revealed by the accompanying chart.

WHEN THE SERUM OF THIS GROUP MEETS THE RED CELLS OF THIS GROUP THERE IS	I	II	III	IV
I	—	—	—	—
II	AGGLUTINATION	—	AGGLUTINATION	—
III	AGGLUTINATION	AGGLUTINATION	—	—
IV	AGGLUTINATION	AGGLUTINATION	AGGLUTINATION	—
OF AMERICAN POPULATION THIS GROUP FORMS ABOUT	45%	35%	15%	5%

The agglutinative qualities of the blood, when once established in an individual, are permanent for life, and are as characteristic of him as the color of his hair or the lines of his fingers. As research progressed it became clear that the blood groups are hereditary, and that their inheritance follows, with perfect regularity, the law of Mendel. The hereditary units or factors are A and B, so that a person who inherited A from one parent and B from the other would have in his blood both A and B and would thus belong to Group IV.

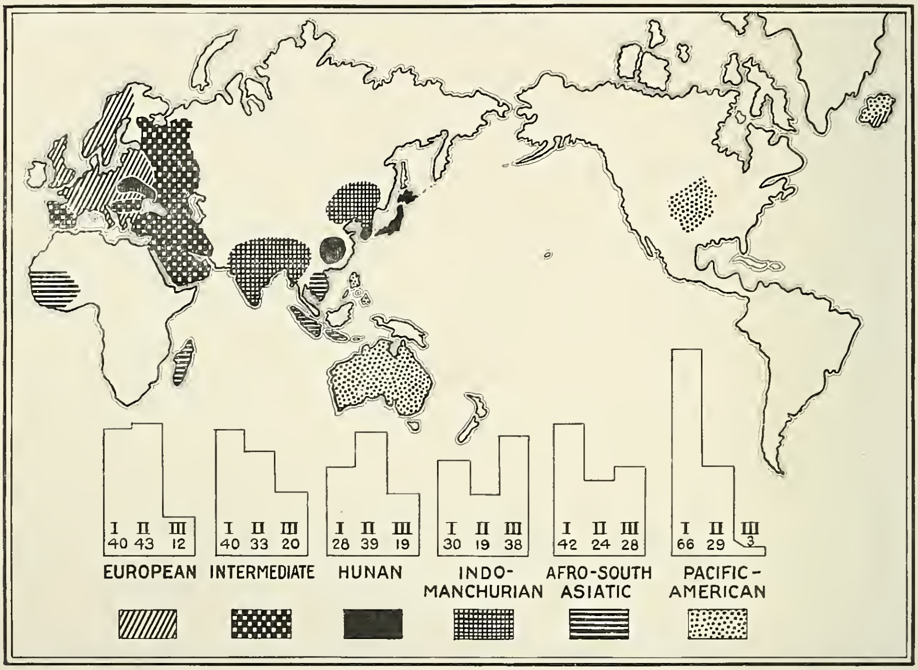
It would seem that hereditary characteristics such as these, permanent in the individual, and, moreover, easily tested, should have considerable anthropological significance. But it was not until 1918 that Ludwig Hirschfeld and his wife, Hanna Hirschfeld, working with the Swiss Red Cross in Serbia, had an opportunity which befalls few scientists. Serbia was, at that time, a melting pot of the world. Into it poured troops from all the European countries, from Africa, from Arabia, Turkey, Russia, and even from India. Hirschfeld examined and classified the blood of soldiers from all these countries, and combining his facts with some already published, was able to show that the proportions of persons of different blood groups are different for each race.

He found that, in a general way, the races from the North of Europe such as the English and the Germans, have a great excess of the Substance A (the Group II substance), while the races from Africa and Asia had far more of Substance B (the substance of Group III). The intermediate races around the Mediterranean basin he found contained about equal proportions of A and B. From this he made the deduction, which, however, is far from being accepted by all scientists, that the substance A must have originated as a mutation, which arose in prehistoric times somewhere in Europe, and that the blood Group I showing the absence of both A and B is the original blood condition of the human race, while the substance B originated in Asia, also in prehistoric times. The present distribution of A and B, which is such that some of each is present in each race, would then be accounted for by the wandering and intermingling of races which is known to have taken place.

Since the work of the Hirschfelds, a great many additional races in other parts of the world have been studied and the facts have turned out to be a great deal more complicated than Hirschfeld at first supposed. All the subsequent work has confirmed the observation of a characteristic proportion of the four groups in each race. But the theory as to the site of origin of A and B does not seem to hold, as there are races in Africa, Asia, Australia, and America which show a high proportion of A to B just as do the North Europeans.

A map of the world showing our current knowledge of the geographical distribution of the groups is appended. Six fundamental types, based on the characteristic proportions of the different blood groups have been tentatively set up. The proportions of the three more common blood groups in each of these types are shown in the diagram below the map. Group IV has been disregarded because it forms so small a proportion in all of the groups excepting one, the Hunan type. Each of these types has characteristic proportions which distinguish it clearly from the others. Thus the European type is characterized by a relatively high proportion of Group II as compared with Group III. Two of the Asiatic types, the Indo-Manchurian and the

Afro-South Asiatic, which is found on the fringes of the Indian Ocean, are characterized by the reverse, more of III than of II. The Pacific-American type, composed chiefly of the Australian aborigines and the American Indians, shows an enormous excess of Group I. The Hunan type shows less of Group I than any other types, and it shows an unusual proportion of Group IV. The Intermediate type for the most part inhabits the land lying between Europe and Asia. Its proportion of the groups is such as to really suggest an intermingling of the European and Asiatic types.



Map showing distribution of populations having different types of blood-group combinations. Graphs giving average percentages of blood groups I, II, and III in each type

It is clear, as one studies the map, that we are not in a position to give a really full explanation of the relation of blood groups to races. The picture puzzle is too incomplete. Only a small part of the population of the world has been studied. Nevertheless, the available facts point to a few striking suggestions.

Close examination of the figures brings out the existence of transition races whose proportion of the blood groups seems to indicate clearly that they were formed by the mingling of two adjacent races. For example, the Koreans show a transition between the Hunan type and their northern neighbors, the Manchurians.

Extraordinarily interesting is the fact that the Jews in each country where they have been examined do not, apparently, form a uniform Jewish group at all, but closely resemble the population of the country which they have inhabited. Thus the German Jews in Berlin are almost identical

PERCENTAGE OF THE FOUR BLOOD GROUPS IN VARIOUS LANDS

Group (according to Jansky) Red cell characteristics	I O	II A	III B	IV AB	Racial Index A/B	No. of persons tested
I. EUROPEAN TYPE						
Swedish	36.9	46.9	09.7	6.4	3.3	533
Swedish	33.5	51.0	10.0	5.5	3.5	500
Norwegians	35.6	49.8	10.3	4.6	3.6	436
English	46.4	43.4	07.2	3.0	4.5	500
French	43.2	42.6	11.2	3.0	3.2	500
Italian	47.2	38.0	11.0	3.8	2.8	500
Danish	47.3	36.7	12.0	4.0	2.5	150
Germans (in Heidelberg)	35.3	47.6	12.2	4.6	3.1	500
Germans (in Heidelberg)	40.0	43.0	14.0	3.4	2.7	1000
Germans (in Hungary)	40.8	43.5	12.6	3.1	2.9	476
Germans (in Kiel)	39.8	42.8	14.0	3.4	2.7	500
Germans (in Leipzig)	34.5	41.5	16.5	7.5	2.0	1000
German Jews (in Berlin)	42.1	41.1	11.9	4.7	2.7	230
Austrians	42.0	40.0	10.0	8.0	2.6	....
Bulgarians	38.0	41.8	15.6	4.6	2.6	500
Serbians	38.2	41.6	16.2	4.0	2.5	500
Greeks	39.0	40.6	14.2	6.2	2.5	500
II. INTERMEDIATE TYPE						
Arabians	43.6	32.4	19.0	5.0	1.5	500
Turks	36.8	38.0	18.6	6.6	1.8	500
Russians	40.7	31.2	21.8	6.3	1.3	1000
Jews[1] (Spanish)	38.8	33.0	23.2	5.0	1.3	500
III. HUNAN TYPE						
Japanese	26.8	40.9	18.4	13.9	1.69	363
South Chinese (Province of Hunan)	31.8	38.8	19.4	9.8	1.66	1296
Hungarians	31.0	38.0	18.8	12.2	1.6	1500
Roumanian Jews	26.1	38.8	19.8	15.3	1.6	211
IV. INDO-MANCHURIAN TYPE						
Ainu[2]	19.0	32.7	34.5	13.7	0.93	205
Koreans[2]	28.0	32.0	26.5	12.7	1.16	363
Manchus	26.6	20.6	38.2	8.5	0.75	199
North Chinese (Pekin)	30.0	26.0	34.0	10.	0.82	1000
Gypsies (in Hungary)	32.4	21.1	38.9	5.8	0.6	385
Hindus (Indians)	31.3	19.0	41.2	8.5	0.56	1000
Poles[2]	32.5	20.9	37.6	9.0	0.51	11488
Polish Jews[2]	33.1	17.4	41.5	8.0	0.50	818
V. AFRICAN-SOUTH ASIATIC TYPE						
Negroes (Senegal)	43.2	22.6	29.0	5.0	0.8	500
Americanized Negroes[2]	49.0	26.9	18.5	5.5	1.4	270
Madagascans	43.5	26.2	23.7	4.5	1.09	400
Sumatrans	43.7	23.0	29.0	4.3	0.82	546
Sumatra Chinese	40.2	25.0	27.6	7.2	0.92	592
Javanese	39.9	25.7	29.0	5.4	0.9	1346
Annamese	42.0	22.4	28.4	7.2	0.8	500
South Africans[2]	52.0	19.2	27.2	1.6	0.7	250
VI. PACIFIC-AMERICAN TYPE						
North American Indians	77.7	20.2	2.1		10.0	947
Australian Aborigines	57.0	38.5	3.0	1.5	8.8	204
Icelanders[2]	55.6	32.1	9.6	2.6	3.4	800
Filipinos	64.7	14.7	19.6	1.0	0.76	204

[1]Jews—"Refugees from Monastir—a people who came from Spain about 400 years ago."—Hirschfeld.
[2]These races do not exactly coincide with the type, but represent a transition to an adjacent type and have been omitted in calculating the average percentage.

with the general German population. The Spanish Jews tend to resemble the Arabs, the Roumanian Jews show a proportion of blood groups not unlike the Hungarians, and the Polish Jews show percentages strikingly like those of the other inhabitants of Poland.

In contrast to this is the fact that the Gypsies correspond to the Indo-Manchurian type in the proportion of its blood groups. This seems significant in view of the fact that the Gypsies are noted for never mixing with the population of the countries through which they wander and that they are traditionally supposed to have come from central India.

The striking resemblance of the figures of the Japanese, the Chinese in the southerly province of Hunan, and the Hungarians, is possibly accidental, since similarities of populations do not necessarily mean relationship; such similarities are bound to occur occasionally by accidental combinations.

Even more remarkable are the proportions of the Ainu—a wild primitive race living in the north of Japan and now rapidly becoming extinct. Because of their obvious physical peculiarities they have been called a "race island." They have been tentatively placed in the Indo-Manchurian type but they really do not resemble any other race. They have less of Group I than any other people.

The fact that races which resemble each other are usually geographically adjacent is perhaps the fundamental fact of greatest importance.

The direction from which a clearer understanding is likely to come is indicated by the recent discovery, again by Landsteiner, that substances A and B are found in the higher apes such as orangs and chimpanzees. Landsteiner's data show that both A and B are found in different varieties of the anthropoid apes, A predominating in some varieties, B in others. This remarkably interesting fact, while adding further proof of the close relationship between man and the anthropoids, makes it seem probable that the blood groups go back to a period when humans and anthropoids were not yet separated. This discovery of Landsteiner, of course, does not provide an explanation of the characteristics of races but simply throws the explanation further back.

The Ordeal of Getting Civilized

TROUBLES OF AN INDIAN TREADING THE WHITE MAN'S PATH

By GILBERT L. WILSON

THE old Indian was wending his way upward to his cabin, but stopped halfway up the hill. He was too far away for us to see his features, as he stood gazing earnestly into the evening shadows where they fell on the rolling Missouri; then he turned again toward his cabin.

The young reservation schoolmaster laughed.

"Old Wolf-eye," he said, "I guess he is thinking of other days. He often comes out in the evening and stands gazing at the river. He finds it hard to live like a white man, but he is making a plucky try at it."

"Making any progress?" I asked.

"More than I would make if I were an old buck like him. He's been out in twelve war parties and lifted a half dozen scalps. He walks the white man's way now—has a small trading store beside his cabin; and with a few cattle and horses, and a potato field, and corn, he manages to get out a pretty fair living."

"Does he know English?"

"No, can't speak it anyway. He attended the reservation school for a time, after he was thirty years old, and learned to figure and spell easy words, so he can keep accounts in his trading store; but he has to have an interpreter if a white man comes in. Old Wolf-eye isn't a bad fellow, honest as pure gold."

"Good qualities," I said.

"They certainly are; and Wolf-eye isn't above learning yet, if he is old. Last winter he let his squaw go down to the woods every Monday and cut the week's wood. In the evening the old buck went down with his pony and sledge and hauled the wood home. I told him that wasn't a white man's way; that our women didn't cut the wood; men did that. He was much surprised. 'Indian women always chopped wood in old times,' he said. 'I thought white women did.' The next week old Wolf-eye went to the woods with his ax, and in the evening his squaw brought down his horse and sledge. I guess Wolf-eye isn't as good an ax man as his squaw, for his load was smaller." And the schoolmaster chuckled.

I had wondered what would be the trials of an Indian getting adjusted to civilized life and it struck me that here I had a real find, a native of the old school, who could make clear to me the difficulties a barbarian must experience in treading the white man's path. I determined to seek out Wolf-eye.

The evening of the next day found me with my interpreter, Wolf-eye's nephew, in the old Indian's cabin. The sickly glow of a kerosene lamp half-lighted the room. Wolf-eye sat rather back in the shadows, but his face was toward the light and showed heavy but regular features, with full lips, wide cheek bones, and kindly eyes. He wore a calico shirt outside his overalls; on his feet were moccasins. He was smoking a long-stemmed pipe of red-stone. Evidently he was expecting us. A comb lay on the table and his hair, untinged by gray, was newly kempt. Indian-like, Wolf-eye let me begin the conversation.

"You Indians don't show your age," I began diplomatically. "I think you are older than I, but your hair is black as a raven; mine is quite gray."

His answer rather startled me.

"I wish my hair was gray. Then I would be a white man."

"But why would you want to be a white man?"

"Because then I could learn more about this world. I can speak very little English; and there are not more than 500 people to whom I can speak in my own language. What can I learn of them? I know a big war has just ended in Europe. What caused that war? I want to *know* things." The interpreter's English was broken, but I have put his words into intelligible idiom.

"But Wolf-eye," I said, "at least you can live like a white man even if you are not white."

"That is not an easy path for an Indian to walk. Indian ways are not white man's ways, and one cannot refuse to keep to the customs of his tribe. In olden days, we Indians held our foods almost in common. When one family ate, all ate. When one family starved, all were starving. We could not do otherwise. There were few families in the tribe which had not more than once been saved from starvation by food stores of others, especially in winter.

"We do not live so close to starvation now, but we find it hard to forget our old customs. A young couple, just home from the white man's school, are eager to raise wheat and build a good house. In the fall, they gather in their crops and store up potatoes, beans, and dried meat for winter. Then their relatives come to visit them, and stay until all their food stores are gone. I do not think white people do that.

"It is the same if we try to raise stock. Our agent tells us that we ought to raise hogs. My son bought a pig to raise. He built a pen for that pig, and fed it much corn; and he subscribed one dollar for an agricultural paper, to learn how to raise that pig. In the paper he read that he should let the pig out every afternoon for fresh air. So my son bought an alarm clock for two dollars, and set the alarm every day for four o'clock, so he would remember to let out his pig. The pig grew big and fat, and the bigger it grew the more corn it ate. That pig never seemed to get enough corn. In October my son butchered that pig. Then all the families of his relatives came to see that dead pig, and to every family my son gave a big piece of meat. In four days all the pig was eaten. My son says it does not pay to raise pigs."

"But this reservation has fine grazing lands," I said. "Why don't you keep milch cows?"

"We tried to keep milch cows," answered Wolf-eye, "for we liked the milk. But none of our older Indians can read or speak English. The Government has allotted us farms and tells the Indians they must live on their farms. But these farms are far apart. The 500 Indians of my small tribe are scattered for fifty miles along the Missouri River. They have no books to read, no magazines to amuse them. An Indian family becomes lonesome and goes to visit friends; maybe they cross the Missouri in a flat boat, and are gone two or three weeks. When they come home again they find their cows dry; or the cows are wild, and kick if the Indians try to milk them. Also the coyotes have stolen the Indian's chickens. One cannot keep a strong heart when things are like that."

"But your young men are educated in our schools. If they are ambitious, they can join white communities and live like white men."

"That is hard to ask of them. A young man's heart yearns for his own people. In olden times, a young man was ambitious. He was eager to be a warrior, not that he liked to fight, but if he struck an enemy, every one praised him, the girls smiled at him, and he could marry any one he wanted. White men are ambitious to make money, so that others will think well of them, and they can marry into good families. But we Indians cannot get rich on this reservation, where all our relatives visit us and eat our food. There is now nothing to make us ambitious."

"But if your young men are educated and know English, why cannot they compete with whites, and get rich as white men do?"

"That is not easily done. Our reservation schools are not good, and an Indian lad is not equipped as a white boy is equipped. Then, even if a young Indian has a strong heart, there is not much he can do on this reservation and his relatives often try to keep him back in the Indian ways."

"Cannot many of your young men find employment with white people?"

"Some of them do, but white men often refuse to employ Indians. Even if trained to some trade, an Indian raised on our reservation cannot know the thousand-and-one little things that will make him at home in white society and which are such a help to one's work."

"But white men usually treat Indians kindly, do they not?" I asked. "Americans admire the Indians. Many books are written about Indians and their customs."

Wolf-eye answered with feeling, but he spoke calmly.

"For twenty years I have tried hard to learn white men's ways. In all that time I have met but three white men who treated me like a brother, Mr. Hall, the missionary, an agency clerk, and a man who came to us from the American Museum of Natural History. We Indians are proud. It hurts our hearts when white men tell us we are greasy and dirty. We do not like to have them say, 'You are just like dogs!' We Indians know very well how we now live, and that our old customs do not fit into the life our young people must learn to live. In old days, every young man went each morning for a bath in the Missouri; in winter he cut a hole in the ice, and after his bath, rubbed himself with white clay. We lived then in Like-a-fishhook Village, right on the river. Now our families are, many of them, two or three miles from the river, and we have no baths in our cabins.

"Our clothes are not neat and clean, like white men's clothes. In olden days, we dressed in skins, which we could clean with white clay. Now our clothes are of cloth, and we do not know how to care for them. Many of our women own washtubs, and know how to use soap; but it is hard for them to heat water in our cold winters. Our cabins are small; our women cannot take their tubs out of doors in the biting wind, when the ice is four feet thick on the Missouri; and if they wash the clothes in the cabin, the air gets full of steam while the water that splashes on the floor freezes. Then the door is opened to let out the steam and the room gets cold; so we build a hot fire in the stove, until we have to open the door again, to cool the cabin. Our children thus catch cold, and have lung sickness."

"But you have more to eat now than

you had when you lived by hunting, have you not?" I asked.

"Yes, but we do not know how to prepare many of our new foods. In old days, when a buffalo was killed, our women knew how to cook every part. But our women cannot make things like rice, potatoes, wheat, and oats, into good-tasting foods. And this I think very bad for sick people. An Indian woman's baby gets sick. The reservation doctor is maybe thirty miles away. That Indian woman gets scared. She does not know what to do. She remembers that when she feels tired, she drinks coffee, and it makes her feel good. So she makes a big pot of coffee, and gives it to that baby. Maybe that is why so many babies die on this reservation."

"Did they not die so in olden times?" I asked.

"Not so many died. In winter we lived in earthlodges, down in the timber, out of the cold prairie winds. The fire did not warm the lodge much, but we had warm robes and plenty of fresh air came down through the smoke-hole. We did not sicken and die then."

"But you have many things, now, that you did not have then. Do you not live more comfortably?"

"In many ways, yes. We have iron axes, and iron hoes and guns. In my grandfather's lifetime we had few horses; and when we made long marches over the prairie, our baggage was borne on the backs of women, or on travois dragged by dogs. Old people suffered very much on these marches; if they fell sick, we sometimes had to leave them to die on the prairie. Horses have made traveling easier for our tribe.

"Iron axes make thé work of our women easier. When I was a boy, we still lived in earthlodges, which our women built. My grandfather told me that it was hard to cut posts with stone axes, and split puncheons with horn wedges. Our iron hoes are better than our hoes of bone; and we can cultivate more corn now that we have plows.

"But I am not sure that gunpowder has been a blessing. For a time that made it easier to hunt game, but the buffalo herds were soon killed off. Then, in olden days, when we fought with arrows, not so many men were killed. After the Sioux got guns, they could come opposite our village, and shoot across the Missouri at our women as they went down to get water. The Sioux could not have done that with arrows."

"I am sure horses are useful to the Indians," I said, "and you have other live stock, also."

"Yes, we have cattle; some families raise pigs, and not a few have chickens. But we have other live things from white people that we do not like. We have rats and a new kind of mice. We did have lice in old times, but we never had flat bugs that now get into our beds.

"We knew what fleas were. When a hunter killed a kit fox and fetched it home, he always found himself covered with fleas that came out of the pelt. But he put a robe over him and smoked some sage under it, and all the fleas were killed or driven off. When we first got white men's fleas, we thought they were like kit fox fleas; but we soon found they were not. 'Kit fox fleas hardly bite us,' our old men said. 'But these new fleas are different. They have big teeth.' Some summers our cabins are just overrun with fleas. If a family is away for two or three weeks, they hardly dare enter their cabin. Sometimes a man rolls up his trousers and smears oil over his legs before he will enter: the fleas die if they hop up on the oil that is on his legs."

"But I hear that the Indians are having better health now that they send more often for the reservation doctor when they are sick."

"That is true. I think he understands many white men's diseases better than our medicine men do. Then, too, he tells us that in the white man's road we are now trying to travel, there are many things that make us have diseases, that we did not know in our old life. He says we will get lung sickness if our cabins are not clean. My wife sweeps my cabin every day and I whitewash the outside and the inside twice a year. If my child takes sick, I send for the reservation doctor right away. But my father was a medicine man who said sickness comes from evil spirits. If the doctor does not come at once to my sick child, I sometimes sing one of my father's sacred medicine songs. I cannot always wait till the doctor comes. Once a man from a museum wanted to buy my father's medicines. I was afraid to sell them, because I knew the wonderful things those medicines had done. I worship the one, true God now, and I know it is wrong to worship my father's medicines, and I never do worship them. Still, I know the magic cures they have done, and I was afraid to sell them to the museum until one night I had a dream from my father's spirit that they would be put into a big house built of stone, in New York, where they would rest forever and white people could see them. I thought, too, that it was perhaps best to sell them away from the reservation. I am a Christian now and if those medicines are in New York the spirits that may be in them will not get angry at me because I do not worship them. It is very hard for me to be a Christian because I cannot read the Bible much in English, and so I cannot know all of God's commandments. Then, too, I see Christians do things which the missionary tells me are wrong when I do them. I do not understand it!"

"Your children will understand better, perhaps. They are learning the Christian way in the mission schools."

"It is true; but they are learning many things that I cannot believe. The missionary teacher tells my son that the earth is round like a ball. That seems foolish to me. I have stood on the top of one of the Rocky Mountains, and the earth looked flat, just as it does here on the prairie. The teacher also says it is wicked to make war, and our Indian warriors did wrong in old days when they went out to fight other tribes. Why then do white men make war? In that big war in Europe, the Government took many young Indians from this reservation to be soldiers, to fight the Germans. Why don't white men leave off making war?"

And come to think about it, why *do* white men make war?

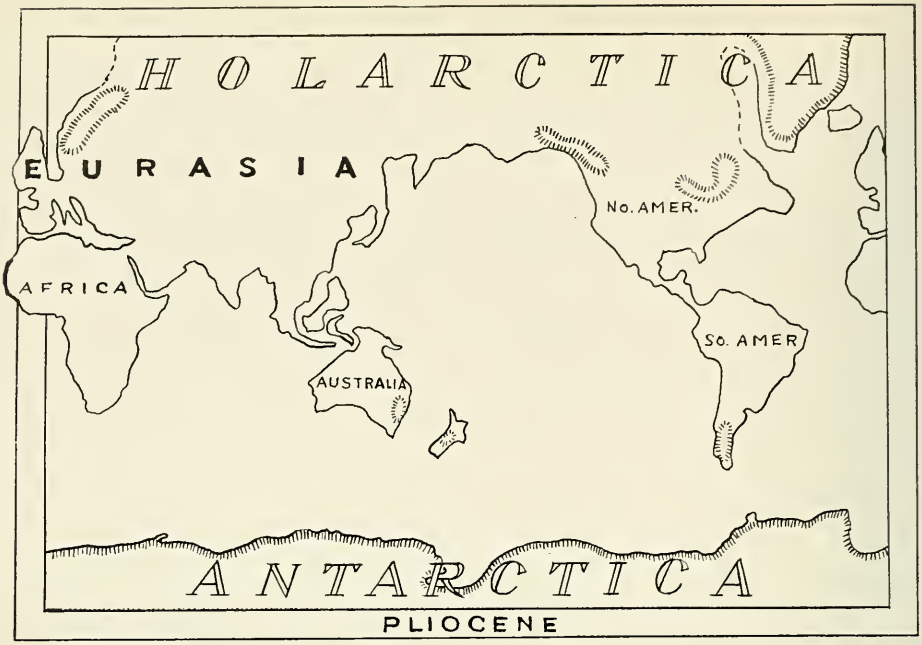


Fig. 1. Map of the hypothetical Eurasian-American continent during the Pliocene

The Ethnological Problems of Bering Sea

By WALDEMAR JOCHELSON

THE ethnological problems of Bering Sea are not geographically limited to that region. They embrace areas much farther to the west, east, and south. It is the aim in this paper to review briefly the question of the Asiatic origins of the American aborigines, but as the title of this paper indicates, the author believes the original migrations from Asia to America took place in the region of Bering Sea. This does not take into account the wanderings on a smaller scale which have taken place in more recent times. Asia is now separated from the American continent by a strip of water sixty miles wide with several small inhabited islands situated in the middle. The Eskimo who live on both shores of the Seward and Chukchee peninsulas at the present time frequently move from one continent to the other. In Asia, on the northern shores of the Arctic Sea, there is evidence in the names that villages now occupied by the Chukchee were formerly in the possession of Eskimo.

In discussing the original peopling of America from Asia, which is no longer a mere unsupported hypothesis but a theory founded on facts, it is necessary to take into consideration the aspects presented by the physical appearance of the peoples, the ethnological and linguistic relationships, and geological conditions.

First we need to consider in what geological period the peopling of America might have taken place. To answer the question, attention must be turned to the land connections existing in prehistoric times before, during, and after the glaciations.

There is proof of a former land connection between the Seward and Chukchee peninsulas in the similarity of the rock structure on the two sides of Bering Strait.

The map (Fig. 1) as rearranged by Professor Henry Fairfield Osborn,[1] America in the middle of the Pleistocene, and the reindeer, elk, musk-ox, bison, mountain sheep, and black bear appeared in America toward the end of that period.

Now all of these mammals, including the mammoth, were hunted by man in Asia, as is shown by numerous archaeological proofs.[3] We may be sure man

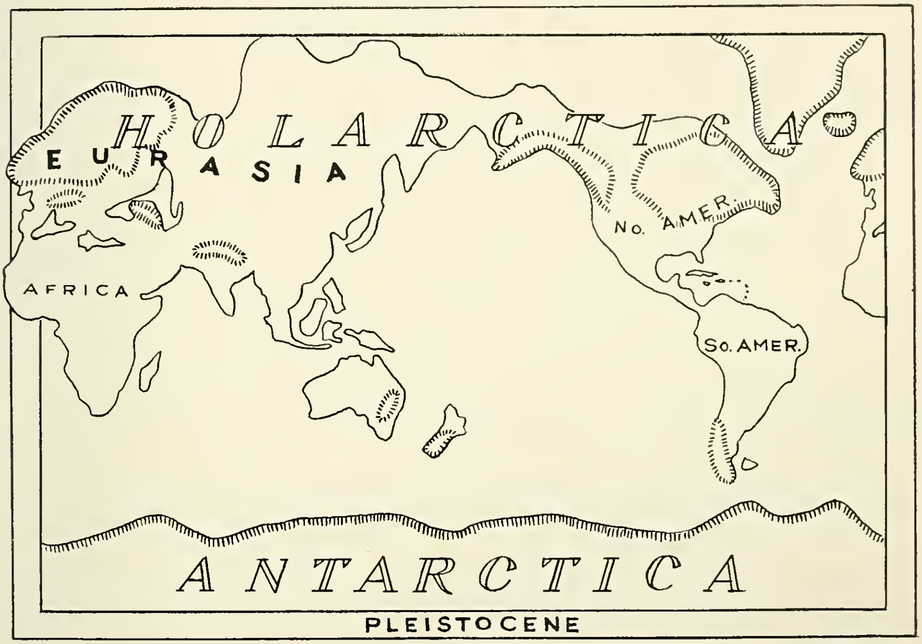


Fig. 2. Map showing the connection which it is assumed existed between Eurasia and North America in the Pleistocene

after Dr. W. D. Matthew, shows Holarctica as it may have been during middle and upper Pliocene. At that time North America and Eurasia are supposed to have formed one continent favoring a wide dispersal of mammals. The second map from the same source[2] shows a hypothetical land bridge between the Old and New worlds in the Pleistocene period, which bridge facilitated migrations at that time. The mammoth crossed to followed his prey in their wanderings to America over the vast continental plateau which probably occupied what is now Bering Sea, Bering Strait, and a part of the Arctic Sea. The Holocene, or Recent Times, was a period of continental depression, and Asia and North America became completely separated, preventing further intermigration of land mammals.

[1]Osborn, Henry Fairfield, *The Age of Mammals in Europe, Asia and North America*, New York, 1919, p. 303.
[2]Ibid, p. 373.

[3]See Dr. Vishnievski's chapter on "Fossil Man in Russia" appended to the Russian translation of Prof. Osborn's work *Men of the Old Stone Age*. Leningrad, 1924. Also Prof. B. E. Petri's *The Siberian Paleolith, Irkutsk, 1923; The Far Past of the Buryat Country, Irkutsk 1922; The Neolithic Colony in Pestehanaya Bay of the Baikal Sea, Irkutsk, 1921.* (All in Russian)

Soundings made by G. M. Dawson[1] in Bering Sea revealed a shallow marine plateau beginning just north of the Unimak Pass and running northwestward to the vicinity of Cape Navarin in Siberia. This he sees as the remains of a wide terrestial plain which formerly connected North America with Asia and persisted during a long period of geological time. (See Map 3)[2]

Without attempting to determine the time, Professor Boas in a general way put forward the theory of a migration back and forth between Asia and North America, basing his conclusions on the results of the investigations carried on by the members of the Jesup North Pacific Expedition.[3] The races situated on the two sides of the Pacific Ocean show a tendency to depart from the Mongol-Asiatic type.

He suggested that the race living in America was cut off from its congeners in the Old World and forced to migrate southward by the spread of the last ice cap. At the end of that glaciation, as the ice retreated in both North America and Asia, communication between the two continents again became possible, while Europe was cut off by the wide expanse of the Atlantic Ocean. Members of the American race moved back toward the north, crossed to Asiatic soil, and occupied the northeastern part of Siberia. I have called these Siberian tribes who have remigrated from America to Asia, Americanoids.[4] We shall find a corroborative parallel in the history of the distribution of certain Asiatic zoölogical species.

The Russian zoölogists Severtzoff and Nassonov,[5] after studying the distribution and structure of the wild sheep, have both come to the conclusion that this genus migrated from high Asia to America before the last glaciation; that in America they were driven south by the glaciation; that afterward the American stock spread again to the north, giving origin to another group, and finally that this new group spread back into the Asian continent and occupied eastern Siberia. The result is that the present Siberian sheep do not stand geographically and structurally in close relation with the sheep of high Asia.

Notwithstanding the differentiation of human types which occurred in America during and after the glaciation, by reason of isolation, the Indians present a fairly homogeneous aspect and exhibit a certain number of characteristics which they have in common with the Americanoid tribes of Siberia, and by which the latter differ from the Mongoloids of Asia.

First we may consider the skin color. Field anthropologists well know how difficult it is to determine the various shades by means of a scale. The existing tables of nuances do not help, but one can readily distinguish the fundamental racial pigment. The yellow of the Mongoloid, ranging from a light lemon-yellow tint to a dark or dirty yellow, is easily distinguished from the reddish-brown tints of the American Indians and the Americanoid Siberians, particularly the Koryak and Chukchee, the purest blooded of them. In many instances I had occasion to compare with these two the bluish-milky-white or rosy-white pigment of the skin of northern Europeans.

[1]Dawson, G. M. Geological Notes on some of the Coasts and Islands of Bering Sea and Vicinity (*Bull. Geol. Soc. Amer.* Vol. 5, 1894, p. 117).

[2]To the southwest of this line the sea-bottom reaches a depth of more than 3000 fathoms.

[3]Boas, Franz, Ethnological Problems in Canada (*The Journal of the Royal Anthrop. Institute of Great Britain and Ireland*, Vol. XL, 1910, p. 537); Idem. The History of the American Race (*Annals N. Y. Acad. Sci.*, Vol. XXI, pp. 177–183, 20 March, 1912).

[4]See Jochelson W. *Archaeological Investigations in the Aleutian Islands*. Published by the Carnegie Institution of Washington, 1925, p. 7.

[5]See Sushkin P. P. Outlines of the History of the Fauna of the Palearctic Asia (*Science*, May 15, 1925).

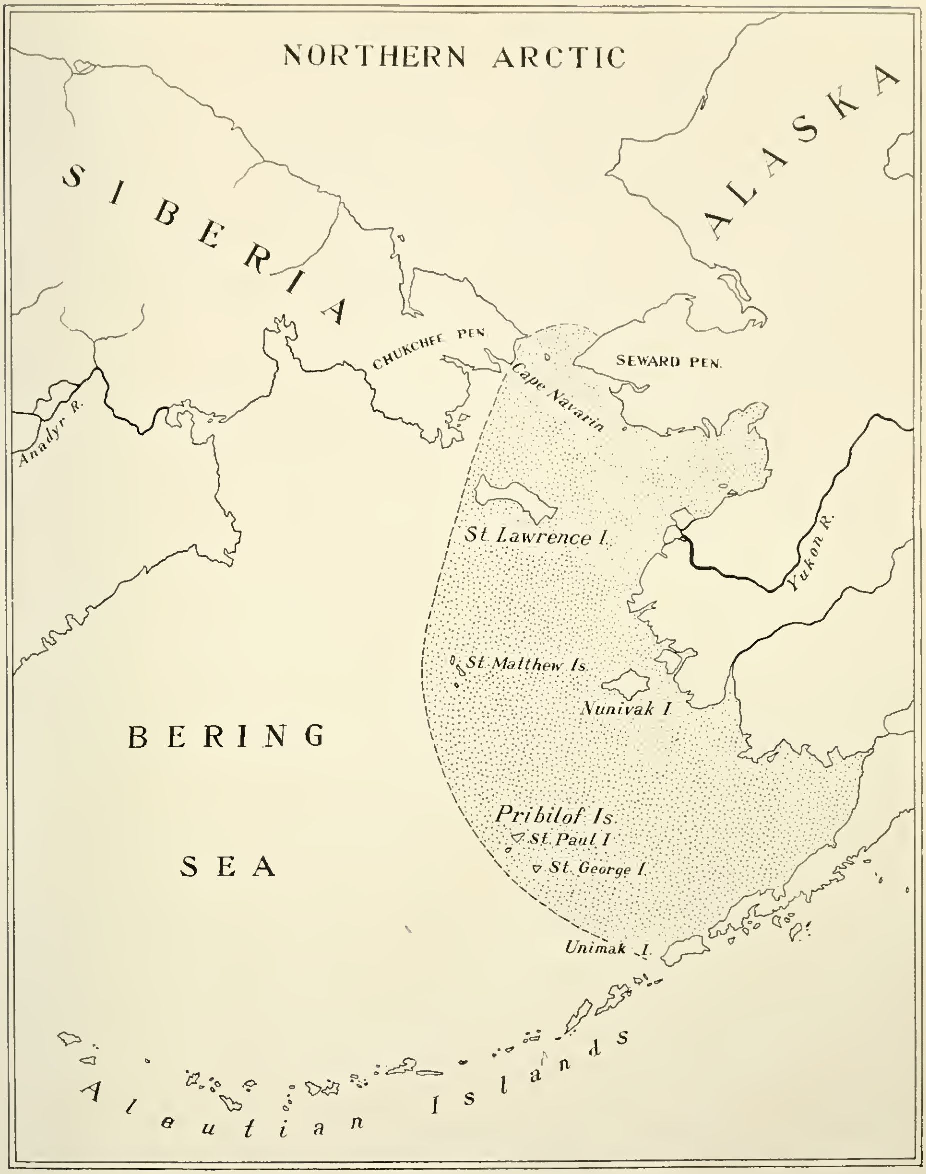


Fig. 3. Map of Recent Times showing no land connection between Asia and America

The head index of the Chukchee and Koryak is identical with that of the Indians of Northwestern America. The nose of these groups is not so broad and flat as that of the Mongoloids. The Mongoloid eye with its epicanthic fold is rare among them. The lips are moderately full and the cheek bones are less prominent than in the Mongoloids.

There are also certain cultural traits common to America and Eastern Siberia. Some of the most prominent characteristics of certain American languages are also found among the Americanoids of Siberia. There is also much that is common in their folklore, particularly tales about the mythical Raven, which indicates a common origin for their mythologies.

There are, however, certain things in the social structure and material culture of both groups which differ, and which must be explained in one way or another.

The looseness of the social structure of the Siberian Americanoids as compared with the class systems of the Northwestern Indians may be explained by the supposition that the social structure of the Northwestern Indians is a later growth.

The reindeer-breeding practised by some divisions of the Koryak and Chukchee, a specific Asiatic cultural achievement, was either acquired from the Siberian Tungus, or Samoyed-Finnic tribes or was achieved by imitating their domestication of wild reindeer. The skin-boat and sea-hunting of the maritime Koryak and Chukchee is taken from the Eskimo culture. The Kamchadal, although geographically the farthest from the Northwestern Indians, are culturally the nearest to them. They have no reindeer, no skin-boats, and represent a genuine coast or river-fishing tribe. In one direction the material culture of the ancient Kamchadal differed from that of the Northwestern Indians. The latter had no pottery, while my excavations on the Kamchatka Peninsula brought to light a peculiar kind of pottery adopted from the ancient inhabitants of Japan, the Ainu.

I stated in the early part of this article my belief that the so-called Americanoid Siberians are Indians who returned to Asia after the ice cap in Siberia and North America subsided. We may assume that this occurred at the beginning of Recent Time. But at what time did the original peopling of America from Asia take place? Certain writers, among them Holmes, Hrdlička, and Kroeber, are inclined to refer this to the end of the Pleistocene or even the beginning of Recent Time, that is, about 10,000 years ago. To this contention certain others are opposed.

Explicit objections have been raised by Dr. Pliny E. Goddard.

Linguistic evidence has been in existence for nearly a century, which makes the peopling of America in recent times improbable. Such diversity of languages as appears in America calls for many milleniums. Time has to be allowed for man to reach Patagonia where he appears to have been contemporary with an extinct ground sloth. Long after man reached America, maize was domesticated, together with many other native American plants, and only after that the great civilizations of Peru, Yucatan, and Mexico Valley grew up. In addition to these arguments for a longer period of time during which American culture may be supposed to have developed, we must consider a recent find which makes it certain that man was in America during Pleistocene times: Flints have been taken by skilled museum workers from under a completely fossilized skeleton of an extinct species of bison lying in an undisturbed Pleistocene formation in Texas.

These main arguments of Doctor Goddard's, which do not differ particularly from those put forward by Professor Boas many years ago, I have cited in order to show the differences of opinion concerning the time of the migrations. We may, of course, assume that there was more than one wave of migration. These important prehistoric considerations do not interfere with our theory of the ultimate remigration of certain groups of American Indians to Siberia. However, the question is at the present time far from a final solution. We cannot say that we know all the nooks and corners of the problem. But more difficult still is the Eskimo problem.

The Eskimo, with the exception of some small groups on the Chukchee peninsula, live in Arctic America and, together with the Indians, they form the native population of America, which at some undetermined period migrated from Asia. The Eskimo at present separate the Indians from the Siberian Americanoids. The culture of the Eskimo forms a unit and the same is true of their speech. All Eskimo dialects form one language, including the Aleut and Kodiak dialects. Somatologically they show certain diversity in their cephalic indices. While the eastern divisions are dolichocephals the western ones have a brachycephalic and even a hyperbrachycephalic head index. The facial bones of all divisions, however, show Mongolic dimensions. Even among the Aleut, who were much mixed with Russians, I met striking Mongoloid faces with a yellow skin color of a darker tint. Somatologically we must separate the Eskimo from the Indians and from Siberian Americanoids. But at what period the Eskimo migrated to America, whether earlier than the Indians or later, whether at one time or by waves—these questions must remain unanswered at least for the present. It seems to be certain, however, that occupying the northern part of North America after the last glaciation, some division of the Eskimo moved toward the southwest, thus separating the Siberian Americanoids from the Northwestern Indians kindred to them.

Doublers used in twisting two-or more ply yarns were made of Chonta palm, and had a carving in relief at either end. They are about 12″ long

EXAMPLE OF PREHISTORIC PERUVIAN WOOD CARVING

Wood Carving in Ancient Peru

BY CHARLES W. MEAD
Honorary Curator of Peruvian Archæology

THE old Peruvians, who excelled in ceramics, textiles, metallurgy, and architecture, did not, as a rule, carry wood carving to a very high state of development. This could hardly be expected of a people living where sandy deserts form so large a part of the coast region of Peru. Wood was scarce, and what little the inhabitants did have was brought from a considerable distance. The conditions in these deserts were most favorable for the preservation of wooden objects, yet few specimens of wood have been recovered in excavations.

The objects of wood comprise masks, handles of battle axes, ceremonial wands, and the doublers used in

The carvings represented a man or some animal, and formed shoulders which prevented the yarn from slipping off the stick making yarn. The implements used in weaving, and spoons are the most commonly encountered. Such specimens show the same artistic feeling, if less technical skill, that is found in the textiles, pottery, and metal work of ancient Peru.

The best specimen of old Peruvian wood carving in the Museum's collection was excavated by A. F. Bandelier, at Pachacamac, in 1894. It is 4½ inches high, and represents some high potentate, or perhaps a god, about to decapitate a man. In his right hand he holds a hafted stone ax. His left hand grasps the prostrate victim by the hair of his head. The victim's arms are tied behind his back. On the back is carved a man with headdress. He also holds a hafted ax in his right hand. The specimen is much defaced by the work of borers.

Right side.—The object is hollow, and it is very possible that it was carried on a stick in some ceremonial. Some hollow metal objects were so carried

Left side.—The depressions representing the eyes and mouth were doubtless once filled with nacre, as were also the circular depressions

Rudolf Martin
1864-1925

Recollections of Professor Martin as a Teacher

By DINA JOCHELSON

THE CLASSICAL and monumental work of Professor Martin, *Lehrbuch für Anthropologie* has furnished the very foundation for anthropological instruction particularly relating to anthropometric technique. I leave to others the preparation of memorial notes expressing appreciation of the deceased as the scholar ranking with Broca, Ranke, and other great anthropologists. It is my wish to say a few words about Professor Martin as a teacher.

I was a candidate for a degree in medicine in the University of Zurich in 1900 when I was notified that I was to take part in the Siberian Division of the Jesup North Pacific Expedition. The leader of this Division was my husband, Waldemar Jochelson, and I was expected to take over the anthropometric work in Siberia. In order to prepare myself for this field work I registered for the regular courses in anthropology given by Professor Martin, and also for the laboratory work in the anthropological institute of the University of Zurich, which had been created by Professor Martin. Subsequently, in 1903, my dissertation for the degree of M. D. was also an anthropological one and was prepared under the direction of Professor Martin.

Professor Martin's courses were required for students in the natural sciences but not for medical students. His lectures, however, attracted students from various faculties, historians, geologists, and others. It is well known that people ordinarily prefer to study foreign lands rather than their own country. So it is with anthropology, the science of man is often found less interesting than the knowledge of other zoölogical divisions. Professor Martin, however, had the secret of winning large audiences to hear about man. His lecture room was always filled to its utmost capacity, and he never inquired whether his hearers were entitled to admission or not. He was interested rather in the diffusion of knowledge than in fees. He was rewarded for his disinterested devotion to science by the interest with which his hearers followed his lectures. His friendly personality and graceful appearance were in themselves attractions, and his clear voice, and fluent, eloquent, High German speech animated the dry bones of human anatomy even as a mountain brook flowing down bare Alpine rocks would add life and interest to a landscape. For example, no one could be more strongly scientific and at the same time more clear and popular in his presentation of the Darwinian theory and its bearing on the history of man's origin.

When Professor Martin learned that I was going to undertake field work, he gave me special instruction in addition to his regular lectures and the laboratory hours.

I shall always remember his yearly receptions at his villa near Zurich, where his anthropological students were invited to join his family circle. General unrestrained conversation was followed by scientific discussions. Professor Martin at that time was working on his handbook, and among his students were the now prominent anthropologists: J. Czekanowski of the University of Lwow, and D. Schlaginhaufen of the University of Zurich.

Professor Martin was as great a scholar and teacher as he was a man. The last two years of his life he experienced constant physical suffering; nevertheless, he continued his lectures, and in his last months, when he was confined to his bed by heart disease, he wrote reviews and edited his anthropological journal. He remained at his post until his last breath, and in him science lost one of its greatest soldiers.

A Biographical Sketch

By CHAS B. DAVENPORT

ANTHROPOLOGY has suffered a grievous loss in the death of Professor Rudolf Martin at München on the 11th of July last. There may have been greater anthropologists; but it was he who organized the *science* of physical anthropology.

Rudolf Martin was born July 1, 1864, at Zurich, the only son of a manufacturer. He studied at the universities of Freiburg i. Br. and Leipzig, receiving the degree of Ph.D. at the latter university, submitting a thesis on Kant. Probably under the stimulus of Wiedersheim and Weismann also he became interested in natural science and became docent in anthropology at Zürich in 1891. Here he laid the foundations of his life work. In 1899 he became ausserordentlich professor and in 1905 full professor. He early undertook journeys to see for himself the centers of anthropological research on the one hand, and primitive peoples on the other. He traveled in France, England, and Spain. He journeyed to Patagonia and published on the physical anthropology of the natives (1893) and on ancient Patagonian skulls (1896). He journeyed to the Malay Archipelago, also, and there studied the Semang and Sakai (or Enoit) on which he published in 1905. These experiences in the field acquainted him with certain defects in the available anthropometric apparatus and led him to the invention of a set of instruments for which he found a skillful manufacturer in P. Herrmann of Zurich. In 1911 he relinquished his chair in Zurich, partly for reasons of health and especially to devote himself to the publication of his *Lehrbuch*. At the outbreak of the war he had to leave Paris hurriedly, where he had done most of his literary work. Shortly thereafter he sent his book to the publisher, whence it appeared in 1914.

In 1917, after the death of Ranke, Martin was called to München as professor of anthropology. He united the anthropological institute and the anthropological, prehistoric collections of the city, and raised both to a preëminent position. He undertook an extensive investigation of the effects of war and its aftermath upon child development, measuring and photographing thousands of school children. Recently he became interested in the bodily form of athletes and the possibilities of physical development in students of secondary and higher grades of the educational system.

Rudolf Martin was a man of quiet mien with a capacity for ceaseless work. Literally to the day of his death, while kept from excruciating pain only by narcotics, he dictated letters, revised theses, wrote up his researches, and revised his book. With this industry was a love of order and detail. Thus, in 1907 he published a system of physical-anthropological bibliography (following a decennial classification), incited thereto by his friend, Dr. H H. Field of the Concilium Bibliographicum. This industry and love of detail were combined with erudition and breadth of view; and this combination made possible his epoch-making *Lehrbuch der Anthropologie*, a treatise of 1200 pages, with 460 figures and including a bibliography of 100 pages and a very large number of tables. In this book the compilation of a single table often involved the review of scores of authors. Finally, in his last years he founded the *Anthropologische Anzeiger* and personally collected titles and news for this quarterly.

Martin's organizing ability is shown not only by his book but also by his Institute, which became perhaps the greatest in the world, and by the city-wide scope of his anthropometrical investigations. Martin's ingenuity is revealed by the instruments that he invented, and his quality as a teacher by the number of his students, by their varied published researches, and by the loyalty which they yielded to him, as was especially shown on his sixtieth birthday. To help in instruction, he prepared, while at Zurich, a set of twenty-four wall charts in anthropology, ethnology, and geography.

The breadth of Martin's interest was very great and made him a delightful companion. That he was a student of Kant has been told; in describing his travels he considered zoölogical and geological questions, as well as anthropological. In his treatment of the Senoi he traces their history and relationships, and shows them to be one of the most primitive of peoples. He was a connoisseur and collector of art, a lover of music and of nature.

Martin's place in anthropology will probably be recognized in the future as this: the contributor of an account of the anthropology of two primitive peoples, and student of the development of children and of athletes; the organizer of instruction and perfector of anthropometric instruments; and the founder of a new era by the publication of the greatest compendium of the science of physical anthropology that has ever been produced. Doubtless just this love of organization and completeness interfered with the conduct of numerous, original researches of a fundamental sort. In a way he sacrified much of the fame that comes through a great contribution of original work in order to organize a science that stood badly in need of organization.

Alanson B. Skinner

1886-1925

ALANSON B SKINNER, formerly assistant curator in the department of anthropology at the American Museum, was accidentally killed in North Dakota August 17, 1925. At the time of his death Mr. Skinner was connected with the Museum of the American Indian, Heye Foundation, and was engaged in ethnological studies among the surviving Dakota tribes. He was an energetic field worker, carrying on researches both in ethnology and archæology, a very successful lecturer on the American Indian, and the author of numerous scientific papers.

Mr. Skinner was born in Buffalo September 7, 1886. His first scientific work was as a helper to Mr. M. R. Harrington, then engaged in local archæological work for this Museum, when Professor Frederic Ward Putnam was still the head curator in anthropology. Subsequently, Mr. Skinner, a boy in his teens, made a careful archæological survey of Staten Island, his home, excavating many important sites. It was in fact the thorough exhaustive study of this definite island unit that laid the foundation for his mastery of eastern archæology. He loved the out-of-doors and was especially successful in making contacts with the Indians. He believed, and rightly, that the study of archæology necessitated also an understanding of the living Indians, and in consequence, he acquired the field technique of the ethnologist.

Because of his intimate knowledge of local problems, he was brought into the department in 1907, and immediately entered upon a productive career. His first important field trip for the Museum was to James Bay, Canada, where he made collections among the Eastern Cree Indians. This was followed by a second trip to James Bay to study the Saulteaux Indians. Following this, in rapid succession, were studies of the Menomini, Ojibway, Oneida, Winnebago, Eastern Dakota, Bungi, and Plains-Cree. Perhaps the most serious undertaking was crossing the Everglades to collect among the Seminole in 1910. In addition to these major trips, there were brief archæological excursions in Pennsylvania, New Jersey, and New York State, and particular mention should be made of excavations on the Abbott Farm at Trenton, New Jersey.

Mr. Skinner resigned his position as assistant curator in 1916 and joined the staff of the Museum of the American Indian, Heye Foundation. He was at the Milwaukee Public Museum from 1920 until 1924, when he returned to the Museum of the American Indian.

Mr. Skinner was not only a genius in exploration, but an energetic investigator, as his list of published papers will show:

BIBLIOGRAPHY

The Indians of Greater New York and the Lower Hudson.
Notes on the Eastern Cree and Northern Saulteaux.
Political Organization, Cults, and Ceremonies of the Plains-Ojibway and Plains-Cree Indians.
Societies of the Iowa, Kansa, and Ponca Indians.
Social Life, Ceremonies and Folklore of the Menomini Indians.
The Sun Dance of the Plains-Cree.
The Sun Dance of the Plains-Ojibway.
Notes on the Sun dance of the Sisseton Dakota.

All these were completed before Mr. Skinner left the Museum in 1915, since which date many other papers were published, including the following:

Explorathon of Aboriginal Sites at Throgs Neck and Clasons Point, New York City.
Material Culture of the Menomini.
Medicine Ceremony of the Menomini, Iowa and Wapeton.
Notes on Iroquois Archæology.
Notes on the Bribri of Costa Rica.
The Pre-Iroquoian Algonkian Indians of Central and Western New York.

A complete list will be found in *Indian Notes* Volume II, Number 4, October, 1925, published by the Museum of the American Indian, Heye Foundation. With his untimely death, these contributions came to an end, marking the premature close of a notable career.

NOTES

EXTINCT ANIMALS

Forthcoming Memoir on the Mastodon and Elephant Family.—Professor Osborn's eighteen years of exploration and research on the Proboscidea, beginning with a visit in 1907 to the North African home of the Order, is culminating with the completion of his manuscript of a Memoir to be entitled *The Evolution of the Proboscidea* and to be published as a separate volume from the American Museum press during the coming year. This Memoir has been prepared with the aid of the J. Pierpont Morgan Fund and the Morris K. Jesup Fund.

The subject will be divided into twenty-four chapters beginning with Chapter I, "The Origin and Classification of the Proboscidea, Mastodonts and Elephants," and concluding with Chapter XXIV, "Bibliography of the Proboscidea." The manuscript covers 785 pages and includes altogether 269,000 words, which will rise to over 300,000 in the supplementary chapters and bibliography. There are upwards of 500 illustrations, mostly to be printed in the text. These illustrations include facsimile reproductions of every type figure, so far as available, of the three hundred or more species described since Linnæus named *Elephas indicus* in 1754. The reproduction of these type figures, gathered often from very rare sources and represented by only one or two copies in all the American libraries combined, is an extremely important part of the work in its bearing upon the future study of the Proboscidea, especially in this country where so few libraries contain the older classics of palæontology. This monumental work has been greatly aided from the beginning by the coöperation of all the leading palæontologists of the world who have access to original proboscidean fossils and to the more or less imperfectly described collections in the museums of the world. Among these coworkers in this great undertaking who have expressed a very lively interest in the forthcoming Memoir is Dr. W. O. Dietrich of the Geological and Palæontological Institute of Berlin, who writes as follows (3 October, 1925):

> Mit verbindlichsten Dank bestätige ich den Empfang Ihrer ausgezeichneten Synopsis fossiler Proboscidier welche mein lebhaftestes Interesse erregt. In allen Punkten kann ich freilich nicht zustimmen.

Dr. Lucien Mayet of the University of Lyon also writes (9 November, 1925):

Cette question, si considérable, des Mastodontes est encore bien complexe et bien incertaine. Aussi attendons nous impatiemment qu'avec votre admirable génie synthétique vous lui donniez clarté et précision. Ce sera une nouveau et grand service que vous aurez rendu à la science paléontologique.

These encouraging letters of appreciation are enjoyed not only by the author but by the many able and willing assistants in the Museum who have rendered invaluable aid in the preparation of the manuscript and illustrations, especially Miss Mable R. Percy and Mrs. Lindsey M. Sterling. These letters will also encourage our printing department in the great task of getting this Memoir into bound form.

HISTORY OF THE EARTH

Dr. C. A. Reeds represented the American Museum at the annual meeting of the American Association for the Advancement of Science at Kansas City, December 28–January 2, where he read a paper on "New York City as a Field for Earthquake Study."

Doctor Matthew recently lectured at Cleveland before the Natural History Society and three other audiences on "The Succession of Life through the Ages," an outline of the history of life on earth as shown by the fossil record.

LOWER INVERTEBRATES

During the month of July, Curator Miner, coöperating with Research Associate Frank J. Myers and assisted by Dr. G. H. Childs, artist, visited the Mount Desert Island biological laboratory to complete the field studies on rotifers and associated pond life in connection with the Rotifer Group, now in an advanced state of preparation. Many forms of minute pond life, including the associated water plants, were studied, and about one hundred water-color sketches were secured. Mr. Myers also advanced another stage on a new section of the monograph on North American Rotifers which he is completing in collaboration with Dr. H. K. Harring of the United States National Museum.

MAMMALS

Mr. Harvey S. Ladew left New York City on January 7 for an expedition to Bolivia and adjacent parts of South America. He took with him Mr. G. H. H. Tate, an assistant in the department of mammalogy, and has generously volunteered to pay all of Mr. Tate's traveling expenses as well as the costs of equipping the expedition, in order that the Museum may secure collections of mammals and birds from the regions he visits. Mr. Ladew plans to be gone three or four months, and the exact details of his itinerary will be arranged after his arrival in Bolivia, when he can acquaint himself with local conditions. The immediate objective is a large plantation situated on the Amazonian slopes of the Andes, near Mt. Sarata, in Bolivia. Working out from this Hacienda, Mr. Ladew and Mr. Tate will cover some of the mountain plateaus, making such short trips as promise the best results. Eventually the party will leave Bolivia either by descending one of the tributaries of the Amazon or by working southward and coming out through Argentina and Paraguay.

This is Mr. Ladew's first visit to South America, but he is not a novice in exploration, having been on long trips in the Old World. It is fortunate for the Museum that Mr. Ladew's interest in science leads him to wish to do more than the average tour in South America, and his desire to have a Museum man accompany him will undoubtedly result in valuable additions to our collections.

Collection from Southern Africa.—A recent letter from Mr. Lang, who remained in Africa at the close of the Vernay-Angola Expedition, reports that he has been very successful in his reconnaissance in Southern Africa. He states that he has shipped to the Museum considerable collections made at Luderitz Bay and elsewhere. He has found it necessary to request an additional two months' leave of absence in order to cover the itinerary he has planned.

The American Society of Mammalogists will hold its Eighth Annual Meeting in the American Museum on the 28, 29, and 30 of April. Special exhibits will be arranged for the mammalogists in the halls and laboratories of the departments of mammals, vertebrate palæontology, and comparative anatomy. Papers will be given in morning and afternoon sessions during the conference, and it is expected that many interesting topics will be presented.

Bone Growth in the Albino Rat.—In an interesting article dealing with bone growth in the albino rat by Frederick S. Hammett, under the title "Systemic and Sex Determinants of Bone Growth (*Mus norvegicus albinus*)," Biological Bulletin, Vol. L, No. 1, Jan., 1926, pp. 61–71, it is shown that the growth of the femur follows that of the body more closely than does the growth of the humerus.

The period of weaning brings a marked reduction of growth capacity and the ripening of the sex glands brings another; thus the checking of the systemic growth factors brings about the observed weight and length differences in the adult males and females.—H. C.R

SCIENCE OF MAN

Archæological Work in Cañon del Muerto was begun by Earl H. Morris in 1923. A very remarkable collection was secured, rich particularly in sandals and other textiles. This work was continued in 1924, but mainly for the University of Colorado which furnished the funds. Mr Charles L. Bernheimer generously contributed a share of the support on behalf of the American Museum. The work held so much promise for the future that Mr. Ogden Mills has provided ample funds to continue it for three years.

Dr. A. V. Kidder, of the Peabody Museum of Harvard, but also connected with Phillips Academy of Andover, Massachusetts, was loaned by the latter institution to participate in this work. He, Mr. and Mrs. Morris, and several other workers, some of them volunteers, spent the latter part of September, October, and the early part of November, 1925, in active excavation. Again very important specimens and information were obtained. Of particular interest is the material from the period which lies between the Basket Makers who had no pottery and the Pueblo cliff-dwelling peoples who later occupied the same sites. The life of the prehistoric dwellers in the Southwest is now known with greater detail than that of any other such people. Pottery and architecture develop under our eyes, but objects used in religion and ceremonies have persisted from the earliest times. A medicine man's outfit from the earliest burials would still serve a modern Southwestern priest.

One of the most interesting finds last fall work was an eagle buried under a basket with mice and other small animals placed with him as food after his death.

Mrs. William Boyce Thompson Expedition.—The archæological work in Arizona supported by Mrs. William Boyce Thompson was resumed by Mr. Erich Schmidt in October. Additional rooms in the ruin known as Togetsoge were cleared and the adjoining cemetery thoroughly explored. Mr. Schmidt examined a ruin on Roosevelt Lake and later, at the request of the city authorities, did some preliminary digging at a large ruin, Pueblo Grande, near the city of Phoenix.

Dr. Margaret Mead, now in Samoa studying as a Fellow of the National Research Council, has been appointed assistant curator in ethnology. Doctor Mead is recognized as one of the most brilliant of the recent graduates of Barnard College, receiving her doctor's degree from the department of anthropology two years after her graduation. She will look after the collection from the Pacific Islands and continue her research.

Dr. J. Alden Mason, who has been assistant curator of Mexican archæology since January, 1924, resigned at the end of 1925 to accept a position at the University Museum of Philadelphia. Doctor Mason came to the American Museum from the Field Museum of Natural History where he had held a similar position for some years. During Doctor Mason's connection with the Field Museum and previously, he had much field experience which took him to the Mackenzie River in Canada, into Mexico on several occasions, and to Colombia in South America. His general ability and his wide knowledge of specimens and people make his leaving the American Museum a loss to be regretted.

At the end of the present academic year Harry L. Shapiro will join the staff of the department of anthropology as assistant curator of physical anthropology. Mr. Shapiro has been trained at Harvard University where he is now serving as a tutor. He has had field experience at Pitcairn Island, where he studied the race mixture resulting from European mutineers and native women. The results of this trip will constitute Mr. Shapiro's dissertation for the degree of Doctor of Philosophy which he expects to receive in June. The collection of Professor von Luschan acquired through the generosity of Mr. Felix Warburg provides Mr. Shapiro an unusual opportunity for research.

Mental Capacity of Australian Aborigines.—In a recent number of Natural History, a couple of instances are given of Australian aborigines who in mental capacity are apparently not inferior to the average white man. In 1892 I lived for nearly nine months in North Queensland, and was in daily intercourse with the natives. I had been led to believe that the Australian native was the lowest living human type, and I expected to find him not only in a low state of civilization but mentally on quite a lower plane than the European. I soon found, however, that this was by no means correct. Naturally one who has from infancy lived in the open bush or in the rudest of bark huts, and who knows absolutely nothing of civilization as we know it, will have a different outlook on the world from ourselves. Of course the natives had, and I suppose still have, different ideas from ours on many questions of right and wrong, but I soon came to the conclusion that they were intellectually not inferior to the average white, and that even morally if they stood on a slightly different plane it was not a lower plane.

It is said that the native cannot count and that he has no words in his language for any number higher than three—that he can count only one, two, three, plenty. Yet if sent with a flock of 2000 sheep to a station 100 miles away he knows if any have been lost and how many. Frequently natives journey with transport teams, and put up for the night at wayside inns. It was found that the native servants could soon take a hand at euchre and play just as well as their white masters. They certainly know the nine from the ten, and the right bower from the left.

When in North Queensland, I was reported to be the best checker player in the district. One day a full-blooded native was brought to me to have a few games. It was said that he had beaten all the whites with whom he had played. Though I managed to hold my own, I remember he got two draws off me, and that he played a remarkably fine game. Considering that he had probably never seen a white man till five or ten years previously, it must be admitted that at least some natives are not much if at all inferior in mental ability to the whites. Perhaps the superior types of natives are even more intellectual than the average whites.

As naturalists they are marvelous. They have a remarkable knowledge of the various trees, shrubs, birds, beasts, lizards, and insects. In this they resemble the South African Bushman. It is said that some years ago a new star was first noticed by a Bushman herd. Such an observation one might also expect from a native Australian.—Robert Broom.

ERRATUM

In the article in this issue of Natural History entitled "The Ethnological Problems of Bering Sea," an error has been made in Map 3 on page 93. Cape Navarin should have been indicated on the point to the south of the Gulf of Anadir.

REPTILES AND AMPHIBIANS

Dr. G. Kingsley Noble, curator of the department of herpetology, has recently returned from abroad, where he visited the museums of Germany, Austria, Switzerland, France, Belgium, Holland, and England. The three main objects of the trip were successfully accomplished.

First, he negotiated exchanges of reptiles and amphibians with the various museums visited. Five hundred and sixty-five specimens were acquired and arrangements were made for securing about two hundred more. Nearly three hundred species in this series are new to our collections; forty-three genera and one subfamily were not previously represented in our Museum. As a result of these exchanges more genera and species have been added to our collections than in any previous year. Incidentally, up to this time, many of the forms were not in any museum in America.

Secondly, Doctor Noble made a record of the exhibits of reptiles and amphibians in the foreign museums. These data will serve as a useful basis when the final exhibition plans for the New Hall of Reptile and Amphibian Life in the American Museum are considered.

Thirdly, a study was made of all the amphibian collections, both recent and fossil, in the museums visited. These studies will serve to complete Doctor Noble's research work of the last five years on the phylogeny of the Amphibia.

Mr. Clifford H. Pope, zoölogist of the Third Asiatic Expedition, writes from Foochow, Fukien Province, China, November 16, 1925, that he is sending a very large shipment of reptiles and amphibians, as well as other vertebrates, to the Museum. He continues, "We had a very successful season so far as general collecting is concerned. I succeeded in obtaining several series showing the early stages of development of various Amphibia. Eggs were very hard to find after June, and the continuous rains through April and May made work difficult. As it was, my feet were put in very bad shape by the wading and I had to spend a whole month sitting down or working only indoors.

"The collection on the whole is richer in species than the Hainan lot. Of snakes there are about fifty against twenty-seven species in the Hainan collection. I found what I take to be the eggs of *Pachytriton*.

"My plans for the spring are uncertain. I think that I can still secure some good material here in Fukien and may stay until late fall."

Mr. Pope's shipments have not yet reached the Museum, but two volumes of colored drawings by his Chinese artist, Mr. Wang, show that the collections are rich in rare forms.

LOUIS R. SULLIVAN

The Galton Society at a recent meeting passed the following Resolution:

Whereas, The late Doctor Louis R. Sullivan was one of the most active members of the Galton Society, of which he was elected a Fellow in 1918, soon after the foundation of the Society;

Whereas, He presented at its meetings the chief results of his important investigations upon the racial history of the Polynesians, the racial composition of the present mixed population of the Hawaiian Islands, the relationship of the Punin Ecuador skull, and other topics of exceptional anthropological interest;

Whereas, At the time of his death Doctor Sullivan's most ably conducted and comprehensive studies were leading him to still more important conclusions concerning the classification and evolutionary history of the races of mankind;

Whereas, The American Museum of Natural History has undertaken so far as possible not only to complete and publish the investigations upon which he labored almost to the day of his death, but also to carry on further researches along the lines planned by him;

Whereas, His good humor, his breadth and sympathy, as well as his keen and sensitive intelligence and other attractive personal qualities had inspired the devotion of his many colleagues and friends;

Therefore be it resolved: That the members of the Galton Society hereby record their appreciation of the fruitful life and works of their late friend and colleague and their gratification that the investigations conducted by him are to be carried on along the lines he had planned;

And be it further resolved: That a copy of this resolution be forwarded to the widow and family of our late friend and colleague in token of our deep sympathy for their loss.

(Signed) Charles B. Davenport,
Chairman
William K. Gregory,
Secretary.

NEW MEMBERS

Since the last issue of Natural History, the following persons have been elected members of the American Museum, making the total membership 8519.

Benefactor: Mr. Geo. Eastman.

Associate Founder: Mr. D. E. Pomeroy.

Patrons: Mesdames D. C. Cook, Annie Trumbull Slosson, and Mr. John F. Fowler.

Honorary Fellow: Mr. Lincoln Ellsworth.

Life Members: Mesdames F. H. Cabot, George M. Gould, A. G. Hull, Wm. E. Keith, William H. Moore; Miss Elizabeth A. Hull; the Rev. William D. Westervelt; Prof. Wendell T. Bush; Dr. W. P. Thompson; Messrs. Walter L. Bogert, Frederick J. Burghard, Andrew Carnegie, 2d., Lammot duPont, Thos. A. Edison, Henry Fitzhugh, Alex. Goldsmith, Richard Kelly, Ringland F. Kilpatrick, Samuel H. Kress, Charles F. Noyes, Jackson E. Reynolds, J. Stillman Rockefeller, A. B. See, Edgar V. Seeler, Jr., Frank P. Shepard and Andrew Castle Westervelt.

Sustaining Members: Mrs. Horace Havemeyer; Miss Mary Taylor Moulton; Doctor Thomas T. Gaunt; Messrs. Willard V. King, and William C. Potter.

Annual Members: Mesdames J. Robinson Beard, Percival Beresford, Martha L. Bryant, Mildred Bedard Caldwell, Chas. W. Campbell, J. Radford English, F. Shelton Farr, Jos. Fels, Walter Gibb, Philip G. Gossler, W. H. Grueby, Ralph Guinzburg, Esther Wadsworth Hall, Cornelius S. Lee, Elliotte Little, W. S. McPherson, Douglas M. Moffat, Charles Lathrop Pack, D. F. Phillips, Emmy Pohlmann, Arthur J. Rosenthal, William H. Sage, Lisa W. Sandford; Misses Marjorie

Cohen, Marguerite L. Modine, Margaret Dole, Mary B. Hervey, Caroline D. Hewitt, Helen J. Piper, Sara Rossmoore, Lizzie U. Smith, Flora Agnes Sporborg, Jean Walker, Louise Whitin; Professors Henry S. Graves, Graham Lusk; Doctors Burrill B. Crohn, George Feldman, Sigmund W. A. Franken, H. F. Hammer, Edgar A. Ill, Fred'k. C. Keller, G. Alfred Lawrence, Alexander T. Martin, Lawrence K. McCafferty, Robert L. McCready, Philip Meirowitz, Fordyce B. St. John, J. Perry Seward; Messrs. Welles L. Allen, John Hartwell Bennett, Frederick T. Blakeman, Charles A. Boehrer, Chester A. Braman, Jr., John B. Burnham, Sidney B. Cardozo, A. Polhemus Cobb, Davis H. Crompton, Frank Damrosch, Alan B. Deitsch, Thomas C. Desmond, Goldthwaite Higginson Dorr, Ferdinand Eberstadt, William M. Erb, E. Fellman, Ben Felsenthal, Clyde A. Flint, Alex. V. Fraser, Arthur A. Gammell, Francis H. Geer, DeForest Grant, Lawrence S. Greenbaum, Lloyd C. Griscom, Mark Groskin, George Gilman Hall, Edward M. Healy, Henry S. Hendricks, Henry B. Heylman, Walter Hidden, Robert Horn, Seymour Phillips Houghton, C. Sherman Hoyt, John C. Hughes, Richard Hymes, Phillips Isham, Huger W. Jervey, Donald Kaufmann, Sigmund Marshall Kempner, Peter Lorillard Kent. Edward A. Kimball, Chas. M. Kohn, R. B. Koon, Isaac Lorberblatt, E. Herrick Low, Percy C. Madeira, John Lee Mahin, Chas. R. Miller, Spencer Miller, Jr., Cornelius von E. Mitchell, Wm. S. Moore, Edward T. Nichols, 4th., Chas. P. Northrop, Henry Wade Nuckols, Wm. E. Owens, A. E. Merriman Paff, Herman Palmer, Edmund A. Prentis, Jr., Marshall Prentiss, George M. Pynchon, R. Bartow Read, George Richards, C. C. Rose, Carl F. Schippell, Raymond J. Schweizer, K. Spalding, Raymond B. Stringham, Wm. H. Stewart, Lewis S. Thompson, Jr., William P. Thompson, Harry S. Vosburgh, Clarence F. Waldman, Harry W. Watrous, S. J. Wise, Emanuel Sisterhood of Personal Service, Horace Mann Elementary School, The Lincoln School of Teachers College, and Yeshivath Torah Vodaath.

Associate Members: Mesdames E. J. Armstrong, Ralph Case, Stephen O. Edwards, W. S. Granger, Mary H. Hale, Mary E. Hickey, Ella L. Horr, Harriet C. Miller, Andrew Jackson Ralston, Lillia C. Selby, D. T. Teare, Daniel S. Tobin, Charles F. White; Misses Theodora M. Cope, Charlotte Dailey, Edith Evans, Nancy Hall, H. L. Haskell, Jessie Kenyon, Elizabeth Price, Sue Robinson, Gretchen Thompson, Edith B. Todd, Enid Wallace, Martha S. Whitmarsh; the Rev. James E. Barbour and the Rev E. C. Chorley: Prof. E. W. E. Schaer; Doctors Paul Peter Babiy, R. P. Batchelor, R. O. Cooley, Robert Goodale, J. Darwin Pines, Emmet Rixford, Dudley Smith, D. A. Stewart, Wm. D. Swan, John S. Unger, Karl von Vietinghoff; the Hon. José J Zuno; Messrs. C. M. Adams, John Adams, Silas Reed Anthony, James W. Arrott, Geo. S. Avery, P. H. Blanding, Richard W. Blanding, Clarence S. Brigham, W. P. Bryan, Carl W. Buchheister, Malcolm G. Chace, H. T. Chapman, Ben E. Clement, Frank E. Curran, Howard Chalmer Dailey, James H. Deering, Otto Degener, Grenville Elderedge, Brooks Fleming Ellis, E. S. Esty, Anthony Euwer Jr., Francis Cope Evans, Walter H. Faunce, John R. Freeman, Charles Goodnight, George Burton Gorham, Jr., Millen Griffith, Jr., Edwin Charles Hall, Mike S. Hart, W. B. Hart, Alfred M. Hilton, Paul B. Howland, George H. Hudson, Frank S. Kelly, Clyde C. Leaver, Miguel Lillo, R. J. Longstreet, Cassius S. Lyman, Edward G. Lyon, Frank Norman MacLeod, John Williams Macy, Jr., Alvan C. Mason, Wm. L. Mauran, Jr., R. Hamilton McCormick, Albert Davis Mead, Albert Morgan, L. S. Morrison. A. A. Olsson, William B. Ouellette, Herbert Parker, S. N. Pentecost, David Perpente, Francis J. Pettijohn, James Phinney, C. K. Rathbone, DeLancey Rochester, Jr., John L. Rochester, W. F. H. Rosenberg, Paul M. Ryan, A. M. Scott, William T. Sexton, Wm. N. Simpson, Truman R. Taylor, Mark W. Tenny, Chas. F. Tillinghast, Harrell Townsend, Chas. C. Trump, John Van Benschoten, Jr., Wm. Wallace, Deming Wheeler, Frederick A. Whitney, Thomas F. Wiesen, C. H. Younger, and the Highlands Country Club.

INSECT NUMBER

MARCH-APRIL

It is fitting that, following the present number of **Natural History**, which tells of Man, the issue for March–April should be devoted to the chief competitors of Man, namely, the Insects, "our rivals in these latter hours, and perhaps our successors." No class of animals has a more intimate bearing upon human welfare and possibly regarding no other is knowledge so essential. Some of the ways in which the public is being informed about insects are discussed by Dr. F. E. Lutz, curator of entomology, American Museum, in the opening article of the issue, which is illustrated by a representative series of insect pictures taken by the author.

The harmful phases of insect life are presented pithily by Dr. L. O. Howard, chief of the Bureau of Entomology and generalissimo of the force of economic entomologists to whose defensive warfare it is due that insect enemies have not made larger inroads upon the plants that furnish us with food and raiment.

Some insects devour our crops, others endanger health. The work of medical entomology is illustrated in an account which Dr. Joseph Bequaert gives of his recent trip into the mosquito-infested Amazon country as a member of the Hamilton Rice Expedition.

Without wishing to minimize the danger from certain insects, it is in order to recall the benefits, far outweighing these injuries, which we derive from other insects. It is not true that the only good insect is a dead insect any more than, for that matter, this statement, with substitutions, was ever true of the Indian. Some of the ways in which insects render indispensable services to man are told by Dr. F. E. Lutz in his article, "Friendly Insects."

Prof. T. D. A. Cockerell of the University of Colorado has traveled widely and, in making new observations, is able to draw upon the rich stores of his knowledge for comparison and contrast. In his article, "The Insect-hunter Abroad," he comments entertainingly and informingly upon the matters of entomological interest that came to his attention in his journeys to various island groups of the Old World.

Dr. Vernon Kellogg, permanent secretary of the National Research Council, enjoys, and with full justice, a reputation not only as one of the foremost entomologists but as one of the most delightful writers upon insects, and he well sustains this reputation in a contribution entitled "The Color Dust of the Butterfly."

A foundation for the knowledge of insects cannot be laid too early and it is with particular pleasure therefore that announcement is made of an article for children by Miss Edith M. Patch, state entomologist of Maine, who tells the fascinating life story of one of our common moths.

We are apt to think of insects as creatures of the air and earth, but our ponds and running streams also harbor insect populations. Some of the little-observed phases of insect life in the waters are revealed through an article and attractive photographs by Mr. William M. Savin, who is well known to readers of Natural History through his previous contributions.

Every group of insects has its points of interest but there are few that so well repay the observer of their habits as the bees. Of the honey-bee everyone knows something, but the wild bees are still relative strangers to many of us. Some of their fascinating, yet perplexing, habits are touched upon in an article by Mr. Herbert F. Schwarz, research associate in Hymenoptera, American Museum.

If space permits, other articles will be added, but at best a single issue of the magazine can touch on only a few of the interesting phases of a class of animals that in number of species and in number of individuals within those species far exceeds all the other living forms on this globe.

PRINCIPAL ORDERS OF INSECTS

CHART PREPARED BY A. J. MUTCHLER AND FRANK E. LUTZ
The American Museum of Natural History

	WINGS	MOUTH	GENERAL	YOUNG (NO YOUNG INSECTS HAVE WINGS.)
DIPTERA Mosquitoes, Gnats and Flies ('Field Book,' pp. 229–278)	Two (the hind wings being replaced by a pair of knobbed structures called halteres); rarely none.	Lapping or piercing.	Prothorax small. Five or fewer antennæ joints in typical flies. In Mosquitoes, Gnats, etc. the antennæ have numerous (more than five) segments.	Maggot-like; legless. Some terrestrial; others aquatic. Pupal stage sometimes active but even then not similar to adult.
LEPIDOPTERA Butterflies and Moths ('Field Book,' pp. 115–228)	Four. Thickly covered with scales which are usually so closely placed that the veins can not be seen.	Sucking and, when not in use, coiled under the head. Sometimes poorly developed.	Body covered with hairs or scales. The antennæ of ordinary butterflies are somewhat long and slender, with a swelling at the extremity. In the skippers the extreme end terminates in a thin recurved hook. The antennæ of moths are variable but are usually more or less "feathery"; no knob at tip.	Worm-like ("caterpillars") with three pairs of legs on the front body segments; also leg-like "props" on other body segments. The majority are plant feeders. Inactive pupal stage.
HYMENOPTERA Bees, Wasps and Ants ('Field Book,' pp. 406–454)	Four or none. Veins and cross-veins not very numerous. Hind wings smaller than the front ones.	For chewing or for both chewing and sucking	Tarsi five-jointed. The ovipositor of the female usually a sting, sometimes sawlike; very long in some parasitic species. Commonly the abdomen is thin before joining the thorax.	Various. Those of sawflies look like caterpillars and feed on or in plants. Others usually legless and maggot-like. Inactive pupal stage.
COLEOPTERA Beetles ('Field Book,' pp. 280–405, 498)	Four (hind wings rarely absent). Front wings (elytra) without apparent veins (raised ridges are not veins) and usually horny; sometimes very short. Hind wings usually covered by the stiff elytra.	Chewing. In weevils the head is prolonged like a beak but there are tiny jaws at the tip.	The antennæ very variable, usually eleven jointed.	Often caterpillar- or worm-like, with jointed thoracic legs. Sometimes maggot-like, legless. Mouth parts usually with strong mandibles. Inactive pupal stage.
HETEROPTERA True Bugs (Water-boatmen, Back-swimmers, Squash-bugs, Bed-bugs, etc.) ('Field Book,' pp. 95–114)	Four. Front wings usually somewhat leathery at the base; membranous near the tip.	For piercing tissue and sucking juices. The beak is attached to the front end of the underside of the head.	Prothorax distinct. Antennæ with few joints; those of land species usually longer than those of aquatic ones.	Similar to the adult. Some aquatic; others terrestrial. No inactive pupal stage.
HOMOPTERA Cicadas, Leaf- and Tree-hoppers, Plant Lice, White Flies, Scale Insects, etc. ('Field Book,' pp. 80–94)	Four, two (male scale insects), or none. The front wings are similar in texture throughout.	For piercing tissue and sucking juices. The beak is attached to the hinder part of the underside of the head.	Prothorax distinct. The antennæ are usually short and not many-jointed. The cicadas are among the giants of this order, while some of the white flies and scale insects are hardly more than just visible to the eye.	Similar to the adult. The males of scale insects pupate but usually there is no inactive pupal stage.
ORTHOPTERA Roaches, Praying Mantis, Walking Sticks, Grasshoppers, Katy-dids, Crickets, etc. ('Field Book,' pp. 62–76)	Four or none. Front wings toughened; narrower and thicker than the membranous hind ones.	Chewing. The mandibles are conspicuous.	The antennæ more or less thread-like; in some cases much longer than the body. Crickets, roaches, etc. have a pair of short appendages at the end of the body. Crickets, grasshoppers, katydids, etc. have large hind legs. Female crickets, katydids, etc., have rather long ovipositors.	Similar to the adult. No inactive pupal stage.
DERMAPTERA Earwigs ('Field Book,' p. 61)	Four or none. Front wings short and leathery. Hind ones large and nearly circular; readily folded from near the center (when folded usually projecting slightly beyond the upper pair).	Well developed for chewing	Antennæ rather long. A pair of strong movable forceps at the end of the abdomen. Often confused with Staphylinid beetles, which also have short wing covers; but beetles do not have forceps on the abdomen.	Similar to the adult. No inactive pupal stage.
ODONATA Damsel-flies and Dragon-flies ('Field Book,' pp. 42–50)	Four. Elongate; not plaited when at rest. A notch resembling a joint (called the "nodus") near the middle of the front margin of each wing.	Well developed for chewing.	The antennæ are very short and not very noticeable.	Live in water. The damsel-flies have three smooth, flat gills on the tip of the abdomen, but the dragon-flies do not. Lower lip long, jointed, and with a pair of claspers on the free end. No inactive pupal stage.
ISOPTERA Termites ("White ants") ('Field Book,' p. 76)	Four (males and fresh queens) or none. Wings are more or less leathery; narrow; laid flat on the back when not in use (hind not folded). Front wings about as wide as hind ones.	Chewing. In some cases the jaws are extended some distance in front of the head.	Tarsi apparently 4-jointed. Body whitish. Prothorax conspicuous. Live in colonies; wingless "workers" usually most abundant. At some seasons large numbers of winged males and females leave the nest together.	Similar to the adult. No inactive pupal stage.
THYSANOPTERA Thrips ('Field Book,' p. 79)	Four or none. Wings elongate, with few veins, and fringed behind (usually in front also) with long hair.	Greatly modified, forming a cone attached to the back part of the head beneath and used for sucking.	Small; rarely 0.3 inch long. Not more than two tarsal joints; a bladder-like structure on the tip of the last joint. Usually found in flowers.	Somewhat similar to the adult but the change to adult approaches what is called a complete metamorphosis.
CORRODENTIA Book-lice and Bark-lice ('Field Book,' pp. 76–78)	Four, two, or none. When present, hind wings smaller than the front ones. Wings when at rest held like the sides of a steep roof.	Chewing.	Small; soft-bodied. Tarsi with less than five joints. Prothorax small.	Similar to the adult. No inactive pupal stage.
TRICHOPTERA Caddis-flies ('Field Book,' pp. 57–60)	Four. Fairly well covered by very fine hairs. Numerous longitudinal and few cross-veins.	Poorly developed; the chewing type.	The antennæ are thread-like and, in some species, several times as long as the body. No prominent appendages at end of abdomen. Prothorax small.	Worm-like; legged; most of them make portable houses for themselves from pieces of leaves, small sticks, sand, or a combination of these. All of the young live in water. Inactive pupal stage.
MECOPTERA Scorpion-flies and others ('Field Book,' pp. 56–57)	Four Somewhat elongate. Numerous veins.	The head is prolonged downwards forming a beak, bearing chewing mouth parts at its end.	The males of scorpion-flies have a pair of claspers at the end of their abdomen. These and the turned up end of the body suggest a scorpion. Others look like craneflies with too many wings.	Caterpillar-like and live on or just below the surface of the ground, especially if it be moist. They are carnivorous. Inactive pupal stage.
NEUROPTERA Ant-lions, Aphis-lions, etc. ('Field Book,' pp. 53–56)	Four. Somewhat elongate. Usually with many cross-veins (covered with fine powder when veins are few). Hind wings usually about the same size as front ones.	With strong mandibles for chewing.	Tarsi five-jointed. The antennæ of ant-lions are enlarged toward the tip (club-shaped or with a terminal knob); others have thread-like antennæ without terminal enlargement.	Live on land: the ant-lion in a pit made in sand or loose soil; the aphis lion on plants with their prey. Inactive pupal stage.
MEGALOPTERA (Alder-flies or Oral-flies and Dobson-fly) ('Field Book,' pp. 52–53)	Four. Usually large as compared with the body. Longitudinal and (usually) cross-veins numerous. Hind wings folded like a fan when at rest.	Grasping or chewing.	The antennæ are either long and many jointed or shorter and comb-like. The body is quite flattened.	Live in water. Crawl out and bury themselves in earth above water to pupate. On each of the first seven segments of the abdomen are five-jointed appendages ("gills") and a similar (but longer and unjointed) appendage forms a kind of tail. Inactive pupal stage.
PLECOPTERA Stone or Salmon-flies ('Field Book,' pp. 50–51)	Four. Usually with many cross-veins. Hind wings broader than the front ones.	Chewing.	Body somewhat flattened and with two prominent, jointed appendages at end of abdomen. Tarsi three-jointed.	Live in water. Similar to adult. A pair of appendages at end of abdomen. No gills along the side of abdomen No inactive pupal stage.
PLECTOPTERA May-flies ('Field Book,' pp. 40–42)	Four, or in rare cases, two. Cross-veins numerous. Hind wings much smaller than the front ones.	Chewing.	Body usually with three long, thread-like appendages at end of abdomen. Antennæ very short.	Live in water. Similar to adult but with gills along the sides of abdomen. Usually with three appendages at end of abdomen. No inactive pupal stage.
SUCTORIA Fleas ('Field Book,' p. 279)	None.	Sucking.	Small. Body flattened vertically. Hind legs fitted for jumping. Parasitic; chiefly on mammals, including man.	Worm-like; they live in rubbish such as accumulates at the edges of carpets and in the folds of upholstery. Inactive pupal stage.
SIPHUNCULATA Sucking Lice (Cooties, etc.) ('Field Book,' pp. 78–79)	None.	Sucking.	Small. Body flattened horizontally. Tarsi hook-like. Beak not jointed. Parasitic; chiefly on mammals, including man.	Somewhat similar to the adult. In the egg state they are called "nits." No inactive pupal stage.
MALLOPHAGA Biting Bird Lice ('Field Book,' p. 78)	None.	Fitted for biting off particles of feathers, hairs and scales of the skin from the animals on which they live.	Very small; rarely 0.1 inch long. Body flattened horizontally. Parasitic; usually on birds.	Somewhat similar to the adult and in both this and the adult stage are rarely found off the bodies of mammals on which they live. No inactive pupal stage.
THYSANURA AND COLLEMBOLA Silver-fish, Spring-tails, etc. ('Field Book,' pp. 39–40)	None.	For chewing; much reduced; drawn into the head and scarcely, if at all, visible.	Delicate and usually small. Appendages on under side of the more or less cylindrical abdomen.	Similar to the adult. No inactive pupal stage.

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Every year brings evidence—in the growth of the Museum membership, in the ever-larger number of individuals visiting its exhibits for study and recreation, in the rapidly expanding activities of its school service, in the wealth of scientific information gathered by its world-wide expeditions and disseminated through its publications—of the increasing influence exercised by the institution. In 1925 no fewer than 1,775,890 individuals visited the Museum as compared with 1,633,843 in 1924 and 1,440,726 in 1923. All of these people had access to the exhibition halls without the payment of any admission fee whatsoever.

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The **SCHOOL SERVICE** of the Museum reaches annually about 6,000,000 boys and girls through the opportunities it affords classes of students to visit the Museum; through lectures on natural history especially designed for pupils and delivered both in the Museum and in many school centers; through its loan collections, or "traveling museums," which during the past year circulated among 410 schools, and were studied by 977,384 pupils. During the same period 672,479 lantern slides were loaned by the Museum for use in the schools, the total number of children reached being 3,941,494. 1,076 reels of motion pictures were loaned to 48 public schools and other educational institutions in Greater New York, reaching 333,097 children.

The **LECTURE COURSES**, some exclusively for members and their children, others for the schools, colleges, and the general public, are delivered both in the Museum and at outside educational institutions.

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For a detailed list of popular and scientific publications with prices apply to:
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NATURAL HISTORY

JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

EXPLORATION·RESEARCH·EDUCATION

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NATURAL HISTORY

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DEVOTED TO NATURAL HISTORY, EXPLORATION, AND THE DEVELOPMENT OF PUBLIC EDUCATION THROUGH THE MUSEUM

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FRANK E. LUTZ, EDITOR

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THE BEAUTIFUL COLORS

of butterflies are due to very minute scales, as is pointed out by Doctor Kellogg in "The Color Dust of the Butterfly" in this issue. Of the two butterflies shown here, the Monarch is red because its scales contain red pigment, but the Morpho is that beautiful blue because its scales bear excessively fine ridges that reflect the rays of light in such a way that they interfere with each other and produce a blue iridescence

NATURAL HISTORY

VOLUME XXVI MARCH–APRIL, 1926 NUMBER 2

Taking Nature Lore to the Public

BY FRANK E. LUTZ

HE is a selfish man who, knowing interesting things, does not pass on that information to his fellows. He is worse than selfish if he has acquired that knowledge through the help of his fellows and, nevertheless, imparts it to at most the favored few of them who are working along the same lines. It is clearly the duty of entomologists and it should be their pleasure to tell others about insects. Furthermore, in view of the increasing and vital connection between insects and human welfare, it is essential that the coming generation of men and women be better informed concerning their six-footed friends and enemies than our generation has been.

The American Museum's department of entomology has not been unmindful of these things and has with pleasure tried to do its duty, not alone in research, but also in education by means of exhibitions, by the printed word, by talks given to visible auditors and also broadcast by radio, and, finally, by taking the message to people out-of-doors. Some of the ways in which we have told about insects in our exhibition hall were illustrated in a recent number of NATURAL HISTORY and the present issue is an illustration of our efforts with printed words, efforts in which we have been generously assisted by willing and able colleagues. Let me tell you briefly about the other ways in which we are taking insect lore to the public.

Just a word in passing as to research, for research need not be as distinct from "taking nature lore to the public" as it usually is. Our Station for the Study of Insects is mentioned below in connection with our "Nature Trails,"

At the entrance to our grounds

but one of the main purposes for which that station was established was research. Our hope is that there we may learn more about the lives of the common insects that the public sees but does not understand—and neither do we. We are so ignorant of the intricacies of entomology that we can learn much by a study of the common things at our very doors. These are of popular interest, at least, and the knowledge we gain about them is certain to have an application in cases of less common

"Headquarters" Cabin of the Station for the Study of Insects. The automobile is the one that several years ago served as laboratory, living quarters, and means of transportation for one of the Museum's entomological field parties in Colorado

The automobile that brought cooked food from Bear Mountain Inn to our cabin at the Station for the Study of Insects species; also what we learn about insects that are not injurious will help us with those that are. Doctor Howard has developed this same idea more fully in his article in this issue of NATURAL HISTORY and—who knows?—our station may become like that for which he pleads. At any rate, we hope that in our research there we may be practical, even though the immediate application of our work may not be apparent, and that we may be popular in the sense that we keep in mind our duty to the public.

Lecturing is older—much older—than writing as a means of imparting information; and, except for the limitation in the number of people that can be reached by one person, it is often more effective. Since, just as in books, a good picture is frequently worth pages of text and sometimes indispensable, so in lectures illustrative material, either the actual specimens or pictures or both, are exceedingly helpful. This is particularly true if, when dealing with living things, the pictures show the things as living—if they display that very common attribute of life, motion.

Furthermore, motion pictures with accompanying captions can be made to tell a continuous story that can be given well without the necessity of the lecturer who prepared them being present and, also, there is no limit (except cost) to the number of copies that can be made of a film and these copies can be shown throughout the world. The motion picture, then, is a means of multiplying the reaching power of a lecturer, a feature that is quite akin to that of books and magazines.

It is not easy to make motion pictures of insects because of the small size of the subjects and because many insects move very rapidly in comparison with their size. A motion-picture film is only an inch wide and, if the photograph of the insect be made only one-tenth natural size, that insect would go entirely out of the picture if it moved ten inches at right angles to the camera; it would go out of sharp focus if it moved that distance toward or away from the camera. This difficulty is increased as we attempt to make the photograph more nearly natural size (as are also other difficulties, including illumination) and a photograph of an ant, for example, one-tenth natural size is rather small.

However, these are merely difficulties to be overcome by special instruments and better technique. Mean-

Getting "inside facts" concerning an Oak-apple, a structure which a wasp forces the oak to make as a nursery for young wasps. From the film "Winning the Insect-life Merit-badge"

Stages in the life of the Monarch butterfly. From the film "Winning the Insect-life Merit-badge"

while, we can show insects that are large enough to yield satisfactory results with our present apparatus and skill. That the case is not hopeless is shown by a film that was recently prepared for a lecture to children of members of this Museum and is now being used more generally. It is entitled "Winning the Insect-life Merit-badge."

"Merit-badges" are given by scouting and other organizations to such of their members as have met given requirements in certain lines of endeavor. To win the insect-life merit-badge of the Boy Scouts, the boy must learn a great deal concerning insects and the lives that they live. This the boy did and the film shows some of his activities and some of the activities of the insects that he saw. Characteristic "shots" from this film are reproduced here; the department's association with young people who are interested in nature will be mentioned shortly.

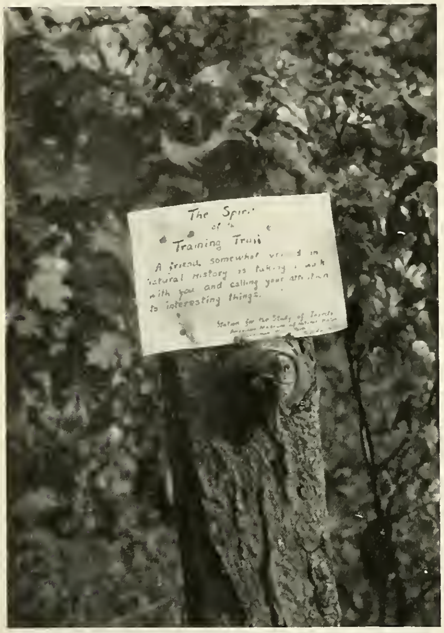
First, however, let me speak of another method of "multiplying the reaching power of a lecture," the radio. There is no good way of determining how many people hear a radio talk, since many of the more thoughtful listeners are not likely to write in about it but, when a fifteen-minute discussion of some entomological topic broadcast in this way is followed by the receipt of intelligent letters concerning it, written by people distributed from Maine to Virginia, one can be certain that many others, equally worth while, heard it but did not write. We are told that the potential audience of such a talk includes more than a million people of all ages. "Some Interesting Habits of Our Native Bees," "Insect Sounds," and "The Friendly Insects," printed in this issue of NATURAL HISTORY, are examples of radio broadcasts given by this department.

And, then, there is the matter of telling people about insects when these people are out-of-doors where they can see living specimens. I do not mean personally conducted field trips. On them one who knows can benefit at most fifteen or twenty people at one time. We label our museum exhibition halls so that visitors do not need a guide. Why not follow the same method where Nature provides the exhibits? The newspapers described our "Nature Trails" in the Harriman State Park, near Tuxedo, New York, as an "insect zoo" and that was a rather fitting name for one section of the trails. On the other hand, it told only a part of the truth, for we believe that, to understand and thoroughly appreciate the lives that insects live, you must not only see live insects but you must know about their environment, about the plants upon which they feed, and about the animals that feed upon them; you must sense the light, the shade, the moisture, and the temperature that go to make up the habitat of the insect. So, at the Station for the Study of Insects, where we made our first Nature Trails, we told our visitors about the plants, for example, and, if the visitor was interested in plants, we had something for him even though he was not interested in insects.

We told about these things partly by word-of-mouth but largely by labels and we tried to make these labels as human as every-day conversation.

There were two Nature Trails, each about half a mile long and roughly circular. One was called the "Training Trail" and the other the "Testing Trail." Information was given on the Training Trail but on the Testing Trail there were fifty numbered questions about the plants and the insects along its sides. If a visitor wished to

With the Bees. A Boy Scout is taking his test in bee-keeping. From the film "Winning the Insect-life Merit-badge" "test" himself, he could write his answers to these questions, bring them to us, and we would tell him his score. Also, we had competitions both between individuals and between teams.



Explaining to our visitors that the underlying idea, the "spirit," of the Trail is that "a friend is taking a walk with you and pointing out interesting things"

Instead of risking confusion by attempting to tell something about everything that grew along the Training Trail (and, for the most part, we included only those things that naturally grew there) we picked out just a few of the easy and most interesting things, especially things concerning which there is popular misinformation. Also, we largely avoided technicalities. For example, it is a technical matter to distinguish the various oaks of the black-oak group and even the specialists do not agree. So we merely said that members of the black-oak group can be recognized as belonging to that group by their having a tiny bristle at the end of each principal lobe of a leaf, while members of the white-oak group have no such bristles. We told that the acorns of the black-oak group are not palatable, while those of the white-oak group are more or less so; that many insects recognize the difference between these groups and feed only on the leaves of one or the other; and so on.

We tried to teach some underlying principles of conservation by showing that, if a flower is picked, the plant's children (its seeds) are killed; that, given a chance, a small tree would grow to become a large one; and that plants, the chestnut for example, suffer from diseases just as we do. (American chestnuts have been killed by a fungus disease and not by insects.) We asked people to benefit themselves and others by not needlessly stepping on or breaking a living plant. This they did in a mighty fine way and, as a result, although thousands tramped our Training Trail, it is at no place where it really was a trail (and not a road) more than eighteen inches wide. Only a few not-yet-knowing people—possibly hopelessly ignorant or selfish—picked the flowers that others wished to see or dropped paper where it would mar the beauty of God's out-of-doors, which it is our right to enjoy unspoiled.

The underlying idea of our labels, the "spirit of the Training Trail," was that "a friend is taking a walk with you and pointing out interesting things." This friend, the label we put there, when showing the winding tunnel inside a leaf where a tiny caterpillar spent its life feeding and growing, quoted Lowell:

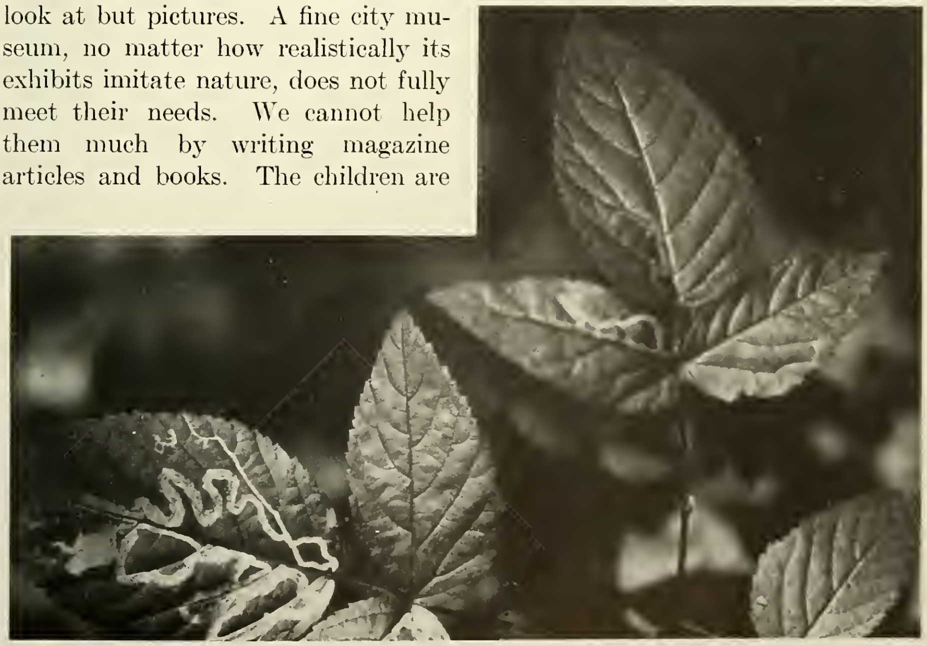
> There's never a blade nor leaf too mean
> To be some happy creature's palace.

and, as the visitor walked by the side of the babbling Wild Cat Brook, one of these friendly labels reminded of Stevenson's

"There's no music like a little river's. It plays the same tune (and that's the favourite) over and over again, and yet does not weary of it like men fiddlers. It takes the mind out of doors; and though we should be grateful for good houses, there is, after all, no house like God's out-of-doors. And lastly, sir, it quiets a man down like saying his prayers."

We put these Trails where we did, so that they might be convenient of access to the automobiling public but especially that they would be relatively near the many organization (scouting, charity, and industrial) camps in the Interstate Park. Do you realize that thousands of children from cities and towns are camped there, each for a week or more, every summer? It is not enough to lecture about nature to these children during the winter seated as though in school and with nothing to look at but pictures. A fine city museum, no matter how realistically its exhibits imitate nature, does not fully meet their needs. We cannot help them much by writing magazine articles and books. The children are in the Park every summer with nature all about them. It is the time and the place to tell them what they are keen to know.

The better of these camps have "nature councillors" and exceedingly useful camp museums, the latter preferably made by the children themselves. The Nature Trail is an additional help. Some have called it an "outdoor museum" but it is not that, for a museum is a place to which specimens are brought and in which they are stored. The nature-trail idea is to leave things where they are but to label them with interesting facts. If interesting facts are given first, less interesting ones will then be more readily grasped. Is that not true in your own case? After you have learned that a toad catches insects for food, that its young are tadpoles living in water, and that, though warty itself, it does not give warts to people who



The winding tunnel in a leaf that was "some happy creature's palace"

The official staff of assistants in the 1925 Nature Trail work

A team of East-side New York boys that took part in a contest on the Museum's Testing Trail. The little fellow in the center made high score

The bridge that carried the Museum's Nature Trail across Wild Cat Brook. It was built for us by Boy Scouts

Household insects are not out-of-door creatures and, so, on the Museum's Nature Trail they were shown in a tent

ALONG OUR NATURE TRAIL

INSECTS AND OTHER ANIMALS ALONG THE TRAIL

Aquatic insects in glass dishes, small creatures that live on the ground in moist places were caged in plaster boxes

The "insect orchestra," composed of crickets and the like. Models of a cricket's musical instrument were in the tin box

Watching the earwigs along the Trail

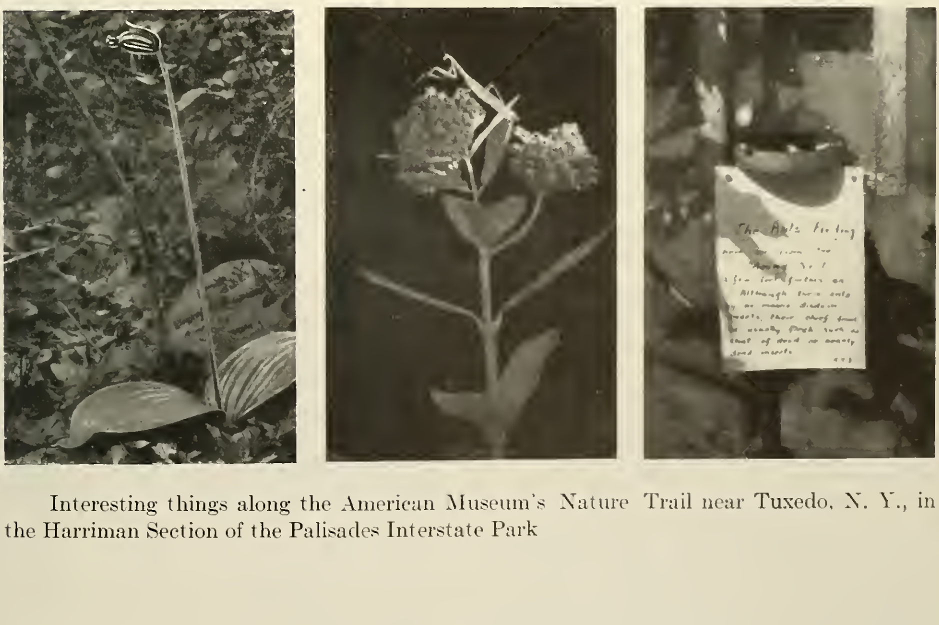
touch it, you will probably care to know that the scientific name of toads is *Bufo*, that the species you are looking at is *Bufo am ricana* and that it differs from another native toad, *Bufo fowleri*, in such and such characters. At any rate, on our Training Trail the labeling was not a catalogue of species but a personal conversation.

If there is but one Nature Trail in a large region, something is gained, since it is possible for people to come from a distance to see it; but that is not "taking nature lore to the public"; it is asking people to come to nature lore. So, it was extremely gratifying to see with what enthusiasm various camps took up the idea and made Nature Trails of their own. The children, in doing this work, learned more than they could possibly do by merely studying a trail that some one

A group of boys at the ants' feeding box in a tree else had made. Furthermore, they had a sense of proprietorship; that trail was theirs; they had become part owners of nature and their fathers and mothers and all their relatives and all their other friends were welcome to come and share in the joy of knowing about out-of-doors. Thus our half-mile of Training Trail grew in a season to more than ten miles and this fact, even more than the kind verbal comments of our visitors, made us think that our work was worth while.

During the winter the Manhattan Girl Scouts made a Nature Trail on the Palisades and New York school teachers made one in the N. Y. Botanical Gardens. Others are planned throughout the country literally from the Atlantic to the Pacific. Why not? Why should there not be written or printed "friends" in every city, state, and national park telling people something concerning the things there — not just the names of them but something that appeals? Why should not the camping grounds of automobile tourists be made more than mere overnight stopping places? If a commercial concern thinks it is worth while to put its slogan where you cannot help but see it while you eat your wayside lunch, why is it not the duty of those who know about nature to meet you there and by neat, chatty labels tell you something worth while? That would be taking nature lore to you and to others of that vast company of people we call "the public," and it would be well worth while.[1]

[1]The American Museum of Natural History has issued a pamphlet telling in some detail about our Nature Trails and making suggestions concerning this work. It is available to anyone who is interested in starting such a Trail.



Interesting things along the American Museum's Nature Trail near Tuxedo, N. Y., in the Harriman Section of the Palisades Interstate Park

A Great Economic Waste

WHAT WE ARE DOING AND WHAT WE MUST DO IF WE WOULD CHECK THE RAVAGES OF INSECTS

By L. O. HOWARD

Chief of Bureau of Entomology, U. S. Department of Agriculture

This exceedingly important topic is treated here by a man than whom no one can speak withg reater authority. For years Doctor Howard has been chief of the Bureau of Entomology of the U. S. Department of Agriculture and under his direction that bureau has assumed and maintained the front rank in our battle against our enemies among the insects.—The Editor.

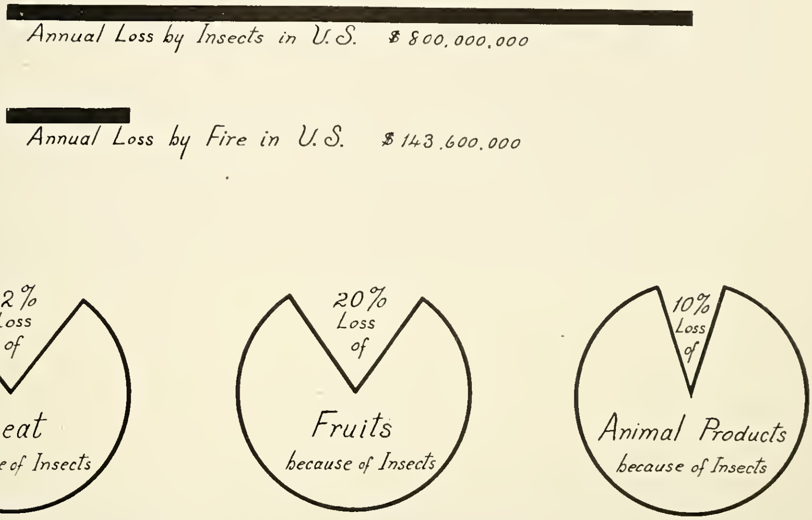
TIME was when the study of entomology was considered a trivial pursuit. Most of the people who took it up were collectors purely and simply. Descriptions of species which carried and established names were needed so that specimens might be labeled and catalogues prepared. While the pure collector's spirit—the spirit which reaches out after rare species to fill gaps—animated most of these men, there were others deeply interested in the strange lives of many species, in the infinite diversity of life-methods that exist among them, indicating to the minds of some, like dear old William Kirby, Rector of Barham, for example, "the glory, power, and wisdom of the Almighty."

A bean plant seriously injured by Mexican Bean Beetles that fed on its leaves

But the opinion of people in general on the subject of insects, and their opinion of the men who study them, have changed greatly these later years. It has become strikingly obvious that insects are collectively the most important enemies and rivals of humanity on earth. It has become perfectly plain that if human beings are to maintain their hold on this globe, if they are to continue to exist, they must learn to

Larvæ and adults of the Mexican Bean Beetle, an injurious relative of the beneficial Lady Beetles. It is now seriously abundant in parts of the United States control insects. So the entomologist has risen in our esteem. In him and the results of his work lie our hopes for the future comfort, happiness, and prosperity, and even the very existence of mankind.

Then, too, the entomologists themselves have changed. A new type has arisen among them. He is termed the



Diagrams indicating the great economic waste caused by a few injurious kinds of insects. The figures are, of course, based on estimates and they vary from year to year

economic entomologist, and he is devoting his life to the study of insects for the purpose of finding means of controlling their multiplication and spread and thus limiting or doing away with the enormous damage they are bringing about.

It is probably unnecessary to dwell at length upon this damage, but something about it must be said here. It has been estimated that the money loss from the work of insects in the United States exceeds two billions of dollars yearly. To put it in other words, *insects in this country nullify the expended labor of a million men.* They destroy, in their feeding, from one-tenth to one-fifth of all the crops planted. They carry and spread plant diseases which destroy an additional percentage of some of our crops. They damage stored food and other stored products. They transmit certain diseases of man, reducing his economic efficiency to the extent of hundreds of millions of dollars annually. They lessen the value of his cattle and of his other domestic animals by direct parasitism or by the carriage of disease; and in many other ways they are destructive to his interests.

Governments have begun to realize all this, and government services of trained men working on the many problems involved are springing up in all civilized countries. The United States and Great Britain with its numerous dominions and colonies have been the leaders, but France, Italy, Germany, Japan, and many other countries are also active in this way. The appropriations made by governments in support of the work have been growing rapidly, especially since 1900, and for the fiscal year ending June 30,

A mass of Japanese Beetles feeding on apples. Damage done to the leaves can also be seen here. This species (*Popillia japonica*) is related to our May Beetles and was first seen in this country ten years ago near Philadelphia, probably having been brought from Japan as eggs or young in the soil about the roots of shrubs

1926, our own Congress has given the Bureau of Entomology of the Department of Agriculture $2,500,000 to be expended in the study of insects in the effort to control crop pests.

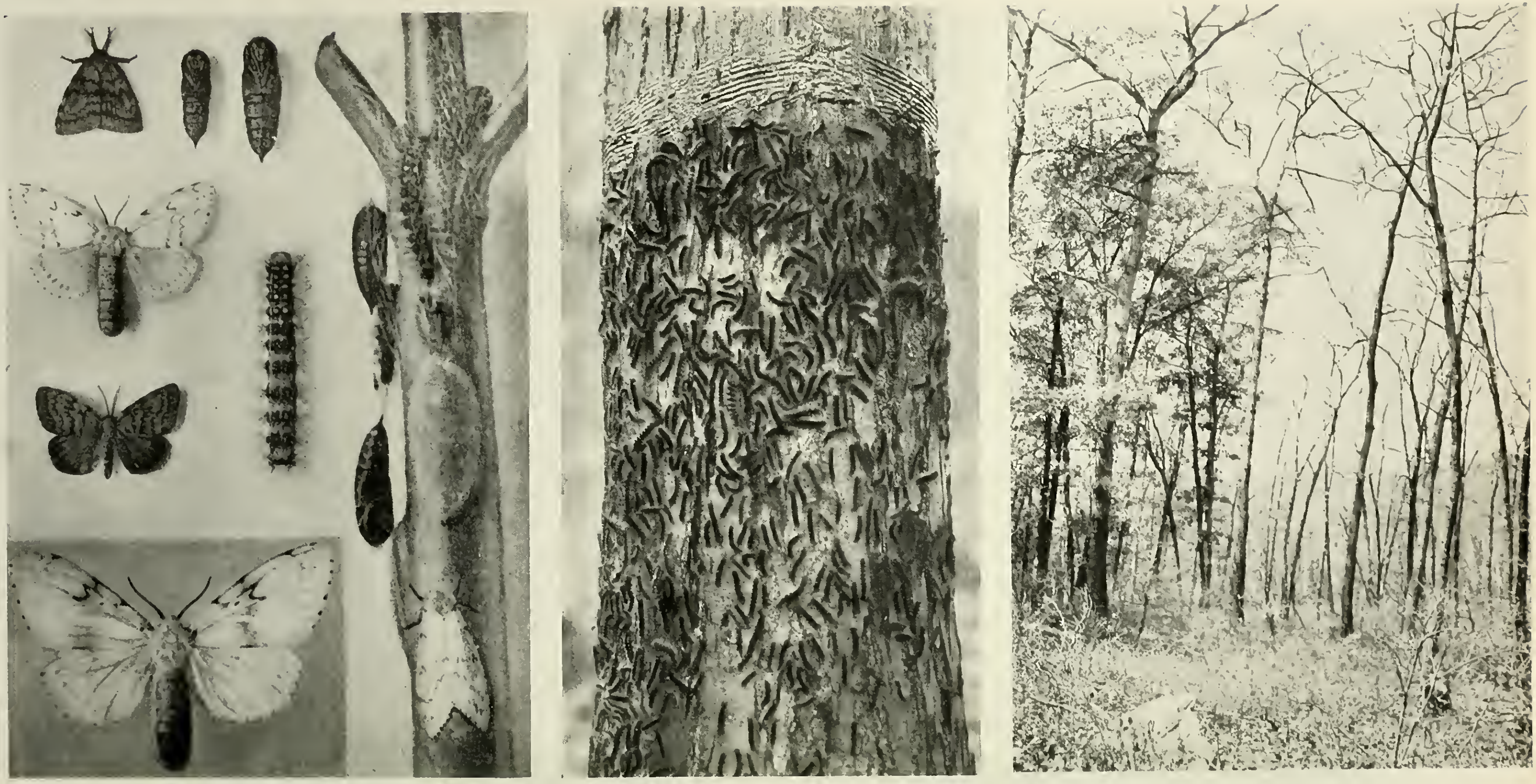
This is a very large sum, and would seem to the average man amply sufficient to finance all sorts of research. And it is true that with its aid an enormous amount of useful work is being done, and that during late years many successful means of control have been elaborated, demonstrated on a large scale, and given to the public.

But at the same time these large appropriations have been budgeted strictly. A large part of the money has been called forth by great emergencies, like the invasion of the cotton belt by the Boll Weevil; like the threatened disastrous spread of the Gipsy Moth, of the European Corn-borer, of the Japanese Beetle. In these cases and many others of scarcely less importance, such as the Mexican bean beetle, the alfalfa weevil, and the peach moth, the need for speedy relief has been very great and all possible efforts have been made to prevent spread and to find the quickest and cheapest way to kill enough of the pests to allow the agricultural industries involved to continue with profit.

An enlarged picture of a Japanese Beetle
It is naturally about half an inch long

A golf course at Riverton, New Jersey, near the center of the Japanese Beetle infection. The young of this insect live underground, feeding on the roots of grasses to such an extent that the sod can be "rolled up like a carpet"

Sod pulled aside, disclosing the young of the Japanese Beetle feeding at its roots



THE GYPSY MOTH

This species (*Porthetria dispar*) was introduced from Europe about 1868. Larvæ, pupæ, and adults are shown at the left, the male being smaller and much darker than the female. The middle picture shows a mass of larvæ trying to climb up a tree trunk but stopped by a band of sticky material. Of the trees on the right, those with leaves were protected by such bands; the others were not so protected and Gypsy Moth larvæ defoliated them

ORIENTAL FRUIT MOTH

This was discovered in the District of Columbia about 1913 and described as a new species, *Laspeyresia molesta*. It probably reached there from Asia in a shipment of Japanese flowering cherries, for it bores in the twigs of these trees. It also attacks plums and, as is shown on this page, peaches. It is related to the very destructive Codling Moth, an immigrant from Europe

This is all perfectly natural; it is all just as it should be, except that it is being impressed upon us more and more that we are not able to do other than *insects.* It is equally obvious that insects are our worst rivals and enemies, and that they are apparently better fitted for existence on the earth than

Corn injured by the European Corn-borer (*Pyrausta nubilis*), introduced into this country about fifteen years ago and now found in Canada and much of northeastern United States

superficial work upon the basic aspects of insect life. It is obvious that if we are to continue to support our increasing millions, we must eliminate waste. *And it is obvious that the greatest of all wastes is the appalling amount of labor and money that we use literally in feeding* are human beings. Therefore, successfully to fight them, we must know absolutely all about them.

Confronted with such a fight, it is pitiful how little we know about our worst enemies. We can catch them in traps; we know that we can poison them with certain chemicals; we know that in some cases we can vary our methods of cultivating crops so as to lessen insect damage; we know that in certain instances we can utilize the services of the insect enemies of injurious forms, and other things we have found out that we can successfully use.

But the vastly greater part of the work of the economic entomologist has not been basic, and it cannot be basic under present conditions. No government has ever made appropriations for basic studies, and such studies as are being conducted in the university laboratories and in the museums are being carried on in a more or less desultory way and the workers are necessarily isolated. The work of the economic entomologists who are employed by the general governments and by the different states has consisted, and must consist, largely of efforts to apply known facts to special problems. The emergencies confronting these men have been so great that they have had no time to conduct the long investigations that might give them other weapons than those nearest at hand. Their fight has been so strenuous that in a way they have lost their perspective.

It is true that they have done magnificent work. They have confronted many difficult situations with success notwithstanding their simple weapons. But the great basic principles which have brought about the conditions that they have been called upon to meet have not been considered by them in their haste for immediate relief measures. Their knowledge of the forms they are trying to fight is hardly more than superficial when we stop to realize what should really be known.

There is a crying need for funds adequately to endow prolonged and profound studies of many questions relating to insects. These creatures differ radically in most ways from any form of life of which we have anything like intimate knowledge. We have no definite information, for example, as to such simple things as the sight, the hearing, the senses of smell and of taste; we have no definite knowledge of what it is about certain plants or

The European Corn-borer: larva, pupa, male, and female

certain types of food that attracts insects; we know practically nothing about the problem of nutrition in the case of insects; we know almost nothing about the diseases of insects; neither have we any competent knowledge of the intricate phases of parasitism, nor of the exact effects of temperature or moisture. Neither are we able with absolute certainty to place all insects in their proper groupings and to know exactly the relationships that exist among them; and there are very many forms which as yet have not been described and named. This description and naming, this establishing of the relationships among the different forms, enabling the identification of a given species among its innumerable relatives, may seem unprofitable labor, but it is as essential as the machinery for the identification of the human

Larvæ of the Cotton-boll Weevil feeding inside of a boll which they have destroyed

malefactor in the criminal courts at law; and the taxonomic tables worked out by the close students are as useful and as important as the fingerprint records in such courts.

The elaborate studies that have been made of all of the physiological reactions of the human species and other warm-blooded animals must be made also of the insects if we are to begin to know them as they should be known and if we are ever to control them. How can such vitally necessary work be done?

One cannot blame a busy Congress, harassed by the insistent urge of the country's crying needs, absorbed in its efforts to respond to the most urgent, the most immediate of these needs, without compromising the financial position of the public treasury, if it fails to do more than try to meet situations as they exist at the present moment. There is no present hope, then, from government.

But there should be a permanent foundation for the study of the fundamentals of insect life, administered by the Smithsonian Institution possibly, or possibly in some other way. Such a foundation should organize a large group of the best-trained men, who should be charged with the careful study of every phase of insect life from the chromosome to the last reaction of the adult throughout the enormous range of variation that exists in this now almost mysterious insect complex.

From the work of such a group of men would come ultimately a wealth of knowledge that would enable civilized man to fight his worst enemies, *not half blindly as now, but with a perfect understanding of everything about them.*

An enlarged photograph of the Cotton-boll Weevil, a Mexican insect that has invaded southern United States

With such knowledge, the control of insects may possibly prove to be a comparatively simple thing. Without it, we are working more or less in the dark.

The Parima River near the terminus of the Rice Expedition. Photograph by Hamilton Rice

Insects and Man in Tropical America

IMPRESSIONS FORMED ON A JOURNEY TO THE RIVER AMAZON AS ENTOMOLOGIST OF THE THIRD HAMILTON RICE EXPEDITION

By J. BEQUAERT
Department of Tropical Medicine, Harvard Medical School

Theodore Roosevelt said, on his return from South America, that the most dangerous animals he met were insects. Doctor Bequaert is an international authority on these foes of man's health and vividly describes them here. However, as he shows, the case is far from hopeless and we may look forward to the day when "jungle peril" will be a thing of the past.
—The Editor.

DURING the summer of 1924, I was given the welcome opportunity of visiting the River Amazon, a region of unusual fascination to the naturalist. The party to which I was attached as entomologist was organized by the department of tropical medicine of the Harvard University Medical School, under the leadership of Dr. R. P. Strong. It was itself the medical branch of the Third Hamilton Rice Expedition to South America. It is characteristic of the rapid growth of medical entomology that nowadays no medical expedition to the tropics deems it feasible to dispense with the services of an entomologist. A brief narrative of my experiences in South America will, perhaps better than an academic disquisition, make it clear why so much importance is attached at present to the investigation of insects in their relation to health.

The main purpose of Doctor Rice's expedition was a geographical survey of the Uraricuera and Parima rivers, which form the western headwaters of the Rio Branco, on the borderland between Venezuela and Brazil. This objective was successfully reached by Doctor Rice in the early part of 1925, though not without much hardship and danger. Lack of time, however, prevented most of the medical party, including myself, from traveling beyond Caracaray, a small Brazilian settlement at the head of steam navigation on the Rio Branco.

On the evening of June 25, I sailed from New York on a steamer of the Booth Line, and early in the morning of July 11 sighted the coast of Brazil, at the mouth of the Pará River, where I joined the rest of the party. A modern liner on the high seas is probably the last spot an entomologist would choose as a promising field for research. Yet a little investigation of forecastle, hold, or pantry discloses the presence of many insects that either have elected the vessel as a permanent abode or travel as stowaways, having gained access accidentally in merchandise or supplies. I do not refer here to any of the few insects of unsavory reputation that insist upon claiming man as their closest friend. I wish rather to call attention to a multitude of stragglers of more independent habits: beetles whose grubs live in foodstuffs, in timber, or in raw materials; roaches that pilfer the provisions; ants that nest in hidden corners and make steady raids upon the pantry; flies that bite animals and man or whose maggots thrive in refuse; parasitic wasps that merely prey upon their neighbors; and many others. This assemblage of insects, highly artificial to be sure, nevertheless is unique in that its members are all domestic, having adapted their habits to those of man. They form a true entomological underworld, with all the cunning and endless ramifications the word implies.

Ever since the early Egyptians and Phœnicians raised shipbuilding and navigation to an art, insects of many kinds have traveled back and forth between the continents. The opening up of the route to India and the discovery of the Americas gave a tremendous impulse to these exchanges, which became still more frequent after steam navigation and railroads practically annihilated distances. Some insects have now become such thorough cosmopolites that their original home is as difficult to trace as the ancestry of the American Indian. The whole subject is of much interest to the biologist: it not only gives a clue to the present world-wide range of certain insects, but incidentally throws much light upon the problem of migration and upon the various ways in which animals become adapted to a new environment.

Moreover, insect tramps are of foremost importance to the sanitarian, since they are so often instrumental in the spread of epidemics. It is no longer necessary to dwell upon the transmission of plague by rat fleas and the rôle ships play in carrying this dreadful scourge into healthy territory. Perhaps it is not so clearly realized that the yellow-fever mosquito (*Aëdes ægypti*, or *Stegomyia fasciata*, as it is more commonly known by medical men) and the disease which it transmits owed their wide extension in tropical and subtropical regions to transportation by ships. From the fifteenth century to the present day yellow fever was one of the diseases most frequently afflicting those traveling by ship, so much so that it was familiarly known as "ship's fever" or "yellow jack." Everybody who has visited tropical harbors knows from experience that mosquitoes readily enter ships that are at a wharf or alongside lighters that come from the shore. But, while most of the species disappear soon after the vessel leaves port, living *Aëdes ægypti* may be carried great distances. Repeatedly they have been found alive in temperate harbors even on modern steamers coming from mosquito coasts. In the old days of sailing-ships, the damp, dark, and stuffy living quarters offered almost ideal conditions for the adult yellow-fever gnat. In addition, it could breed freely during the voyage in the storage tanks and casks, or in the rain collected in a sail, which were then the only sources of drinking water. Indeed, the transmission of yellow fever from port to port was clearly recognized long before the rôle of the mosquito became known. The slave ships were looked upon with particular suspicion and one well-meaning writer even stated that yellow fever was the price Europe paid for the slave trade. There can be little doubt that the yellow-fever mosquito was carried by ship from West Africa, probably its original home, to the Americas, where it is now found in the tropical and subtropical parts; along the Amazon and its affluents it has extended as far as steam navigation reaches. Since, once infected with yellow fever, *Aëdes ægypti* may transmit it to man for at least from fifty to sixty days thereafter, the rapid spread of the disease over a large territory is easily understood.

After a long ocean journey the approach to a new tropical coast has for the naturalist a charm of its own, compounded of a peculiar mixture of glad excitement over having reached a promised goal and of subdued anxiety before the mysteries of the unknown. Many subtle influences seemingly conspire to render it an experience not to be forgotten. My first acquaintance with Brazil was no exception to the rule. For some hours before we descried the coast, turbid waters, unwilling to lose their identity in the brine of the ocean, had heralded the river of the legendary Amazons. A soft, strangely scented land breeze greeted us long before the low shores began to show as dim specks at the horizon. With dawn we found ourselves entering the broad estuary of the Pará River and soon the first messengers from the tropical land came aboard: large hawk moths and elegant butterflies gracefully fluttered over the decks, and swift dragon flies rested for a while in the riggings. As the ship closed in on the shore, insect life became more obtrusive: soon the first horseflies were netted, while a good-sized, black *Ammophila* wasp caused some commotion by stinging one of the lady passengers without the slightest provocation. Thus, in various ways Nature warned us that we were about to enter the domain not of man but of the insect.

Soon the white towers of the cathedral of Belem do Pará (as the city of Pará should properly be called) appeared above an agglomeration of low houses. We passed an old, circular fort of red bricks, built upon a rock in midstream, and entered port. Eventually, after the tedious formalities of debarking, we were installed at a comfortable hotel. Here none of the windows were screened and no mosquito bars were provided in the rooms. We were confidently told that mosquitoes were unknown and, as a matter of fact, owing to the drought prevailing at the time, very few of them were in evidence. We devoted the next few days to the fauna and flora of the vicinity. Although we found much to interest us, the locality is no longer the naturalist's paradise described in such glowing terms by H. W. Bates. The reason is not far to seek. At Bates's time Pará had a population of less than 20,000 inhabitants, while today it has more than 200,000 and extends over a large area. On our very first walk we became acquainted with that minute, but extremely troublesome pest of the American tropics known as the red-bug or harvest mite, commonly called "chigger" in the

United States and "*mucuim*" in Brazil. These mites are the larval stages of certain species of *Trombicula*, the adults of which are much larger, velvety red, predaceous creatures. The red-bugs themselves are extremely minute, generally bright red, spider-like, six-legged creatures, just barely visible to the naked eye. They often occur in abundance on low vegetation, particularly in pastures, in certain cultivated fields, and in waste places covered with rank weeds. Here they await a chance to reach the body of some animal on which they suck blood for a time. When they find their way to man, they attack the skin, causing intolerable itching, followed by papules surrounded by red or violaceous spots. In certain persons who are particularly sensitive, the effects may be extremely serious. There is no evidence that the American red-bugs carry a specific disease, but a species in Japan, *Trombicula akamushi*, transmits the *tsutsugamushi*, or Japanese flood river fever, from a rodent to man.

Our stay at Pará was all too brief. Late in the evening of July 19 we embarked on a steamer of the Lloyd Brazileiro for Manáos. The next morning found us traveling through the *Furo*, or Narrows, of Breves, a series of winding channels, two hundred to three hundred fifty yards wide, which connect the estuary of the Pará and Tocantins with that of the Amazon. The low, muddy banks, periodically flooded by the tide, are densely covered with a maze of luxuriant vegetation, where the crude huts of the *caboclos*, or half-Indians, nestle between the delicate fronds of elegant *assahy* palms (*Euterpe*). The whole region is, however, very unhealthful and a hotbed of malarial fever, so that we were glad to leave it before sunset and to enter the southern branch of the Amazon delta.

For the next three days we feasted our eyes upon the glorious scenery of the mightiest river of the world and, in the cool, breezy evenings, enjoyed the magic of the brief tropical twilight. This monarch of rivers is so wide and deep and carries such a huge volume of water that, were it not for the speedy current, one might easily mistake it for an inland sea—the *Rio Mar* of the Portuguese. Although innumerable low, marshy islands generally obstruct the view of the main banks, there are many stretches of open water eight miles or more in width, where both shores are barely visible at the same time. When the ship followed the banks, we could study the vegetation at leisure. The immensity of the Amazonian forest is proverbial and somewhat appalling to the newcomer. Its dangers, imaginary and real,—the worst of which is perhaps famine—seem to produce a kind of mental paralysis upon the mind of the average explorer, who all too readily describes it, with Alberto Rangel, as a "green Inferno." Throughout the lowlands of Amazonia the vegetation is generally a rain forest perennially green. The most striking points of difference from temperate woods are the huge dimensions of many of the trees; the unchecked growth, most of the plants being evergreens and very few of the trees ever shedding all the leaves at once; the endless variety of the flora; the abundance of creepers, or lianas, and of epiphytes, or air plants; the predominance of certain strange trees, such as palms; and finally the almost total absence of grasses. In Amazonia, however, as elsewhere in the tropics, there are three quite distinct types of forest, each with its own interest for the naturalist and with its peculiar problems for the sanitarian.

Second growth, or secondary forest, is the type which the newcomer to Amazonia is most apt to meet first, and it unfortunately is the poorest of the three. It is found in the neighborhood of all towns and villages, where at one time or another the primeval forest was cleared away by man to make place for crops or to furnish firewood or timber. When such areas are permitted to return to the wild state, they are not at once reclaimed by the original virgin forest, but they rapidly develop a peculiar, artificial plant growth, where the trees are much less varied than in primary rain forest, never reaching large dimensions, while the undergrowth tends to become an impenetrable jungle. In Brazil such second-growth woods are usually marked by dense groves of trumpet trees or *imbaubas* (*Cecropia*), which shelter stinging ants in their hollow trunks. Favorable breeding places in profusion are here provided for hosts of mosquitoes, especially for malaria-carrying anophelines, in the stagnant, grass-grown rain puddles, in the swampy glades, in holes of decaying tree stumps, and similar places. During the day the insects hide in the dense weeds and in the evening migrate to the near-by human settlements. The "jungle" at the outskirts of towns is perhaps the most troublesome problem confronting anyone attempting to control the mosquito pest in the tropics. Too often the expense involved in eliminating all breeding places in the surrounding second growth is out of all proportion to the size of the town.

As one travels along tropical rivers, one has many opportunities of studying another type of rain forest, known to botanists as inundated forest. It covers all those stretches of alluvial, low country that are periodically flooded by the rising rivers or by the rains and that remain under water for weeks or months. In Amazonia such flooded forests generally go by the name of *igapó* or *gapó*, while the alluvial areas which they cover are called *varzeas*. The water-logged condition of the soil excludes most of the trees that grow in primary rain forest on high, dry ground. On the whole, the vegetation does not reach any considerable height; but, on the other hand, it grows quite close, and the numerous intertwining lianas and spiny creepers transform such growth into an almost impenetrable thicket. The unusual extent of *igapó* forest is one of the most striking peculiarities of the Amazon Basin. At the season of highest water, when the Amazon rises fifteen to forty feet above its lowest level, the whole alluvial valley forms, as it were, a major bed to the river, some fifteen to thirty miles wide, where the current flows swiftly between the very trunks of the trees. It is then possible for canoes to travel through the forest and pass across-country from one affluent to another. When the flood slowly subsides, it leaves behind many pools and even small lakes partly choked with floating plants. The stagnant water as well as the muddy shores form ideal breeding grounds for hordes of biting insects. Here originate myriads of winged pests that assail the traveler on the rivers or the venturesome camper on the shores: mosquitoes, or *carapanas*, some of which (*Psorophora*) bite during the day and are replaced at night by other kinds (*Mansonia*); sand flies, or *muruim*, particularly objectionable on account of their minute size, which facilitates their attacks, and their persistence at dusk and dawn; and horseflies, or *mutucas*, of many species. Even the most fastidious tourist, who merely gathers his impressions of Amazonia from a comfortable deck chair, does not fail to make the acquaintance of the little *mutuca* known as *cabo verde* (*Lepiselaga crassipes*). This pernicious insect is probably responsible for more bad language than any other of the multifarious pests of tropical America. It is about the size of a house fly, black with clear wing-tips, a sprinkling of bright green scales over head and thorax, and eyes curiously checkered in zigzag fashion with green, blackish purple, and bright violet blue. Its flight is so silent and it settles so cautiously that it generally takes its victim unawares. It always reminded me in this respect of the much-dreaded tsetse fly of African rivers. Sometimes the bite is hardly perceptible, but generally it feels like a sharp prick of a pin. The bitten spot swells to a large wheal and produces intense itching, which may last for a long time. Often a drop of blood trickles from the gash made in the skin by the sharp proboscis. It is fortunate that this fly does not carry the germ of any disease, at least so far as we know at present.

I regret to say that I cannot give a first-hand description of the third and most interesting type of Amazonian forest, namely, the virgin or primary rain forest of the upland, or what the Brazilians call *terra firma*. I had no occasion in Brazil to visit any point away from the rivers, where the forest had not been spoiled at one time or other by the destructive activity of man. From accounts by creditable and experienced observers, such as Ule and Le Cointe, I judge, however, that the characteristics of primeval Amazonian woods are not very different from those of tropical African forests, which I visited some years ago. The immense trees, like huge pillars of a lofty cathedral, rise from a hundred to a hundred fifty feet in height and support a dense canopy of foliage, through which the fierce rays of the tropical sun are filtered into myriad beams of subdued light. The undergrowth of small trees and bushes is rather scattered; and, as the floor of the forest bears but few and low herbaceous plants, it is not so very difficult to walk between the trees. The only serious obstacles that impede one's progress are the many fallen trees and partly decayed stumps. Moreover, if one dares to stray away from the beaten path, one is soon hopelessly lost in the seemingly uniform maze, unless one has acquired through long experience the Indian's astute sense of direction. An overawing silence generally reigns, and one meets but rarely with wild animals or even with birds. These higher forests are the most healthful part of the country and relatively free from insect pests. They harbor, however, the small *tatukira* midge (*Phlebotomus*), which infects man with the germs of cutaneous leishmaniasis, a grave skin-disease of the South American forests.

In spite of its many discomforts and dangers, there is much of real beauty in the equatorial forest. To me it is a source of perennial surprise that poets have so seldom been inspired by the glory of the tropics. The splendor of the "grandiose equatorial vegetation, as it sprouts from a soil drenched with storms and unfolds its evergreen foliage in the scorching light," would, it seems, suffice to fire the imagination. Let us hope that some future Byron will do it justice! Perhaps the very complexity of equatorial nature baffles the mind and hinders the flight of Pegasus, for nowhere is Goethe's saying more true that "one sees only what one knows."

That part of the river known as the Lower Amazon extends from the estuary to the confluence of the Rio Negro. It is a stretch some 1,100 miles long, navigable at all times for sea-going vessels. Thus the very center of Amazonia is placed in direct connection with all the ports of the world. The focus of Amazonian trade is Manáos, situated three degrees south of the equator, on the left bank of the Rio Negro, about six miles from the main Amazon. Although founded in 1669, it was still a small town of 5,000 inhabitants or less at the time Wallace and Bates visited it. Owing to the growth of the rubber trade, it has become during the last thirty years a city of considerable importance, and in 1914 the population was estimated as between 60,000 and 70,000. At present it is struggling through a period of decline, but its central location in one of the richest natural regions of the world vouchsafes its future prosperity. It is a typical tropical city, with many of the unsanitary conditions and not a few of the discomforts which one expects of such places. It is only fair to add that, through the efforts of some far-seeing citizens, there is promise of improvement even in matters of hygiene. Here as elsewhere, even in more enlightened communities, the chief struggle is against the apathy and ignorance of the mass of the population, who seemingly attach more importance to political squabbles than to the care of health.

A pool at Manáos that is well suited to the needs of mosquitoes. Photograph by Ralph Wheeler

I was not disappointed in my expectation of finding at Manáos much of interest in the entomological line, even though the original vegetation has been wantonly destroyed for many miles around the town. The region appears to offer an environment particularly favorable to mosquito life, for no less than thirty-two species of these insects are already known from the town and its immediate vicinity. Perhaps the most common of them is the yellow-fever mosquito (*Aëdes ægypti*), which I

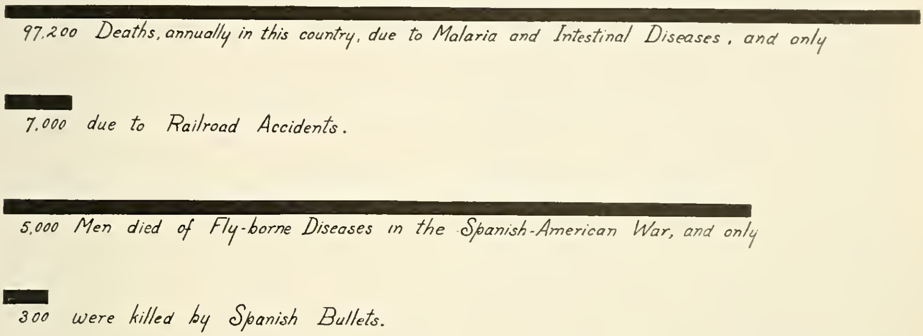
On an upper branch of the Rio Branco. Black flies breed here in countless numbers, their larvæ clinging to the stones in the swift rapids. Photograph by Hamilton Rice

found breeding in most of the freely exposed receptacles containing pure water, especially in tanks of drinking water. The five-banded mosquito (*Culex quinquefasciatus*) preferred dirtier water, but was hardly less abundant. Adult malaria mosquitoes, or anophelines, were rare, their development seemingly checked by the drought; but I found their larvæ in large numbers floating between the water plants that choke the creeks, or *igarapés*, dividing the various sections of the town. These creeks also harbored the remarkable larvæ of *Mansonia*, which, unlike those of most other mosquitoes, do not come to the surface to breathe, but attach themselves to the roots of floating vegetation, especially of water lettuce (*Pistia stratiotes*), cutting the bark of the root with their sharp air-tubes. The adults of most Mansoniæ are severe biters and those of *Mansonia titillans* fly considerable distances often entering houses of Manáos.

During the short trip on the lower Rio Negro and Rio Branco, we became acquainted with several insect pests not encountered before. One of these, which no member of the party is likely to forget, was the minute black fly locally known as *piúm* (*Simulium amazonicum*). It torments the traveler all day long, but especially in the morning and before dusk. H. W. Bates's account of its activities can hardly be improved upon:

We made acquaintance on this coast (viz. the southern shore of the Amazon, near the mouth of the Rio Negro) with a new insect pest, the *piúm*, a minute fly, two-thirds of a line in length, which here commences its reign, and continues henceforward as a terrible scourge along the upper river, or Solimoens, to the end of the navigation on the Amazons. It comes forth only by day, relieving the mosquito at sunrise with the greatest punctuality, and occurs only near the muddy shores of the stream, not one ever being found in the shade of the forest. In places where it is abundant, it accompanies canoes in such dense swarms as to resemble thin clouds of smoke. It made its appearance in this way the first day after we crossed the river. Before I was aware of the presence of flies, I felt a slight itching on my neck, wrist, and ankles, and on looking for the cause saw a number of tiny objects having number of discolored punctures that are crowded together. The irritation they produce is more acutely felt by some persons than others. I once traveled with a middle-aged Portuguese, who was laid up for three weeks from the attacks of *piúm*, his legs being swollen to an enormous size, and the punctures aggravated into spreading sores.

I have by no means exhausted the list of the insects of medical importance which I observed during my short trip to the Amazon. Enough has been said,



The importance of insects as shown by their effect upon human life. The figures are, of course, only approximate. From an exhibit in the Hall of Insect Life, American Museum

a disgusting resemblance to lice, adhering to the skin. This was my introduction to the much-talked-of *piúm*. On close examination they are seen to be minute two-winged insects, with dark-colored body and pale legs and wings, the latter closed lengthwise over the back. They alight imperceptibly, and squatting close, fall at once to work, stretching forward their long front legs, which are in constant motion and seem to act as feelers, and then applying their short, broad snouts to the skin. Their abdomens soon become distended and red with blood, and then, their thirst satisfied, they slowly move off, sometimes so stupefied with their potations that they can scarcely fly. No pain is felt whilst they are at work, but they each leave a small circular raised spot on the skin and a disagreeable irritation. The latter may be avoided in great measure by pressing out the blood which remains in the spot; but this is a troublesome task, when one has several hundred punctures in the course of a day. . . In the course of a few days the red spots dry up, and the skin in time becomes blackened with the endless however, to make it quite clear that the complete control of insect pests in the tropics is a truly Herculean task. Perhaps the reader may even have gathered the impression that the fight is too formidable for the puny efforts of mankind. Yet the findings of entomologists have already paved the way for the ultimate victory, as I purpose to show by two examples taken from the history of yellow fever and malaria.

The conquest of yellow fever and its far-reaching results in opening up the tropics would be a fit subject for an epic. For two hundred years at least this dreaded disease had caused great loss of life and much destruction of wealth. Perhaps the deadliest epidemic that ever visited the United States was that of yellow fever in 1878, when in the Mississippi Valley alone more than thirteen thousand people lost their lives. The Spanish-American War finally focussed attention upon the need of eliminating this disease. At the time it was believed that no newcomer to Cuba could escape it. During the early years of the American occupation of the

> Shake, from the deep foundations of the world,
> Th'imprisoned plagues; a secret venom oft
> Corrupts the air, the water, and the land.

It is true that ever since 1881 Dr. Carlos Finlay had contended, from epidemiological evidence, that a mosquito conveyed the disease, and that he had

Yellow fever is steadily retreating before the attacks of entomologists as is shown by the blackened areas on these maps. Courtesy of the Rockefeller Foundation

island, all efforts to combat it were in vain, simply because the relation between the disease and a certain mosquito was unknown. At Havana, in 1900, there were a greater number of cases than there had been for several years. At the dawn of the century exact knowledge of yellow fever was not much more advanced than when Armstrong wrote:

> And though the putrid south
> Be shut; though no convulsive agony

even positively incriminated the true culprit, *Aëdes ægypti*. But too little was known at that time of insects as potential carriers of germs for Finlay's arguments to make much impression upon the physician. In 1877 Patrick Manson had shown that a worm, *Filaria bancrofti*, which lives in the human body, develops in the common five-banded mosquito of the tropics (*Culex quinquefasciatus*). So novel was this discovery that even eminent parasitologists received it with scepticism. It was not until 1898, when Ronald Ross, in India, and Grassi, in Italy, demonstrated that malaria is invariably carried by anopheline mosquitoes, that the medical world was inclined to approach the problem of yellow fever with a more open mind. At Havana, in 1900, an American Commission, headed by Dr. Walter Reed, succeeded in transmitting the disease from a sick to a healthy person by the bite of gnats, *Aëdes ægypti*, raised from eggs. In the course of the experiments several other important facts were discovered. These, together with a knowledge of the habits of the mosquito, made it possible to devise effective measures of control. Within a few months yellow fever was eliminated from Havana where it had existed continuously since 1762, and where even in 1900 it caused 310 deaths. The last case of the year 1901 occurred in September. Fifteen years later Colonel Gorgas was able to write that "with one exception there has been no case of this disease in Havana since that date." Nowadays Havana is a

The yellow fever mosquito. From an enlarged model in the American Museum

much-vaunted winter resort, while only twenty-five years ago even a brief stay in the city was regarded as almost certain death to the outsider.[1]

[1]The fascinating story of the conquest of yellow fever may be read in Rubert Boyce's *Yellow Fever and its Prevention* (New York, E. P. Dutton and Company, 1911.)

A glance at the interesting map recently published by the Rockefeller Foundation (p. 142) clearly indicates how a knowledge of the mosquito and its ways is rapidly driving yellow fever from the face of the earth. Formerly this disease was more or less endemic

Mr. Koch-Grünberg, a member of the Rice Expedition, who died of malaria, following a mosquito's bite. Photograph by Hamilton Rice

along the Amazon: in 1906 it killed 253 persons at Pará; from 1893 to 1903 there were 142 deaths from yellow fever at Manáos and the number increased to 1386 during the brief period between 1905 and 1913. Means of controlling the transmission of the disease by the mosquito were then applied, with the result that only one fatal case has occurred since at Manáos. At the time of our visit yellow fever was utterly absent from the Amazon Basin, although its carrier, *Aëdes ægypti*, was extremely abundant in all settlements and on board ship.

Malaria-ridden Vista Alegre. In the foreground is the expedition's launch, named for Mrs. Rice. Photograph by Hamilton Rice

With yellow fever so successfully eliminated, malaria is at present the foremost sanitary problem of Amazonia. The ravages of this disease are not so spectacular as those of yellow fever, yet they are perhaps much more important social and economic factors. A very large proportion of the population along the Amazon and its affluents may be said to be more or less chronically infected, which goes far to explain the prevalent lack of ambition and the physical and mental weakness of the people. Although with length of time the adult natives acquire a certain degree of immunity, they still pay a heavy death toll to paludal fevers. According to Dr. Alfredo da Matta, the eminent physician of Manáos, in that city between the years 1895 and 1914 no less than 12,209 deaths were due to either acute or chronic malaria, accounting for more than 34 per cent of the total death rate. Still, Manáos, Pará, and some of the larger towns along the Amazon may be regarded as relatively salubrious, as much work in sanitation and prophylaxis is carried on, while doctors and hospitals are available for the treatment of cases. Conditions are much worse in the smaller settlements, and in certain areas along the Rio Branco malaria of the most dangerous type is rife. Brazilian as well as foreign observers all come to the conclusion that it is the cause of much poverty and misery and one of the chief reasons for the country's economic stagnation.

Investigation has shown that three factors are needed for the spreading of paludal fevers: man, the malarial germ, and an anopheline mosquito. Malaria is due to a microscopic germ developing in the blood. In order to infect another human being, the germ must pass through an anopheline mosquito, where it undergoes a definite cycle of development. Eventually it produces a form, which, upon being injected into the blood by the bite of the gnat, again causes fever in man. If any one of the three links of the chain be broken, the disease is unable to

A typical scene in a tropical city that has not yet adopted good sanitation. Photograph by James P. Chapin

propagate and soon dies out. This is the basic idea underlying all attempts at controlling malaria. A healthy community may, for instance, keep out paludal fevers, even when anophelines are present, by excluding all infected outsiders or by isolating them in screened rooms until they are cured. Sometimes it is possible to extirpate malaria from an infected locality by isolating and curing all cases, thus preventing the mosquitoes from acquiring the germ. In practice, however, it has been found that it is difficult completely to eliminate all human carriers of malarial germs or to prevent anophelines from becoming infected. As a matter of personal safety in malarious countries one should live in mosquito-proof houses and sleep under a properly adjusted mosquito bar,—the *conopeum* of the Romans; the judicious use of preventive quinine may also be helpful. Sanitarians are now fairly well agreed that in order to eradicate malaria a relentless and intelligent war must be waged against the mosquito carrier.

Undoubtedly in certain regions anophelines are present, while malaria is unknown, because the disease either was never introduced or it disappeared for some reason or other. On the other hand, we may feel quite satisfied that, where anophelines are absent, paludal fevers are not only unknown but are unable to attack the inhabitants even when cases of the disease are introduced from malarious areas. To fight

"From the frying pan into the fire": the moat protects the tree from leaf-cutting ants but breeds mosquitoes. Photograph by James P. Chapin the anophelines with any chance of success, a thorough knowledge of their habits is a prerequisite. The eggs are laid singly at the surface of the water, where they float for a time before hatching. The larvæ are aquatic, as are those of non-malarial mosquitoes, but, unlike these, they lie horizontally at the surface of the water. The pupæ also live in the water. Both larvæ and pupæ are able to move about and to dive, but they cannot stay any length of time below the surface without drowning. It is in the larval and pupal stages that mosquitoes are most vulnerable, so that the main efforts of the sanitarian must be directed against the breeding places.

The bearings of malaria and other insect-borne diseases on human culture and progress are undeniable. Some years ago, Sir Ronald Ross, while traveling in Greece, was forcibly impressed by the prevalence of paludal fevers in what was at one time the cradle of Western civilization. He argued that the valleys of Greece in the time of the Persian wars could not possibly have been as malarious as they are now. The disease, he supposed, entered the country about 500 B.C. or later, by the introduction of *Anopheles maculipennis* or of infected soldiers or slaves from Asia. It then crept slowly up the valleys, destroying the rural prosperity, without which the subsequent decline of the country was but a matter of time.[2] I am well aware that the argument will hardly appeal to the average historian, especially if he be imbued with what may perhaps be called the "race complex." Yet much might be said to support the biologist's view that there is "no reason to suppose that the Roman and the *Megatherium* were not struck down by similar causes" (Ross).

Moreover, whatever lessons the past might have to teach us, the chief interest of mankind centers in the future. The time is at hand when the most progressive races of mankind will be driven by dire necessity to the virgin fields of endeavor in the tropics. We are far beyond the stage in which mere courage and physical strength fulfill the requirements of success in tropical enterprise. The tropics and their riches will ultimately belong to those peoples who skilfully apply the multiple resources of human knowledge. To insure a healthy, productive, and contented life will be the first problem to solve. It is therefore safe to predict that entomology will have an ever-increasing share in the settlement of equatorial regions. When one reflects upon the present importance of the study of insects in the realm of theoretical as well as of practical science, it is hard to believe that twenty-five years ago entomology was the neglected stepchild of biology. But, like Cinderella, she has come into her own and begins to receive the homage even of those who formerly snubbed her. However, her true triumphs are yet to come in the tropics, where the struggle between insect and man assumes a fierceness not dreamt of by dwellers in temperate climes.

[2]The historical foundation for Ross's theory may be found in W. H. S. Jones's *Malaria, A Neglected Factor in the History of Greece and Rome* (1907) and *Malaria and Greek History* (1909.)

The Friendly Insects[1]

By FRANK E. LUTZ

It is quite natural that the "average man," whatever that means, thinks that insects in general are pests. The only insects which he notices closely are those that force themselves into his field of thought by attacking his prized possessions or even his more intimate person. It was for this reason that the Persians considered Beelzebub, the "Prince of Insects," to be a devil, and today "bug" means something that does not accord with our notions of what ought to be, whether it is a man who differs from us in opinions and hobbies or a flat, brown creature that lives in some people's beds.

Without doubt there are insects which, so far as man is concerned, are now unmitigated nuisances. In former times, however, even some of the most loathesome of these were made use of. In the days of Dioscorides "nine bed-bugs enclosed in a bean" cured fever and Pliny said that a hen which had eaten one bed-bug would be immune for twenty-four hours to the bite of an adder—a sort of a prototype of "an apple a day keeps the doctor away"—but in these enlightened days we take quinine for fever and we have found simpler methods of raising chickens.

However, there are more than half a million different kinds of insects and the wholesale condemnation of the class has been based on sad experiences with one or two hundred. Is that fair? And might it not be well to wonder whether in the remaining hundreds of thousands we have friends as helpful as the few which we are forced to notice are powerful foes? Also, are there neutrals?

There is almost no mammal, bird, fish, or any other back-boned animal, including man, that does not live at the expense of other living things, plant or animal. Live by killing or injuring is the rule of "higher" animals. If most insects follow the same rule, is that to their discredit? But there is an interesting thing about the food of insects: a given species is quite likely to have a very limited menu. A rabbit will nibble any plant that is not actually distasteful or difficult to chew and a cat will eat any kind of bird that it can catch or of mice or of fish or even of grasshoppers, but it is somewhat exceptional to find a species of insect that feeds on anything but closely related plants, if it be a plant-feeder, or on anything but closely related animals, if it lives on meat. Indeed, some species of plant-feeding insects confine their attention exclusively to a single species of plant and a similar limited taste is possessed by many meat-eaters.

Man, either because of his inherent egotism or for some other reason, thinks that the world—and, indeed, the whole universe—exists solely for him. At the same time, there are many kinds of plants for which he has no particular use and the thousands of kinds of insects which feed on nothing but these cannot logically be considered as injurious to him.

Then there are the weeds. "Weed" has been defined as "a plant out of place" and man has usually done the

[1]One of the American Museum's radio broadcasts.

misplacing, accidentally carrying in his commerce the seeds from one country, where the plant is controlled by natural conditions, to another favoring its immoderate spread. Man does not like weeds and should be grateful to the hundreds of different kinds of insects that feed on these unwanted plants.

But what about the insects that feed on the plants that man does want? It must be admitted that there are such "undesirables." I do not know how many undesirable people there are per thousand in an average community—not really criminal but undesirable. Are ten in every thousand, one per cent, poor citizens? Well, there are about 15,000 different kinds of insects in the general vicinity of New York City and less than one per cent of these can be said to be even moderately injurious to either man's purse or his person; somewhat less than "half of one per cent" are, however, decidedly injurious, so injurious that man must fight them vigorously.

Where did these three or four dozen different kinds of insects that threaten our very existence come from? Almost every one is a "weed," a creature that is out of place because man has brought it in his commerce from some other country to this one: gypsy moth, Japanese beetle, European corn borer, Hessian fly, San José scale, and so on, to say nothing of the domestic roaches, house-flies, bed-bugs, and the like.

The gypsy moth is only moderately destructive in its native Europe and the Japanese beetle does no more harm in Japan than do many of our closely related "June beetles" here. Why should the foreigners multiply so mightily in the United States? Without showing how one factor after another cannot explain the phenomenon, we may come immediately to the point that, when man introduced these insects, he failed to introduce other insects which preyed upon and kept them in check in their native homes.

De Morgan (Swift wrote nearly the same thing) was speaking in the direction of the truth when he said:

> Great fleas have little fleas upon their back to bite 'em.
> And little fleas have lesser fleas and so *ad infinitium.*
> And the great fleas themselves, in turn, have greater fleas to go on;
> While these again have greater still, and greater still, and so on.

Literally thousands — how many thousands we do not yet know—of different kinds of tiny insects obtain their entire food by eating and killing other insects. Very few birds live exclusively on other birds; very few fish live exclusively on other fish; but relatively few meat-eating insects feed on anything except other insects. On the other hand, there are few, if any, plant-feeding insects that do not suffer from the attacks of these parasites or predators. That is the reason that our native plant-feeders are rarely seriously injurious and then not for long; there is a "balance of nature" when man does not upset it. This balance may swing back and forth, as in the case of the Tent Caterpillar, but it is there.

Now, when man's commerce brings a plant-feeding insect to this country from its native land, the insects which preyed upon and kept it in check there are left behind. The plant-feeder finds itself in a land of plenty free from any effective enemy. No wonder that it multiplies if the climate and food are at all suitable. What is man to do about it? Man upset the balance of nature; let him try to restore it by importing the particular kinds of insects friends that, all unobserved by him, were fighting his battle for him in the country from which the pest came. This is not always easy to do, since the parasite, despite what De Morgan and Swift thought, frequently has no insect parasites from which it is

Leaf-feeding caterpiliars bearing on their backs the cocoons of the parasitic wasps that keep them in check. From the film "Winning the Insect-life Merit-badge"

relieved when brought here, and so it has all the disadvantages of meeting a new environment without leaving the compensating advantage of unusual freedom. If, as sometimes happens, these "little fleas have lesser fleas," it is to our interest to find this out and carefully avoid bringing our friends' enemies here.

Our Government has been doing just these things and with marked success. The work should be heartily supported but the reason for mentioning it here is to emphasize the fact that we owe our lives to thousands of kinds of insects that are in our gardens, our meadows, and our woods,—to thousands of friendly insects that are keeping our native plant-eaters from multiplying to such an extent that our country would become a barren waste unable to support either beast or man.

Then, there is another thing. Suppose a body of men were to say to the rest of us that they would make it possible for us to have delicious fruits and beautiful flowers but in return their relatives would take, say, twenty per cent of the fruits and flowers they make possible. Suppose we could not get fruits and flowers in any other way. Would we consider that body of men or even their relatives unfriendly because of the twenty per cent commission? Scarcely, although we might try to beat the bargain as to the relatives. Insects are doing and since the Garden of Eden have been doing just that. (I hadn't thought of it before, but Man's downfall can be traced to insects, for there would have been no apple for

An exhibit in the American Museum showing a bumble-bee on an apple blossom. The bees go to the blossoms to get food for themselves, but in doing so they unwittingly transfer pollen that makes it possible for fruit to follow the blossom

Eve had not some insect carried pollen from another blossom to the one which by reason of that pollen developed into the fatal apple.)

Of course, it would be silly to say that, if insects had never been, we would have neither fruits nor beautiful flowers. We do not and cannot know what other resources Nature might have employed. We do know, however, that for most plants it is well—and for many plants necessary—to have pollen (the plants' male element) brought from some other flower than the one which furnishes the female element (the germ from which, after pollenation, the seed developes). This is particularly true of the flowers which by reason of their showy petals appeal to our sense of beauty, including those which develop luscious fruits. Insects deprive man of about twenty per cent. of his apple crop—in some districts even more—but man would have no apples at all were it not for the many kinds of bees, as well as the butterfliesand other insects, that transfer pollen as they pass from blossom to blossom.

And, then, we must thank insects for our birds, some as beautiful as flowers and with the added charm of song. Small-headed sunflowers in blossom add striking color to my yard and are vibrant with bees and butterflies. The activities of these insects transfer the pollen that insures a good "set" of seed. Then the petals droop, the seed matures and my small sunflower plants blossom anew, but this time into gold-finches feasting merrily on the seeds which they owe to insects. To be sure, grasses and other inconspicuous flowers are pollinated by wind, but this would be a dreary world with grasses as our chief flowers and without the many birds, more beautiful than vultures, that get a large part of their food either directly or indirectly from insects.

How then does the account between insects and man stand in this world over which he strives to have dominion? With respect to most insects, decidedly in their favor, for either they are living their own most interesting lives without any appreciable effect on man's or they are doing him friendly service of vital importance. A very few insects are causing an immense amount of damage, this damage being done chiefly by species which he has introduced into countries where the particular sorts of friendly insects that prey upon them do not exist. Furthermore, many of the native insects now doing little harm are potentially just as injurious and will "break out" if anything happens to decrease materially the numbers of the friendly insects that are keeping them in check.

Enjoying an apple that was made possible by an insect pollenating the blossom. From the film "Winning the Insect-life Merit-badge"

Man now has apparent dominion over the earth but his dominion is being seriously contested by six-footed animals, a class of creatures that were here long before there was a man or any other hairy vertebrate and that, unless man learns more about them, may cause his destruction. In this battle for life which he is waging, it is a poor policy to study only the enemies and then only those that are most active. We need to know more about our potential but not yet active enemies and much more about our friends among the insects. This is one of the reasons that the American Museum of Natural History started and is conducting (in, as yet, a very small way) its Station for the Study of Insects where living insects may be closely observed in their natural environment.

The Color Dust of the Butterfly

By VERNON KELLOGG
Permanent Secretary and Chairman of the Division of Educational Relations, National Research Council

DOCTOR KELLOGG tells us here what it is that makes the "flowers of the air" so beautiful and points out ways in which a butterfly may benefit by the scales that cover its wings. There is some difference of opinion as to these benefits but the statements made by Doctor Kellogg, which are based primarily on his own personal studies, express the view most generally held.
—THE EDITOR.

WE call the moths that flutter about the lamps in the evening "millers" because they are covered with "flour." But the dull-colored Miller Moths are not the only moths that are flour- or dust-covered; all of their near relatives, the Hawk Moths which hover, hummingbird-like, at twilight over the honeysuckles and petunias, the great cecropias and beautiful lunas ("pale empress of the night") and all the butterflies, white and yellow, blue and red and vari-colored, are covered with a fine flour which rubs off at slightest touch and sparkles on one's fingers, in the sunlight, like diamond dust. This dust of the butterfly is its gold and silver and gems, its silk and satin gown, for all of the beautiful colors and bizarre and delicate patterns of the butterflies' wings are made by it; the ever-changing, metallic reflections of the great blue-green Brazilian Morphos and of our own little Blues and Coppers which dance about the wet spots of the roadways; the rich red-brown of the Monarch and Viceroy, the black and yellow eye-spots of the Satyrs, the silver patches on the hind wings of the Fritillaries, and the tiger bands of the Swallowtails—all are made by the butterfly dust. But so minute are the particles of the dust that to see what they look like as separate bits we must turn to our microscope for aid.

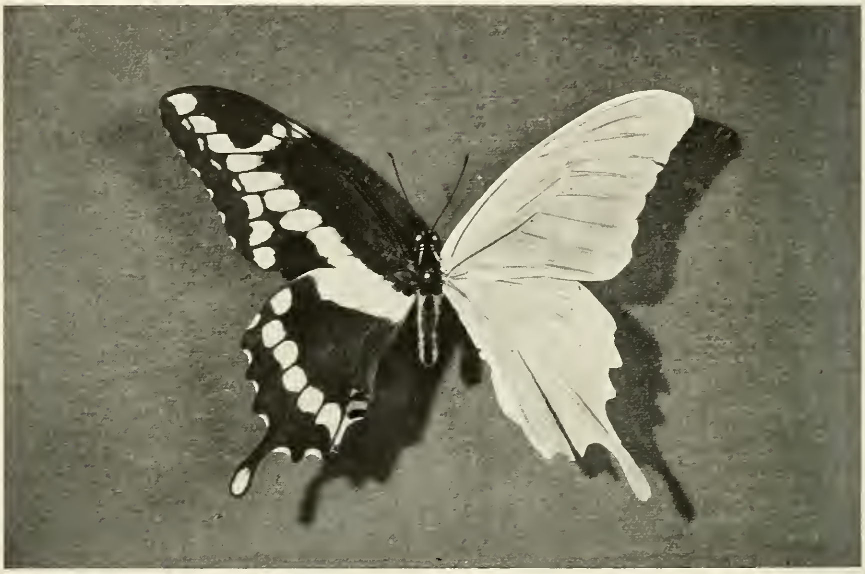
If we rub a little of the dust from the wings of a common white Cabbage Butterfly on a glass slide, and then look at it through the microscope, what a revealing of delicacy of structure and symmetry of outline! And how varied the forms which this butterfly dust presents! While some of the particles are short and broad, others are slender and long; some have smooth, even margins and some have little teeth or points ranged along one edge. Careful looking, however, will pretty soon show us that, despite the apparent variety and difference of shape and appearance, there are certain important points of resemblance and uniformity among the particles.

First, all are of a character which may best be described as scale-like; they are truly little scales. They are flattened, and usually longer than broad, and have at one end a minute projecting stem or pedicel, while the opposite end is usually the broadest part of the scale. Each scale is thus composed of an expanded blade and a narrower stem. We see, also, that the surface of the blade part is crossed from stem end to opposite margin by many extremely fine parallel lines, or striæ; these lines are really little alternate ridges and grooves running along the surface of the scale. The margin opposite the stem end of the scale is either even or from it project the pointed teeth, short or long, few or many, already spoken of. The side margins of the scale are never toothed but always run in straight or curving lines back to the stem. In length the scales vary from $\frac{1}{350}$ to $\frac{1}{30}$ of an inch, the average length being abuot $\frac{1}{100}$ of an inch. If we cut across one of these scales and examine the cut surface, we discover that each scale is a tiny flattened sac with the narrow space between its lower and its upper wall filled with granules of coloring matter, or sometimes simply with air.

Thus this more careful examination of the butterfly's dust shows that it is composed of a host of minute flattened sacs or scales which are all formed on one general plan, although the first glance through the microscope revealed an apparently confused variety of objects.

The scales on the microscope slide lie in miscellaneous array due to the violence of our handling; on the wings, however, they are bestowed with beautiful regularity of arrangement. If we examine under the microscope a small bit of wing from which all the scales have been rubbed off, we see that the wing surface is crossed by regular rows of little pits or pockets. Into these tiny pits the short stems or pedicels of the scales fit, the scales thus

Scales from a moth's wing, showing gradations between a simple, hairlike structure and a broad, pronged one. Very greatly magnified being regularly arranged in rows running transversely across the wing, i.e., from front to hind margin, all with their stem ends pointing toward the base of the wing (that part nearest the body). And if we examine now a bit of wing with scales on it, undisturbed, we see that the transverse rows of scales are so near together that the ends of the scales of one row overlap the bases of the scales in the next row in front and, besides that, in each row the scales are set so thickly that they overlap each other laterally. By this doubly overlapping arrangement there is formed a complete sheathing or shingling of the scales over the wing surfaces.



A butterfly which has had the scales removed from its right wing, leaving that wing colorless

The number of scales on a butterfly's wing is enormous. For example, on the wings of one of the large blue Morphos from Brazil there are 165 rows of scales, with 600 scales in each row, on every square inch of wing surface. This makes 99,000 scales to the square inch. As the under surface of the wing is covered by scales as well as the upper surface and as the upper and under surfaces, combined, of the fore and hind wings have an area of about fifteen square inches, the total number of scales on the wings of a Morpho is approximately 1,500,000.

What is the use of the scales? For one of the first questions that the student of natural history asks in his study of any part or organ of an animal's body is, what is the use or function of this part? The answer to this question in the case of the scales is, I believe, this: they have two principal functions, namely, to strengthen and protect the delicate wing membrane, and to produce the varied colors and markings of the wings. In addition, some of the scales have other uses to which I shall refer later.

The wings of insects must sustain the burden of the insect's body in flight, and must be strong enough not to break or fold when they strike the air the powerful blows necessary for swift sustained flight. The wings of a butterfly are composed of two thin transparent membranes (an upper and a lower) which are stretched over and supported by a few strong ribs or veins. The veins run from the base of the wing to the outer margin, spreading apart and becoming thinner and weaker as they approach the margin of the wing. These veins can be readily seen if one rubs off most of the scales from the upper and lower sides of the wing. Now, in the wings of most insect kinds there are many short cross veins which connect the longitudinal veins and make the wing skeleton stronger. But in the butterfly and moth wings there are but one or two of these cross veins. The strengthening of the wing membranes is accomplished by the firm continuous sheath of overlapping scales. When the wing beats against the air, the resistance of the air tends to bend the wing at right angles to its length. It is evident that the arrangement of the scales, with long axes at right angles to the direction of the strain, and with the broad tips of one row overlying the narrow stem ends of the row in front, is the best possible for this strengthening purpose. Each scale is also made strong by the fine parallel ridges, or striæ, which run across it in a direction at right angles with that of the strain. The covering of scales also protects, in some measure, the delicate wing membranes from injury, especially from raindrops.

The second and undoubtedly a more important function of the scales, however, is that of producing the varied colors and patterns of the wings. This function may, at first thought, seem to be of little real use or advantage to the butterfly. But many naturalists believe that most of the striking colors and markings displayed by insects, as well as by other animals and by flowers, are of direct help and use to the animal or plant in its life. The butterflies are preyed on by many insect-eating birds and lizards, and any means which will help them to elude their pursuers will be of direct

From an enlarged model of a Cabbage Butterfly's wing on exhibition in the American Museum. Note the regular arrangement of the scales

advantage to them. Keen sight and hearing and smell, and swift flight, should be advantageous. And if the butterflies could be colored and marked in such a way as to cause them to be difficult to distinguish from the leaves or flowers or the ground upon which they customarily alight, so that they would often be overlooked by their enemies, that should also be an advantage.

Now it is evident that just this condition of things obtains in many cases. The Graptas, or Hop Merchants, which appear in the fall, with their brown and ragged-edged wings, flutter about like dead leaves driven in the wind; and many of the Pierids have the under sides of the wings colored yellowish-green, so that when sitting, with wings closed above the back, on some green-leaved yellow-flowered growth like the mustard, they can hardly be distinguished from the plant.

On the other hand, it may be advantageous for the butterfly to be conspicuous and unmistakably recognized. For example, the common large red-brown Monarch is not liked by birds; it has a bad-tasting acrid juice in its body, and flies about without any attempt at concealment, apparently immune from attack. Its vivid color makes it easily recognizable to any bird and, after a few trials of the ill-tasting morsels, birds let the big, red-brown butterflies severely alone. But there is another butterfly, known as the Viceroy, which is not ill-tasting and would be a choice morsel for any bird that might catch it. But it, too, is let alone by the birds. Why? Because it mimics the Monarch! Its colors and patterns are almost exactly the same as those of the Monarch, and the birds mistake it for this ill-tasting species.

But we must return to the butterfly dust on which depend all this color and pattern that may be of so much importance in the life of the butterfly. How are the color and pattern actually produced?

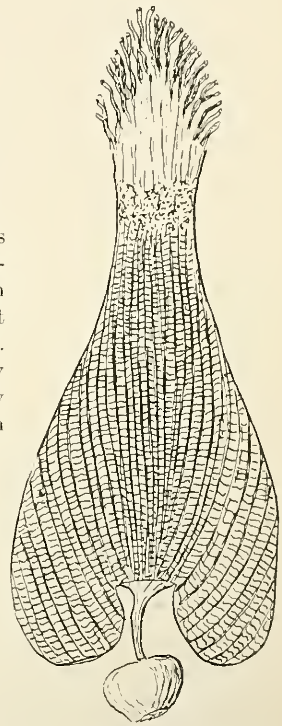
As we have already learned, each tiny scale, usually less than one-hundredth of an inch long, is really a flattened sac, whose two opposite walls do not quite touch. The narrow inner space between the walls in some scales is empty, in others it is more or less nearly filled with fine colored particles, pigment granules. The color of the scales possessing pigment is that of the pigment, because the thin membrane walls of the scale are always transparent. Thus, if all the scales on a butterfly's wing contain brown pigment grains, then the wing itself will be colored solid brown. But very rarely do we find a butterfly's wing entirely of one color. And so we find on a single wing scales similar in shape and size but containing differently colored pigments.

Scales produce color in still another way. Everyone has seen butterflies with wings whose colors are iridescent or metallic, changing in tint as one views them from different angles. The common little Lycænas, the Blues that dance about springs and wells or wet spots in the roads, have colors of this kind. Now, if one rubs some of the scales from a wing which has these iridescent bluish colors and puts them on a glass slide under a microscope, allowing the light to shine through them from the mirror below (examination by transmitted light), one will find, on looking through the microscope, that these scales are not blue at all but either contain brownish pigment or are entirely empty and transparent! If, however, we put something dark under the glass slide, allowing no light to pass through the scales (examination by reflected light), they will again show their metallic changeable blue tint. Indeed, it is not necessary to examine the scales under a microscope. If we hold a *Lycæna* butterfly with wings outspread between the eye and a lighted window or lamp, the wing will no longer appear to be blue but will be a dull yellowish-brown. Hold it down toward the floor or against a dark wall and it will regain its shining blue and greenish tints.

This difference is explained by the character of the structure and arrangement of the scales. Whenever rays of light fall on a series of transparent superposed plates, as for example a number of thin glass plates placed one on top of the other, the eye perceives various shining colors caused by the interference of the light waves. Illustrations of the production of these colors are numerous and familiar, as in the beautiful colors of the soap bubble, and of oil films, and the prismatic rings which are shown by pieces of mica or by bits of weathered glass. Now, recalling the arrangement of the scales on the wing membrane, the regularly overlapping rows and the lateral overlapping in each row, is it not obvious that we have on the butterfly wing exactly the means necessary to produce physical colors, namely, a series of superposed transparent plates, composed of the delicate transparent walls of the scales? And the colors resulting from this structure and arrangement of the scales are those brilliant metallic blues and greens which vary and change with the changing point of view.

But the scales produce physical colors in yet another way. Remember that each scale bears on its surface many fine parallel ridges, or striæ. Now, brilliant physical colors are produced (by interference) when rays of light are reflected from any surface which has on it very fine ridges or cut-in lines. This, of course, is familiarly illustrated in physical laboratories by the finely ruled Rowland and Rutherford gratings. The ridges on the scales are very fine; on the scales of the Monarch butterfly the ridges are $\frac{1}{12500}$ of an inch apart and on certain scales of the Brazilian *Morpho* the striæ are only $\frac{1}{35000}$ of an inch apart. This striated structure of the scale therefore also produces physical colors.

Two other functions are sometimes subserved by the scales. There can often be found on the upper sides of the wings of male butterflies scales of peculiar shape more or less numerously distributed among the more usual scales of the wing surface. These peculiar scales, when highly magnified by the microscope, give evidence of having many fine openings on the



A butterfly's scale that is specialized in such a way that it gives off an odor. Very greatly magnified. Only males have such scales

surface or at the tip, and it has been proved that a strong-smelling, usually aromatically fragrant substance exudes from these fine pores. These androconia, as the fragrant scales are called, occur commonly on the male of the familiar white cabbage-butterfly, for example, and if one of its wings be rubbed between the thumb and finger you can smell on your finger-tips this butterfly scale odor. The odorous scales are possessed only by the male butterflies and the scent is supposed to be attractive to the females.

As to the other of the two special functions, certain butterflies are known to make faint squeaking noises, and these sounds are produced by the rubbing together of the fore and hind wings. Unusually large and strong scales arranged in a series of rows in particular places on each wing are the structures which produce the sounds.

Finally, we may examine our scales again with another question in mind. Naturalists believe that all the seemingly intricate structures and organs of an animal's body have been developed from more simple structures. If so, what is the simplest, the most generalized, type of the scales?

Among all insects the commonest covering structure of the wings and body is hairs. The simpler and older kinds of insects have hairs on their wings. Can the butterfly scale, with its broad blade and its handle-like stem, its pigment granules, and its effective color-producing structure be derived from insect hairs; be in fact simply a modified or specialized hair? The examination of almost any butterfly's wing will prove this to be the case, for on almost any moth or butterfly wing a series of gradatory forms between simple cylindrical tapering hair and flattened, stemmed scale can be found. The transition from long slender simple hair to broad flat scale most commonly occurs by a slight widening of the tip into two, three, or more branches or fingers lying in one plane, or by the gradual shortening of the basal part of the scale-hair, accompanied by a widening and "filling-in" between the bases of the fingers. This "filling-in" or palmation in the perfect scale may extend almost or quite to the tips of the "fingers," or the fingers may remain as long as the broad blade part of the scale or longer. There is thus produced a flat scale with more or less shortened stem, and with the margin opposite the stem entire or two- to several-pointed, the points being of greater or less length. The fine longitudinal ridges, or striæ, appear with the first widening of the hair. Another common mode of transition is shown in the wings of the cossid moths. Here the scale-hair first widens and flattens at its tip; there is then a gradual shortening and widening for a considerable distance behind the tip so that there is formed an elongate, rather spoon-shaped scale, which continues shortening and widening, the point of greatest width coming nearer and nearer to the tip of the scale. There is thus produced a short broad scale with rounding truncate outer margin, the scale being widest at this margin. The margin is entire, no fingers or teeth appearing anywhere in the course of the development.

Thus the dust of the butterfly is revealed to us as possessing an intricate structure, as disposed in symmetrical arrangement on the wing surface, and as of important use in protecting and strengthening the wings, producing colors and patterns, giving off odors, and making sounds. Finally, the origin and evolution of the scales from simple hairs is readily to be seen.

A similar study, with similar results, may be made of any of the other parts of the butterfly body. The odd shapes, the strange structures, the peculiar habits of insects have meanings, the discovery of which requires careful and persistent study, which is nevertheless always delightful and fascinating. The solving of each particular problem gives us for reward that pure pleasure which is the mainspring of the scientific seeker's endless questing, the happy consciousness of the personal discovery of one of Nature's ways.

Some Interesting Habits of Our Native Bees[1]

By HERBERT F. SCHWARZ
Research Associate in Hymenoptera, American Museum

IN a radio talk recently delivered by a member of the department of entomology of the American Museum you were told that it is only through the constant vigilance of our insect friends that we are able to escape the destruction of our insect enemies, and you were given an insight, too, into other ways in which mankind has benefited from the often unnoticed activities of insects. But I should feel sorry if you thought they had no other claim upon our gratitude than as destroyers of the injurious of their kind or as agents in bringing our fruits to maturity. They have an interest for our mind as well as for our pocketbook. Just as birds are appreciated today not merely for seconding the efforts of our insect friends in policing the fields and orchards but more especially for the beauty and charm they add to life, so the time may come, I trust, when without undervaluing the economic side, there will be a more general recognition of the fascinations of insect behavior and a more impelling curiosity to pry into its mysteries. No matter what group you may select for observation, you will be sure to feel, as your knowledge deepens, a sense of awe at the intricacies of life revealed by these fellow denizens of our planet. Bees, regarding which I am privileged to speak to you tonight, have a fascination that is inexhaustible, but other workers in entomology will claim—and possibly with justice—that the group in which they are interested offers just as thrilling a field for study.

When I say bees, most of those who are listening in will doubtless think of the hive-bee and indeed not one talk but many might be devoted to this wonderful insect. I must resist the temptation to tell you something about this bee: the precision with which it builds its comb; the nice division of labor within the colony by which the newly emerged bees assume the task of tending and feeding their younger sisters while those a little older range over the fields gathering nectar and pollen; the restricted life of the queen, whose days are spent in the darkness of the hive egg-laying; the curious provision of nature whereby the bees are able through special feeding of the larva to produce a queen bee instead of a worker; and other phases of these highly organized insect societies. I say I must resist the temptation, for my topic is concerned with our native bees and, strange as it may seem in the case of an insect so abundant everywhere in our fields, the hive-bee is an alien from the Old World that was unknown in the Western Hemisphere before man introduced it along with his sheep and his pigs, his cows and his horses.

To our wild bees let us then turn our attention. They constitute, indeed, a very large group. Some conception of the variety of forms may be had when it is stated that more than 150 species have been recorded from the state of Connecticut alone. Some of our species are, of course, of relatively wide distribution, but others are of comparatively restricted range. In Europe there are some 2000 species

[1]One of the American Museum's radio broadcasts.

and, considering the extent of our country and its contrasted life conditions, it is safe to assume that when our bee fauna is completely known, it will considerably exceed this total.

Among the flower-visiting insects which attract the attention of everyone are the bumble-bees. During the days of May, in the vicinity of New York, the huge queen is conspicuous as she flies noisily humming from blossom to blossom. At a time of the year when ladies are laying aside their winter furs, Mrs. Bumble appears clad in a brightly-hued mantle of pelt. But she wears it not from vanity but from necessity. It is not a garment to keep off the chill of spring nights but part of her working equipment. Those furlike hairs that clothe her thorax and abdomen, when viewed under the microscope, are found to be branched and their function is to sweep up the pollen that lies in the flowers. The pollen grains that are thus captured in the hairy envelopment of the bee are brushed together by her, moistened, and ultimately plastered on the polished surface of her hind legs along which they work their way upward as more and more pollen is added from below. Finally, the bee, with great lumplike attachments of pollen adhering to her hind legs and her crop full of nectar, flies heavily laden back to the nest, which not improbably is located in the deserted hole of a field-mouse. Within, there is as yet no active colony of worker bees. In fact, not a wing is stirring, for, unlike the hive of our honey-bee, whose populations carry on from year to year even though the life of the individual is brief, the nest of the bumble-bee is an annual affair, founded in the spring and deserted in late summer or fall. At that time the old queen, the workers, and the males die, and only the young queens, usually the last-born of the brood, survive to spend the winter in seclusion, awaiting the call of spring before they in their turn each seek out a nest and establish a family.

At first all of the duties of the nest devolve upon the queen. The pollen she has gathered is deposited in a pile, and in a little wax cell constructed on this pile is laid the first batch of eggs, which in turn is covered with a thin protective papering of wax. As the larvæ emerge and grow, the mother bites through this layer of wax from time to time in order to deposit additional food or, in the later stages, to feed the growing infants individually. Most interesting of all, perhaps, is her habit of incubating the eggs, for when she is not employed in other duties, she is found extended over the little wax enclosure. In front of her is a wax container full of liquid honey and from it she takes refreshment every now and then. The habit of covering her brood hen-wise does not cease with the emergence of the larvæ or even with their pupation, for when the time comes for the larvæ to spin their cocoons, these cocoons are often so arranged that the queen can sit enthroned upon them. Before the first-born members of the colony have reached the adult stage, the queen has laid additional batches of eggs, but before the larvæ that emerge from them are very far along, their elder sisters have matured and have begun to take over many of the duties previously shouldered by the queen alone. Her place in life henceforth is confined to the nest itself, laying eggs some of which, as the season advances, will develop into males.

The fact that in the early broods only females are represented serves to emphasize the very unimportant part that the male plays not only among the bumble-bees but among all bees. The female is the progenitor of the race in an unusually complete sense of the term, and upon her devolves the task of building and furnishing the nest, and of providing the bee-bread for the brood. Here is a feminism in which responsibilities have taken the place of rights.

There are several species of bumble-bees in the vicinity of New York and the life histories of these bees, like their color and the proportions of their body parts, have their points of difference.

The bumble-bee is one of the social bees. Indeed it and its guest *Psithyrus* are the only social bees other than the hive-bee that are found in our latitude. All the other bees are solitary. By solitary we do not mean necessarily living in isolation, for some of the solitary bees already approach a social condition by selecting nest sites in more or less close proximity to others of their kind. Certain bees of the family Halictidæ even have a common entrance-way leading to nests that are otherwise independent, much as apartment-house dwellers ascend a common elevator shaft to reach their separate establishments. But by "solitary bees" we mean those that have no real contact with their offspring and that hence form no colonies or families. The solitary bee, like the social bee, forages industriously, seeks out appropriate nest sites, and carefully prepares them. But when she has deposited the nectar-moistened pollen in the cell awaiting its reception and has laid her eggs upon this food supply, she seals up the cell and flies away. She does not interest herself further in the fate of her offspring.

Among the solitary bees none are more fascinating than those belonging to the family Megachilidæ, and of all the Megachilidæ I would assign first place from the standpoint of interest to the Leaf-cutters. These bees build their nests in cylindrical hollows,—a reed or the hollow stem of a bush furnishes an excellent nest site. In the darkness of these shafts they construct their cells, thimble-shaped enclosures of leaves, the pieces of which are so perfectly fitted together, with resulting compactness and firmness, that, even when the stem is opened and the cells are removed, these retain their shape, resembling in their totality a green bar. Yet the leaf particles of which the cells are made must be cut in the fields and gardens, perhaps far from the nest itself. Those intended for the side walls must be of an oval shape, those with which the mouth of the cell is sealed must be of a perfect rotundity and of just the right diameter so that they may firmly close the orifice of the cell. The bee has no compass or instrument of precision with which to make her measurements; for cutting-tools she has only her jaws. Yet she works without hesitation and the figures she snips out of the leaves are shaped as though they were intended to illustrate a textbook of geometry. No wonder that in former times, when ignorance of nature was greater, men finding these nests thought them the work of witchcraft!

Every summer I make it a practise to lay out in the garden hollow reeds, and now and then I am rewarded by having a *Megachile* build in them. Even more satisfactory is it to observe the bee at work among the leaves. When you go to the country this summer, see if you cannot find some tree or bush with leaves the edges of which have been defaced with circles and ovals. If you will tarry at the spot, you will be fairly certain to see the insect artisan return to her quarry, for the bee is apt to visit again and again the same plant and, more often than not, several of her kind are seeking building material for their independent nests at the common source of supply. Why they should concentrate their attack upon a single plant when others of the same kind, and apparently equally suitable, are often growing close at hand, I cannot tell you, unless it is that the bee, who is a very methodical person, follows the conservative principle of "letting well-enough alone."

Belonging to the same family as the Leaf-cutters are several interesting genera. Bees of the genus *Osmia* sometimes employ a kind of green paste that derives its color from the leaf material contained therein and with this substance fashion their cells. Bees of the genus *Dianthidium* are partial to the use of resin in constructing the compartment in which the larva is to live and undergo change, awaiting the time of her "coming out," for the bee, too, has her *début* and, considering that her childhood is spent in darkness and solitude, her entry into the great world may, for aught we know, have even more *éclat* than that which we associate with a flight into the social world. Then there is the genus *Anthidium*, the females of which use soft flocculent material scraped from plants, and in this cottony envelopment establish their nurseries. The bees of these genera, all members of the large family Megachilidæ, carry their pollen not as do the bumble-bees and most other families of bees, on the hind legs but on the under side of the abdomen. For the purpose the female has a dense covering of hairs on this part of her body.

But the Megachilidæ are only one of the many families of solitary bees. Some of these families, like the Xylocopidæ and the Ceratinidæ, are known as carpenter bees because they are expert wood-carvers; others, like the Andrenidæ and Halictidæ, tunnel their nests in the earth. Far down in the scale of the bees is the family Prosopidæ,—little black, almost hairless bees with yellow markings that give them a wasplike appearance. They do not carry pollen, as do other bees, on the outside of the body but swallow it and later regurgitate it with the nectar they have similarly swallowed.

From of old we have been taught to regard the bee, like the ant, as the symbol of industry, and mortals, too inclined to follow the genial ways of idleness, have been urged to pattern their lives after these insects. And yet among the bees as among the ants there are those whose only source of livelihood is preying upon others. There are parasitic genera of bees the females of which lurk about the nest sites of industrious bees and, when a cell has been stocked with pollen and is about to be sealed, slip cautiously in and lay their eggs upon the gathered store. *Psithyrus*, the parasite of the bumblebee, goes even a step further, brazenly making her home in the nest, not infrequently stinging to death the legitimate ruler and always, to some extent at least, usurping her place. *Psithyrus* rather resembles her victim but some other parasitic bees—the Nomadidæ for instance—are very wasplike in appearance. It is interesting to note that the parasitic bees have no pollen-collecting apparatus and would be unable to rear a brood if it were not for their craftiness in laying their eggs upon the stores gathered by others.

But let us turn from these degenerate members of a noble order and in closing emphasize a few of the things we owe to these insects. From of old the hive-bee has given us honey. In a cave discovered in 1919 in Valencia, Spain, is a picture made thousands of years ago showing a man of the Glacial Age removing a honeycomb while an angry swarm buzzes about him. Honey was sold in the markets of ancient Egypt. It used to be cheap in those days, fetching only about five cents a quart. Much more important, however, is the service performed by bees in pollenating the flowers. There are whole groups of plants that would disappear from the earth if it were not for the visits of these indefatigable insects. The flower-starred meadows would soon be barren, many of our fruits would cease to ripen; the world would be a dreary place indeed. In New Zealand red clover would not set seed until the bumble-bee was introduced into the islands. It is said that the turtle-head flower is dependent solely upon the bumble-bee, and the bee *Colletes latitarsis* apparently confines its visits almost exclusively to the flowers of the *Physalis*. If you would have the world a flower garden, conserve the bees or, to put the same thought in a little different form, spare our native wild flowers and the bees will see to it that seed is set and that thus the beauty of the floral world is renewed from year to year.

A rock painting at the Cuevas de la Araña northwest of Biscorp, Valencia, Spain, representing a gatherer of wild honey in prehistoric times. The bees are disproportionately large but allowance must be made for the tendency to magnify the antagonist when the attack is vicious. The original painting is in red. A copy of it was made by W. K. (1921) and published in Obermaier's *Fossil Man in Spain*, and that copy is here reproduced, natural size, thanks to the courtesy of the Hispanic Society of America

Principal Orders of Insects

By A. J. MUTCHLER AND FRANK E. LUTZ

MANY lovers of natural history seem to be overawed by the number of different species of insects and the hopelessness of ever learning to recognize them all. The numbers are indeed vast and nobody—not even the most learned of professional entomologists—can tell the specific name of each of the insects living within a few miles of his home. In such a case, what is the amateur to do?

Opinion differs concerning the answer to this important and oft-repeated question. Some advise the amateur to take up only a small portion of all the insect fauna of his region. That cuts down the problem, to be sure, but it deprives one of the joy of knowing about the great majority of the living things that are all around him.

Let us take some actual figures. In the 1910 list of the insects of New Jersey compiled by John B. Smith, there are 10,385 species enumerated from that state. These are assigned to 3,486 genera. The genera are distributed among 331 families and, finally, these families are grouped into orders, of which there are 22.

It doubtless would be possible for a careful, industrious student of New Jersey insects to learn to recognize its 3500 genera. He probably would find by the time he had finished that there are 3600, but that is another matter. However, if our amateur were content just at first to learn to recognize families, the task would be decreased to about one-tenth. Would that be worth while?

So far as we know, no one has deliberately set out to learn the characteristics of all of the families of insects and has accomplished it, without first becoming so interested in some certain family or group of families that he became a specialist. But there are certain very definite advantages to the amateur in learning families first. One of these advantages is, of course, that his problem is reduced to practical proportions. Another is that there are several books on American insects available that will help him to recognize all of the principal families. But still another and a great advantage is that, once you know the habits of one member of a family, you have what is usually a fairly accurate outline of the habits of the other members of that family. And, after all, it is the great diversity and interest of insects' habits that give a general knowedge of entomology its charm.

Learning to recognize twenty-two principal orders of insects is an even simpler task. This is comparable to learning to tell the difference between turtles and snakes or between cows and whales. The chart that forms the Supplement to this issue of NATURAL HISTORY has proved very useful in nature-study classes, Scout rooms, and the like. We hope that it may be useful to many of you and that the rest of you will pass your copies on to some one who may care to have them. The brief statements made on the chart are not in every instance universally true—exceptions are the rule in entomology—but they will serve in most cases.

SWALLOWTAILS

and (above) their less ornate relative, the Clouded Sulphur (*Colias philodice*, under side on the right). Just below are the male (left) and female Asterias Swallowtail (*Papilio polyxenes*). Finally, we show the male (left) and female Spicebush Swallowtail (*P. troilus*)

Our Common Butterflies

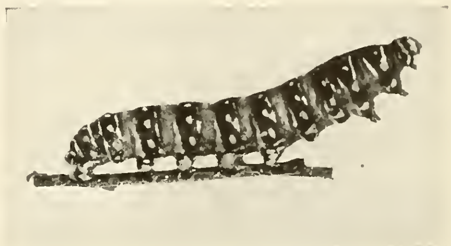
By F. E. WATSON AND F. E. LUTZ

In this case "our" refers to the vicinity of New York City, although most of these species are widely distributed. Haunts, food-habits, and life histories are given in tabular form following the text.—The Editor.

THE graceful flight and beauty of adult butterflies have made them the most popular insects, but in their youth they have in the eyes of many people little beauty and can only crawl and eat. They are "horrid caterpillars," poisoned by gardeners and shunned by all except the few who see in them the possibilities of maturity. However, not all caterpillars develop into butterflies; the greater number become moths, and some creatures which strongly resemble caterpillars are really quite different from either butterflies or moths.

A useful distinguishing characteristic of insects is the possession of three pairs of true legs. Nothing else which the amateur is likely to notice has just this number. Spiders have four pairs and centipedes have many; they are not insects. Now a caterpillar *appears* to have more than three pairs of legs, but it will be seen upon close examination that the three front pairs are the only ones which are jointed. The other "legs" are not true legs but merely fleshy props. Young leaf-feeding beetles do not have these props and young saw-flies (relatives of wasps) have five or more pairs in the middle of the body, whereas young butterflies have four pairs and a pair of claspers at the hind end of the body.

When young Lepidoptera have eaten their fill once they cast off the skin they have been wearing and get a larger one. This process is repeated three or four times, and finally they are full-grown caterpillars. Then, if they are young moths, they seek a suitable place and usually spin a cocoon of silk threads. Inside of this they molt once more, but instead of becoming a larger caterpillar each turns into a mummy-like pupa. If they are young butterflies, the fundamental process is



An Asterias Swallowtail caterpillar. Note the two kinds of legs

the same but no cocoon is made. The pupa, which is also called a chrysalis, hangs naked. Perhaps the single thread around the body of some of them and the silk which fastens the tail to the supporting surface represent the moth's cocoon.

The distinction between adult moths and adult butterflies is largely a matter of habits and "feelers." The antennæ are a pair of appendages on an insect's head which are popularly called "feelers," although, as a matter of fact, insects smell and possibly hear with their antennæ as well as feel. The antennæ of butterflies are threadlike and have a knob or swelling at the tip. The antennæ of many moths are clearly feather-like. In others the plumules are not visible to the naked eye and the antennæ look like threads but they almost never have a swelling at the end large enough to be confused with the knob of butterflies. Then, too, all our butterflies fly only in the daytime, while all but a very few of our moths fly only at night.

SWALLOWTAILS

These are the giants of our northern day-fliers and belong to the genus *Papilio*. The conspicuous resemblance of their hind wings to the "swallow-tails" of the sartorial art and their large size distinguish them from all of our other Lepidoptera except the pale-green night-flying Luna. The *Papilio* which is largely yellow and has, among other black markings, three or four short black bands on the front half of each front wing is the Tiger Swallowtail. Sometimes the female of this species has the yellow replaced by sooty brown except for the marginal spots. This form is rare with us but is quite common in the South.

The Asterias Swallowtail is about as common as the Tiger. Its young feed on parsley, carrot, celery, and parsnip leaves. The adult male may be recognized by the row of yellow spots across the middle of the wings. These spots are sometimes much reduced in the female. The row of blue spots, inside the marginal yellow ones, is more distinct in the female than in the male.

The Spicebush Swallowtail, our commonest species, has a single or at most an incomplete second row of greenish-white spots on the front wings. The hind wings are usually suffused with greenish in the male and bluish in the female. Its larvæ feed on sassafras and spicebush leaves.

WHITES

A white butterfly is a common sight and a guess that it is *the* Cabbage Butterfly (*Pieris rapæ*) will almost always hit the mark. There are really three kinds of white butterflies in the Northeast whose young feed on cabbage and allied plants. Two of them are natives, but the third was accidentally brought from Europe to the vicinity of Quebec about 1860. Since that time, aided doubtless by further importations, it has spread over the whole country and, like its compatriot the English sparrow, it has alargely replaced its native relatives in the more densely populated regions. The European Cabbage Butterfly has the tips of the upper side of the front wings black; there are two black spots on each of the front wings of the female and one on those of the male; the under side of the hind wings is yellowish and without markings.

With us the Mustard White, or Immaculate Cabbage Butterfly, has practically no markings on the upper surface of the wings, although in other parts of the country it is subject to many interesting variations.

The Checkered White, or Southern Cabbage Butterfly, has no definite black tips to the front wings, but it has two or three distinct black spots on the upper surface of each in the male and many dusky spots in the female.

There is a pretty little White that may be recognized by the green marbling on the under side of the hind wings. It is called the Falcate Orange-tip from the shape and color of the front wings, although only the males are orange-tipped.

(See also the next section.)

YELLOWS

Several species of yellow butterflies are closely related to the Whites just described. They nearly all feed on clover and its allies. It should be re-

TIGER SWALLOWTAIL (*Papilio glaucus*)
Male, above; female, form *turnus*, below

WHITES AND YELLOWS

From above downward.—Cabbage Butterfly (*Pieris rapæ*); male, left, and female. Mustard White (*P. napi*). Checkered White (*P. protodice*); male, left, and female. Falcate Orange-tip (*Anthocharis genutia*); male, left, and under side. Little Sulphur (*Terias lisa*); male, left, and under side

Regal Fritillary (*Argynnis idalia*); male, above, and under side

marked parenthetically that when the food of a species is mentioned we mean the food of its young, for adult butterflies do not eat. At most they sip water from wayside pools or nectar from flowers through a coiled tubelike mouth which entirely lacks teeth or even jaws.

The most common Yellow in the Northeast is the Clouded Sulphur. It may be distinguished from the Little Sulphur by its size and by the presence of a silvery spot on the under surface of each hind wing. Occasionally the normally yellow parts of the Clouded Sulphur are white but the silvery spots differentiate it from the Whites. This variation is confined to the female.

THE FRITILLARIES

Three of our Fritillaries have a wing expanse of at least two inches. They are tawny or tawny-red above, variously studded with silvery white spots below. The upper surface of the hind wings of the Regal Fritillary is nearly black but the base is tawny and there are two rows of light spots. The outer

Great Spangled Fritillary (*Argynnis cybele*); male, above, and under side

row of these spots is tawny in the male, both being whitish in the female. The Great Spangled and Smaller Spangled have no white markings on the upper surface and the wings are darker at the base than elsewhere although not at all black except for spots and irregular bands. It is difficult to distinguish between these two species, the chief difference being on the under side of the hind wings, which in the Great Spangled have a much wider and paler yellow band than in the Smaller Spangled. The latter is the smallest of the three. All of them feed upon violets, as do the Meadow and the Silver-bordered, their smaller relatives. The last two species are very similar on the upper side but on the under side the Meadow does not have any silvery spots.

The Pearl Crescent, which feeds upon asters, should be considered with the last two mentioned, for each has the upper side tawny, closely checkered with black. The under side is yellowish mottled with brown, a whitish crescentic spot near the middle of the hind margin being usually present and frequently accompanied by other similar spots.

The Baltimore has the ground color of both wings black, bordered with

Smaller Spangled Fritillary (*Argynnis aphrodite*); male, above, and under side

orange-red spots within which are two or three rows of white spots. The under side is similar to the upper but with additional spotting. This butter fly is subject to great variation. During the season in which they are born the caterpillars are gregarious, living within a web with which they envelope their food-plant, the Turtle-head and, less commonly, allied plants. After molting three times, the whole colony hibernates within the web, made more dense for the purpose. In the following spring, they leave the web, disperse, and feed upon a great variety of plants..

ANGLE-WINGS

The Angle-wings "look as if Mother Nature had with her scissors snipped the edges of their wings, fashioning notches and points according to the vagaries of an idle mood." The wing expanse is about two inches and, while the upper surface is tawny, variously marked, the under surface is a combination of brown and gray which corresponds so closely with the color of dead leaves that an Angle-wing at rest on the forest floor is extremely well hidden.

The Violet-tip has a tail suggestive

From above downward (under sides on the right).—Silver-bordered Fritillary (*Brenthis myrina*); Meadow Fritillary (*B. bellona*); Pearl Crescent (*Phyciodes tharos*); and the Baltimore (*Melitæa phaëton*)

of the Swallowtails. The upper surface of this tail and the adjacent marginal portions of the hind wing are tinged with violet. On the under side of each hind wing there is a pair of silvery markings which are somewhat like an interrogation point. The young feed on elm leaves.

The Hop Merchant or Comma has a silvery comma or parenthesis on the

From above downward (under sides on the right).—Violet Tip (*Polygonia interrogationis*); Hop Merchant (*P. comma*); and Gray Comma (*P. progne*)

under side of each hind wing and there is considerable yellowish color on the under surface of both pairs of wings. The first name given here refers to the feeding habits of the young but wood-nettle is the preferred food-plant.

The Gray Comma or Progne has a silvery marking similar to that of the Comma but smaller, and the under

Mourning Cloak (*Aglais antiopa*); upper, above, and under side

surface lacks yellow. Its young prefer the leaves of currant and gooseberry.

The Angle-wings hibernate as adults.

VANESSAS

The Red Admiral has "eye-spots" (circular spots surrounded by one or more rings of a different color) on the under side of the hind wings but they are usually very indistinct. This species can best be recognized by the brilliant red band crossing each black front wing.

Eye-spots are very distinct on the under surface of the hind wings of Hunter's and the Thistle Butterflies. For some strange reason, these, but more particularly the latter, are also called the Painted Lady or Painted Beauty. The Thistle is one of the most widely distributed of butterflies—as widely as the thistles on which it feeds. There are usually four eye-spots on each hind wing, below, these spots being smaller than the two of Hunter's.

The Mourning Cloak, or, as the English call it, the Camberwell Beauty, is blackish with a lighter margin

THREE COMMON VANESSAS

The upper sides are shown on the left; the under sides on the right. From above down they are the Red Admiral (*Vanessa atalanta*), Hunter's Butterfly (*V. huntera*), and the Thistle Butterfly (*V. cardui*). Each of these has also been put in the genus *Pyrameis*, instead of *Vanessa*

underneath, and blue-black-brownish edged with yellow above. Its spiny young feed on willow, poplar, elm, and the like.

The Buckeye has a narrow orange band near the border of its brown wings. Each front wing is ornamented with a whitish transverse band and a large eye-spot. The hind wing has two of these eye-spots. Beneath, the front

Buckeye (*Junonia cœnia*); upper, left, and under sides

wings are similar but duller in color. The hind wings are grayish, brownish, or reddish, with the eye-spots represented by mere spots or dots.

The Vanessas, like the Angle-wings, hibernate as adults hidden away under a pile of fence rails, in a hollow log or in some such nook.

THE RULERS

The Monarch, or Milkweed Butterfly, during early autumn assembles in great swarms in the northeastern United States, large numbers hanging quietly from the leaves and branches of trees and shrubs. These flocks then move southward, suggesting the migration of birds. It is believed, but not positively established, that there are return migrants in the spring. At any rate, none of us has ever found the Monarch in the North during the winter, although its black and yellow banded larvæ with their long flexible "horns," and its gold-dotted delicate bluish-green chrysalis are as easily recognized as the adult.

The Viceroy resembles to an astonishing degree the common and wide-spread but not closely related Milkweed or Monarch Butterfly. Its general color is a tawny red; the wing veins are outlined in black, and there is a white-spotted black margin to the wings. So far, the description will fit either species, but the Viceroy has a narrow black band across the middle of the hind wings which the Monarch lacks. Like other members of its genus (*Basilarchia*), it hibernates as a larva in a silken-lined tube formed of part of a leaf of the food-plant and attached to a twig by silk.

The Blue Emperor is also called the Red-spotted Purple, the red spots being at the apex of the front wings on the upper side but more scattered on the lower side. This is, perhaps, our most beautiful butterfly and is subject to great color variation. Some indi-

RULERS

From above downward.—Monarch (*Danus archippus*); Viceroy (*Basilarchia archippus*) and Blue Emperor (*B. astyanax*) viduals have the red spots on the upper side entirely wanting. In others there is a distinct greenish cast, especially distinct on the hind wings. It has also a very rare form, *albofasciata*, so called because of the white band on both fore and hind wing. This form closely resembles the White Admiral of the Catskills and northward, but white-banded specimens taken in the vicinity of New York City are *albofasciata*.

THE EYED BROWNS

The common Nymphs have eye-spots on the upper side of the front wings. The general color is brownish. That of the Common Wood-nymph is dark but the eye-spots of the front wings are set in a yellowish band. There are not usually more than two, if any, spots on the upper surface of each hind wing.

The Common Grass-nymph has a row of four small spots on the upper surface of each front wing and the Little Wood-satyr has but two. The brown of both is rather pale and both have the spots on the upper surface of the hind wings "eyed."

Common Wood-nymph (*Satyrus alope*), above; Common Grass-nymph (*Satyrodes canthus*), left; and Little Wood-satyr (*Neonympha eurytus*)

HAIR-STREAKS, COPPERS, AND BLUES

We can give only a few examples of this large family of small and often brilliant butterflies. The legs of the slug-shaped caterpillars are so shortened that these creatures seem to glide rather than crawl. The larvæ of many species secrete a sweetish fluid which is eagerly gathered by ants and the larvæ will usually be found with one or more ants in attendance. Of the species mentioned below, the larvæ of the Coral Hair-streak feed at night, and during the day remain beneath the surface of the ground in ants nests at the foot of the food-plant. Their chrysalis is also formed there.

From above downward (under sides on the right).—Gray Hair-streak (*Strymon melinus*). Coral Hair-streak (*S. titus*). Banded Hair-streak (*S. calanus*)

The Gray Hair-streak has the upper side of both wings brownish-gray, with an orange patch on each hind wing. Beneath, the wings are light gray with two dark, white-edged lines in addition to the orange patches. Each hind wing is also provided with a long threadlike tail.

The Coral and Banded Hair-streaks are brown on the upper and under sides of their wings and without markings above. Below, the Banded has two narrow blue bands, and, on each hind wing, one or two orange patches, a blue patch, and a threadlike tail; the Coral has a row of black dots near the center, and a band of coral-red spots (sometimes absent on the front pair) along the margin of each wing.

The American Copper has its front wings coppery-red with some black spots. Its hind wings are brownish with a coppery-red border. The under side is similar but much paler.

The Tailed Blue is a delicate little blue creature which has tails that may be seen by looking closely, but it is apt to be confused with the Common Blue—its extremely variable relative. Each of them has several generations a year, although the latter is frequently called the Spring Azure on account of its abundance when other butterflies are scarce.

From above downward.—American Copper (*Heodes hypophlæas*); male, left, and under side. Tailed Blue (*Everes comyntas*); male, left, and under side. Common Blue (*Lycænopsis pseudargiolus*); male, left, and female; below them three showing variations of under side.

THE SKIPPERS

These butterflies, belonging to the family Hesperiidæ, get their common name from their rapid, darting flight. They are, for the most part, small and dull-colored. The sexes of some species differ in the markings on the upper side.

The Silver-spotted Skipper may be recognized by the large silvery spot on the under side of the hind wings. It is extremely pugnacious and will dash at any insect which flies near it.

The Sooty-wing has nearly black wings, the front with some minute white dots; the female has additional indistinct white dots on the hind wing. The under side is similar but paler.

Numitor is called the Least Skipper because of its small size. Its wings are tawny and dark brown. The front wings are generally dark above but have a light front margin below.

The Tawny-edged Skipper has the front wings in the male tawny with a brown border and the hind wings brown. The female has brown wings

From above downward.—Silver-spotted Skipper (*Epargyreus tityrus*), upper and under sides. Left, Sooty-wing (*Pholisora catullus*); right, Least Skipper (*Ancyloxypha numitor*) Males, left; females, center; under sides, right: Tawny-edged Skipper (*Polites cernes*); Yellow-spotted Skipper (*P. peckius*); Volcanic Skipper (*Catia otho egeremet*)

with a few tawny spots on the front pair, which also have a tawny upper edge in some specimens. Beneath, the front wings are similar but paler; the hind wings are dull greenish-yellow with an indistinct band of minute whitish dots across their centers.

The Yellow-spotted Skipper has

From above downward.—Mormon Skipper (*Atrytone hobomok*); male, left, and under side; female, left, and the variety *pocahontas*. Little Glass-wing (*Atrytonopsis verna*); male, left; female, center; and under side.

bright yellow spots, as shown in the figure, on a brown ground color. These are brighter and larger on the under side of the wings. Other species have similar colors but the pattern is different.

The Volcanic Skipper is dark brown with a few yellow spots on the front wing. The under side is similar to the Tawny-edged, but darker, with the band on the hind wings more distinct.

The Mormon Skipper has two female forms. The typical one is tawny orange with dark brown borders; the other (variety *pocahontas*) is dark brown with white markings. They are less common than the typical form.

The Little Glass-wing has dark brown wings with whitish-translucent spots on the front pair. The under side is similar to the Volcanic, but the spots are whitish, not yellow.

In addition to those already mentioned, there are about twenty other species which are rather common in this vicinity, but longer and more technical descriptions than can be given here would be necessary for their identification. They are, for the most part, Hair-streaks and Skippers, small brownish or brown and yellow creatures which flit before our eyes and then, aided by their concealing colors, disappear.

Explanation of Following Table:

E = Egg. L = Larva (caterpillar). P = Pupa. A = Adult. The "calendar" will vary somewhat with locality and weather.

TABLE OF LIFE HISTORIES

NAME	Nov. to March	April	May	June	July	Aug.	Sept.	Oct.	Preferred Food-plant	HAUNTS
Tiger Swallowtail	P	PA	AEL	LP	AEL	AELP	AELP	P	Wild Cherry	Open Fields and Woods
Asterias Swallowtail	P	P	AEL	LP	AEL	AEL	AELP	LP	Wild Carrot	Open Fields, Meadows
Spicebush Swallowtail	P	PAE	AEL	LP	AEL	ALP	AELP	LP	Sassafras	Open Fields, Woods, Meadows
Cabbage Butterfly	P	PAE	AEL	PAEL	AELP	AELP	AELP	ALP	Cabbage	Gardens, Open Fields
Mustard White	P	AE	AEL	LPA	AELP	LPAE	AEL	LP	Two-leaved Toothwort	Open Woods, Wood Roads
Checkered White	P	AE	AEL	PAEL	AELP	AELP	AELP	ALP	Wild Peppergrass	Open Fields, Waste Places
Falcate Orange-tip	P	AE	AEL	LP	P	P	P	P	Lyre-leaved Rock-cress	Open Woods
Clouded Sulphur	LP	PA	AEL	AELP	LPAE	AELP	LPAE	AEL	Clover	Open Fields, Meadows
Little Sulphur	?	?	?	AELP	AELP	AELP	AELP	A	Sensitive Pea	Open Sandy Fields
Regal Fritillary	L	L	L	LP	PA	AE	AEL	L	Violet	Wet Meadows
Great Spangled Fritillary	L	L	L	LPA	PA	AE	AEL	L	Violet	Wet Meadows
Smaller Spangled Fritillary	L	L	L	LPA	PA	AE	AEL	L	Violet	Wet Meadows
Silver-bordered Fritillary	L	LP	PAE	AELP	LPAE	LPAE	AEL	L	Violet	Wet Meadows
Meadow Fritillary	L	LP	PAE	AELP	LPAE	LPAE	AEL	L	Violet	Wet Meadows
Pearl Crescent	L	LP	AEL	AELP	PAEL	AELP	AEL	AL	Aster	Open Fields, Meadows
Baltimore	L	L	LPA	LPAE	LPAE	L	L	L	Turtle-head	Wet Meadows & Marshes
Violet-tip	A	A	AEL	AELP	AEL	AELP	LPA	PA	Elm	Open Woods, Lanes, Roads
Hop Merchant	A	A	AEL	AELP	AEL	AELP	LPA	A	Wood Nettle	Open Woods, Lanes, Roads
Gray Comma	A	A	AEL	AELP	AEL	AELP	LPA	A	Currant	Open Woods, Lanes, Roads
Red Admiral	PA	A	AEL	AELP	PAEL	LPA	PA	PA	Nettle	Wood Roads, Lanes
Hunter's Butterfly	PA	A	AEL	AELP	PAEL	LPA	LPA	PA	Sweet or White Balsam	Open Fields, Meadows
Thistle	A	A	AEL	AELP	PAEL	LPAE	PAEL	PA	Burdock	Open Fields, Waste Places

TABLE OF LIFE HISTORIES

NAME	Nov. to March	April	May	June	July	Aug.	Sept.	Oct.	Preferred Food-plant	HAUNTS
Mourning Cloak	A	AE	AEL	LP	AEL	LPAE	AELP	LPA	Willow, Elm	Open Woods, Lanes
Buckeye	A?	A	AEL	AELP	PAEL	PAEL	AELP	LPA	Geradia	Open Fields & Roads
Monarch	Absent	Absent	AEL	LP	AEL	AELP	LPAE	ALP	Milkweed	Open Fields, Meadows
Viceroy	L	L	LP	AELP	AEL	ELPA	AEL	L	Willow	Damp Places, Meadows
Blue Emperor	L	L	LP	LPAE	AEL	LPAE	AEL	L	Wild Cherry	Lanes, Orchards
Common Wood-nymph	L	L	L	LP	PA	AEL	AEL	L	Grasses	Grassy Meadows
Common Grass-nymph	L	L	L	LPA	PAE	AEL	L	L	Grasses	Wet Meadows, Swamps
Little Wood-satyr	L	L	PA	AEL	AEL	L	L	L	Grasses	Grassy Places, Edges of Woods,
Gray Hair-streak	P	P	PAEL	AELP	PAEL	PAEL	AELP	LP	Pea & Bean Family	Dry Fields
Coral Hair-streak	E	E	EL	LPA	PAE	AE	E	E	Wild Cherry	Open Fields
Banded Hair-streak	L	L	L	LPA	AE	AE	EL	L	Hickory	Wood Roads & Woods
American Copper	P	PA	AEL	AELP	PAEL	AELP	PAEL	AELP	Sorrel	Fields, Roads, Meadows
Tailed Blue	L	PA	AEL	AELP	LPAE	AELP	AEL	L	Round-headed Bush-clover	Open Fields, Meadows
Common Blue	P	AE	AEL	AELP	AELP	AELP	AELP	LP	Maple-leaved Arrow-wood	Open Woods
Silver-spotted Skipper	P	P	AEL	LPAE	PAEL	AEL	ALP	LP	Locust	Open Fields near Locust Trees
Sooty-wing	L	LP	PAEL	AELP	LPAE	PAEL	AEL	L	Pigweed, Amaranth	Waste Places, Roads
Least Skipper	P?	P	PA	AEL	PAEL	LPAE	AEL	P?	Grasses	Grassy Places, Fields & Meadows
Tawny-edged Skipper	P	P	PA	AEL	AELP	LPAE	AEL	LP	Grasses	Grassy Places, Fields & Meadows
Yellow-spotted Skipper	LP	LP	PA	PAE	AEL	LPAE	AEL	LP	Grasses	Grassy Places, Fields & Meadows
Volcanic Skipper	L	L(P?)	(LP?)	PAE	AEL	AEL	L	L	Grasses	Grassy Places, Fields & Meadows
Mormon Skipper	LP	LP	PA	PAE	AEL	L	LP	LP	Grasses	Grassy Places, Edges of Woods, Meadows
Little Glass-wing	L	L	LP	PAE	AEL	AEL	L	L	Grasses	Grassy Places, Fields, Meadows

ALL THE INTERESTING FEATURES OF A BROOK ARE BY NO MEANS ABOVE THE SURFACE OF ITS WATERS. NATURE HAS HIDDEN MANY FASCINATING INSECTS THERE—WINTER AND SUMMER

Some Residents of a Brook[1]

By WILLIAM M. SAVIN

By no means all of the interesting features of a brook are above the surface of its waters, nor are they only the scaly vertebrates so tempting to the angler. Nature has hidden many fascinating insects underneath stones on the brook's bottom and others among the submerged plant life, while still others go darting here and there, now up and now down.

Judging by several things, including the respiratory system, scientists believe that many, or possibly all, of our aquatic insects are descendants of truly terrestrial ones. The whirligig beetles that swing their dizzy circles on the surface of the water, now and then diving to escape danger from above, have the same sort of breathing apparatus as the tiger beetles that live on the hot sand of the dryest barrens. However, when they dive they carry down with them a supply of air safely tucked away between body and wings, a tiny bubble usually showing at the wings' tips. The young of these whirligig beetles, somewhat wormlike creatures living entirely in the water, have gills along each side of the body; but these gills are connected with an internal respiratory system that is similar to that of any caterpillar.

Whether adult or young, an insect has in its body a system of tubes that carries air directly to the various tissues. This, you will note, is quite a different arrangement from that of vertebrates where blood goes to lungs or gills for a supply of oxygen which it then carries to the tissues. The gills of the young whirligig beetles mentioned above cover openings into the system of air-tubes, called tracheæ. Through the walls of these tracheal gills the air contained in the body of the insect is purified.

The whirligig beetles swing their dizzy circles on the surface of the water

These beetles, then, are really, as one might say, terrestrial insects living in the water just as whales are terrestrial mammals that have taken to the ocean. In a way they are like toads and frogs, amphibia. However, aquatic beetles make up only a small portion of all beetles and the others are purely terrestrial.

Each principal order of insects has at least a few more or less aquatic representatives, the degree of adaptation to that environment varying from merely an ability to live on the surface of the water to a condition of affairs where the entire life is spent underneath except for short mating flights and journeys from one locality to another. But, all adult insects are fundamentally creatures of the upper air and even those adults that are usually submerged

[1]Illustrations from photographs by the author, except as noted.

must come to the surface to breathe just as whales come up to "blow." Curiously, the orders in which every species has aquatic young, such as the dragon-flies, the May-flies, and the stone-flies, have adults that never enter the water except to lay eggs, and few do even that.

Of the insects living on the surface of the water and rarely going beneath, the water-striders are among the most

A dragon-fly nymph (left) and the skin of one (right) out of which has crawled the winged adult

Water-striders glide about on still places in the brook, pouncing upon helpless insects that have fallen in

interesting. They are true bugs; that is, they have piercing mouth-parts, four, if any, pairs of wings, and "incomplete metamorphosis." By the latter phrase we mean that the young just hatched from the egg looks much like the adult except that it is small and has no wings. From time to time, as it gets older, such an insect sheds its skin, at each molt becoming larger and looking more grown-up, until finally there comes the molt that discloses the full-fledged adult. These striders glide about on still places in the brook, pouncing upon helpless insects that have fallen in and sucking their juices. The reason that the striders can walk on the water is that their feet are fitted with hairs and lie out flat so that they do not break through the surface film. Even a needle can be floated in this way if it be greased and gently laid flat on water.

It is also interesting that relatives of these striders of still places in our brooks are the only insects of mid-ocean. How such creatures can weather the storms of an angry sea is a mystery. Once they have been submerged and thoroughly wetted they seem unable to regain their ability to float unless they can crawl out on some object and dry themselves. Failing this, they drown; and, yet, there they are in numbers many miles from shore.

The dragon-flies are, perhaps, the most spectacular insects of a brook, darting back and forth like miniature air-planes and making landings on the tips of reeds,—such landings as must be the envy of every aviator that has given them a thought. The young of these dragon-flies live in the water, where they feed on the larvæ (the

A dragon-fly at rest

young) of mosquitoes and other aquatic animals.

Dragon-flies belong to the order Odonata but this order is clearly divided into two parts: the true dragon-flies and the damsel-flies. Quite apart from technical characters we may distinguish the adults of these two groups by the fact that, when they are at rest, the dragon-flies hold their wings out at the sides and the damsel-flies hold them together over their backs. Even the young differ and in a curious way. The young damsel-fly has three leaflike gills at the hind end of the body. These gills not only absorb air from the water but they act as sculling oars when the young damsel-fly wishes to go forward. The young dragon-fly, on the other hand, takes water into the hind end of its body, where there is an air-absorbing surface, and when the young dragon-fly wishes to go forward, it shoots this water out forcibly and pushes itself ahead in this way.

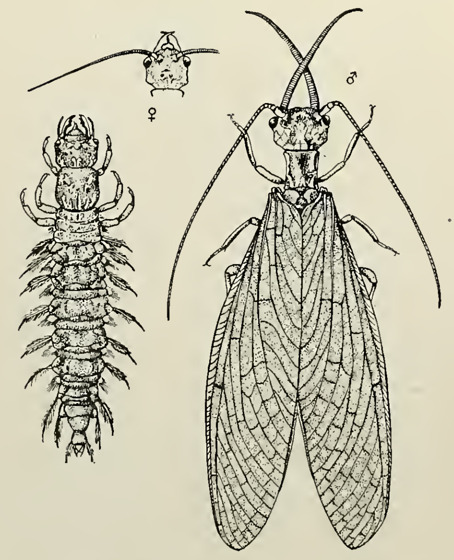
When the young Odonata, dragon-fly or damsel-fly, is half grown or larger, we can notice small pads on its back just behind its head. These are the wings developing inside of its skin. At each molt the pads get larger and finally the youngster crawls out of the water onto a stick or a rock, its skin splits down the back, and an adult, fully equipped with most useable wings, pulls itself out of its swaddling clothes. There is no apparently resting pupal stage, between the larval and the adult

The "swaddling clothes" of a Stone-fly

stages, as there is, for example, in the case of butterflies.

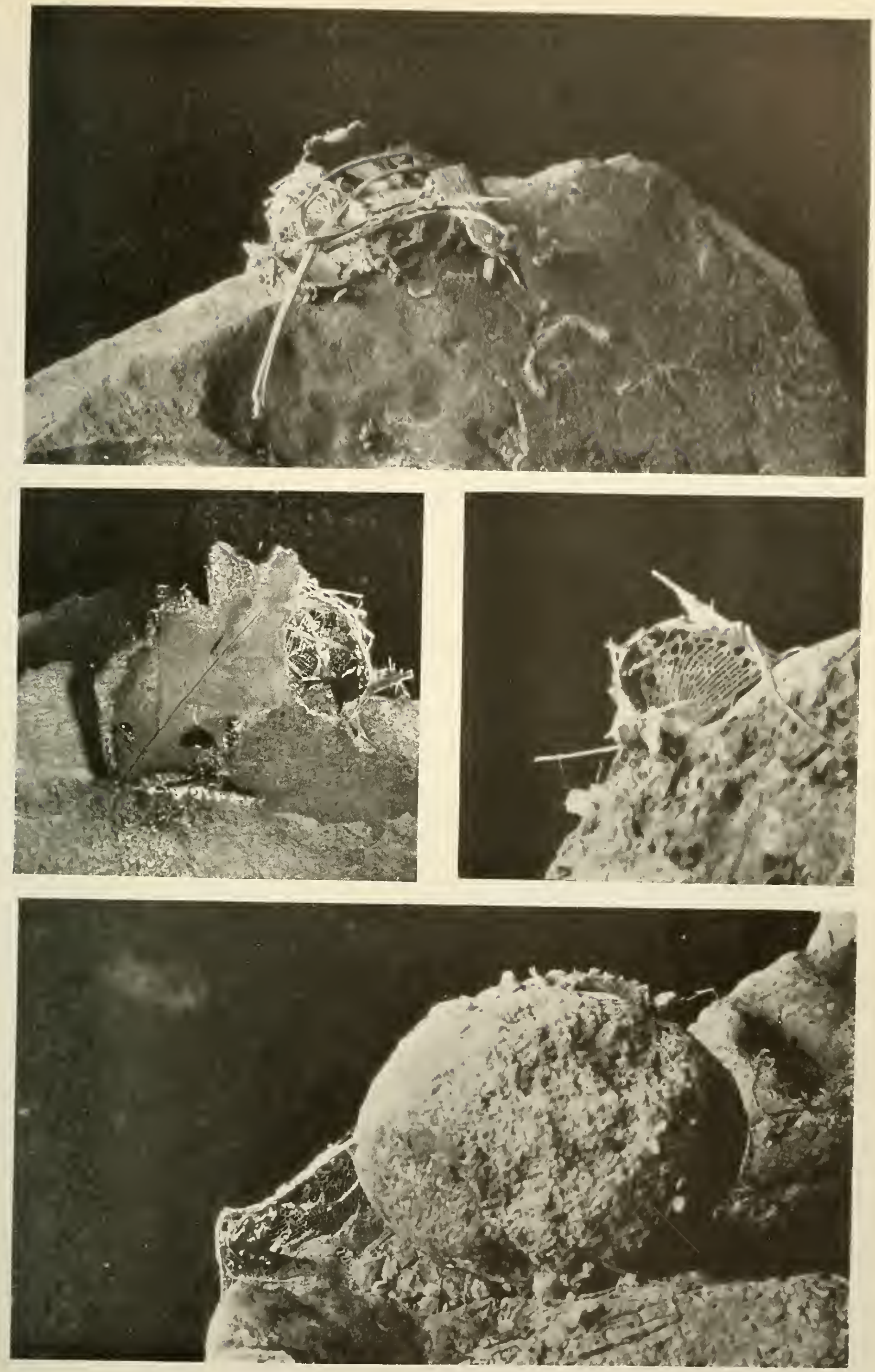
This absence of the pupal stage is characteristic also of other orders of aquatic insects. One of our illustrations shows the split skin from which an adult stone-fly had emerged. May-flies have a similar history but they are an interesting exception to the rule among insects that there is no molt after functional wings have been acquired. When the May-fly "nymph" crawls out of the water, its skin splits in the regular fashion, a winged creature comes out, flies around a bit and then its skin splits and the adult May-fly emerges, leaving behind the "subimago" envelope, complete even to the part that covered the wings. This relict looks exactly as though it were all that remained after some enemy had killed a May-fly and picked its skin—not its bones, for it has none—clean. Instead, it is a joyful indication of a freer life—though brief—a life of aerial dancing and mating.

Many a fisherman knows the horrid-looking hellgrammite hiding underneath stones on the bottom of a brook but not all of them know what happens to this hellgrammite if it is not used as bait for bass or some other fish. When its time comes to leave the water of its own accord, it crawls onto the bank and under a stone there. Since it has "complete metamorphosis," it does not immediately become an adult but the skin splits and discloses a pupa. After the insect has spent some time in this stage the pupal skin splits and out comes the adult. It is called a dobson-fly but it is merely the hellgrammite grown up. The accompanying illustration shows the unforgetable appearance of a male dobson-fly and the head of his smaller-jawed spouse.



The hellgrammite (left) pupates and then becomes either an adult male dobson-fly (right) or his more docile-looking mate, whose head is shown above. From Lutz, *Field Book of Insects*

Opinion differs, of course, but to me the most fascinating residents of a brook are the caddis-flies, skilled artisans in wood, stone, or silk, as the case may be, and probably the aquatic branch of a line of descent that gave us the butterflies and moths. The young caddis-flies are wormlike affairs, really not beautiful in themselves but some of them do truly wonderful things. Most of them construct cases in which they live with only their heads and the leg-bearing part of their bodies exposed. Those kinds that live in still water make their cases with light material, some using sticks, others bits of leaves. Of those that use sticks, some place them lengthwise of the body, others crosswise and neatly arranged like the logs of a cabin. The kinds that live in swifter water are more given to using stones or bits of sand and one of these quite unintentionally played a neat joke on the collectors of shells. It builds a case coiled like a snail's shell and makes it of grains of sand so skillfully and so smoothly joined together by a secretion from its mouth that human beings were completely fooled into thinking that the caddis case was really the shell of a new species of snail. Occasionally a caddis-worm that uses stones to construct a case will add a real snail-shell to its masonry, not even rejecting one that still contains a living snail. In such instances many differences of

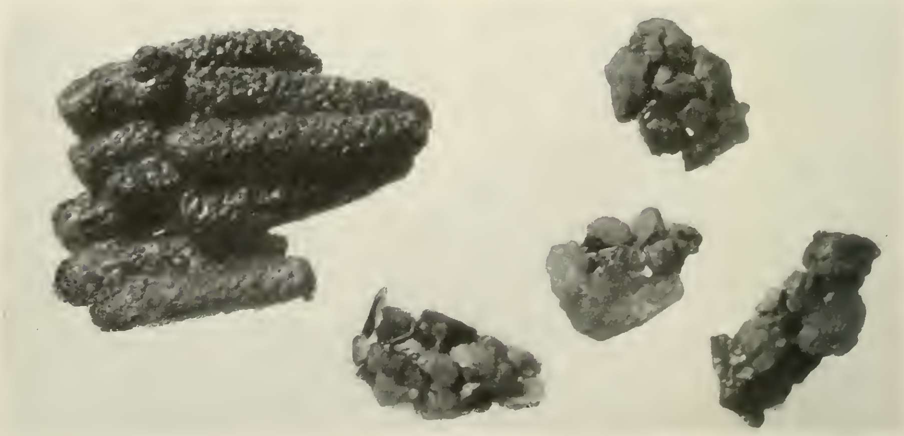


HYDROPSYCHE'S NET

The worm-like larvae of this genus of caddis-flies builds its square-meshed net of silk in the swiftest part of the brook, facing upstream to catch what may come its way. The upper figure shows the rear of such a net strongly stayed with sticks and pebbles opinion must arise between the caddis and the snail as to direction of movement.

The young caddis-fly pupates in its case, having first fastened it securely to some under-water support, such as a stone. When the complicated readjustments have been made within the body of the pupa, changing the wormlike young into a mothlike adult, the pupa leaves its case, swims to the surface of the water, and splits its skin. The adult is out and away, sometimes so quickly that it seems as though it had flown out of the water.

In the very swiftest current, where the water rushes over impeding rocks, we may usually find young *Hydropsyche*, builders of stone fishing-huts and traps. Put less figuratively, it is like this. Each of these young caddis-flies constructs out of silk and stone a case for itself securely fastened to a rock. Near this case a frame-work of sticks is made and across it is woven a square-meshed net of silk. This net always faces against the current and the accompanying illustrations show its construction quite clearly. When the young *Hydropsyche* is hungry, it has but to go a few steps—hazardous steps they are, though, in that swift current—from its home to its net, there to eat what the stream may have brought to it.



The larvæ of most caddis-flies live in cases built of sand, pebbles, sticks, or leaves, according to the species. Those that live in swifter water use pebbles of sand as is shown here. At the left is a clump of cases which the owners have fastened together while each pupates within its own

The Insect-hunter Abroad

By T. D. A. COCKERELL
University of Colorado

Professor Cockerell, an old friend of the readers of Natural History, is here kindly taking us with him to interesting islands, not seeking knowledge that is of immediate economic value or specimens with which to decorate our homes, but for the pure joy of learning more about the world in which we live.—The Editor.

THE student or collector of insects, when he goes abroad, requires no costly apparatus. A few dollars will purchase net and pins, collecting-boxes and killing-bottles, and all may be stored in a very small space. Having arrived on some foreign shore, in the proper season, he does not search long before he is rewarded with an abundant harvest. Returning home with his collections, whether he studies them himself or hands them to various specialists, he is almost certain to find that he has obtained species new to science, or has learned new things about the distribution or habits of previously known species. During the winter months, his eye wanders over the series of specimens, and he recalls with pleasure this or that expedition, even the various hardships appearing attractive in retrospect. He is not insensible of the fact that many of the specimens are beautiful in form, marking, or color, and is glad to combine æsthetic with intellectual appreciation. Finally, if he can find some like-minded brother entomologists to view his discoveries, listen to his yarns, and envy his success,his cup of pleasure is full, and he resolves that next time he will do even better. Such being the opportunities and rewards, we marvel that there are not more entomological travelers.

It is true indeed that the museums are crowded with insects which no one has time to study. At Oxford I found a couple of bees collected by Charles Darwin on his famous voyage in the "Beagle." To this day they have never been identified. From the Berlin Museum I received a collection of bees obtained by Ferdinand Deppe in Mexico in 1829 So greatly has this fauna been neglected, that several were still new to science, though they were obtained early enough to have been described by Lepeletier. What is the use of piling up materials faster than they can be examined, crowding our collections with huge masses of unassorted specimens?

The matter takes on a different aspect when we think of collecting in order to investigate scientific problems, or merely for the purpose of getting personally acquainted with the wonder and beauty of nature. It is all very well to read about the splendid butterfly *Vanessa tammeamea* of the Hawaiian Islands, each anterior wing with a figure like a red goblin on a black ground. It is a pleasure to see it in a museum, but what is that compared with watching it circle among the trees on the tropical slopes of the Manoa Valley? When one has seen an insect in its natural environment it is possible to think of it as a living thing instead of something dead and done for. When some particular problem is attacked, all the abundance of the museums is likely to prove inadequate. Suppose we are tracing the evolution and distribution of a particular group. Rarely do

STEEP CLIFFS OF THE ISLAND OF KAUAI, NEAR HAENA we find sufficient specimens for more than incomplete and preliminary discussion. In many cases, it is necessary to collect the material with a particular point in view. We want to know the amount of variation in different parts of an insect's range; we want to know its connection with particular plants, or its habits. We wonder how it maintains itself, and what are its natural enemies. Long and magnificent series in the collections are apt to be puzzling and disappointing. The specimen of a certain butterfly from a certain place is peculiar. Is there then a peculiar race in that locality, or did some collector pick this out from an abundance of ordinary individuals because it was unusual? Recent intensive work on butterflies, as on birds and mammals, has revealed the existence of many local races or subspecies, best appreciated when a long series from each place can be examined. These studies may seem trifling at first, but we are catching evolution at work, seeing the beginnings of differentiation. It is through the study of minutiæ that biology advances, just as it is with chemistry and physics.

There is a peculiar fascination about the fauna of an island, or better still a group of islands. How did the various forms of life get there, and in what manner have they departed from the characters of the original immigrants? What have isolation and special circumstances done for them and to them? Nowhere can these matters be studied better than in the Hawaiian Islands. The splendid *Fauna Hawaiiensis* makes the determination of species relatively easy, yet leaves more than enough new work yet to be done. The islands themselves are charming beyond description, and their people are friendly and hospitable. The climate is healthy, while the United States guarantees security and peace. All this is only five days from San Francisco.

I can never forget July 16 1924, when Mr. O. H. Swezey took me through the forest on Mt. Tantalus and the upper part of the Manoa Valley. The locality is just above Honolulu but still retains most of the original fauna and flora. This was the happy hunting-ground of the Rev. T. Blackburn many years ago. In his day the conspicuous black-winged bee *Nesoprosopis fuscipennis* was rare, so rare that he found only a single example of the female sex. I got it in abundance, both sexes. Has it greatly increased in the last fifty years, or did I happen upon an unusually favorable locality at exactly the right time? At the same place we found numerous ichneumon-wasps with dusky wings, bearing a dark spot near the tip. This is *Echthromorpha maculipennis* of Holmgren, and *Echthromorpha* is a genus which is especially characteristic of islands. It is puzzling to know how they cross the sea, apparently having advantages in this respect over most other ichneumons.

At the head of the Manoa Valley I captured a slender, clear-winged dragon-fly, one of Blackburn's discoveries, *Nesogonia blackburni*. It belongs to a genus of one species only, confined to the Hawaiian Islands. Its affinity is with the widespread *Sympetrum*, some species of which probably wandered across the sea long ago, and its descendants have become sufficiently different to be placed in a distinct genus. It is found on several of the islands, and Perkins says: "This dragonfly exhibits much variation in color, size, and other respects, and both general variability and local are evident." There is thus an opportunity for intensive study, with the certainty of interesting results.

On Mt. Tantalus we are again reminded that we are following Blackburn's footsteps by taking a beautiful little butterfly, uniform emerald green on the under side of the wings. It is called *Lycæna blackburni*, and is peculiar to the Islands. I met it again near the Volcano House on Hawaii. On the way down the Manoa Valley, I found a brilliant shining purple ladybird beetle. It is *Orcus chalybeus*, imported by the economic entomologists to feed on scale insects. My specimen is a female, with dark-lobed prothorax; in the male these lobes are cream-colored, so that the sexes look at first like different species.

The insects of the islands may be divided into several groups on the following bases: (1) species belonging to genera which are confined to the islands; (2) belonging to genera also found elsewhere, but the species peculiar to the islands; (3) species also found elsewhere, but probably not introduced by men; (4) species accidentally introduced, and (5) species purposely introduced. The introduced species are now very abundant, and in the vicinity of towns or along the coast appear to be dominant. The interrelations of these different groups, which naturally react on each other, afford endless opportunities for study. Furthermore, among the endemic species, some are widespread, others confined to particular islands, or even to very restricted localities on those islands. In the museum it is difficult to understand the meaning of all this, but in the field certain facts are obvious. Thus we may see how, close to the Volcano House on Hawaii, there are abrupt changes in climatic conditions, so that in a few minutes one may pass from one environment into another which is radically different. Insular endemism within the group is a never-failing source of interest. How far are the species of the several islands distinct from one another? Which islands have most recently been formed, or most recently been connected with others, judging by the fauna? Can we, by very careful statistical studies, discern the beginnings of insular differentiation in species which occupy several islands?[1]

Of all the islands, perhaps the most interesting is Kauai. Far to the northwest, separated from Oahu by a channel which it takes all night to cross in the inter-island steamer, it naturally shows a large proportion of peculiar organisms. *Carelia*, a remarkable genus of snails, is entirely confined to it and to the neighboring small island of Niihau. Kauai is believed to be of relatively great antiquity and, although thousands of feet of volcanic strata are exposed in its deep cañons, volcanic activity is entirely extinct. In a beautiful archipelago, this island is exceptionally lovely and, as it has been less visited by entomologists than most of the others, it offers excellent chances for discoveries. The lowlands, however, have been mainly given over to pineapple and sugarcane, and it is necessary to search in the moist forests of the mountain area for the characteristic native insect fauna.

My visit to Kauai resulted in some conchological discoveries,[2] but nothing of importance in entomology, because I could not reach the heights. I was very fortunate in being able to join the excursion of the Trail and Mountain

[1]The introduction to the *Fauna Hawaiiensis* (Vol. I, Part VI), by Dr. R. C. Perkins, is a work of classic rank, discussing the various zoölogical problems presented by the islands with a thoroughness and breadth of knowledge which has perhaps never been equalled in a work of this type.

[2]See *Nautilus*, Jan. 1925.

Trail and Mountain Club on the Island of Kauai. The truck was stuck in the mud and was pulled out by the caterpillar tractor

Club of Honolulu, led by Mr. R. J. Baker, the photographer. The group of sixteen men and women occupied a two-ton truck, which traveled rapidly over the asphalt roads. We stopped at various points, walking up into the forest or along the shore, and camped on the beach where the bathing was good. After spending a night at the Barking Sands we started along an unpaved road, to regain the high road to Waimea. Before we had gone far it began to rain violently, and in a little while the surface of the powdery road was covered by an inch or so of sticky mud. The heavy truck refused to go, its wheels revolving without any resulting progress. Once or twice we nearly went into the ditch. The whole company labored, pushing and putting various things under the wheels, all the time in pouring rain. In spite of our lack of success, the greatest cheerfulness, one might almost say hilarity, prevailed. Presently some one saw a caterpillar tractor in a near-by field and this machine, constructed like an army tank, readily pulled us out. Once on the paved road, we were soon in Waimea, where there was no place to camp except on the platform at the foot of the pier, which was at any rate roofed over and so protected from the rain. Being wet to the skin and without other clothes, we executed all the dances and physical exercises we could think of, while rows of Japanese children viewed the spectacle with polite amazement. As this was the first time the Trail and Mountain Club had thus visited Kauai, the children had probably never before seen women in hiking costume, but they restrained their emotions as children of our race would never have done. They would not even take candy until their elders gave consent. The trip was celebrated by a ballad, beginning thus:

Oh, we're camping on Kauai,
As the treasured moments fly,
And we live once more as life was meant to be,
For we've left the teeming city,
And to those we give our pity
Who never camped betwixt the palms upon
the beach and sea.

All of which may not be, strictly speaking, entomology, but that does not matter. And for a token that I was really there I have before me a row of splendid flies, shining green and purple, captured at Waimea. Do not regard them with scorn, because they are the introduced *Volucella obesa*, widespread over the earth. Many years ago, my wife took exactly the same species at Quirigua, Guatemala.

On the other side of the globe, far out in the Atlantic from the coast of northern Africa, are the Madeira Islands. They consist of Madeira proper, Porto Santo, the Desertas, and a number of islets. Like the Hawaiian Islands, they are volcanic and, like them, they seem never to have been united with any continent. The entomologist whose "footprints" we see on all sides here is T. Vernon Wollaston. I have his book, *Coleoptera Atlantidum, being an enumeration of the Coleopterous Insects of the Madeiras, Salvages, and Canaries* (1865), one of the great contributions to the philosophy of entomology. My copy possesses added interest from containing the book-plate of Frederick Ducane Godman, a name so well known to us in connection with the natural history of Central America. Wollaston's specimens may be seen in the British Museum and at Oxford. My wife and I visited the Madeiras in the winter of 1920-21. Living in Funchal, the one large town, we found a fauna consisting largely of species introduced during the long period of human occupation. It is easy, under such circumstances, to mistake wholly the true character of the fauna. Thus the Madeira Diptera which were identified by Becker are essentially of European type, common flies to be found almost anywhere on that continent. In this they strongly contrast with the beetles, a very large proportion of which are endemic. But the beetles were collected by Wollaston with great industry in every wild place he could reach, while almost all of the flies came from Funchal or the immediate vicinity. It still remains for someone to explore the out-of-the-way spots, and obtain the peculiar Diptera which very possibly occur there. Some of the smaller crane-flies, or Tipulidæ, may be especially worth while. Thus the genus *Dicranomyia* is not in the Becker list, but I collected *D. canariensis* of Becker at Funchal, December 29 and 30; and at about 3000 feet altitude on the Pico do Serrado my wife obtained Wollaston's *D. maderensis*, along with the interesting little *Dixa puberula* Loew. Mosquitoes from Funchal were ordinary species, probably introduced (*Culex pipiens*, *C. tipuliformis*, *Theobaldia longiareolata*), but the buffalo-gnat (collected by our young friend Fred Jones) proved to be *Simulium ornatum nitidifrons* Edwards, recently described. We found one species of moth-fly, *Pericoma meridionalis* Eaton, not listed by Becker. All these flies were determined for us by Mr. F. W. Edwards of the British Museum. Small gnats of the genera *Chironomus*, *Culicoides*, and *Forcipomyia* have not yet been definitely identified. Among the larger flies at Funchal was *Stomatorrhina lunata*, with beautifully banded eyes. These details are not in themselves of much interest to those unfamiliar with the insects but they show that even a small amount of collecting produces results of scientific value. Perhaps the most interesting capture in Funchal was that of a pretty little moth, new to science, brought to us by Fred Jones, the son

Porto Santo with the Ilheo de Cima in the distance. Date palms in the foreground

of our host at the hotel. It has been named *Cosymbia lilacinipes.*[1]

In Madeira we went to Machico, Canical, and over the pass to Porto da Cruz. But by far the most interesting expedition was to Porto Santo, the island where Columbus once lived, and from which he looked across the ocean, wondering what might be on the other side. The house he occupied was only a few steps from the one which we occupied in Villa Baleira. There was no regular boat to Porto Santo, and we therefore took passage in a large fishing vessel which had come to Funchal for commercial purposes. Late at night we put out of Funchal harbor, watching the bright lights receding as we rounded the point to the east. They gave us the cabin de luxe, namely the row-boat hauled up on the deck, and in this we rested, listening to the musical chant of the sailors as they plied the long oars. The following day we came safely to Porto Santo, and were carried through the surf by strong arms, and deposited on the sandy shore. The island is very small, and can be readily explored on foot. The greatest interest, however, centers in the outlying islets, some of them no larger than a big building, yet supporting peculiar snails and beetles. Thus on the Ilheo de Cima, on which stands the lighthouse, the specimens of the ground beetle *Scarites abbreviatus* are all of gigantic size, constituting a well-marked race which I named *cimensis.*[2] Other peculiar beetles were found on other islets, and unquestionably more remain to be found. Most remote was the small Nordeste, where landing was difficult as the boat rose and fell with the waves, giving us but an instant for a successful leap to the rugged lava rock. Here we got a new beetle, and snails which live nowhere else, one of

[1]*Proc. Entom. Soc. Washington*, XXV. 163. (1923.) With regard to the Becker Diptera I did not have access to the published account, but derived my information from the collection identified by Becker, in the Seminario at Funchal.

[2]*Proc. Ent. Soc. London* for 1921. p. lviii. For a general account of I. de Cima and its peculiar snails, see NATURAL HISTORY, May–June 1922, p. 268. For the general problems connected with Madeira Island beetles, see *Ann. Mag. Nat. Hist.*, June, 1923, and for Lepidoptera, *Entomologist*, Nov. 1923.

Villa Baleira, Porto Santo

them of exceptional beauty. The visit suggested the following lines:

NORDESTE

Islet girt by tossing seas,
Facing ev'ry wind that blows,
Raging storm or gentle breeze,
Here the orange *Lotus*[1] grows.

Here alone in all the earth,
Some things of beauty do abide,
And on this lonely rock had birth
And never yet have crossed the tide.

Who can say what rugged shore,
What heart with brambles overgrown,
May give to those who will explore,
Some treasures all its own.

When we finally had left the Madeiras and sat down to supper in the dusk of the evening, Nordeste came in view through a porthole opposite, like a picture in a frame. It was our last sight of the islands.

The Japanese islands differ in almost every respect from the Madeiras or the Hawaiian group. They are of "continental" type; that is, they represent a partially submerged area which was once connected with the Asiatic mainland. The Japan sea, between the main island of Japan and Siberia, is very deep, but to the north and south there is comparatively shallow water. Indeed, the Gulf of Tartary, separating Sachalin Island from the Amur region to the west has every appearance of being an old river valley, the river flowing south into what is now the Japan Sea. Northward, one may still go from Japan to the mainland, crossing only narrow straits; those of Tsugaru, La Perouse, and the very narrow head of the Gulf of Tartary. Furthermore, the Kurile Islands form stepping stones from Japan to Kamchatka, as we all know from following on the map the recent flight of the American aviators. To the naturalist the biota of Japan is full of interest. What proportion of the types observed came in from the north, or are related to those of the northern mainland? How much is there of the fauna of China and Korea? How much evolution has taken place within the Japanese area? What has

[1] *Lotus floridus* (Lowe). See *Torreya*, XXII, p. 7 (1922).

been the influence of climate, what of available migration routes? My own visit to Japan, in 1923,[1] was so brief that it was not possible to make any extended observations. At Tsuruga, on the west coast, it was very easy to notice the mingling of northern and southern types of life, the latter apparently predominating. Thus the large snails, superficially similar to those of Siberia, differ anatomically, and are really of southern origin. Some of the plants are closely related to Chinese species. The sweet-scented tree, *Hovenia dulcis*, so attractive to bumble-bees, has a wide range on the mainland, even to the Himalayas. On the other hand, the species of bumble-bees, and some of the butterflies, have northern and northwestern affinities. The famous Japanese beetle (*Popillia*), which has caused so much trouble since its undesired arrival in the state of New Jersey, was found at Tsuruga on roadside weeds, doing no harm. It is doubtless controlled by its natural enemies. We stopped at Gifu to visit the celebrated entomologist Yasushi Nawa, who is now bedridden and unable to continue active work. In his museum we saw many Japanese insects, and were especially interested in a fine collection of fossil insects, apparently of Tertiary age. When these are worked up, they will undoubtedly throw much light on problems concerning the origin of the Japanese fauna. A conspicuous feature in Japan is the abundance of cicadas, which are caught by the children and kept in little cages. We heard at Tsuruga the one which Dr. D. S. Jordan refers to, as having a voice so like a bird that he was deceived. Japan is a beautiful country, and we found the people very friendly. The visiting entomologist is sure to reap a rich harvest, and although very much has been written on Japanese insects, there is still plenty to do.

Collecting insects at Tsuruga, Japan, June, 1923

[1] For details see *Scientific Monthly*, April 1925.

The Adventures of Ctenucha

A MEADOW CATERPILLAR

By EDITH M. PATCH
Department of Entomology, University of Maine

CHILDREN, here is a story written especially for you by one of the best-known of all women entomologists. But, although an "-ologist," Miss Patch is one of you, as you know if you have read her "Hexapod Stories" or her "Bird Stories." We hope you, no matter how old or how young you are, will like this story as much as we do and we will try to have Ctenucha on our Nature Trails next summer. Perhaps you, too, can find and keep one for a pet.—THE EDITOR.

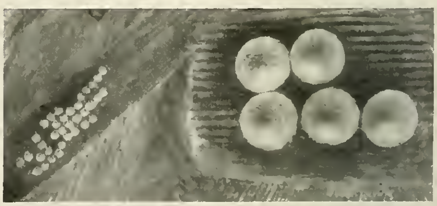
CTENUCHA had her first adventure while she was young. She was, indeed, so very young that she was still living inside an eggshell when things began to happen.

The eggshell which was her first home was shaped like a ball, except that one side was flat. The flat side was fastened to a blade of grass. The egg was so small that it would have taken more than twenty like it, resting side by side, to make a row an inch long. There were nearly two hundred similar eggs in rows on grass blades near the egg in which she lived. Inside of each of these eggs was a brother or sister of Ctenucha's.

After she had lived for ten days in the egg, it changed color. It had been yellow at first, as yellow as honey. On the eleventh day the egg looked gray. The shell itself was not gray. It was really as white as a pearl. The egg looked gray because something inside had turned dark and was pressing against the shell. The dark thing was Ctenucha's head.

The next day the dark head showed even more plainly through the thin shell. Little Ctenucha was moving her jaws in a hungry way. It is not unpleasant to be hungry if there is good food to eat, and the wee caterpillar liked eggshell. She scraped and scraped against the shell with her jaws for hours until at last she made a hole in it. There was no reason then why she could not have crept through the hole, except that she was so hungry for eggshell that she ate her way out instead of creeping out. So she stayed and ate until she was no longer inside the shell but most of the shell was inside of her.

That was Ctenucha's first adventure, eating her way into the world of sunshine. You need not be surprised to learn that a creature who began life so strangely should do other queer things from time to time. That is, they seem odd to us, though all Ctenucha really did was to live a natural caterpillar life. If you wish to see for yourself how she acted, you need only find an egg like hers and watch from the time the baby insect eats its eggshell until its last adventure.



Eggs (much enlarged, on the right) of Ctenucha. Each caterpillar eats the shell of the egg from which it hatched

Ctenucha had sixteen feet. Three pairs of them were on jointed legs near her head. These she did not use much

Various patterns in the last coats worn by Ctenucha caterpillars

in walking. She held them somewhat like hands at each side of her food when she was eating. She crept with the other five pairs, soft clinging ones with which she could hold firmly to the thin edge of grass.

She did not need to learn to creep, and it was well for her that she could travel at once; for, soon after she had finished her breakfast of eggshell, she was ready for dinner. Perhaps it was the smell of growing grass that made her hungry, for she crept about the plant until she came to a tender leaf. Then she began to nibble. From the moment she first tasted grass, she seemed contented with that sort of food; and, as long as she was a caterpillar, she sought no other kind. Her journeys for meals took her no farther than from one grass plant to another, and some days she ate so steadily that it would be hard to tell when her breakfast left off and her supper began.

After eating busily for several days, she stopped to rest. She was forced to stop because she had grown so fast that her skin could not hold any more body. When she was in that sort of fix, she pulled herself out of her skin, but that took time. She rested quietly until the tight skin ripped back of her head. Then she crept out of it, leaving the skin, old skull and all, lying on the grass. She did not need it any longer because a new coat of skin had grown to take its place. She could now again eat grass until this new coat, in its turn becoming too tight, would be discarded.

That is the way Ctenucha passed the days until fall—eating, growing, resting, molting. Every time she molted she had a different-looking skin. She changed her coat for a bigger and prettier one each time. Her first little coat had been whitish yellow with tiny black dots from which grew a few dark hairs. Each new coat had more hairs than the one before. The garment she was wearing when cold weather came had a row of black hairs down the middle of the back with a stripe of yellow hairs on each side.

Ctenucha's home was in a northern part of the country where, during the cold winter, the grass stops growing and the ground is covered deeply with snow. Some animals in that part of the world must live all winter without eating. Bats and bears and woodchucks and skunks and frogs and earthworms and many insects can do this. All these animals that live during the winter without eating, manage in much the same way. Each seeks a comfortable place and goes to sleep. That is what Ctenucha did. Her winter's adventure was a nap. But her sleep was not so sound as that of some of the other animals; and when it was warm enough, as perhaps during a January thaw, she wakened and went for a walk. A party of boys and girls who were tramping across the fields on their snowshoes when the weather was mild saw a black-and-yellow creature hurrying over the snow, and they called it a "winter caterpillar" and wondered where it was going.

After fasting all winter, Ctenucha was very hungry in the spring and, when the grass began to grow, she ate greedily. The coat in which she had slept was no longer pretty. The yellow hairs had faded until they were the color of old straw, and the black tufts were dingy. She could not change this garment for a better one until she was plump enough to molt, but she ate so many tender grass blades that by the middle of April she could not swallow another mouthful.

She crept to a bit of stubble and spun a thin mat of silk upon the dry stem. She tangled the hooks of her ten creeping feet among the threads of the mat and rested quietly with her head down. After a while she pulled her head back out of her old skull and then she looked as if she had a swollen neck. The new head inside the old skin pressed so hard that at last the skin tore at the "collar," and Ctenucha's head popped through the hole. The six jointed legs and the ten creeping feet were all pulled out of their old stockings and Ctenucha crept forth like a new creature. She left her old coat lying on her molting-mat on the stubble and went in search of fresh grass.

Before she molted in the spring, her coat, as you may remember, had a row of black tufts down the middle of the back. There were more than one thousand caterpillars of the same kind in the meadow where she lived, and every one of them wore a winter coat like hers, with black tufts in a row down the back. All these thousand and more caterpillars molted their winter coats in the spring, after they had been feeding on grass for a while. Some of the new spring coats had black tufts on the back and some of them had white tufts. Of course, the caterpillars could not choose which color of tufts they would have. Each one had the kind that grew, just as you have dark hair or light hair, without choosing.

Ctenucha's spring coat had a row of white tufts bordered on each side by a soft yellow stripe. Her ten creeping feet were red, not bright red, but a soft dark shade. Her head was the same pretty color, except her face, which was black. If, some spring day, you chance to meet a creature like her, with a black and red skin and a yellow and white coat, you will be glad to see so good-looking a caterpillar.

Fine as the new spring coat was. it did not last long; for one day Ctenucha pulled the hair out of it, and then she was as queer as a hen without any feathers.

The day she pulled out her hair was the time of one of her greatest adventures—the day she made her cocoon. I like to remember that day, because she wove a basket-like cocoon without making one mistake; although it was the first cocoon she had spun and there was no one to show her how to do it.

After Ctenucha had taken the last bite of grass she was ever to swallow, she sought a piece of bent stubble and crept to the under side of it. Clinging to the dry stem, back down, she began to spin. Perhaps you know that a caterpillar has silk glands in its body where liquid silk is made. When a caterpillar is ready to spin, the silk drools out of an opening through the lower lip and, when it touches the air, it is stiffened into a thread.

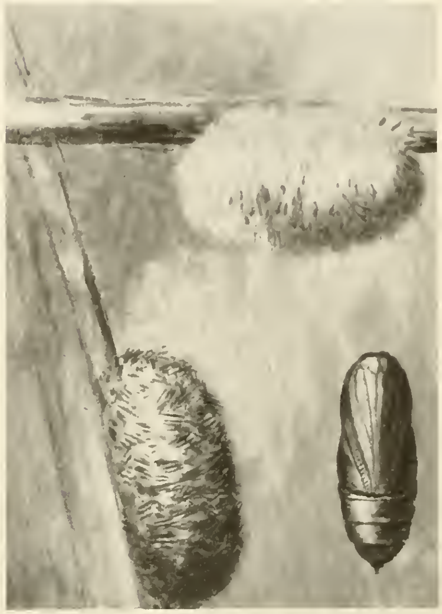
Ctenucha had spun silk before. She had made a mat of silk in which to tangle the hooks of her creeping feet while she molted. The molting-mat held her old skin steady while she pulled herself out of it. But to make silk enough to cover her whole body was quite a different matter.

Against the lower edge of the stubble she first spun a strip of silk about as long as she was herself. She clung to this with her creeping feet while she made the rest of her cocoon. When she was spinning, she used her jointed feet somewhat like little hands to guide the thread and to help shape the cocoon. She wove the edges down at each side and each end until they nearly met at the middle and then she joined the edges.

Some caterpillars weave their cocoons entirely of silk, but Ctenucha did not. She used hair also, making a kind of haircloth cocoon; and the hair that she used she pulled out of her coat. First she would add some silk to the edge of the cocoon, and then she would reach her head back and grasp a mouthful of hair close to her skin and pull it out. It came out quickly. I do not think the jerk hurt her. She would tuck the mouthful of hair endwise into the silk she had just spun, and then she would spin more silk in which to tuck the next mouthful of hair.

She worked without wasting any time or any motions. When she was spinning the left side of the cocoon, she reached to her left side and pulled hair from that part of her coat. By pulling hair that was nearest the place she was spinning, she saved time and strength. She did not weave in a quick nervous way. She wove slowly and steadily and she did not stop to rest until the cocoon was quite done.

When Ctenucha's cocoon was finished, her body was stripped of its hair. She had just enough hair for the cloth



Haircloth cocoons, each woven by a young Ctenucha using silk made by itself and its own hairs. Also a pupa, which is the stage between caterpillar and adult moth

of her cocoon. Do you not think that it is wonderful that she could weave that perfect little basket-like cocoon the first time she tried? No one to show her how! Not stopping until it was finished! Measuring out her hair so that there was enough for the cocoon and none to spare!

It seems fitting that she should have a marvelous cocoon, for remarkable things happened in it. In fact, two of her best adventures took place inside the cocoon.

After her weaving was over, Ctenucha lay quivering with the changes that were taking place in her body. After a day or so of waiting, her caterpillar skin ripped down the middle of the back far enough so that she could squirm out of it. She looked queer while she was doing this, for she

A full-grown Ctenucha, now an adult moth with fore wings like "changeable silk," a peacock-blue body, and orange head and shoulders

was not a caterpillar any longer. She was, instead, a soft wriggling object with six legs (much longer than any she had had before), four wing-pads that flopped a very little, a long straight quivering tongue, and two feelers. Legs, wing-pads, tongue, and feelers all moved feebly for a minute or two and then they were glued fast to her body by the fluid that had helped loosen the old caterpillar skin and then hardened in the air inside of the cocoon.

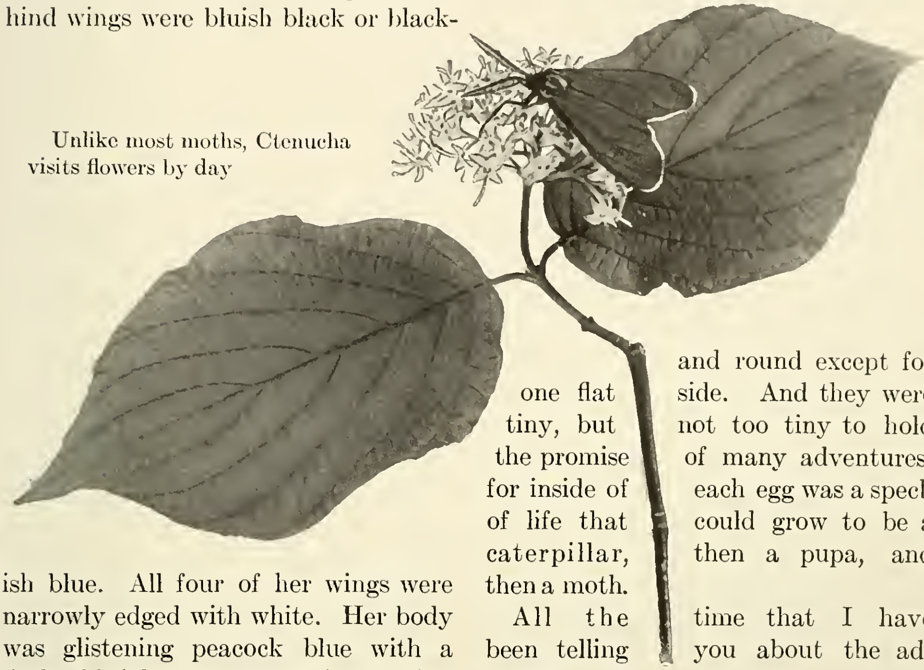
Ctenucha was a caterpillar no longer. She had changed into a pupa. When she first became a pupa, she was bright red with a row of cream-colored spots down her back, but she soon turned dark brown all over and was so shiny that she looked as if she were covered with varnish. At the tail end of the pupa there were some tiny hooks that caught into the silk of the cocoon.

First she had been an egg, and then a caterpillar, and then a pupa. What would she be next? Next she would be a moth; but not until she had lain waiting, as a pupa, for sixteen days. Then the shiny brown skin cracked open and she came out of it. The hooks on the end of the pupa held the skin steady while she pulled herself free. She pushed her way through one end of the cocoon and waited for her wings to expand and grow strong.

Ctenucha was at last a moth, a full-grown insect with wings; and the adventures that lay ahead of her were quite different from those of her caterpillar days. I cannot tell you whether she had a better time after she came out of the cocoon than she did before she wove herself inside of it. I can only say that she had acted as if she were a contented caterpillar while she was nibbling her first breakfast of eggshell, while she was munching her many dinners of grass, and while she was weaving her one wonderful cocoon. After she became a moth, she still acted as if it gave her pleasure to do what things she could.

Most kinds of moths fly only at night, but Ctenucha flew during the sunlight hours. She visited clover, spreading dogbane, meadow sweet, viburnum, and other flowers. She carried her long tongue coiled tight like a watch spring while she was flying; but when she reached a flower, she straightened her tongue and put the tip of it into the tube of the blossom and sipped the sweet nectar she found there. She drank dew, too, feeling along the grass blades with the tip of her tongue and sipping the dewdrop as she did nectar. Sometimes she flew to bushes and trees where there were colonies of aphids and drank the sweet liquid, called honeydew, that aphids drop from their bodies.

It was not easy to see her colors when she was flying, but while she was feeding at a flower it was possible to look closely. Her fore wings were a queer color. Sometimes they looked rusty black or brown and sometimes bronze or purple or green. Like "changeable silk" their colors were different when they were turned in different ways toward the light. Her hind wings were bluish black or black-



Unlike most moths, Ctenucha visits flowers by day

ish blue. All four of her wings were narrowly edged with white. Her body was glistening peacock blue with a dash of bright orange color just behind her head. Her head was orange-colored, too, except the middle of her face which was blue, and her feelers and mouth parts which were black.

However pleasant she may have found the flowers, she did not spend all her time among them. She had another adventure of much importance. There were her eggs, nearly two hundred of them, that needed to be glued to grass blades. Even the sweet taste of nectar or honeydew did not tempt her to neglect her eggs. She put them in rows, close together, sometimes more than twenty on a single leaf of grass. Like the one in which she herself had started life, they were yellow as honey and round except for one flat side. And they were tiny, but not too tiny to hold the promise of many adventures, for inside of each egg was a speck of life that could grow to be a caterpillar, then a pupa, and then a moth.

All the time that I have been telling you about the adventures of Ctenucha, I have been wishing that you might have an adventure of your own. I have been wishing that you might see an egg like one of Ctenucha's hatch; or notice such a caterpillar at molting time; or watch one weaving a cocoon; or find a moth whose body is glistening blue trimmed with bright orange, and whose wings have queer changing colors. Perhaps my wish for your adventure may come true. Wishes often do.

Insect Sounds

By Frank E. Lutz

THE first part of this article was delivered as one of the American Museum's radio broadcasts. That fact explains the references to receivers and transmitters, also the dashes that represent the making of sounds. The second part taking up the same subject from a different angle and for a quite different audience was given subsequently at a meeting of the Entomological Society of America in joint session with the Ecological Society of America.

I

When I was asked, more than a month ago, to hand in a title for this evening's talk I played safe and said I would speak on "Some Interesting Habits of Insects." That gave me a very wide field from which to choose a very few remarks.

I live in one of New York's suburbs and there I have a small yard seventy-five feet front and two hundred feet deep. In that yard I have personally observed more than 700 different kinds of insects. Now, if 700 different kinds of birds came into your back yard and if each of these 700 different kinds of birds had some interesting habit or some curious turn in its life-history, you would marvel at the opportunity lying at your very door for the study of nature. That is the case with those who know something about the ways of insects. Samples of some of the species that live in or that have visited my back yard are on exhibition at the American Museum of Natural History. It is not so easy for us to exhibit the habits of these interesting creatures, but I will try to suggest some of them tonight and I invite you to become even better acquainted than you are with God's out-of-doors, where these habits are on exhibition day and night, winter and summer.

Recently the Westinghouse Company announced the invention of a new type of microphone intended primarily for use in broadcasting programs by radio, but the men in the Research Department of that progressive company saw the possiblity of using it to study the sometimes faint sounds made by insects. Furthermore, insects have antennæ, and some students, probably influenced by the fact that your aërial and mine are called antennæ, have suggested that insects send and receive messages by a method somewhat similar to radio. Personally, I doubt this, but I have lived so long in an open-minded, scientific atmosphere, that I am willing to admit the possibility of any idea that has not been disproved. At any rate, I think that a radio audience will be interested in the sound-making habits of insects, and so I have selected that as my special topic for this evening.

There is scarcely a grass-plot in the United States that does not contain crickets. At certain seasons of the year some of these crickets become musical and the air is filled with chirps, usually cheerful but occasionally sounding sad and lonesome. How do the crickets chirp and why do some of them chirp, while others are silent?

I must tell you first that the female cricket has a long, slim, needle-like affair at the end of her body and that with this she places her eggs under the surface of the ground. The young cricket as it leaves its underground nest looks much like an adult cricket except that it is very small and has no wings. Like Mr. Finney's turnip this cricket "grows and it grows." From time to time as it grows it sheds its skin but it does not get wings until the last molt, when it is fully grown.

The reason for explaining all of this is that crickets chirp by rubbing their front wings together. Near the front of each front wing of a male cricket (but not of a female) is an enlarged rib or brace. On the under side of this rib is a series of small teeth. Then, on the upper side of each front wing is a small rough spot so placed that when the wings are rubbed together the teeth on the under side of one wing scrape on the rough spot that is on the upper side of the other. If your rheostats and dials can spare you for a moment, stretch your hands out in front of you with the *palms up*. Now, let the knuckles of your right hand represent the file on the underside of a cricket's front wing and rub these knuckles on the callouses at the bases of the fingers of your left hand. That is the idea but, of course, there is no sound produced because your hands are not thin membranes like the cricket's wings. In the case of the cricket this rubbing of a filelike structure on a rough spot sets both wings to vibrating very rapidly, probably at a rate of not far from 15,000 shakes per second. This rapid vibration of the wings up and down as the male cricket rubs them against each other from side to side sets the air to vibrating in waves of such a character and frequency that our ears recognize a shrill sound or chirp. I have here a file and a thin piece of tin and I am going to rub one against the other (---). The tone is not the tone of a cricket's chirp because the tin has not the same qualities as a cricket's wing, but the sound is produced in exactly the same way. Katydids are near relatives of crickets and play the same sort of instrument. Their favorite selection is something like this (---). The effect of this rapid vibration of the cricket's or of the katydid's wings seems to be exactly the same as that caused when electrical impulses rapidly vibrate the diaphragm of our telephone receivers. A difference is that, so far as we know, there is nothing electrical about either the cricket's chirp or the katydid's song. They are purely mechanical.

Now, an interesting point is that only the male cricket has this apparatus and, of course, not even the male has it until it is adult and has fully developed wings. Young crickets are "seen but not heard" because they have no wings and female crickets keep quiet, even when they are adult, because they cannot do otherwise, for their wings have no sound-producing attachments. An old Greek poet whose wife was probably different from mine knew about the prevailing silence of female insects and wrote concerning one kind:

> Happy are cicadas' lives
> For they all have voiceless wives.

So much for the sound-production by crickets, their transmitters. What are their receivers like? You receive sounds by feeling the vibrations of very small diaphragms, one located on each side of your head. I do not mean the diaphragms of your telephone head-set, if you are using one, for, as far as you personally are concerned, the phones are still a part of the transmitting system. I mean your ears and more particularly your ear-drums. Apparently crickets also have sound-receiving diaphragms or ear-drums but they are on the front legs and not on the head.

The next time you see a cricket, catch it. Look on the second main joint of either of the front legs and you ought to be able to detect a small white spot. If you examine this spot with a microscope, you will see that it is really a small diaphragm set into the leg. It is supposed to be an ear and, if it really is an ear, both males and females can hear. We do not know how much they can hear but presumably they can at least hear other crickets chirping.

Tree-crickets, katydids, and all of the grasshopper tribe that, like katydids, have very long antennæ, make sounds in the same way that ordinary crickets do, and they all have much the same sort of receiving apparatus. On the other hand, the grasshoppers that we commonly see, those having short antennæ, are different. Some of them make no sounds that we can hear and apparently have no sound-producing apparatus. Possibly the new microphone will reveal sounds made by them and then we will try to discover how these to us inaudible sounds are made. Others of these short-horned grasshoppers make rasping sounds by rubbing their hind legs against their front wings. Still others make loud sounds by rattling their wings together as they fly. I have here a wooden contraption that we used to call a "razzle-dazzle" or "policeman's rattle." As you twirl it, two thin pieces slap against large cogs and make the noise you will hear shortly; but, first, lift off your ear-phones if you are using much amplification. (---) That noise was made by use of exactly the same mechanical principle that certain grasshoppers employ. When I bought this "razzle-dazzle" last week, a man in the shop remarked that I must be going to a wedding. I was not, but the man's remark was curiously close to a scientific teaching. The grasshoppers that make sounds in this way are, we think, hoping to go to weddings and they plan to be the bridegrooms. The prospective bride is sitting quietly in the grass as her lover flutters in the air above her and rattles his castanets.

A peculiar thing about the receiving apparatus of these short-horned grasshoppers is that the receiving diaphragms or ear-drums are not on the legs as they are in their close relatives, the crickets and long-horned grasshoppers, but on the abdomen, one on each side near the base.

Cicadas (the harvest-flies, seventeen-year locusts, and the like) make sounds that may sometimes be heard by us for a mile or more. The transmitting apparatus in this case is of still another type. There is a pair of transmitting diaphragms on the abdomen at about the same place as the receiving diaphragms of the short-horned grasshoppers. A tendon and muscle is attached to this transmitting diaphragm and by means of these it is pulled in and then suddenly released. As it snaps back, it makes a click. I have here a little tin affair that lecturers often use to signal for a new lantern slide. It is sometimes miscalled a "cricket" but it should be called a "cicada." The piece of tin is bent somewhat and, as I push, it bends the other way with a "click" (---). Then, when I let go, it snaps back and makes another "click" (---). The cicada does this so rapidly that the clicks merge one into another so as to make a sort of a buzz or a roar. The best I can do is something like this (---). It might be mentioned, incidentally, and in accord with the Greek poet, that only the male cicadas make this sound.

It is altogether likely that cicadas would not go to all this trouble in producing sounds if other cicadas could not hear them, but I do not know what their receiving apparatus, if they have one, is like.

It is said that mosquitoes receive sounds by means of their antennæ in a very interesting way. We all know to our sorrow the hum made by a mosquito. It is the hum made by a female mosquito that is of most interest to human beings because only the female bites. Now, the antennæ of all mosquitoes are feather-like or plumed antennæ, but especially so in the case of the males. It is said that the hairs which make up these plumes can be set into rapid vibration by sounding on a violin the same note that is made by the female mosquito. I have not seen this happen myself but I hope to try it out this summer. It is probably true, because we know that a tuning fork or a piano string can be set into vibration by sounding the note for which it is tuned. If the hairs on a male mosquito's antennæ are tuned to vibrate at a note corresponding to the female's hum, he can doubtless feel the vibrations and so hear the hum just as we feel vibrations of our ear-drum and call those sensations hearing. (In that case the mosquito does employ antennæ in its receiving apparatus but there seems to be nothing electrical about it nor anything that corresponds to radio.) Far be it from me to suggest that there is any connection between the facts that female mosquitoes are not voiceless and do bite.

Although there is much more that could be said about the transmission and reception of sounds by insects, there is nothing that is much more definite than what I have told you. Do ants and other insects actually communicate by means of sounds which we cannot hear? No one knows but some of us are trying to find out.

II

Probably the first definite sounds made by land-animals on this earth were made by insects. Before ever birds sang or even frogs croaked, insects had developed a chitinous covering, the segments of which, rubbing together, produced sound-waves. Whether these sound-waves were audible in the sense that there were organisms with nervous mechanisms attuned to them might be the subject of an interesting speculation. Crickets and katydids belong to the order Orthoptera, and orthopteroid insects were abundant in the Carboniferous period. In the fields and forests of those days, or possibly earlier, was started "the poetry of earth" that "is never dead."

Judged by human ears, the best insect-musicians of today belong to rather primitive orders. The more advanced groups, such as ants, bees, wasps, flies, and butterflies, make no sounds that we can hear or else, at most, what seem to us to be nothing more than faint squeaks, buzzes, hums, or clicks. However, it is entirely probable—indeed, practically certain—that insect-sounds are not made for the purpose of being heard by human ears. Whether the insects themselves hear these sounds is the important question and one that has not been—possibly cannot be—determined beyond all doubt.

In this connection it should be remembered that, in man's affairs at least, many sounds are made without intention and even contrary to desire—for examples, sneezing and snoring. No part of the success of a certain popular kind of automobile is due to the various and often loud noises emitted by the machine in action. Using an illustration more applicable to the present subject, the armor of the knights of old creaked and rattled as they moved. Their fellows were able to hear these sounds and reacted to them. A rough spot in a particular joint increased the sound made by the moving of that joint. Now, if the armor-maker purposely designed these joints to creak or if the wearer purposely creaked his armor, even if for no other motive than to tickle his pride (as has been the case with wearers of squeaking shoes), then the creaking of the joint had a significance analogous to that usually claimed for certain sounds made by insects—there was an adaptation of structure to sound-production. But, considering now the sounds made by insects, if they are merely incidental to friction between parts of the body, analogous to unintentional squeaks and rattles of knightly armor, then those sounds have no biological significance, except as they may betray the insect to its enemies.

Man has made many guesses as to the significance of insect sounds, but there are two points in this and similar connections to be kept ever and strongly in mind. One is that in science a good guess is very useful as a starting point but exceedingly harmful if, forgetting that it is after all only a guess, we accept it as a proved fact. The second point is that it is dangerous to judge the actions of lower animals by human standards. Was it not Paul who said that, when he was a child, he thought and acted as a child but, when he became a man, he put away childish things? Well, a man is much farther removed from the lower animals than he is from a child and, except in slang, he is not and never was a bug. Bugs were not even in his ancestral line.

There is much joy to be had in giving free rein to our imagination and, on the other hand, man prides himself on being "practical," meaning that everything must be of some use or be abandoned. The combination of these two human traits has resulted in most ingenious stretches of human imagination to find the "practical" reason for everything that we see or hear in this world.

Prior to the Fifties of the last century scores of books were written to show that God was "practical" and that everything was made by Him to serve some definite, very useful purpose. If no purpose could be imagined, the failure was said to be due to the fact that the ways of God were inscrutable and past finding out. Since the Sixties, thousands of books and papers have been written to show that Natural Selection is eminently "practical" and that everything is forced by it under penalty of extermination to serve some definite and very useful purpose. If no purpose can be imagined, the failure is said to be due solely to our present lack of knowledge but the purpose is not past finding out. We even have a name for this branch of biology. It is ecology, the science that gives a reason for everything.

Lack of knowledge is, I am glad to say, frequently a fact. It is the unknown that makes biology more interesting than arithmetic. Of the many Latin mottoes I have seen—why do they so often put good mottoes in poor Latin?—one of the best for a biologist is that which, being translated, reads: "We are ignorant; let us work under this banner.' Let us work under this banner but let us not dodge under it or use it for the purpose of tying together the pieces of a broken theory.

As to the universal practicality of all creation, I hope that the swinging pendulum of human thought may speedily bring us to a point where the slogan "Whatever is, is good" will be changed to the more moderate one of "Whatever is, is not bad." It is my firm belief that many striking characters and characteristics of animals and plants are of no use to their possessors or to any other creature. As I have said elsewhere, they seem to me to be much like the figures in a kaleidoscope, definite and doubtless due to some internal mechanism but not serving any special purpose.

However, we must be on our guard against carrying any belief too far and it would be absurd to say that no special characteristic of any animal or plant is useful to it; also, while some insect sounds appear to have no biological significance, others do appear to have a very decided significance. In that case, we are brought to the threshold of the real problem, really a double problem: How and why has the ability to make these particular sounds arisen?

Most of the sounds made by vertebrate animals are vocal, that is, they are due to the combined action of lungs and larynx. Insects have no lungs, strictly speaking, and most of the sounds which they make may, for the want of a better term, be called mechanical.

The simplest of these sounds is the striking together of two parts of the body. Certain bees, such as the domesticated honey-bee, and certain flies, such as the Syrphidæ, make a shrill noise when they are captured. For years this sound was supposed to be a vocal one. Instead of lungs, insects have air-tubes running throughout their bodies and opening to the outside as a series of small holes. These openings are sometimes provided with membranous flaps. All of these structures were carefully dissected and beautifully pictured by skilled anatomists, the conclusion being that air, forced out of the tubes, set the flaps into vibration and made the noise. This conclusion became firmly established by ingenious experimentalists, who did many things, including cutting off the wings and noting that this did not stop the sound. Then came one of those troublesome fellows who upset traditions. He pulled out the wings instead of merely cutting them off and then the sound stopped. He did other things also and now we know that this shrill note is caused simply by the bases of the wings beating vigorously against the body.

This sound has been very useful to the proponents of the mimicry hypothesis. According to theory, bees make it to warn their captors that stinging is about to start, a most sportsmanlike trait; flies, on the other hand, make this sound to fool their captors into thinking that stinging is about to start, and that trait is commendable only on the grounds of self-preservation, for flies have no sting. As a matter of fact, spiders are the flies' worst enemies and spiders calmly tie up and kill bee and fly alike, clearly paying no attention to the noise and probably not being able to hear it. Toads, frogs, and lizards are the flies' next worst enemies but these predators finish their prey at one gulp and the insects have no chance to make a sound before they are where feeling rather than hearing is likely to tell the captor whether or not it has swallowed a bee. Birds may be deceived—I do not know—but, despite the fact that a large group of birds are called flycatchers, they are not relatively serious enemies of the Diptera and there are birds that have a fondness for bees—sting, warning sound, and all. Therefore, it seems to me that this shrill sound about which so much has been written has no significance. It is merely an incident to the extra vigorous working of the wing-muscles under the excitement of being captured.

There is a large and widely distributed group of grasshoppers the members of which, unlike those of other groups, have bright hind wings visible only in flight. The males of this group are much given to hovering over the females, displaying these wings and calling attention to the bright colors by a rattling sound made by striking the wings together. At least, that is the way it looks at first glance and it may be true. And so this has become a classic example of the theory of sexual selection. Years ago I myself wrote a perfectly orthodox paper on the "Ecology of Insect Sounds" and used these grasshoppers as the principal illustration. Since then I have spent many hours in the hot sun watching the lady in the case and I must say that, if human lovers received as little response to their serenades as do the courting grasshoppers, most of them would either give up music or remain bachelors. Furthermore, the theory of sexual selection requires that these females have so much better ears than ours that they are able to detect slight differences in either the tone or the intensity of a male's rattle. Of this there is not a single bit of real evidence and, in fact, most of the recent work on the audition of insects tends to the conclusion that, if they are not actually deaf, they certainly pay but little attention to sounds within our audible range. It seems quite possible that this courtship music has no significance other than an incidental hitting together of the wings as the male hovers to get the scent of a female hidden in the grass, for we know that insects have very keen olfactory powers but relatively poor vision.

What I have seen happen is that, when such a male comes back to earth and approaches the female, he nervously twitches his long hind legs up and down. This brings me to a second class of insect sounds, those made by friction rather than beating.

Most insect sounds are made in this way. Although the twitching legs of which I have just spoken caused no sound that I could hear, certain grasshoppers, belonging to a related group but not having bright hind wings, do make a sound audible to us when the hind legs rub against the body.

The most familiar example of insect sounds made by friction is the chirping of crickets. Now, only the males do this. Chirping is distinctly a secondary sexual character, the stock explanation of which is that it is a mating call developed by sexual selection. The adult life of a male cricket lasts a month or so and he chirps most of the time but he spends little of that time in mating. Why does he chirp when there is no female around? Possibly hoping that one will come; I do not know. When he has mated, his sexual life is done but he keeps on chirping to his dying day. I do not know why; possibly to pass the time. I do know this, however, and my knowledge is based on the breeding of literally thousands of crickets while I was using them in a study of heredity: a female cricket pays but little attention to a chirping male. She may wave her antennæ in his direction but so will she when he is not chirping and so will she at a stick or a stone.

One of the most remarkable—shall I say—"adaptations" among insects for the production of sound by friction is possessed by the grub of a beetle. A pair of legs is grotesquely modified and the insect rubs them against a sort of a wash-board affair on its body. This has been as good as a cross-word puzzle for those who hunt for purpose in everything. The creature is immature and so is not looking for a mate. It lives concealed in rotten wood, so we have trouble in believing that it keeps on making the sound to fool unseen enemies that do not see it into believing that there is something dangerous, instead of a nice fat grub, in that piece of wood. One guess, soberly made, is that the sound is to notify brothers and sisters of its presence so that they will not eat too close to its preëmpted property.

When we can explain the purpose of a man's snoring or of the rattling of a Ford car, we may know why this beetle grub rasps. Having slept with a man that snored and having driven a Ford, I believe that the sounds in question are unintentional and quite incidental to the structure of the man and of the machine. May not the same be true of the beetle grub?

Physicists tell us that the intensity of a sound varies as the square of the number of vibrations per second (that is, the pitch) and also as the square of the amplitude of these vibrations. Now, insects are small, weak creatures, and the amplitude of any sound-waves made by them is therefore necessarily small. Consequently, an insect sound must be shrill or it will not be intense enough for man to hear it. We know that some insect sounds are so shrill that they are above the audible range of some humans. It is tempting to wonder if many insects do not make sounds too shrill for any of us to hear. The determination of this is a matter of biophysics and not easy. I spent most of one summer working with the coöperation of Doctor Thomas of the Westinghouse Research Department upon the problem, but we were not successful. Such sounds may or may not be made. We should know before our speculations concerning the sounds which we can hear but which certainly are not made for our ears have become so crystalized that we believe them to be established facts instead of more or less intelligent guesses. Furthermore, if insects in general do communicate with one another by means of sounds, the sounds employed are doubtless those above our audible range.

The significance of insect sounds is still an open subject and, while it is altogether probable that some of these sounds do have a biological significance, I firmly believe that many of them have none, being merely incidental to actions that are not intended to make a noise and to structures that have arisen for some totally different purpose or for no purpose at all.

RALPH WINFRED TOWER
1870-1926

For twenty-three years Curator of Books and Publications and of Physiology in the American Museum

Ralph Winfred Tower
1870-1926

By GEORGE H. SHERWOOD
Acting Director, American Museum

ON the morning of January 26, that dread disease, pneumonia, struck down Ralph Winfred Tower in the very prime of his manhood. He was only in his fifty-sixth year and personal illness had been unknown to him. Thus his death, coming after a sickness of barely seven days, has left his friends and associates stunned by their unexpected loss. Through Doctor Tower's death there is a real void, not merely in the Library staff, not merely in the Scientific Staff, but in the personnel of the Museum as a whole. Doctor Tower was so modest and unassuming that we are only just beginning to realize what an important and necessary share he bore in the life of the Museum and in scientific activities outside.

Ralph Winfred Tower was born at Amherst, Massachusetts, May 24, 1870, the son of the Reverend Doctor Francis Emory Tower and Ella Sophia (Shepardson) Tower. His father was a high-minded, forceful man, a thorough student, and the valedictorian of his class at Amherst. From his father Doctor Tower inherited his studious nature and the great love of books which is so outstanding in his life work. His mother was one of the most gentle and one of the sweetest characters that it has ever been my privilege to know. From her Doctor Tower inherited his genial smiling philosophy and his great love of music.

Doctor Tower's earliest education was obtained in the public schools of Allston, a suburb of Boston, and there is some evidence that his taste for study was not developed in those early years. The back lots of Allston claimed him whenever he could escape from parental discipline. On these same back lots was laid the foundation of his strong constitution and his athletic ability, which won for him the coveted B of Brown University as a pitcher on the baseball team. Even in these early days, however, he appreciated the value of an education. One day his mother heard a caller who was chatting with him say, "Do you like to go to school, little boy?" and the youngster replied, "No, not very well, but I'd rather go to school than grow up and be a dunce."

Doctor Tower prepared for college in the high schools of Brattleboro, Vermont, and Bristol, Connecticut, and from the latter he was graduated in 1888. His high-school studies gave him some difficulty, especially algebra. The principal in exasperation at his slowness in grasping the problem said before the whole class, "Well, you young divine, you will be out preaching before you get that example done." Young Tower was horribly mortified and told his mother that he wasn't going to have anything like that said to him again. He not only passed his algebra but received nearly the highest mark in his class.

In the fall of 1888, Tower entered Colby College at Waterville, Maine, where he remained two years. Then, finding that he could not get the courses in science which he desired, he transferred to Brown University, particularly that he might study under Alpheus S. Packard, a student of the great Agassiz, and the great entomologist of his day. He was graduated from Brown in 1892 and was immediately appointed instructor in biology. In addition to teaching he carried on graduate work and took his Master's Degree in June, 1893. His biological training gave him a keen interest in physiology and physiological chemistry. He determined to make this subject his specialty and to spend a year of study in Germany.

In August, 1893, he married Bessie Belle West and with his young bride took up his residence in Leipzic, where he could work under the great physiologist, Prof. Max von Frey, of the University of Leipzic.

Upon Tower's return from Germany in the summer of 1894, President E. Benjamin Andrews appointed him demonstrator of anatomy, and the following year asked him to develop a course in physiological chemistry as a part of the program for a strong biological department at Brown. Tower held the post of instructor in physiological chemistry from 1895–99, when he was promoted to the assistant professorship and later to the associate professorship in this subject. He held the latter position until 1903, when he resigned to accept the dual post of curator of physiology and curator of books and publications in the American Museum of Natural History, which he filled for twenty-three years.

Tower's greatest service to the Museum and the lasting monument to his memory is the Library, one of the largest and finest devoted to natural sciences in the world, which has been developed by him from an insignificant collection of books to the well balanced, efficient research instrument of today. The question is frequently asked, How did Doctor Tower, a specialist in physiology, happen to take up the development of the Library as his life work? The story dates back to the reorganization of the biological department of Brown University. President Andrews appreciated the necessity of having an up-to-date biological department in order to keep pace with modern thought and modern sciences. He appointed Dr. Herman C. Bumpus the head of this department, and he in turn gathered around him Dr. A. D. Mead, Frederick H. Gorham, and Ralph W. Tower. This nucleus of young biologists laid the foundation of the present strong department at Brown. A library was one of the essentials of such a department. Because of Doctor Tower's acquaintance with scientific literature, combined with his innate love of books, he was entrusted with the problem of building up the department library, in addition to his regular duties as instructor in physiological chemistry. Funds were very limited and a most judicious selection of books had to be made. About this time, 1898–99, the first of the Field Concilium Bibliographicum cards came out and the biological department subscribed for a set. Doctor Tower mastered the intricacies of this system and put the department library on a Field basis. Here, then, was a man, trained in science and not bound by the tradition of any library school, who could apply his training in a common sense way to the development of a special library for workers in natural science.

It was then that President Jesup invited Doctor Tower to come to the Museum as curator of books and publications, and to devote himself to building up an adequate library for the Museum. Doctor Tower applied himself to this new field with singleness of purpose and achieved marked success. While our small Library of that time did contain some rare and valuable works, they were inaccessible, and staff members or others were discouraged from using them. All of this was changed immediately. Doctor Tower organized the existing material, installed the Field Concilium Classification System, and then by a most careful selection of books and through exchanges added to the supply until today the Library contains more than 100,000 volumes. In the meantime through his conviction that the efficiency of a library is determined by its practical use, he encouraged inter-library loans to assist research workers in all parts of the country, and otherwise administered the library in a liberal spirit of coöperation. It is this spirit of helpfulness that is one of the greatest assets of our Library today.

Largely through his influence and because of confidence in him, the Library of the New York Academy of Sciences was deposited in the Museum in 1903. The Academy Library was rich in serial publications of learned societies. Doctor Tower did not try to duplicate the Academy Library but rather used it to supplement the Museum Library. Thus, during the last twenty-three years, although the two libraries were kept distinct on paper, they were physically treated as a unit. This plan worked advantageously for both institutions, but at last a point was reached where it was imperative that the Academy Library should definitely become a part of the Museum Library in order to safeguard for all time this essential unity of operation. Doctor Tower realized the importance of merging these two rich collections that supplemented one another so admirably and one of his last official acts was to carry out the details of the plan. The purchase was made possible through the generosity of Mr. Ogden Mills, a Trustee of the Museum and a devoted patron of the Library.

Although books and publications became Doctor Tower's life work, he never lost interest in his first love, physiology. The Library, however, so absorbed his attention that he had little time to devote to his physiological researches. Nevertheless, through the literature and his contact with medical men and other scientists he kept himself informed of the general progress in this science.

Between 1895 and 1908, Doctor Tower published eleven scientific treatises. The most important of these was his thesis on "The Gas in the Swim-Bladder of Fishes," representing the results of his investigations in the biological laboratory of the U. S. Fish Commission at Woods Hole, Massachusetts, which was accepted as his thesis for the degree of Ph.D., conferred upon him by Brown University. The function of the swim-bladder in fishes and the production of sound by fishes continued to interest him, and his last paper on this subject was published in the Annals of the New York Academy of Sciences in 1908, under the title "The Production of Sound in the Drumfishes, the Sea-Robin and the Toadfish."

It is quite natural to think of Doctor Tower's service to the Museum in the terms of the Library, because this was his greatest achievement, but his participation in other Museum activities was of nearly equal importance. This is particularly true of his service on the Pension Board and on various committees. He was a member of the Pension Board from its creation, and no one could have taken a greater interest in the individual problems of the employees than he. In the councils of the Pension Board and in informal conferences on the welfare of employees, Doctor Tower's opinion commanded the respect of his colleagues, and through his sympathetic understanding of the condition of the employees he gained their loyalty and devotion. Doctor Tower's strong sense of justice, his belief in the equality of each member of the Pension System, his firmness in standing for what he believed was right, and his practical common sense in analyzing difficult problems have contributed much to the maintenance of the integrity of our Pension System, of which we are justly proud.

Closely associated with official pension and welfare work was his service to our employees as general physical adviser and in the giving of first aid. His efficiency and unostentatious ministrations in these emergencies inspired all with confidence. His bright and cheery smile lifted many an employee out of despondency and started him on the road to recovery. A characteristic trait which endeared him to the entire personnel of the Museum was his willingness to give freely of his knowledge and of his time to the humblest of our employees as well as to his most intimate friends. Considered from the standpoint of this activity alone, his death has caused a sad loss.

For about fifteen years Doctor Tower was secretary of the publication committee of the Museum, and in this office his knowledge and advice were of the utmost value. In 1922 he was placed in charge of the printing shop, and through his executive ability and technical knowledge of publication, as well as his conservative recommendations, a printing plant of high efficiency and low cost was developed. Doctor Tower applied his customary thoroughness to the business of printing and handled with equal tact both the labor problems within and the pressing departmental claims for production.

In addition to his manifold duties as a Museum officer, Doctor Tower gave of himself most generously to other activities which he felt would advance science or education. This is especially true of his long service in connection with the New York Academy of Sciences. For twenty-three years he was its librarian, and for nine years its editor.

His most conspicuous contribution to the New York Academy was his nine years of service as its recording secretary, which *per se* made him its principal executive officer. His wide acquaintance with scientific matters, his appreciation of the scientist's view point, and his administrative ability fitted him to be an ideal representative of this distinguished society, while his ability, his good judgment, his clear perspective, and sound advice made him an invaluable adjunct to its Council, and won for him the high respect and honor of all his fellow members of the Academy and its affiliated societies.

At a Memorial service held in the reading room of the Library on Wednesday afternoon, January 27, the day following Doctor Tower's death, President Osborn and other Museum officers paid an eloquent tribute to Doctor Tower's life and work. At this time also Professor Henry E. Crampton, president of the New York Academy of Sciences, so forcefully depicted Doctor Tower's dominant qualities of character and his genius that I have requested permission to incorporate his remarks in this article.

On this occasion, it is my privilege to say a few words about our colleague who has passed away, as an officer of the New York Academy of Sciences; but this privilege is assumed with the greatest difficulty, for I knew him not only as an associate in the Academy but also as a friend during a long period of time.

I like to recall Ralph Tower as I first knew him nearly thirty-three years ago when he came to the Biological Laboratory at Woods Hole, then in its earlier and more primitive days. He was one of a notable group of young workers in the full flush of enthusiasm for their studies in zoölogy. Among others, from Brown University came Gorham, Straus, and later Sherwood, and from Williams there were Peabody, Conant, and Harrington,—two of whom were soon to sacrifice their lives in the quest for new knowledge. And in that group, Ralph Tower was a central figure, always earnest, reliable, and even-tempered, and a man whose winning personal qualities made a real friend of everyone who came to know him.

The years passed, and he came to the American Museum to undertake the exacting duties which he discharged for so long a time, bringing to his new occupations all of the sterling qualities he had possessed at the outset and all that he had gained through his work in science. Later he entered the service of the New York Academy of Sciences, and assumed one office after another—librarian, editor, and recording secretary—until the work of this venerable organization came to be wholly under his direction.

Among the many fine attributes of character and charm that he possessed, to me his outstanding personal quality was the sincere honesty of his every thought and word and action. From this arose the sound judgment upon which all of his associates relied; because of this, also, he was intolerant of sham and pretense, as he was equally ready to appreciate real merit where he found it. And the standards by which he judged others were no more exacting than those which he set for his own thought and conduct.

The Academy has lost a devoted and faithful officer, while every one of us has lost a friend. The ranks close up and we go forward, as we must. Yet in the future, we who knew him, almost will feel the presence of our friend; when problems arise, and we shall ask "What would Tower think about this?" almost we shall hear the calm words of advice and judgment, as we did in the past.

In conclusion, may I quote a few words which to my mind express so adequately the spirit of such a man as Ralph Tower and of all like him who engage in the sincere search for knowledge and truth. They are the words of a great poet, Whittier, and they voice the spirit of a great naturalist, Agassiz, who with his students had lately begun the work at the unique seaside laboratory on the island of Penikese:

> We have come in search of Truth,
> Trying, with uncertain key,
> Door by door of mystery.
> We are reaching, through His laws,
> To the garment-hem of Cause,
> As, with fingers of the blind,
> We are groping here to find
> What the hieroglyphics mean
> Of the Unseen in the Seen;
> What the thought that underlies
> Nature's masking and disguise;
> What it is that lies beneath
> Blight and bloom and birth and death.

Although Museum and Academy interests absorbed most of Doctor Tower's energy, he nevertheless made his contribution to civic affairs, among which were his fifteen years of service on the Library Board of his home city, New Rochelle, first as Treasurer for nine years and then as President of the Board for the last six years. It was during his term of office that the new library building was erected and he had much to do with bringing it to its present efficiency.

One of my most cherished possessions is my long friendship with Doctor Tower, which extends over a continuous period of nearly thirty years. We were *comrades* in all that that word can mean. We worked together, we played together, we shared our sorrows and our joys. My comrade has gone but I feel that his spirit is still with us and will inspireus to better work. I know that this is a better world because he lived in it and it is with real feeling that I say,

> He was a man, take him for all in all,
> I shall not look upon his like again.

Jugatæ, the entomological club at Cornell University

NOTES

ENTOMOLOGY IN THE UNITED STATES

No other group of animals engages the professional work of so many students as does Hexapoda, the insects; and, with the possible exception of birds, no other group fascinates so many amateurs.

It is indeed a backward state that does not have at least one professional entomologist in its official family and some states have well-equipped departments devoted to this study. Then, there is the Bureau of Entomology of the U. S. Department of Agriculture. The Bureau maintains headquarters in Washington but its activities are widespread. For example, in coöperation with New Jersey and Pennsylvania, it maintains at Riverton, New Jersey, a Japanese Beetle Laboratory that employed about two hundred men last summer.

There is an American Association of Economic Entomologists that since 1908 has published the *Journal of Economic Entomology*. The *Annals of the Entomological Society of America* is the official organ of another national society, in this case devoted to pure rather than to applied entomology. A number of societies, primarily amateur and local in character, publish journals of great scientific importance and world-wide circulation. One of these, the New York Entomological Society, has for more than thirty years been closely associated with the American Museum.

Not so long ago it was possible for a young man or woman to become a professional entomologist by the apprentice route, just as they could become lawyers by "reading" in an office, but now entomology is a graduate study in our larger universities. The accompanying illustration is a picture of Jugatæ, an entomological club made up of students and teachers in Cornell. Seated in the center of the front row are Professor and Mrs. Comstock, than whom no one in America has done more to stimulate interest in and diffuse knowledge about insects, spiders, and nature in general. The second person at Professor Comstock's right is Professor Needham, America's leading authority on aquatic insects.

It is with a great deal of pleasure, albeit tinged somewhat with envy, that the American Museum presents to its readers a picture of some of the workers in the best-manned department of entomology of any museum—that of the U. S. National Museum. As a matter of organization, most of these workers are connected with the U. S. Department of Agriculture; but, as a matter of practice, they are on the staff of the Museum.

Number 11 in the picture is Dr. L. O. Howard, honorary curator in the Museum, chief of the federal Bureau of Entomology, and, incidentally, the author of one of the articles in this issue of Natural History. Number 9, Dr. E. A. Schwarz, has long been an outstanding authority on beetles and is honorary custodian of Coleoptera. Other coleopterists are Dr. A. G. Böving (4), Mr. W. S. Fisher (13), and Mr. H. S. Barber (14). Dr. H. G. Dyar (8), honorary custodian of Lepidoptera, is an independent worker who is donating his services to the Museum. Dr. William Schaus (3) is also an authority on butterflies and moths. Unfortunately, the picture does not show two other lepidopterists of the staff, Messrs. Heinrich and Busck. Neither does it show Doctor Aldrich, who is a well-known specialist on flies and has charge of the Museum side of the insect work. Other dipterologists are Mr. C. T. Greene (2), and Mr. R. C. Shannon (12). Mr. S. A. Rohwer (10) is in charge of the taxonomic investigations of the Bureau of Entomology and honorary custodian of Hymenoptera in the National Museum. Other students of this order, which includes ants, bees, and wasps, are Mr. A. B. Gahan (1), Dr. W. M. Mann (6), Mr. R. A. Cushman (15), and Mr. Weld (not shown). Mr. A. N. Caudell (5) is concerned with grasshoppers and their relatives; and Dr. H. E. Ewing (7) with mites and various insect parasites of warm-blooded animals. The others shown are a few of the National Museum's staff of entomological preparators, clerks, and artists. The American Museum most warmly congratulates its sister institution on having such a large number of helpers and on the work that they are donig.

Some of the entomological workers attached to the U. S. National Museum

AN ANCIENT RING OF ENTOMOLOGICAL BEARING

Professor E. B. Poulton, in a personal letter to President Henry Fairfield Osborn, called attention to an ancient ring that has an entomological bearing and was reported upon at a meeting of the Entomological Society of London last year. It was discovered by Sir Arthur Evans in Greece and apparently dates from about 1500 B.C., Butterflies are used to symbolize the soul and the engraver evidently had some knowledge of entomology, for he not only depicts the chrysalis from which an adult butterfly emerges, but he has carved a recognizable Pierine butterfly and associated it with the right sort of chrysalis. This antedates Aristotle by more than a thousand years Incidentally, the letter indicates the breadth of Professor Poulton's keen interest in entomology, an interest that many have come to associate largely with the theory of mimicry because he has done so much in defense of that theory.

HONORARY FELLOWS

On November 9, 1925, at a board meeting of the Trustees of the American Museum, the following resolution was unanimously adopted:

Resolved, That the Trustees desire to record their appreciation of the splendid service rendered by Mr. Lincoln Ellsworth in the recent Arctic flight of Captain Roald Amundsen, in which his courage, endurance, and good judgment were evidenced, and in recognition of his manly qualities and his contribution to polar exploration take pleasure in hereby electing him an *Honorary Fellow* of the American Museum of Natural History—the highest honor in their power to bestow.

On March 17, 1926, the following resolution was unanimously adopted:

Resolved, That the Trustees desire to record their appreciation of the contributions that Mr. Howard Russell Butler has made to the popularization of astronomy through his unique paintings of solar eclipses and other astronomical paintings, and, in recognition of his attainments in this field of science, take pleasure in hereby electing him an *Honorary Fellow* of the American Museum of Natural History.

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Since the last issue of NATURAL HISTORY, the following persons have been elected members of the American Museum, making the total membership 8781.

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PAST RACES OF MAN

MAY-JUNE

The year 1926 opened with a number of **Natural History** devoted to present-day man. The forthcoming issue will tell of recent discoveries regarding the vanished races of mankind —their environment, their industrial and artistic works, and their skeletal remains—and also concerning fossil primates.

The Abbé Henri Breuil—widely acknowledged as one of the two foremost authorities on European archæology—gives a delightful account of how, in company with Capitan and Peyrony, he discovered the tortuous cavern of Les Combarelles with its spirited portrayals of animals and weird anthropomorphic designs. Père Teilhard de Chardin, professor of geology in the Institut Catholique de Paris, describes how, in company with his friend, Père Licent, he found implements of Palæolithic man together with bones of the animals he hunted, buried deep beneath the loess of China and Mongolia. Nels C. Nelson, of the Third Asiatic Expedition and curator of archæology in the American Museum, tells how he found implements of chipped stone, broken pottery, and animal bones dating back to the Stone Age, in the wastes of the Gobi Desert. Othenio Abel, the distinguished professor of palæobiology in the University of Vienna, during the excavation of the Drachenhöhle (Dragon's Cave) near Mixnitz, Austria, in 1920–1923, unearthed Palæolithic artefacts and remains of cave bear under most extraordinary conditions, which he interprets as indicating that cave bears were ambushed and killed by Palæolithic man in this very cave.

Pliny E. Goddard, curator of ethnology in the American Museum, sums up cultural and linguistic evidence which seems to indicate a much greater antiquity of man in America than has hitherto been admitted. In this connection Frederic B. Loomis, professor of geology at Amherst, gives the results of a joint expedition of Amherst College and the Smithsonian Institution to investigate sites reported in Florida, and shows that at four different places there were either human bones or human artefacts associated with bones of mammoth and mastodon, implying an age of some twenty thousand years.

Henry Fairfield Osborn needs no introduction to readers interested in men of the Old Stone Age. He discusses evidence indicating why Central Asia may prove to have been the cradle of humanity. Mr. Harry C. Raven, widely known as an intrepid explorer, and about to leave shortly on a collecting expedition to the Arctic, takes time to report on the unique sculptures in rough-hewn stone which he photographed in the heart of Celebes. These offer a knotty problem to the archæologists, for though one or two show remote resemblances to the strange figures of Easter Island, yet on the whole they seem to be quite unlike any types known hitherto. Frederic A. Lucas, veteran naturalist, explorer, and sailor (from the age of ten!), gives a whimsical account of the grotesque misapprehensions of earlier days regarding fossil animal remains belonging to the Age of Man, which mightily puzzled the enterprising souls who tried to "restore" them. He also adds to our collection of Americana a convincing tribute to "Thomas Jefferson—Palæontologist."

The remaining articles constitute a symposium on fossil man compared with the anthropoids. Raymond A. Dart, professor of anatomy in the University of the Witwatersrand, South Africa, presents a splendidly illustrated account of the discovery of the Taungs skull and brain cast, and rehearses the evidence which leads him to class it as a "missing link," or man-ape. Dudley J. Morton of the Department of Surgery, Yale, contributes a most illuminating analysis of the skeletal structure of Neanderthal man compared with modern man and with the anthropoids. G. Elliot Smith, world-famed anatomist and archæologist, outlines the results of his searching investigations regarding the brain structure of fossil man. William K. Gregory and Milo Hellman—the latter research associate in anthropology in the American Museum—disclose the conclusions reached through their joint research concerning the crown patterns of human teeth, fossil and recent.

Finally J. H. McGregor, professor of zoölogy at Columbia University, shows the methods he employs in making his restorations of fossil man. The famous English painter, Sir Frederick Leighton, used to draw his preliminary sketches of human figures in the nude in order to secure perfect truth of detail, afterward adding the drapery. But Professor McGregor goes further, he models first the skeletal structure of his restorations, then the musculature, and finally the outside layer of flesh and skin.

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For the enrichment of its collections, for the support of its explorations and scientific research, and for the maintenance of its publications, the American Museum of Natural History is dependent wholly upon membership fees and the generosity of friends. More than 8500 members are now enrolled who are thus supporting the work of the Museum. The various classes of membership are:

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Series of illustrated lectures, held in the Auditorium of the Museum on alternate Thursday evenings in the fall and spring of the year, are open only to members and to those holding tickets given them by members.

Illustrated stories for the children of members are presented on alternate Saturday mornings in the fall and in the spring.

MEMBERS' CLUB ROOM AND GUIDE SERVICE

A room on the third floor of the Museum, equipped with every convenience for rest, reading, and correspondence, is set apart during Museum hours for the exclusive use of members. When visiting the Museum, members are also privileged to avail themselves of the services of an instructor for guidance.

THE AMERICAN MUSEUM OF NATURAL HISTORY has a record of fifty-six years of public service, during which its activities have grown and broadened, until today it occupies a position of recognized importance not only in the community it immediately serves but in the educational life of the nation and in the progress of civilization throughout the world.

Every year brings evidence—in the growth of the Museum membership, in the ever-larger number of individuals visiting its exhibits for study and recreation, in the rapidly expanding activities of its school service, in the wealth of scientific information gathered by its world-wide expeditions and disseminated through its publications—of the increasing influence exercised by the institution. In 1925 no fewer than 1,775,890 individuals visited the Museum as compared with 1,633,843 in 1924 and 1,440,726 in 1923. All of these people had access to the exhibition halls without the payment of any admission fee whatsoever.

The **EXPEDITIONS** of the Museum have yielded during the past year results of distinct value. The collections being made by Mr. Arthur S. Vernay in Angola, Africa; the studies of Andean avifauna pursued by H. Watkins in Peru; the three fossil expeditions in the western United States, in New Mexico, and Nebraska and Montana; the extensive survey of Polynesian bird life conducted by the Whitney South Sea Expedition; the work pursued in selected faunal areas of Venezuela by Mr. G. H. H. Tate; the field observations and collections made in Panama by R. R. Benson; the studies of microscopic pond life of Mt. Desert Island by Dr. Roy W. Miner and Mr. Frank J. Myers; the archeological excavations at two important sites in Arizona; and the continuation of the brilliant work of the Third Asiatic Expedition during the past season—these (and the list might be extended) are among the notable achievements of the past twelve months.

The **SCHOOL SERVICE** of the Museum reaches annually about 6,000,000 boys and girls through the opportunities it affords classes of students to visit the Museum; through lectures on natural history especially designed for pupils and delivered both in the Museum and in many school centers; through its loan collections, or "traveling museums," which during the past year circulated among 410 schools, and were studied by 977,384 pupils. During the same period 672,479 lantern slides were loaned by the Museum for use in the schools, the total number of children reached being 3,941,494. 1,076 reels of motion pictures were loaned to 48 public schools and other educational institutions in Greater New York, reaching 333,097 children.

The **LECTURE COURSES**, some exclusively for members and their children, others for the schools, colleges, and the general public, are delivered both in the Museum and at outside educational institutions.

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For a detailed list of popular and scientific publications with prices apply to:
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NATURAL HISTORY

PAST RACES OF MAN

JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY
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THE JOURNAL OF THE AMERICAN MUSEUM

DEVOTED TO NATURAL HISTORY, EXPLORATION, AND THE DEVELOPMENT OF PUBLIC EDUCATION THROUGH THE MUSEUM

PAST RACES OF MAN

EDITORS
WILLIAM K. GREGORY
CHRISTINE D. MATTHEW

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A LATE AFTERNOON IN THE OLD STONE AGE

Courtesy of the artist, Charles R. Knight. The original color sketch was painted under the direction of Henry Fairfield Osborn

Not an imaginary picture but—apart from such unrecoverable details as skin color—a well-documented restoration of the Neanderthal flint workers

NATURAL HISTORY

VOLUME XXVI MAY–JUNE, 1926 NUMBER 3

Group of three small black horses

The Cavern of Les Combarelles

By the ABBÉ HENRI BREUIL

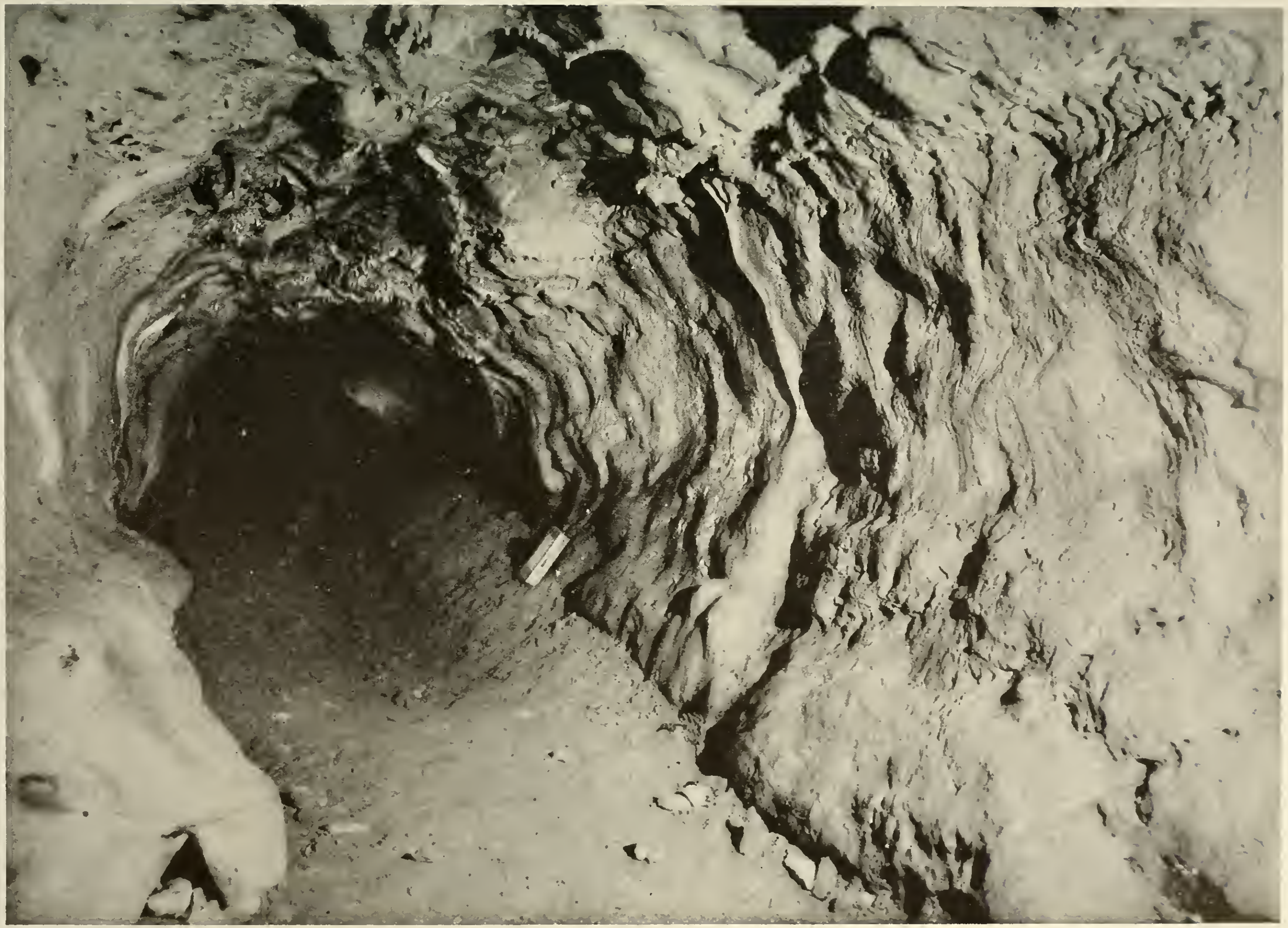
Translated by Christine D. Matthew

It was on September 2, 1901, that, in company with Doctor Capitan and M. Peyrony, I penetrated the low, narrow passages of the cavern of Les Combarelles, the entrance to which—at the bottom of a small valley lying laterally to the Beaune, a tributary of the Vézère—was concealed by a cow stable, and is about a mile and a quarter from the famous site of Les Eyzies. Previously Dr. E. Rivière had made some excavations in a dark passage on the right, at the entrance, where he discovered a Late Magdalenian deposit with abundant specimens of worked bones, chipped flints, needles, and harpoons, associated with bones of reindeer, chamois, horse, and bison; but being confident that there were no deposits in the passage to the left, he abandoned further exploration.

It was this opening to the left we had determined to investigate. Enduring extreme discomfort, we made our way along the low-roofed passage where, about 520 feet from the entrance, we saw that the two walls were engraved with numerous confused and interlacing designs almost invariably covered by stalagmitic deposit exuded from the rock. A hasty examination showed animal figures more or less deeply incised, among which we at once recognized reindeer, a number of horses, and several mammoths, while each moment spent exploring this unique and tortuous gallery enhanced the importance of our discovery. At one time we thought we had reached its end on finding a small recess, some 620 feet from the entrance, ornamented with a magnificent engraving of the cave bear. But then we espied in a corner a very low opening where it was barely possible to wriggle along on one's stomach over the bosses and points of stalagmite which made the ground a thorny way.

After about forty feet of this the roof became somewhat higher so that we could rise to our knees. The designs we now saw were finer and less obscured by the stalagmitic glaze, although the bottom of many of them was below the ground, which consisted of gravel covered by a thick layer of stalagmitic deposit. Among them we noticed several pretty little horses painted in black.

DRAWINGS OF THE CAVERN OF LES COMBARELLES
Part of the pictorial key to the entire series



VIEW IN THE GALLERY OF ENGRAVINGS, CAVERN OF LES COMBARELLES

The passage now narrowed to an opening fourteen inches high and twenty-two inches wide, which I alone was able to crawl through—thus discovering still more designs half-buried in gravel covered by stalagmitic concretion. A pool of water lay across the path beyond which—about 780 feet from the entrance—I stopped before a crevice too narrow for passage. It leads, as we learned later after enlarging the crevice, to a lower gallery with no prehistoric remains, where flows a stream of water that can be followed only for a short distance.

At the time of this discovery the only cave in the neighborhood of Les Eyzies known to be ornamented with designs was the grotto of La Mouthe, discovered six years previously by E. Rivière. Five years previously F. Daleau had announced that on the walls of the little grotto of Pair-non-Pair, Gironde, buried under archæologic deposits of the Age of the Reindeer containing bones of reindeer, rhinoceros, hyena, cave bear, and mammoth, there were rude designs of Capridæ and Equidæ. The discovery in 1878 of the polychrome frescos of Altamira, near Santander, Spain, by the Marquis Marcelino de Sautuola, was very unjustly discredited and by this time almost forgotten.

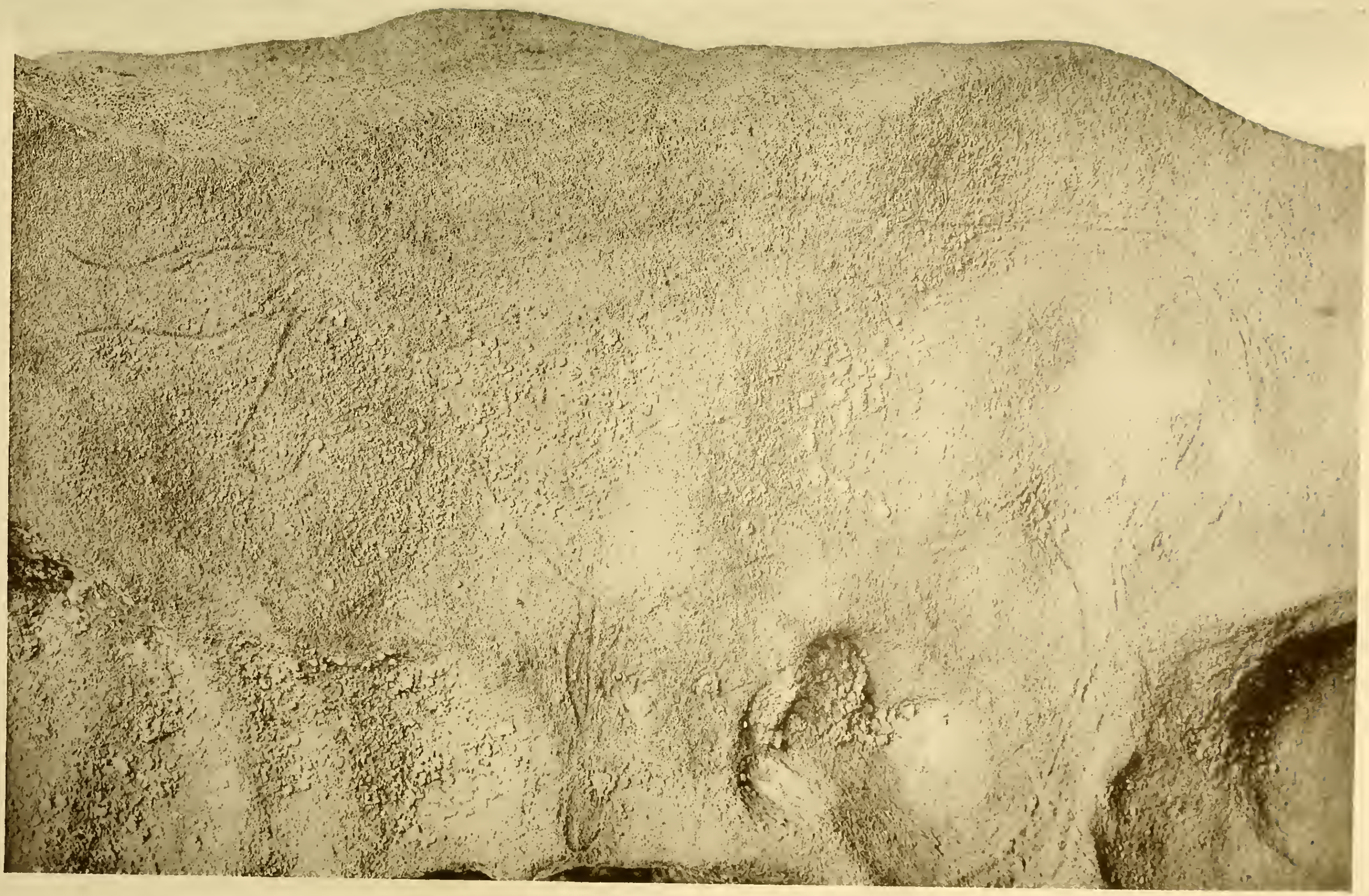
The discovery reported at La Mouthe had been violently denounced by many prehistorians who also lost no time in combating *a priori* the authenticity of the engravings at Les Combarelles, attributing them—in the face of all probability—to political refugees of the time of the first Napoleon.

A week later we had word from M. Peyrony that in a cave even nearer to Les Eyzies, that of Font-de-Gaume, numerous paintings had been found—red, black, and polychrome—many of them similar to those of Altamira, though not so well preserved and in part thickly covered by stalagmitic deposit. During the following years we found engravings like those of Les Combarelles at the neighboring sites of Bernifal and La Calévie. The frescos at Marsoulas, Haute Garonne discovered by Felix Regnault, were examined by Emile Cartailhac, who publicly demanded a reconsideration of the judgment passed on Altamira, and—to complete his "Mea Culpa d'un Sceptique"[1]—invited me to join him in investigating the frescos.

Since then there has been a continuous series of discoveries in the caves of Périgord and the French Pyrenees; an equally important region has come to light in the Cantabrian Mountains of Spain; and additional discoveries in Andalusia, Provence, and Italy, have brought the number of caves and rock shelters now known to be decorated with sculptures, engravings, or paintings, up into the seventies. Cases where painted, engraved, or sculptured fragments obviously broken off the walls have been embedded in undisturbed deposits are so numerous that it is no longer possible to question the Palæolithic age of this remarkable ensemble of artistic work.

But in 1901 the discovery of the engraved cavern of Les Combarelles created a veritable sensation, exciting the liveliest interest in scientific circles, and inaugurating an era of fruitful explorations which have notably advanced our knowledge of the civilization of Late Palæolithic times and of the magical and religious beliefs which then prevailed. Excellent scientific

[1]Title of the article in which, after long incredulity, M. Cartailhac announced that, as the result of his investigations, he was now completely convinced of the authenticity of the Palæolithic paintings.



WILD CATTLE, CAVERN OF LES COMBARELLES
Note the delicacy of the treatment in contrast with the bold handling of the rhinoceros

THE WOOLY RHINOCEROS
Detail of a complete outline sketched by the artist-hunter on the limestone wall of the Cavern of Les Combarelles

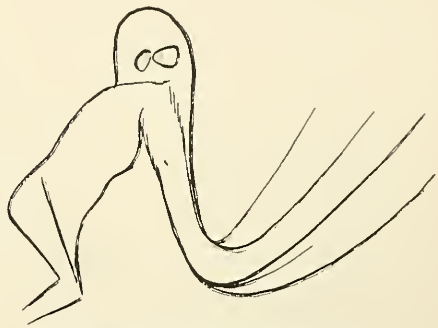
romances of the present day—such as *Les Bisons d'Argile* by Max Bégouen, and *Le fin d'une Monde* by Claude Anet—which familiarize the general public through a medium less tedious and didactic than scientific reports with conclusions reached through the investigations of the last quarter-century, owe their inception to activities that began with the discovery of Les Combarelles.

The study of this cavern—of hundreds of tangled and interlaced designs on the walls of a damp, low, and narrow passage—was entrusted to me, and involved numerous wearisome visits to decipher, trace off, and photograph the various figures. On account of the risk to health and the extreme fatigue involved, it took fully twelve years to complete this work which was frequently interrupted by the exploration of many other caves in France and Spain. Finally, in collaboration with MM. Capitan and Peyrony, I published the full description in 1924,[1] in one large volume, on account of which I was honored by the award of the Elliot medal from the National Academy of Sciences in Washington.

It is the results recorded in this volume which I now propose to discuss, together with additional comments and inferences.

Although the number of engraved designs at Les Combarelles exceeds 400, only the following could be deciphered: 116 Equidæ (chiefly horses but also a few asses or kiangs), 37 bison, 19 bears (cave bear and brown bear), 14 reindeer, 13 mammoths, 9 ibexes, 7 wild oxen, 5 stags, 3 does, 1 Dama deer, 5 lions, 4 wolves, 1 fox, 1 woolly rhinoceros, 1 fish (?), 1 snake (?), 4 designs of huts of the type called tectiform (tentlike) on account of the form of the roof, and a hand silhouetted on a black background. In addition there were several graphic signs, exceedingly simplified, representing javelins and sexual symbols.

The most recent of these designs are those of the mammoth, of which only two or three representations—engraved on bone or ivory—were then known; the woolly rhinoceros, previously unknown in Palaeolithic art; the cave



Man wearing a mammoth's-head mask. The arms immitate the tusks

bear, of which the only other representation known at that time was engraved on a small stone from the grotto of Massat, Ariège; and the great cave lion, possibly portrayed in an engraving of doubtful interpretation on a fragment of reindeer antler found at Bruniquel.

The human figures were so extraordinary that at first we were at a loss how to interpret them. The bodies—in general wretchedly drawn, in comparison with the splendid realism of the animal figures—were frequently topped by heads that were anything but human, although hardly belonging to any particular animal. Only comparative ethnology afforded a reasonable interpretation of these designs as probably indicating an extensive use

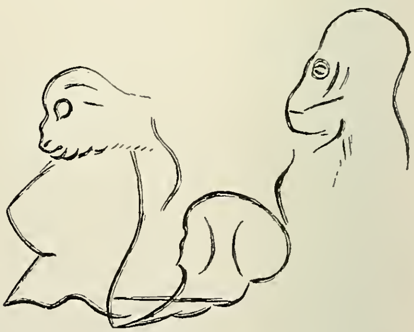
[1] L. Capitan, H. Breuil, and D. Peyrony. *Les Combarelles aux Eyzies.* Masson et Cie., Paris, 1924.

of ceremonial masks and of hunters' disguises—an interpretation confirmed by the unmistakable evidence of later discoveries.

Ceremonial masks of uncertain significance

It is none the less strange that the anthropomorphic designs of Les Combarelles and other caves, as well as those of the same epoch engraved on bone or stone, should be so ambiguous and crude, in contrast to the magnificent artistic development shown in the animal designs. The explanation may perhaps be found in the existence of some sort of taboo prohibiting portrayal of the normal human form—a prohibition which was not so strict at the beginning of Late Pæelolithic time when sculptors worthy of the name carved in ivory or stone the female figurines of Brassempouy, Lespugue, Grimaldi, and Willendorf, and the male and female reliefs of Laussel.

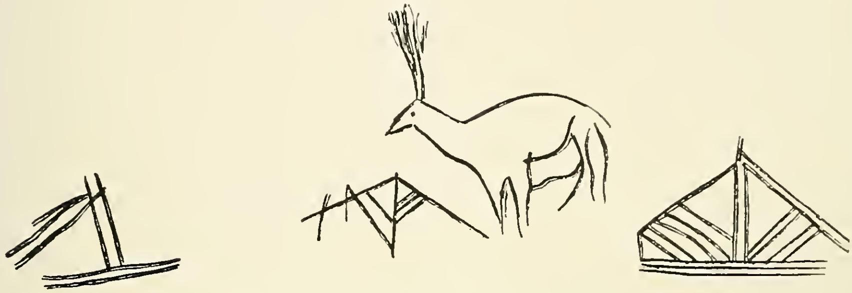
On the other hand, the art of animal representation at Les Combarelles was highly developed; its beginnings were long past. The engraver made his designs with a precise and assured technique. First, with his flint, he lightly outlined the main features of his projected design, with no uncertain touch, upon a hard, rugged, and irregular surface—and this by the feeble light of a tallow lamp, perhaps merely a flat or hollowed stone, or possibly a lump of grease with a small wick inserted. He then cut deeper the silhouette which he had sketched, scraped the lines smooth, sometimes chiseled them out still more to give an effect of modeling or relief, which suggests the further development of relief shown in the magnificent frieze of horses at the neighboring station of Cap-Blanc. The finishing touches consisted of still finer lines to indicate certain minute details, such as the hair, mane, or nostrils. In rare cases color was used to supplement the engraved line; bluish or black streaks are found here and there, and perhaps it is permissable to suggest that organic colors, such as blood, may possibly have been used, but have not lasted, for we know that even now blood is the favorite color used by Australian natives for their tribal art.



Grotesque human heads or masks

It is only in a few figures far back in the cave, representing small horses, that black is most skilfully and effectively used to silhouette the designs in which both line work and filling in denote the hand of a true artist. A little mineral red ocher is used only in outlining two of the huts.

These "tectiforms" are rare here, although abundant at some other sites where they are generally found in remote recesses. Dr. Hugo Obermaier has compared those found in Spain to the "traps for evil spirits" used by the negritos of Malaysia. But it seems to me these "spirit traps" might also serve as tiny dwellings where the spirits might take up their permanent abode, and thus cease to torment mankind. Or again these tectiforms—painted in the innermost depths of the Palæolithic caves—might be intended to localize certain unearthly powers, otherwise undesirable, and to capture their puissance by means of a sort of "tabernacle." This is one aspect of the "mysteries," of the doctrines and ritual practices, which led to the strange assemblage of designs in dark underground passages—in some cases very deep and dangerous, in others uninhabitable and difficult of access, as at Les Combarelles.

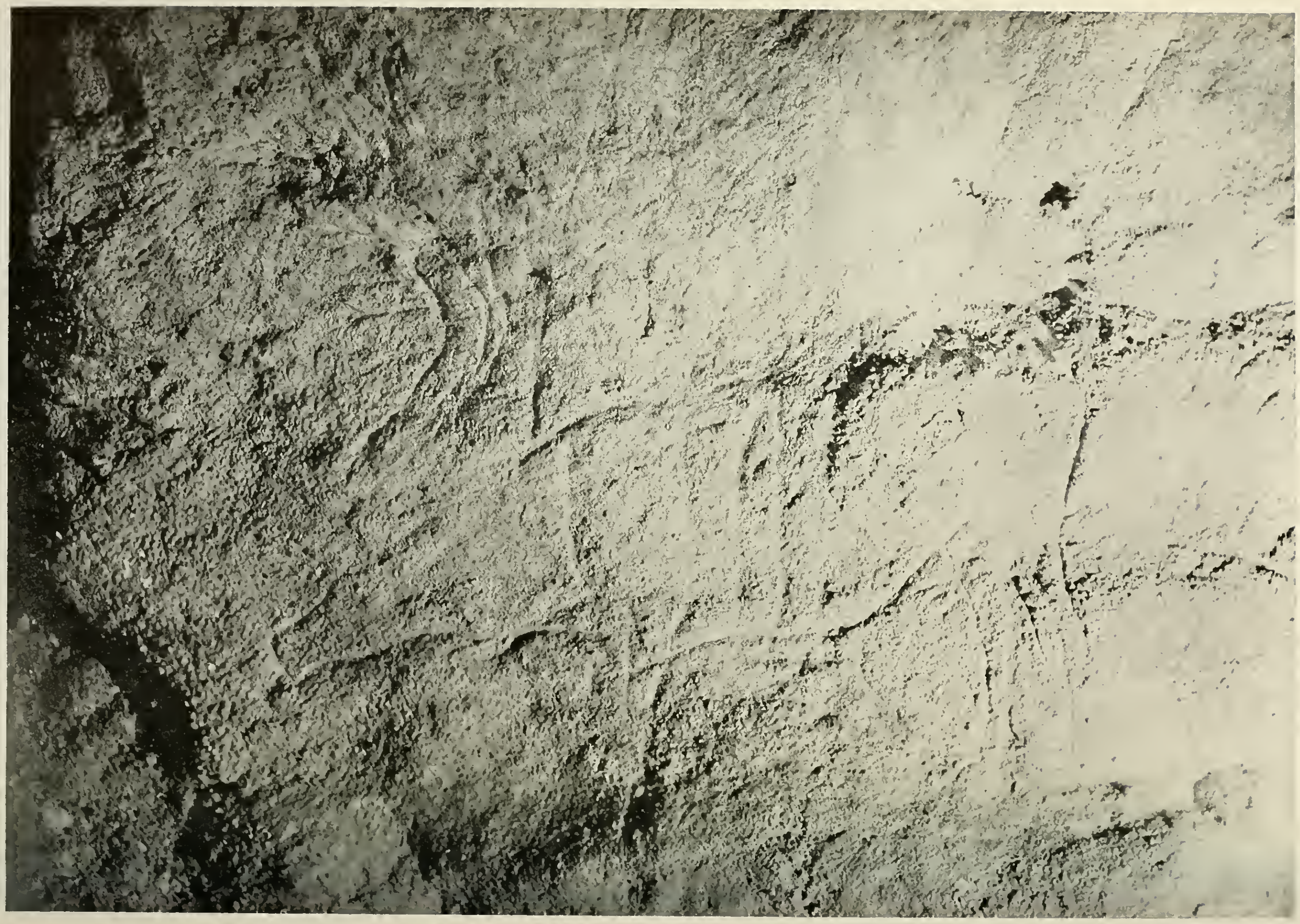


Three tectiforms and badly drawn deer

For the present, however, we will leave these problems.

The artists of Les Combarelles were ignorant of the advanced technique of mural painting as shown in the cave of Font-de-Gaume, less than a mile distant, where the art belongs to a later stage of development. On the other hand, they had ceased to make realistic human forms like those left by the ancient "Aurignacians" of Laussel about three miles away. Their most interesting designs are figures of animals engraved or carved in very low relief. We have already spoken of the most remarkable, but the others—though less extraordinary—are also worthy of study. Examined from an artist's viewpoint they show a profound realism with no affectation. They also show many inaccuracies and negligences which may be due in part to hasty execution, but also to the rocky surfaces, roughened with bosses and holes, on which the artist had to work.

This realistic art, long known from carvings on small objects discovered since before 1860, and so superior, taken all in all, to the works of ancient civilizations, did not arise during an advanced state of cultural evolution, but is due to the fact that among hunters life itself depends closely on keen eyesight, which tends to the development of a memory for form, and a faculty for accurate observation. Thus it comes that we find designs equally worthy of admiration among such primitive peoples as the Bushmen, the Australians, and the

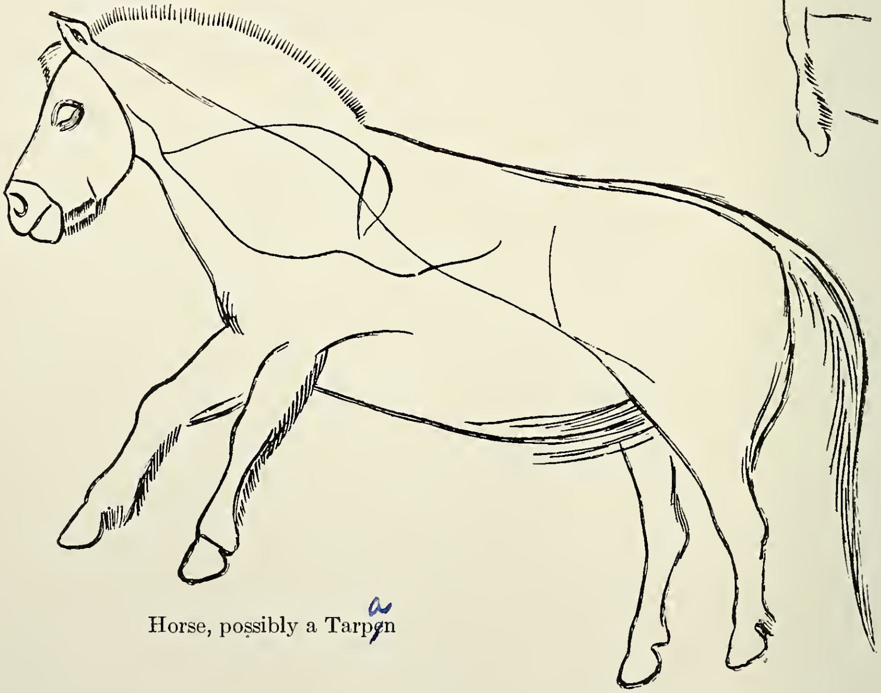


SMALL REINDEER

LIONESS

Eskimos. If it occurs to a hunter to draw, he will always draw well, for he knows how to see accurately, and how to remember what he has seen.

It follows that the designs left by the artists of Les Combarelles have a genuine zoölogic value, and deserve to be considered from this point of view—always remembering, however, that our scientific viewpoint was unknown



Horse, possibly a Tarpon

to them, and that they made their pictures from memory. With this in mind, the study of the designs of reindeer at Les Combarelles, for instance, suggests that the variety they sought to portray was related to the "woodland caribou," which is quite what might be expected in a region close to the southern limit of the distribution of reindeer in western Europe at that time.

Similarly, the study of the designs of horses, on which I have spent much time, bears witness to a great diversity of race at that time and in that region. Even allowing for the differences in appearance caused by age, sex, or season in our artists' models, one also finds a combination—at times quite unmistakable—of different types in the same design. The following are clearly recognizable:

(1) Nordic horse—head heavy, back long, muzzle sometimes decidedly arched.

(2) Celtic horse—head small, back short, rump often rounded.

(3) Lybian horse—profile sinuous, head not heavy, back short and straight, rump not sloping, form lightly built.

(4) Tarpan—head short and thick, back short and straight, tail short, rump not sloping.

(5) An unmistakable ass.

(6) Two kiangs (? probably).

One salient fact is the great number of game animals represented, in contrast to the comparative scarcity of carnivores, while certain carnivores, such as the bear, the meat of which is decidedly palatable, are as frequently pictured as the reindeer. It may legitimately be inferred that the portrayal of these figures was closely connected with the noble art of venery, so essential in those days to the very existence of the peoples of Périgord.

The enormous preponderance of figures of horses here, whereas the bison is dominant at Font-de-Gaume, is doubtless referable to the game preferred by the people of Les Combarelles, but may also be connected with a "division of labor" in hunting magic for each special tribe. For one always comes back to the viewpoint of sorcery to explain—in the light of ethnographic facts—this astonishing development of art in caves so dark and difficult of access.

Doubtless these people loved art for art's sake, but in their environment art—born of the delight of creative work, interesting in itself, and able, through contemplation, to renew the pleasure originally evoked—would not have attained such wide scope if it had not appealed to the strongest interests, to the desire for food, for an abundance of game (magic of reproduction), and for success in obtaining it (hunting magic). To picture a mare, especially giving birth to young, would promote the natural increase of horses. To portray the great cave bear with many javelins sticking in him would assure success in hunting him.

Such were the beliefs that inspired the engravings and paintings of Palæolithic times, which were doubtless executed with ritual solemnity by a caste of sorcerers trained to the work as to a sort of liturgy, in haunts forbidden to common folk and accessible at certain seasons only to the initiated, disguised in their ceremonial habiliments.

Indeed, without straining probability, one might imagine that the people of the Age of the Reindeer celebrated ceremonial feasts something like the "Inviting-in-feast" of the Eskimos held at the winter solstice, in the dead season for hunting, when by means of invocations, propitiations, masquerades, and pantomimes they seek to find favor with the souls of animals hunted and killed during the past summer, so that they may be reincarnated by order of the Great Spirit who rules all the cosmic forces. This was also the time for initiating younger members of the tribe who had reached the proper age into their sexual and social obligations, and to teach them the tribal mysteries and the traditional "catechism" treating of all man needed to know of the world, visible and invisible.

The hunters of the Reindeer Age—simple and elementary as their life was—are by no means to be classed as primitive. From the standpoint of geologic age (about 20,000 years), of human racial types, and even of social organization, they are far nearer to us than they are to the flint workers of Cromer who may date back to a million years ago. They are among our direct ancestors, and their race is not extinct.

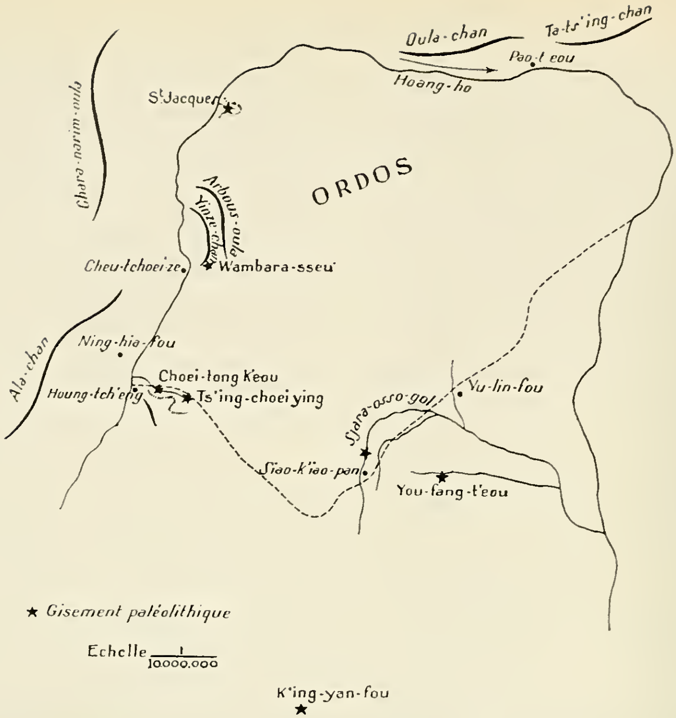


Fig. 1.—Map of Palæolithic beds in the vicinity of Ordos. From Licent and Chardin, 1925

Fossil Man in China and Mongolia

By PÈRE TEILHARD DE CHARDIN

Translated by Christine D. Matthew[1]

In the immense expanse extending from the Himalayas to the Altai Mountains, Pleistocene deposits—that is to say those in which the palæontologist has some chance of discovering traces of fossil man—are represented by thick formations known locally as the Yellow Earth (Hwang Tu). Sometimes the Yellow Earth has been deposited chiefly by the wind, on hill slopes, and then it is granular: this is the loess. Sometimes it is accumulated in the form of dunes or of alluvial deposits, in wide-open basins, and then it is sandy or mixed with layers of clay deposited by ancient lakes or rivers.

The Yellow Earth of China and Mongolia seems to be for the most part contemporary with the loess formations deposited in Russia and in western Europe during the last glacial stage. All together, in fact, they form one continuous mantle containing one and the same fossil fauna—woolly rhinoceros, giant deer, cave hyena, camel, etc. But, until very recently, no trace of man had ever been discovered in this mantle to the south or to the east of the Yenisei. Plainly there were excellent grounds for supposing that man had lived on the Chino-Mongolian plateau in Palæolithic times—that is, before the advent of those Neolithic

[1][Author's spelling of Chinese names retained.—Ed.]

people whose implements and pottery are found in the deposits of black earth superposed upon the Yellow Earth. But there was no convincing proof of this presumed antiquity of man in China.

This proof I had the good fortune to secure in 1923 when—sent by the Paris Museum to study the palæontology of Mongolia—I explored the Bad Lands of Ordos at the very time when my friends of the Third Asiatic Expedition of the American Museum of Natural History were exploring the similar regions of the Gobi Desert. In the southern part of the rectangular desert plateau enclosed by the great bend of the Hwang-ho, my guide—Père Licent, director of the Tientsin Museum—and I discovered three sites containing indubitable traces of Palæolithic man, with stratigraphic conditions and associated fossils that are beyond question.

The first of these sites is more than thirty miles east of the city of Ning-hia-fou, not far from the Ala-chan Mountains. One day, as my friend Père Licent and I were following along a ravine known as the Choei-tong-k'eou, crossed by a brook in a small loess basin, we were surprised to notice in the cliff of loess, at a depth of about forty feet, a well-marked layer of worked stones and broken bones, and we then realized that we had before us a Palæolithic "hearth" absolutely like those I had so often seen in the grottos of France and Spain. The stratigraphic study of the deposit shows that this site was inhabited by man at the commencement of the formation of the loess. Then dust and sand slowly accumulated upon the ancient surface where he had lived, forming a covering at least fifty feet thick. Afterward there was a river, the gravels and mud of which partly cut into and covered the loess. Later the whole accumulation was dissected and planed off, thus forming a new surface where Neolithic man lived, and since then the region has experienced only a course of progressive dissection throughout historic time.

In the "hearths" of Choei-tong-k'eou (for there are several) the animal remains are varied, though not abundant, and include the kiang, aurochs, argali sheep, gazelle, woolly rhinoceros, hyena, and ostrich. On the other hand, the implements of worked stone are plentiful. From a single hearth we collected nearly a thousand kilograms (2200 lbs.). Generally they are coarse implements of quartzite—worked flakes or blades similar to the Mousterian and Aurignacian implements of Europe. But there are also small flint implements, of much finer type.

In the region of Ning-hia-fou the Pleistocene deposits consist of loess not more than 65 feet thick, but 150 miles farther east they reappear, in the form of sands, in much greater volume along the course of a river, the Sjara-osso-gol, which has worn a cañon 230 feet deep into deposits which are exclusively Pleistocene. It was while exploring the walls of this cañon, hunting for fossil bones, that we again encountered traces of Palæolithic man at a depth of some 180 feet below the actual level of the steppe. As at Choei-tong-k'eou these traces were evidently deposited upon the ancient surface of the ground, which later had been gradually buried beneath mighty dunes and bog deposits. But here, clearly, the thickness of the sedimentary covering was unusual.

As to the evidences of human activity, but few stone implements

Fig. 2.—Neolithic beds near Linn-si (Eastern Mongolia). All the stones visible on the ground are those brought there and broken by the Neolithic workers. They are embedded in the black earth which borders the basin

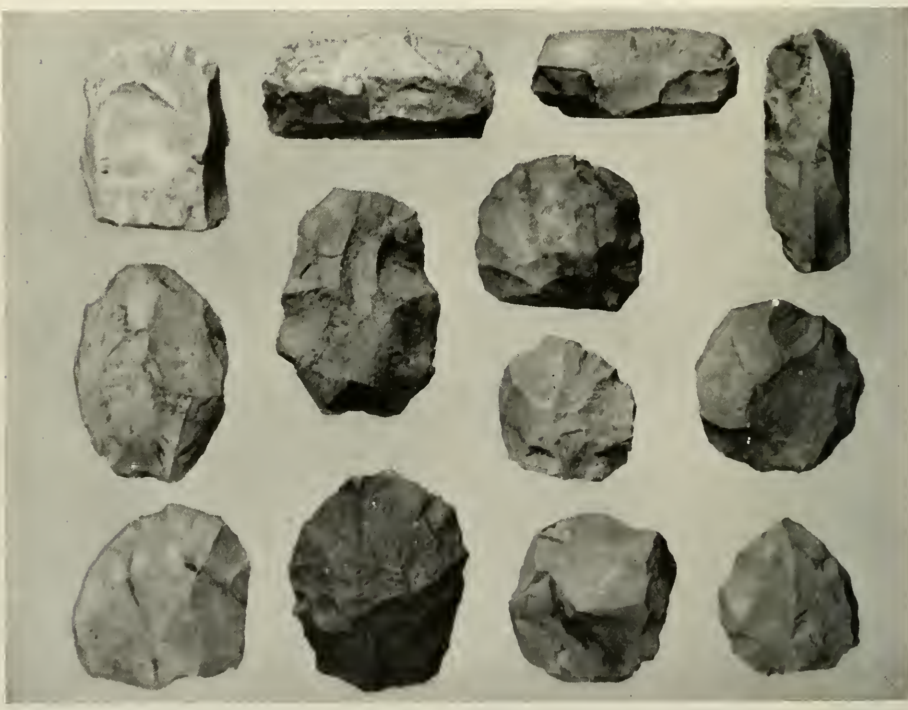


Fig. 3.—A few Palæolithic implements from Choei-tong-k'eou

Fig. 4.—Palæolithic beds of Choei-tong-k'eou at the time of discovery. The "hearth" begins at the point where the man at the right touches the cliff

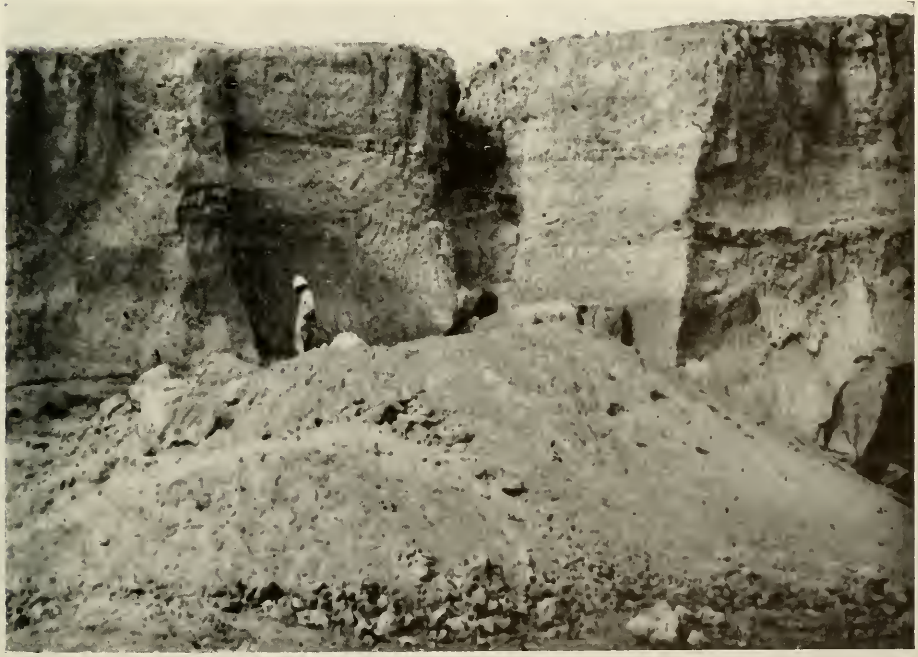


Fig. 5.—After the excavations. The position of the "hearth" is marked by a dark line to the left of Père Licent, who is looking at it

Fig. 6.—The cliffs of Sjara-osso-gol. The Palæolithic remains were found a half mile from this point, at a depth marked by the white star

were found at Sjara-osso-gol, and these were astonishingly small—often simple gravers the size of a hazelnut, retouched in every sense of the word. They were scattered through an enormous accumulation of broken bones of animals which were much fossilized and belonged to a great variety of species including woolly rhinoceros (complete skulls), elephant, kiang, aurochs, gazelle (in hundreds), camel, cave hyena, giant deer, and shells of ostrich eggs. An important series of antlers seems to have been broken intentionally to use as handles for tools or as maces.

In spite of the great depth at which these remains were found, we do not believe that the date of man's occupancy here was much more ancient than at Choei-tong-k'eou. However, the style of the implements differs so much at these two sites that they should probably be considered as representing two different cultures, and possibly two different human races.

The third and last site where we discovered traces of Palæolithic man in 1923 is about 90 kilometers, (55 miles) south of Sjara-osso-gol, in the district of Yu-lin-fou, Shensi, near the village of Yu-fang-t'eou. In this region the ground consists of an enormous thickness of loess, beneath which lies the Red Earth containing remains of *Hipparion*, and the Jurassic sandstone. In places this loess attains a thickness of 500 feet, and between it and the underlying deposits there occurs everywhere an intervening layer a few yards thick formed entirely of débris—chiefly calcareous concretions —accumulated by fluvial action at the beginning of the loess formation. These gravels at the base of the loess are destined to be of prime importance

Fig. 7.—The excavations of Sjara-osso-gol

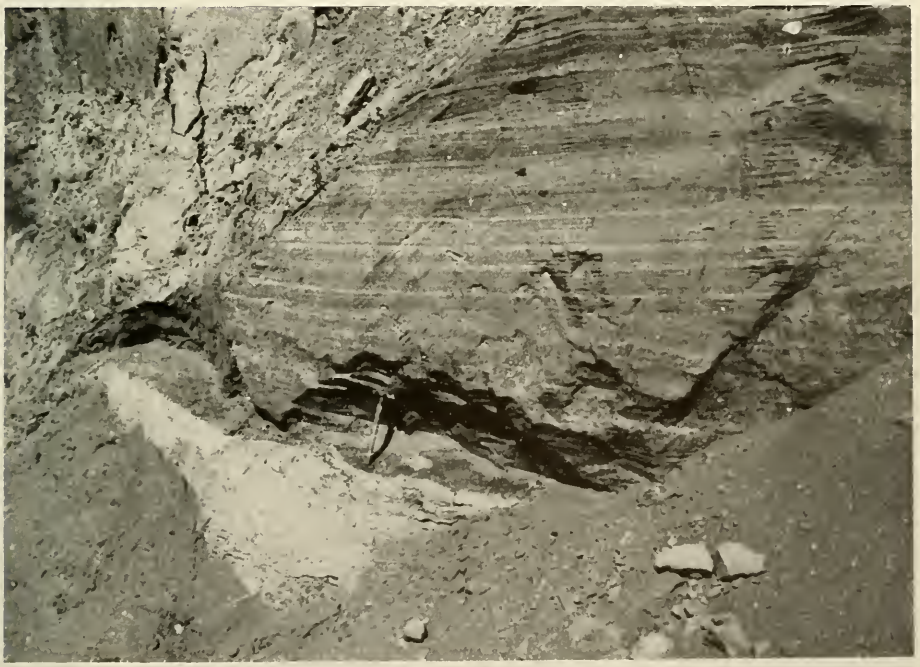


Fig. 8.—The old Palæolithic soil of Sjara-osso-gol. All the bones and the tools (flints) lie on the surface of the lower clay bank, below the stratified sandstone

to the prehistorian for it is here—just below the loess, strictly speaking—that we collected a small number of quartzite flakes which have certainly been fashioned by man. The implements were not assembled at the site of an ancient camp, as at Choei-tong-k'eou and Sjara-osso-gol, but were scattered throughout the gravel. This makes them much more difficult to find, but, on the other hand, their area of distribution is very extensive. Indeed, ever since 1920 Père Licent has from time to time found similar implements in the same gravels at the base of the loess in the neighborhood of K'ing-yan-fou, Kansou, about 125 miles southwest of You-fang-t'eou.

Fig. 8.—A gorge in the country of the great loess (Shensi). The gravels at the base of the loess, containing the Palæolithic flints, form the horizontal cornice seen in the middle of the photograph

The discovery of worked quartzites in these gravels proves that Palæolithic man lived in China not only during the formation of the loess, but from its very beginning, and perhaps even earlier. Thus man has seen China without its mantle of Yellow Earth, which gives us a vivid realization of his antiquity in the Far East. Great as it is, however, this antiquity is as yet less than the known antiquity of man in the West. The loess, as we have said, seems to correspond to the latest stages of the Glacial Epoch in Europe and America. If this is true, then man of the Yellow Earth is far more recent than, for instance, man of the gravels of Chelles and Saint Acheul.

The antiquity of man in China and Mongolia will not compare with that already known for man in Europe until we know if man (and what species of man) peopled eastern Asia at that period when, for the last time, the hippopotamus wallowed in the rivers of England. And not only do we know no answer to this question: as yet we can but guess what regions may supply that answer.

In conclusion, it is of the greatest importance to connect the Palæolithic sites of Ordos with those of Siberia, and to discover human fossils there. Only when a correspondence has been established between the Palæolithic industry of China and that of Russia, and when we have a skull of the man of Sjara-osso-gol or of Choei-tong-k'eou—only then will we be able to determine whether the resemblances of the stone implements of Ordos to the Mousterian and Aurignacian implements are cases of simple convergence, or whether they indicate an actual relationship, either through contemporaneity of time or community of race.

Fig. 10.—Another view in the country of the great loess. As in Fig. 9, the gravels at the base of the loess again form the horizontal cornice in the middle of the photograph

The Dune Dwellers of the Gobi

By N. C. NELSON
Associate Curator of Archæology, American Museum

WHEN several years ago it was proposed that archæology be included in the program of the Third Asiatic Expedition, the suggestion seemed of all things the most natural. Was not Asia the cradle of human kind, and were not the elements of all Occidental cultures—American as well as European—derived largely from the Orient? Next to a systematic search for evidence of Quaternary man at home in America, the most worth-while adventure for one interested in human prehistory was certainly the opportunity to investigate the archæology of the Far East.

And then about a year ago the opportunity arrived. All at once it became necessary to divest the term "Orient" of its enveloping mystery, its glamour and romance, in fact to prepare to meet the hard reality face to face. The new situation put one's faith to the test. Positive historical data about the overflowing East began to seem few and far between. Traditions were not of the stuff that inspired confidence. And as for current scientific hypotheses, developed by my own colleagues in their comfortable studies, about "Central Asia as the original home of the human species," etc., all the known facts were against them. No one had ever discovered a positive trace, say, of Palæolithic man in the Far East, and as for Asia being the mother of all the nations, what was that but a piece of flattering Occidental sentiment?

However, Leader Andrews stood ready with the money and the American Museum granted the time—the least I could do was to go. But throughout the long journey to Peking it was borne in upon me more and more forcefully that the venture was a bit foolish. Some who, it seemed, ought to know, were even frank enough, in parting, to tell me so; and on my arrival in China the prospects did not at once materially brighten. The times were far from auspicious and the field apparently had either been worked or was in some sense preëmpted. Still, no one had any immediate designs on Mongolia, particularly the Gobi Desert; indeed, there were those who were far too ready with the suggestion that the Gobi would be an especially desirable place for me to go, even though a desert would appear to be the last place in which to look for relics of prehistoric man.

Fortunately, it had been my own original choice to make Mongolia the first objective; so that if all attending circumstances seemed to send me there no one was more pleased than I. And why not look for archæological remains in a desert? It is one of the easiest places in which to find such things if they are really there. Besides, had not the Sahara and other African deserts furnished an abundance of relics of all ages? Deserts have not necessarily always been deserts, and we have the word of our own anthropogeographer, Ellsworth Huntington, for it in his *Pulse of Asia* and other writings, that Central Asia was once less arid than at present. Lastly, prehistoric remains of one sort or another had been found practically all around the outer borders of Mongolia, and the members of the Third Asiatic Expedi-

AN EXAMPLE OF POTTERY AND VARIOUS TYPES OF ARTIFACTS MADE BY THE DUNE DWELLERS OF THE GOBI

MR. NELSON MAKING THE PRELIMINARY CLASSIFICATION ACCORDING TO FORM tion, 1922–23, had actually brought out some bits of flints and a fragment of pottery from distant parts of the Gobi itself—not much, but enough to indicate that early man had been there at least in late Stone Age times. Nevertheless, as we climbed over the Mongolian Pass above Kalgan on April 17 and headed into a cold and blinding sandstorm, the prospects looked none too encouraging.

But after clouds comes the sunshine. Once we were away from books and from the effeminizing comforts of civilization, the new environment laid firm hold on us and all fears and doubts vanished. As luck would have it our first night's camp, about one hundred miles from Kalgan, became an enforced stopping place, and we had time to look about for nearly a week. Immediately after breakfast on the first morning, Doctor Chaney, the botanist, and I set out on a tramp across the rolling hill country toward some high rock exposures in the distance, and by ten o'clock I had found my first man-made flint flake! It was a very modest and incomplete specimen, a little weather-beaten and all that, but I wouldn't have exchanged it for a kingdom. There were doubters in camp, of course, who said it had been made by the present inhabitants, the Mongols; but after I had asked some of the visiting natives to show me their strike-a-light flints, I was only the more convinced of the genuineness of my find.

Search as I might, however, I could not discover a second specimen. The finest of white quartz veins cropped out of the high hills, and flakes of all descriptions lay thickly strewn in places—some of them even resembled in form certain well-known Palæolithic implements, and in any case were sharp and perfectly serviceable as tools. None of them, however, showed marks either of human workmanship or of utilization. It was not until we reached our third camp, some 225 miles from Kalgan, that we had a complete confirmation of the validity of our first discovery. Here, Mr. Shackelford, the staff photographer, obtained, two feet below the surface in a vertical gully bank, several cores and flakes of flint and also a number of bits of broken pottery—all unquestionably of Neolithic date.

From this point onward, clear across the Gobi proper and as far into the Altai region as the main Expedition penetrated, we found numerous traces of chipped stone artifacts. This was done at first only by intensive searching of the barren pebbly surface, but as we advanced northwestwardly, the evidence steadily increased both in quantity and in definiteness of character. In one place, some 730 miles from Kalgan, on a high plain lying between the Artza Bogdo mountains and the Ulan Nor (Red Lake), worked reject specimens of considerable variety lay scattered in such abundance that one could scarcely avoid stepping on them. This rich belt was about twenty miles wide and marked a locality where a fine quality of red jasper, especially suitable for the production of chipped tools and weapons, was weathering out of the underlying volcanic formation. Raw material in the form of bowlders and pebbles, having thus been continually renewing itself in inexhaustible quantities, the locality may readily be supposed to have been a main source of supply for primitive man since his first coming into the region. At any rate, with that possibility in mind, a lengthy search was instituted, in which several members of the Expedition took

The dunes of Shabarakh Usu

A nearer view showing dunes redissected by stream and wind

Andrews, Nelson, and Young investigating the site where the Dune Dwellers camped in Stone Age times

Implements found embedded in the sand dunes part, in particular Doctor Morris; but no forms of implements recognizable as of Early Palæolithic type were discovered. The oldest and most primitive forms found included certain pointed flakes and chipped side-scrapers very similar to those of the Mousterian culture in western Europe. Elsewhere, some 900 miles from Kalgan we found, also on the surface, a remarkable form of end-scraper closely resembling the grattoir of Aurignacian and Magdalenian times. The antiquity of our specimens is moreover vouched for by their relatively worn and weathered condition.

These surface finds, numerous and interesting as they were, could not, of course, be regarded as entirely adequate scientific data. They were, in fact, little more than good indications that early man had been about from time to time, his presence extending over a period comprising, doubtless, many thousands of years. Accordingly, we kept a sharp lookout for the occurrence of good geologic exposures of Pleistocene and later dates—hoping we might discover evidences of human occupation actually in place at some depth in these formations. In this quest we ultimately succeeded at some seven or eight localities, the best of them ranging from 700 to 900 miles northwest of Kalgan.

The first and most important of these sites was at Shabarakh Usu, a place already made famous by its remarkable yield of dinosaur eggs; and our last discovery was made in the basin of the Orok Nor, a large sheet of water situated at the north base of the beautiful snow-covered Ihke Bogdo Mountains.

As it turned out, we did not succeed for certain in finding any Palæolithic implements actually imbedded at some depth in formations of Pleistocene age. We did, however, find specimens of the desired type on the surface of such deposits and under conditions which led us to suspect they had weathered out of the same.

Our principal discoveries, comprising artifacts of Mesolithic and Neolithic characteristics, were made in dune formations, probably of early post-glacial age. At any rate, these sometimes extensive wind-blown accumulations, sufficiently hardened by age to support vertical escarpments nearly thirty feet high, occurred with such regularity in the various basins and hollows, great and small, as to suggest their formation having taken place under climatic circumstances decidedly different from those of the present day. Judged by the conditions under which sand dunes are now occasionally forming in the region, these ancient deposits were piled up at a time when their respective basins held bodies of water, from the lee shores of which the dune material was principally derived. Today most of the basins are dry or nearly so, and their dune deposits are all "dead," so to speak, and as a rule in process of being removed at a slow rate by the strong, steady northwest winds. On the other hand, in the basins where lakes are still present, there the dunes are "alive" and continually piling up, sometimes into proportions of surprising grandeur and beauty.

Archæological interest attaches only to the old dead sand dunes which are slowly being eroded away. The winds doing this work blow, as stated, from the northwest. The result is that the ancient dunes today present, on the west or northwest, a series of parallel more or less high promontory escarpments, separated by valleys marking the places where most of the indurated or solidified dune material has been

Good hunting: the archæologist bags his game

scooped out. It was on the floor of these valleys that various members of the Expedition first discovered a great abundance of archæological objects: a moderate number of chipped stone tools and weapons, ground and polished stone tools and household gear, broken pottery, beads and pendants of shell, and, finally, untold numbers of mere rejects or waste specimens—all mixed together as the sandstone matrix in which they had been imbedded was gradually blown away. That this was the real origin of these surface pieces was proved before the end of the first day by examination of the walls of the adjoining promontory escarpments, in which flints, pottery, animal bones, etc. were found to occur in a distinctly stratified order.

The occasion of our first day's archæological discoveries at Shabarakh Usu will probably long be remembered by several members of the Expedition; but the event cannot be described in greater detail at present. It must suffice to say, in conclusion, that during late pre-Neolithic and Neolithic times man lived and worked here, probably near the shores of a small lake, and that the sands blown from its shores slowly accumulated about his rude shelters and ultimately piled up to a height of at least forty feet. This under certain conditions might have happened in a very short time, but the artifact remains imbedded in the sands show that the time was long enough for the culture to change from a phase strongly resembling the Azilian of western Europe to one of out and out Neolithic characteristics.

Fig. 1. Wound in the skull of a cave bear (*Ursus spelæus*) from the Drachenhöhle.—The wound, made by a sharp stone weapon, never fully healed but ulcerated until the time of death. The basilar length of this skull is 45 cm. (17.7 inches). In the fireplaces of Neanderthal man, 1060 feet from the entrance of the cave, we found another skull with a fresh wound in the region of the muzzle. In all probability a blow on the muzzle would cause immediate death, while a blow on the forehead or above the eyes would not necessarily be mortal, and the animal might be able to escape. Even to this day the Slovakians of the Carpathian Mountains kill brown bears by a powerful blow on the muzzle

How Neanderthal Man Hunted Cave Bears

IN THE DRAGON'S CAVE NEAR MIXNITZ, AUSTRIA

By OTHENIO ABEL

AMONG the numerous fossil-bearing caves in Austria the Drachenhöhle or "Dragon's Cave" in Rötelstein Mountain on the Mur River in Styria, is today among those best known.[1] This cave is more than 1800 feet long. The entrance is 3110 feet and the farther end 3280 feet above sea level. It is divided into three sections by two great heaps of stones fallen from the roof, which walled in enormous masses of fossilized bats' guano—or, as I named it, "chiropterite." A third heap of great blocks in the innermost section of the cave is older than the other two stonefalls. As Dr. Josef Schadler and I have shown, it occurred in Pliocene times, while the others fell during the Great Ice Age.

The first heap of stones formed an obstruction behind which there accumulated a great mass of bats' guano containing many hundred thousand fossil bones, chiefly of cave bear (*Ursus spelaeus*). In the basal layers we found bones of *Ursus deningeri*, a form ancestral to the later true cave bears. In the middle layers remains of the true cave bear (*Ursus spelaeus*) were very abundant and showed widely differing variations affecting nearly all parts of the skeleton, but especially the skull and dentition. It was in these layers

[1]The excavations in the Drachenhöhle were made in 1920–23 to secure the fossilized bats' guano or "chiropterite" for agricultural purposes, for after the war Austria had neither natural nor artificial fertilizer. These excavations, under the superintendence of Dr. Josef Schadler, yielded about 2360 tons of chiropterit, containing, on an average, 13 per cent P_2O_5. I was placed in charge of the scientific investigations. In addition to numerous preliminary reports, chiefly published in the *Anzeiger* of the Academy of Sciences, Vienna (23 papers), the scientific staff employed in the Drachenhöhle excavations has prepared a monograph in three volumes which is already in press and will appear shortly. The illustrations accompanying this article are taken from the monograph.

that the cave bears of Mixnitz reached their maximum of size and variability, while in the higher layers of the chiropterit the cave bear was represented chiefly by degenerate pigmy forms, the latest evolutionary stage of the Mixnitz cave bear before extinction. We collected, therefore, in the Drachenhöhle near Mixnitz data for the phylogeny of the cave bear that were unusually complete and very instructive.

But man's first visit to the cave is recorded from a much earlier time, that is, during the Great Ice Age, and especially in its last interglacial period, the time when the cave bear flourished. At this time, and in this region of the Alps, Neanderthal man hunted the cave bear even into the farthest recesses of this cave. In the spring of 1921, while we were excavating just in front of the second stone barrier 1060 feet from the entrance, we uncovered two fireplaces of Neanderthal man, one above the other. Both were paved with flat limestone slabs and strewn with a great number of broken and burned bones of cave bear, together with pieces of charcoal, and a number of flakes and very primitive artifacts of Mousterian type, which were nearly all made of quartzite brought from the gravels at the bottom of the Mur valley to the cave, 1640 feet above the level of the river.

These fireplaces were situated at the opening of a narrow passage—the

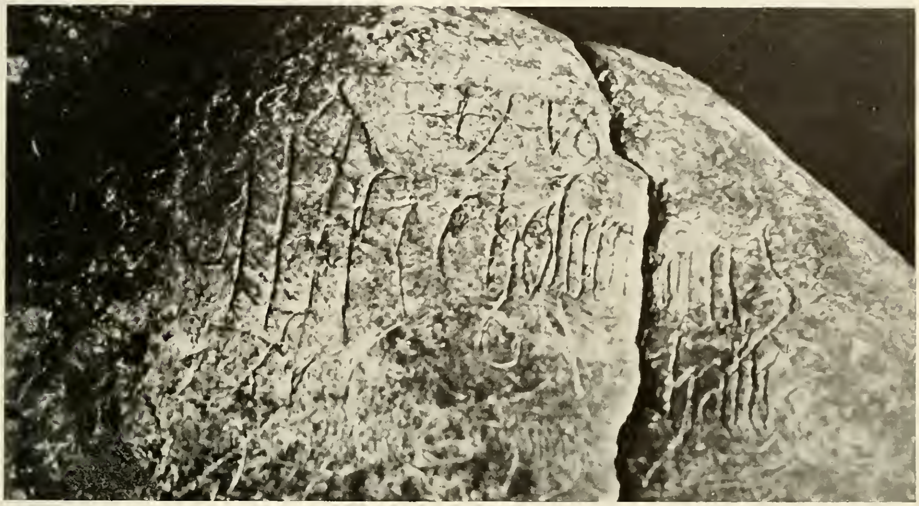


Fig. 2. Inscription on a rock in the Drachenhöhle, dated 1418.—At the top is the date in old characters; below, at the left, a heraldic sign; at the right, "Cholomanus"; third line, "halbe." In mediæval times the Drachenhöhle was already well known, and was visited by priests and nobles of the country. It was long believed to be a haunt of giants and dragons, as well as of the fabulous unicorn. Even as late as the first half of the nineteenth century the abundant remains of cave bears—supposed to be those of unicorns—were still being dug out and used for medicinal purposes

From early mediæval times, and even as late as the end of the eighteenth century, the Drachenhöhle was reputed to be a haunt of giants and dragons. Inscriptions on rocks and on the walls of the cave—the earliest date being 1386—tell of repeated excursions to this "wonder of nature." In olden times visitors marvelled at the numerous fascinating skulls and leg-bones of the giant cave bears, believing them to be the remains of giants or dragons, and thus the name "Drachenhöhle" or "Dragon's Cave" originated.

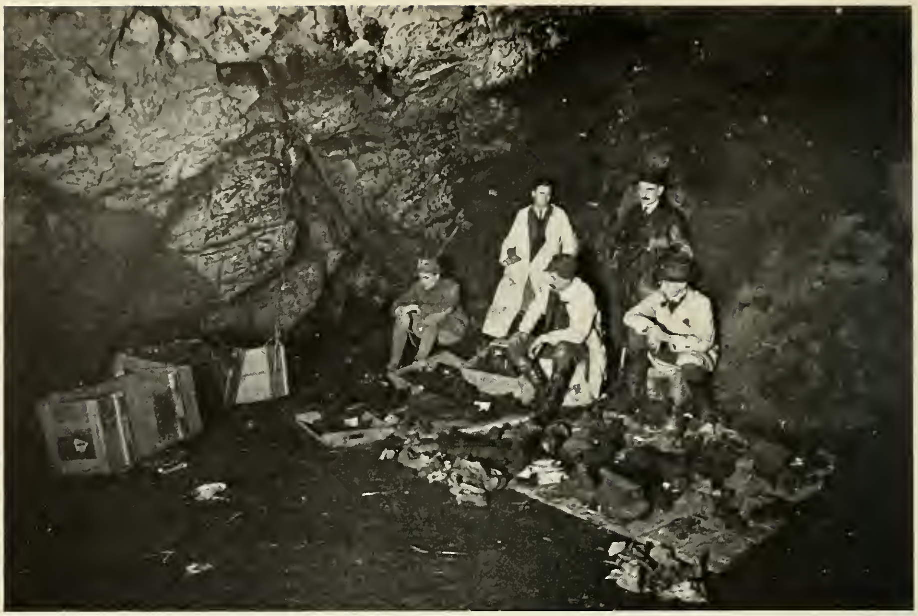


Fig. 3. An excavation party in the Drachenhöhle.—From left to right, sitting: Dr. Wilhelm Marinelli, Prof. Othenio Abel, and Dr. Kurt Ehrenberg. Standing: Dr. Franz Spillmann and Dr. Otto Antonius. By January, 1921, the "Abelgang" had been completely excavated. The material removed contained thirty skulls, numerous lower jaws, and other bones of cave bears, and also the remains of wolves, lions, and smaller mammals.

Fig. 4. Scratches made by cave bears on the walls of the Drachenhöhle.—The walls of the Drachenhöhle which are a Palæozoic limestone, have been much decomposed by bats' guano, and their surface has been transformed into a soft phosphoritic mineral. On this soft surface, in a narrow passage between the wall and a great stone block we found hundreds of claw marks made by cave bears. As Freiherr von Bachofen points out, Neanderthal men must have hunted the cave bears here chiefly by means of the *battue*, and doubtless attacked them suddenly in this narrow defile. The bears, in trying to escape, made these numerous marks on the wall

usual route of the cave bears which hibernated in the warmest (e. g., the innermost) part of the cave. After the chiropterite had been removed, Freiherr A. von Bachofen-Echt followed this path of the cave bears for a distance of about 820 feet from the fireplaces to the end of the cave, and found that the only possible exit for the bears had been through this narrow defile. Here the Neanderthal hunters had stationed themselves, and tried to kill the escaping animals by striking at them with long-handled clubs at the end of which sharp stones were fastened. This accounts for the numerous wounds on the skulls of the cave bears in the Drachenhöhle, later healed if the animals escaped, and always situated on the left side of the skull or lower jaw, that is, just on the side exposed to the hunters' attack when the bears ran along the narrow passage.

Fig. 5. Accumulation of cave-bear skulls in the "Abelgang," a side recess in the Drachenhöhle.—Although the "chiropterite" contained an enormous number of bones and teeth of the cave bear, it was only in this recess that we found the skulls lying side by side. This photograph was made shortly after we began excavating, and shows eighteen skulls *in situ*

In January, 1921, we excavated a little side recess of the cave near the fireplaces, which was filled with a number of skulls and other skeletal remains, chiefly of cave bears. In a space not exceeding two or three cubic meters in extent we recovered thirty skulls, some of them with lower jaws *in situ*, together with many isolated lower jaws and numerous other bones.

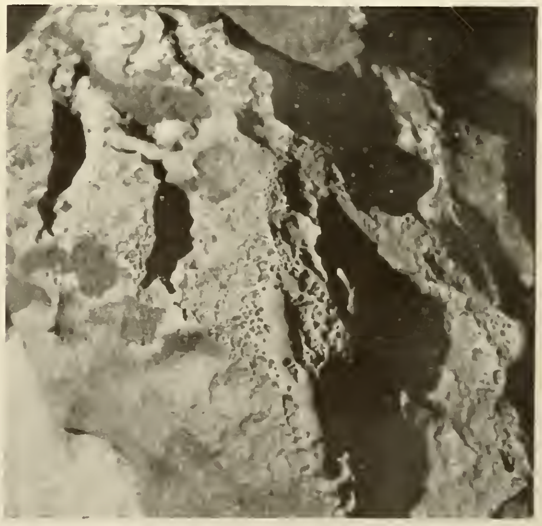


Fig. 6. Rock polished by the fur of the cave bears.—The animals found their way in total darkness, chiefly by the sense of smell, along the walls of the cave and between the great blocks of stone fallen from the roof. In the course of time the edges and corners of these blocks and of the walls were worn smooth by the fur of the cave bears, as they rubbed against the rock

It was a remarkable fact that these bones showed a rather peculiar arrangement. We found that almost all the bones at the bottom were small—chiefly metapodials and vertebræ; at a higher level arm-bones and leg-bones predominated; then came a great series of pelvic bones; and the uppermost layer was composed chiefly of skulls and jaws. Some of the bones were badly rolled, or weathered, or

Fig. 7. Arrangement of the skull and ulna of a cave bear, believed to be the work of Neanderthal man.—In March, 1923, Dr. Josef Schadler found the skull and ulna of a cave bear firmly fixed in the deep marginal fissure between the wall and the floor of the Drachenhöhle. All the circumstances make it most improbable that this could have happened as the result of a fall, or of the action of running water, or of any other operation of the forces of nature

gnawed by wolves; others were broken before fossilization, and one skull showed a healed wound on the left frontal, made by the sharp stone weapon of some Neanderthal hunter.

The question was whether the peculiar arrangement of the bones at this site was artificial (e. g., made by Neanderthal man), or whether it was caused by the action of running water, separating the bones according to their weight, and accumulating them in this pocket or recess, without any human intervention.

The first explanation would be in accord with the observations of Emil Bächler in the "Drachenloch ob Vättis im Taminatale," Switzerland, and also with the similar observations of K. Hoermann in the cave of Petershöhle near Velden, Franconia, Germany. In the Drachenloch near Vättis, 8020 feet above sea level, Neanderthal man buried skulls of cave bear with the adjoining vertebræ in stone chests and covered these with stone slabs. In Petershöhle the skulls and other bones of cave bears were not so regularly arranged as in the Drachenloch, but were irregularly piled in a little recess of the cave.

It is noteworthy that the primitive bear-hunting peoples of northeast Asia —Giljaks and Ainus—observe a peculiar religious veneration towards the skulls of the bears killed by them. It is not impossible that the accumulations of skulls and other skeletal parts of the cave bear in so small an area (eighteen skulls in a space of two square meters) in the Drachenhöhle near Mixnitz may be explained in the same way as the very similar accumulations in the Drachenloch and in Petershöhle.

Dr. Kurt Ehrenberg, who studied this matter together with other features bearing upon the whole problem of fossilization in the Drachenhöhle, is inclined to adopt my earlier viewpoint of 1921, namely, that the whole arrangement of the fossil remains in the recess is due only to the action of running water. On the other hand, he suggests that a curious combination of a bear skull with an ulna may be an instance of the deliberate arrangementof skeletal parts of cave bears by Neanderthal man, similar to the combination of skull and femur in the Drachenloch observed and described by Doctor Bächler in 1921.

The Antiquity of Man in America

By PLINY E. GODDARD
Curator of Ethnology, American Museum

WHEN Columbus arrived in the New World in 1492, he was met by men, inhabitants of America. How long had they been here? There has been much speculation in regard to this question, but not much certain information.

For a time it was a favorite theory that the Indians were the descendants of the ten lost tribes of Israel. When the Indians came to be studied, however, it was found that instead of having a single language related to Hebrew, they possessed hundreds of languages which fall into many groups unrelated to each other. While a few of their practices do resemble those mentioned in the Old Testament, on the whole their customs are peculiar to themselves but with great differences as one passes from tribe to tribe. It is now the accepted opinion that when they came to America they had no domesticated animals except the dog, and no agriculture. They were ignorant of metals but were advanced in stonework. Wherever the remains of man are found, polished stonework appears among them. It is said, therefore, that they came during the Neolithic period. It is only in western Europe that the successive periods of stone art are known, and there the Neolithic is fairly recent, later than the last great glaciation, presumably not more than 25,000 years ago. While it is usually not definitely so stated, it is ordinarily assumed that this date holds everywhere.

Authorities have talked of 10,000 years ago as about the time when men may have crossed Bering Strait, and begun their long march to Patagonia. In America the last ice cap came down as far as Northern New Jersey, over the greater part of Ohio, and covered Nebraska. The beginning of the retreat is estimated at 30,000 years ago, but this retreat was very slow indeed, and did not end earlier than 10,000 years ago. It is for this reason presumably that 10,000 years has been mentioned as the time when men came to America.

There are some reasons, however, for thinking the time must have been longer. According to the old theory, after crossing to America by way of Bering Strait in the north, the Indians moved southward, made their way down the Isthmus of Panama, and peopled all of South America as well as North America. Some time later they began to cultivate maize which was presumably a plant native to Central America. Maize under cultivation has changed its habit of growth so that it can no longer plant itself, but must be tended by man. In connection with its culture extensive irrigation grew up. After that cities and temples were built, and the higher civilizations of Peru, Mexico, and our own Southwest developed. All of this required time. One would be rash to say it could not happen in 10,000 years, but even more rash to say it did happen in that length of time.

Still more convincing is the linguistic differentiation. North of Mexico there are some fifty linguistic stocks or families, that is, fifty languages or groups of languages, so distinct from one another in their vocabularies, that no relationship can be traced. There are many more such families of languages in Mexico, Central America, and South America. There are two theories which might account for such diversity. A people with a single language may have come to America, and remained here so long that wherever a group became isolated its language came to show no relationship to any others, so completely did it become changed. The second theory is that wave after wave of migrating peoples came across, each with a different language, but leaving behind them in Asia no remnants who preserved the language.

The growth of civilization in America and the linguistic differentiation, are strong arguments that America has been occupied by man during a very long period.

The geologists have a way of determining time, but over vast periods. They find one kind of rock on top of another kind and know that certain of them were laid down under water. The palæontologists examining these strata of rock find fossils in them and know that certain forms of life followed certain other forms. They know that during the Ice Age or the Pleistocene, as they call it, certain large mammals were in America. Among these were horses much like those we know, camels, the bison, and the mammoth. They know this because they find the bones and teeth of these animals embedded in gravels and clays, which were laid down during the glacial period. If man's bones were found mingled with these, we would be certain man was also here at that time. Of the animals mentioned above, the horse and camel became extinct in about the middle of the Ice Age. But objects made by man have been found in the gravels and sands along the southern boundary of the ice cap, particularly at Trenton, New Jersey, and in Ohio. Rather than accept these finds as evidence that man was here at the end of the glacial period, it has been assumed either that some mistake was made, or that somehow the object became embedded accidentally where it was found.

From time to time various objects have been found which either resemble an elephant in shape, or on which an elephant had been drawn. These have been presented as evidences that those who made these objects had seen elephants before they became extinct. In practically every case either the resemblance to an elephant has been denied, or fraud has been charged.

Two recent discoveries have changed the situation.

Professor Loomis has found objects, made by man, side by side and underneath the remains of mastodons and mammoths in Florida. Man then was in Florida before the elephants disappeared from this continent. The evidence presented puts the time after, but immediately after, the end of the Ice Age. There was of course no ice cap in Florida, but from earth movements, and the animals found just below the stratum which contains the bones of both men and elephants, the time is fixed.

Mr. Harold J. Cook in *Science* for November 20, 1925, pages 459–60, announced the discovery of three worked flints under the fossilized skeleton of a bison of an extinct species. The conditions under which the remains were found are given by Mr. Cook as follows:

> The bison and other fossils occur in solidly cemented gravels, overlain by about five to seven feet of undisturbed Pleistocene sands and gravels, that are cemented so hard by calcareous cement that the beds are worked

with difficulty, especially when dry. On top of these sands is a disturbed bed of uncertain age, and above this several feet of worked-over sands, silts and soil. The bones found are all well fossilized, and in a state that it would be utterly impossible for erosion to have moved them, without breaking them up and disarticulating the bones, and largely destroying them. Every observed condition clearly points to an undisturbed deposit, and free from such cross-channeling as has worked the materials over at Vero, Florida. The bison pertains to one of the earliest stages of the refilling process in laying down these Pleistocene gravels and is just above the old Triassic floor. It is probable that the bison had been shot and carried these flint points with him to the place where he finally died and was entombed.

Not only is the evidence in this case entirely convincing since the finds were made by Museum men and the formations checked by a competent scientist, but there is the corroboration of an earlier find of the same nature. In 1895 two assistants in the department of palæontology of the University of Kansas found an arrowhead under the right scapula of an extinct species of bison, *Bison occidentalis* Lucas. This find was in Logan County, Kansas, and the formation was identified as Equus Beds of the Pleistocene. In these two cases of extinct bison which had been hunted, if not killed by man, the locations are beyond the region covered by the ice of the last glaciation, so that the determination of the age depends in part upon the presence of the remains of animals supposed to be confined to the Pleistocene.

Even if these animals lingered later in Texas and Florida we must assume that men were in America at the end of the Ice Age, or about 25,000 years ago. They have been here long enough to build civilizations, and for profound linguistic changes to take place. Furthermore, they appear to have been more advanced in their arts than were men in Europe at that time.

That men were here long before is possible. Fossil remains of man have come to light in Lower California and South America which appear to belong to a race very different from the present-day Indians. The evidence in these cases is not such as to settle all doubts, but it is strong enough to create interest and should stimulate further search. The regions most favorable for early man, the uplands of the tropics, have received little attention from field archæologists interested in early man. The prime interest in Mexico, Central America, and the west coast of South America has been in the more recent high civilizations.

Students familiar with European prehistory say that if man were here during Pleistocene times the evidence should be abundant as it is in France and Spain. Let them beware of making the well-known region, western Europe, the standard for the entire world. Preconceptions and generalization based on one region are fatal to the open-mindedness necessary for progress in science.

Early Man in Florida

By F. B. LOOMIS
Department of Geology, Amherst College

IN 1916 Sellards announced the finding of human bones and implements at Vero, Florida, in layers of sand containing the bones of extinct animals, such as the mastodon, mammoth, camel, horse, and tapir. These animals were at once recognized as an assemblage of forms which lived over wide areas of North America in the early Ice Age, a period lasting from about 1,000,000 years ago, to about 25,000 years ago. In North America the horse, camel, and tapir became extinct by the middle of the Ice Age, while the mastodon and mammoth lived on to the end of the Ice Age and a short time thereafter.

Three possible explanations for the presence of the human bones suggest themselves.

(1) The human bones were the remains of a burial or were deposited in these beds by some other artificial means, and were thus mingled with the bones of extinct animals, in which case the find is of little moment.

(2) The human bones were deposited with the sand by natural processes and were as old as the associated extinct animals, in which case man was in America in middle glacial times or about 500,000 years ago.

(3) The above-mentioned animals for some unknown reason lived to a later date in Florida than elsewhere, in which case the human remains could be of any date postulated for the prolongation of the life of this fauna in Florida.

In 1913 a similar find was made at Melbourne, Florida, about forty miles north of Vero. With the foregoing in mind an expedition under the auspices of Amherst College and the Smithsonian Institution went to Florida and spent six weeks or more of the summer of 1925 in an effort to solve the problem. The expedition collected widely both at Melbourne and at Vero.

It is necessary, when collecting in this part of the country to determine, first, where the former drainage of the country had been situated. This is done, in large part, by following the banks of the modern drainage canals and watching for fragments of bones which may have been thrown out by the dredge in digging the canal. Where they occur the canal has crossed a former stream valley, which can be traced from that point a considerable distance. Much of this work had already been done for the party by Mr. C. P. Singleton, who has become very expert in finding the fossil bones. When an old stream valley is located, a pit is dug at random. If bones appear, the pit is enlarged, otherwise it is filled in. The bones may appear at about three feet below the surface, and occur from that level to the bottom of the river deposits, which may continue downward from one to five feet farther, the bottom being indicated by a layer of marine shells or coquina. Negroes were employed to remove the upper layer, and when they came to the bone layers, the representatives of the two institutions took up the work.

In four localities, each isolated from the other by at least a mile, either human bones or tools were found. Three of these were near Melbourne, the fourth near Vero, close to where Sellards had worked. One find was a human skull, crushed flat, together

Upper picture: View of a drainage canal and the excavation near it, in which was found the human skull.

Lower picture: The human skull just before it was bandaged. The arrow points to the skull. Above it is No. 3 layer, below is No. 2 layer

with a part of the arm. Another find was a large flint implement such as is usually called a spear head. The third, near Melbourne, was a smaller flint implement, together with a large number of flint chips and some bits of pottery. The character of the flint implements and the fact that pottery was found give the finds a modern appearance. The possibility of the overlying beds having been disturbed was kept in mind, and special care was taken to extend the work laterally so as to unearth some of the extinct animals in the same layer with each find. The human remains were always overlaid by beds consisting of alternate layers of white sand and black vegetable matter, and it was easy to determine that the human remains had not been introduced into these beds at a later time.

We found three beds, as reported by Sellards, who numbered them from the bottom upward. No. 1 is the layer of marine shells or coquina and is of marine origin. No. 2 is deposited on an irregularly eroded surface of No. 1. It consists of layers, often cross-bedded, of sand, usually brown in color, and without any layers of black vegetable matter. No. 3 lies on the irregularly eroded upper surface of No. 2. It consists of white sand, bedding in alternate bands with layers of black vegetable matter.

We found that all of the animals, horse, camel, tapir, etc., which are characteristic of the early Ice Age in America were confined to the lower of the two river deposits, i. e., bed No. 2. All of our finds of human material were in or at the base of the No. 3 bed, in which there were also numerous bones and teeth of mastodons and mammoths, not to mention deer, dogs, raccoons, etc. This modified the postulates made at the beginning of this article by confining the association of man with the elephants which did live to the end of the Ice Age and a little later. The problems then remaining were the age of bed No. 3, and how long the mammoth and mastodon lived after the Ice Age.

The character of these fresh-water beds also indicates certain oscillations in level of the Florida country. First, when the shell layer or coquina was laid down, Florida must have been below sea level. The shells indicate late Pliocene. Then it was elevated to at least forty or fifty feet above its present level, either in late Pliocene or earliest Ice Age, at which time a drainage system was developed, including such a river as the Indian River and its numerous tributaries. The next movement was a downward one to a level near that of the sea. As a result of this, the valleys of the streams, at least in their lower portions, were filled. The bones in the sand of this fill (No. 2 bed) indicate that this took place in the earlier part of the Ice Age. A second elevation is indicated by the eroded upper surface of this No. 2 bed. Then a second downward movement is indicated by the No. 3 bed. While this No. 3 bed was forming, the bones of mastodons and mammoths were included in the material along with both human bones and tools. The whole question now hangs on when this last filling in took place. The only data which are now available are the bones of the mastodon and mammoth. At first thought one would say it must have been either in late Ice Age or very shortly after the Ice Age. The end of the Ice period is put at 25,000 years ago.

The only possibility of a later date than 15,000 to 20,000 years ago as a minimum, lies in the possibility of these elephants surviving in Florida to a later date than elsewhere. In these beds we are not dealing with a remnant of the elephant fauna. They occur in great numbers. Scarcely ten square feet can be uncovered without finding some part of an elephant bone. Usually less than a square yard is free from them. We found parts, teeth or limb bones, of no less than fifty elephants in our excavations which could not have covered more than two or three acres. The elephants were flourishing during the time that No. 3 bed was laid down. Much the same is true in other parts of the country. Just before they disappeared they were very abundant, then they were all gone, as though swept off by a pestilence. There is no reason to think they lasted longer in Florida than elsewhere. All this, then, would indicate that man of the Neolithic type of culture was in Florida 20,000 years ago at least.

Why Central Asia?

By HENRY FAIRFIELD OSBORN
American Museum of Natural History

The Traditional Homeland of Western Asia—The Northern Asia Center of Quatrefages—The Central Asia Theory of Matthew—The Western Europe Theory of Reinach—American Museum Exploration Revives the Central Asia Theory—Osborn Sets Forth the Claim of Mongolia and the Upland Asiatic Origin of Tertiary Man—Andrews and Nelson Strengthen the Central Asia Theory—Our Tertiary Ancestors "Dawn Men" Rather Than "Ape Men."

IN the history of western thought the traditional homeland of man is doubtless western Asia because of Biblical influence and because western knowledge barely extended beyond the confines of Asia Minor, Palestine, Syria, and Mesopotamia. As to eastern thought on this great subject we are assured that the Chinese believed that they sprang from their own soil, and as for the south Asiatics, they concerned themselves little about the geography of human origin.

The North Asiatic Theory

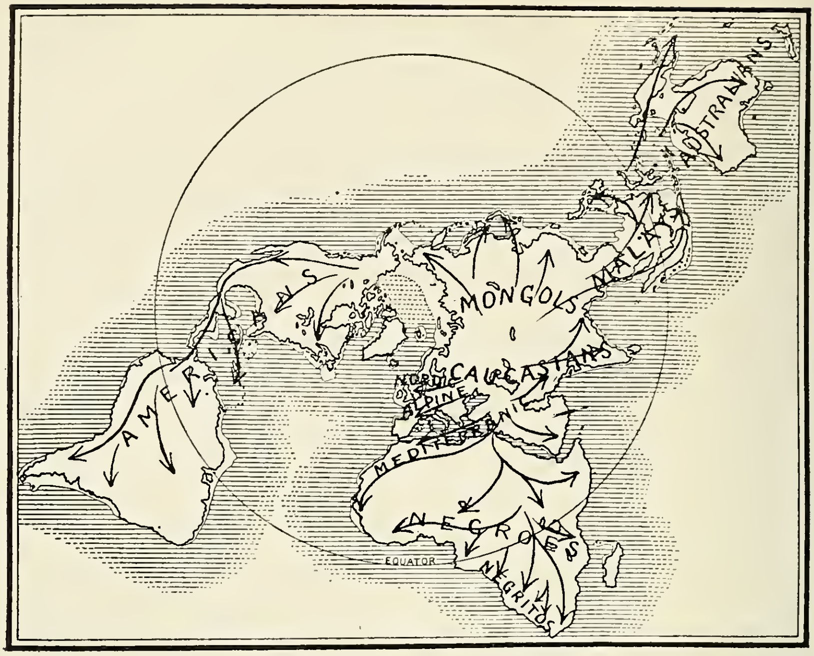
With the beginning of the science of anthropology in France there arose —from the scientific viewpoint— the question of the region in which mankind originated, which is brilliantly discussed by Quatrefages in the fifth chapter of his great treatise, *Histoire générale des Races humaines* (1889), where he handles the specific problem of the 'Origine géographique de l'espèce humaine.' After combating the idea of 'autocthonism'—the springing up of various ancestors of the human race in scattered areas of the earth's surface—and after dismissing the related speculations on 'polygenism' or the independent origin of human species and races, he finally comes to the serious consideration of what he terms 'centres d'apparition' and turns his glance toward the great northern plains of central Asia. He refers with approval to Nordenskjold's theory which places the Eskimos among the most ancient races of mankind, and then describes the theoretic southward migration of primitive tribes enforced by the rigors of the great northern glaciation, as follows:

> Marchant surtout vers le soleil, elles rencontrèrent le massif central et ses dépendances. Elles s'arrêtèrent longtemps dans ces contrées; elles y virent l'aurore des temps qui ont succédé à l'époque glaciare; elles s'y mêlèrent ou se juxtaposèrent à celles de leurs soeurs qui les avaient précédées. Au coeur et tout autour de ce grand massif, les conditions d'existence étaient loin d'être les mêmes. Le milieu fit son oeuvre; et cette region devint ainsi, non pas le *centre d'apparition de l'espèce*, mais le *centre de formation*, ou de *caractérisation des types ethniques fondamentaux* de l'époque actuelle.

At the opening of Chapter VI he describes the peopling of the globe through migration from a north Asiatic center as follows:

> L'espèce humaine, primitivement cantonnée dans un centre d'apparition unique et peu étendu, situé vers le nord de l'Asie, est aujourd'hui partout. Elle s'est donc répandue de proche en proche, en marchant en tout sens. Le *peuplement du globe par migrations* est la conséquence forcée des faits précédemment exposés. Les polygénistes, les partisans de l'autochtonisme ne pouvaient accepter cette conclusion. Aussi ont-ils nié ces migrations.

This theory of a north Asiatic center—defended as it was by the allusions of Quatrefages to a supposed northern influence on Palæolithic art—and of a dispersal along lines of migra-



Dispersal and distribution of the principal races of man. No attempt is made to indicate anything beyond the broader lines of dispersal. From Matthew's *Climate and Evolution*, Page 210, 1915

tion southward, eastward, and westward, is however quite distinct from the theory of central Asiatic origin advocated by Dr. William D. Matthew in his very able address on "Climate and Evolution" before the New York Academy of Sciences, February 13, 1911, in which he sums up the evidence for the origin and dispersal of mankind, as follows:

We may with advantage begin our review of the special evidence in support of our theory with the migration history of man. This is the most recent great migration; it has profoundly affected zoögeographic conditions; it is the one where our data are most complete and accurate; we can perceive its causes and conditions most clearly, and we have a great deal of corroborative evidence in history and tradition.

All authorities are today agreed in placing the center of dispersal of the human race in Asia. Its more exact location may be differently interpreted, but the consensus of modern opinion would place it probably in or about the great plateau of central Asia. In this region, now barren and sparsely inhabited, are the remains of civilizations perhaps more ancient than any of which we have record. Immediately around its borders lie the regions of the earliest recorded civilizations—of Chaldea, Asia Minor, and Egypt to the westward, of India to the south, of China to the east. From this region came the successive invasions which overflowed Europe in prehistoric, classical, and mediæval times, each tribe pressing on the borders of those beyond it and in its turn being pressed on from behind. The whole history of India is similar—of successive invasions pouring down from the north. In the Chinese Empire, the invasions come from the west. In North America, the course of migration was from Alaska, spreading fan-wise to the south and southeast and continuing down along the flanks of the Cordilleras to the farthest extremity of South America. Owing to the facilities for southward migration afforded by the great Cordilleran ranges, the most remote parts of the New World are the forests of Brazil and of northeast South America. In the northern continent, Florida is the most distant from the source of migration.

Matthew's central Asiatic theory of human dispersal is clearly illustrated in his accompanying figure, which agrees with the general thesis maintained in "Climate and Evolution" that primitive races of man, as well as primitive races of mammals, are constantly being thrust out from the center of dispersal into the most remote terminal regions of the earth's surface, whereby, viewing the earth from the North Pole, we see a fringe of primitive peoples—Australians, Bushmen, Negritos, Tierra del Fuegians—thrust into peripheral regions as companions of primitive mammals such as the monotremes, marsupials, and insectivores.

Human Fossils of Western Europe

Quatrefages' great work appeared in 1889. Only two years earlier, in the year 1887, the discovery of two Neanderthaloid skeletons at Spy, near Dinant, Belgium, confirmed the authenticity of the Neanderthal race of man and opened the way for a succession of discoveries of fossil human remains which repeopled the whole of western Europe with various races, species, and perhaps genera of primitive man, thereby accumulating fossil evidence strongly in favor of western Europe as a center of human dispersal.

Since the convincing proof both of the great antiquity and of the gradual ascent of man has been challenged, we may briefly state that the fossilized remains of no less than 116 individuals belonging to the Old Stone Age, or even earlier, have been found during the years 1823–1925.

Broadly classified according to races, they are as follows.

(3) Cro-Magnon and other races of Late Palæolithic times, mostly narrow-headed . . . . remains of 74 individuals.

(2) Low-browed Neanderthal race (Gibraltar, La Chapelle, La Quina, La Ferrassie, Spy, Taubach, Ehringsdorf, etc.) including the ancestral form of Heidelberg . . . . remains of 40 individuals.

(1) Piltdown race . . . remains of 2 individuals. (Possibly also a Foxhall race of Upper Pliocene times.)

The broad- and narrow-headed races of post-Palæolithic or pre-Neolithic time are represented by the remains of at least 236 individuals, and far more abundant are the human remains of Neolithic age.

Meanwhile, during the same period of more than a century (1823–1925), only a single discovery of prehuman or human remains had been made in the whole continent of Asia, namely, the *Pithecanthropus* or Trinil ape-man of Java; and as discovery sites of fossil man gradually studded the entire map of western Europe, was not the suspicion a natural one that man originated not in Asia but in Europe? As Hrdlička observed in 1913:

> Europe, particularly in its more western and southern portions, has thus far proved the richest in ancient human remains. Africa, Asia, and those parts of Oceanica which were formerly connected with the Asiatic continent have as yet been but little explored. The island of Java, however, which is within the last-named region, has furnished an intensely interesting specimen bearing on man's evolution and antiquity. As to America, the researches have thus far yielded nothing that could possibly be accepted as representing man of geological antiquity. For the present, therefore, an account of the very ancient remains of man, with the exception of the Java specimen, must be limited to early European forms.

In 1893 the distinguished French archæologist, Salomon Reinach, deeply impressed with the vigorous development of early civilizations in western

Europe during Neolithic times and throughout the early ages of metal, abandoned the generally accepted theory of an Asiatic origin of these industries as a "mirage oriental" and set forth with scholarly acumen the claims of western and northern Europe as an independent center of cultural dispersal during the Neolithic Age and the succeeding ages of Copper and of Bronze.

Although not unmindful of the weight of fossil and cultural evidence favoring the claims of Europe, the present writer never swerved from his Asiatic beliefs and stoutly maintained that we must nevertheless adhere to the older Asiatic theory as by far the more probable. Thus the problem of the center of human origin, whether Asiatic or European, became one to be settled only by exploration in Asia, no less extensive and no less intensive than that which led to the wonderful discoveries in western Europe between 1823 and 1925.

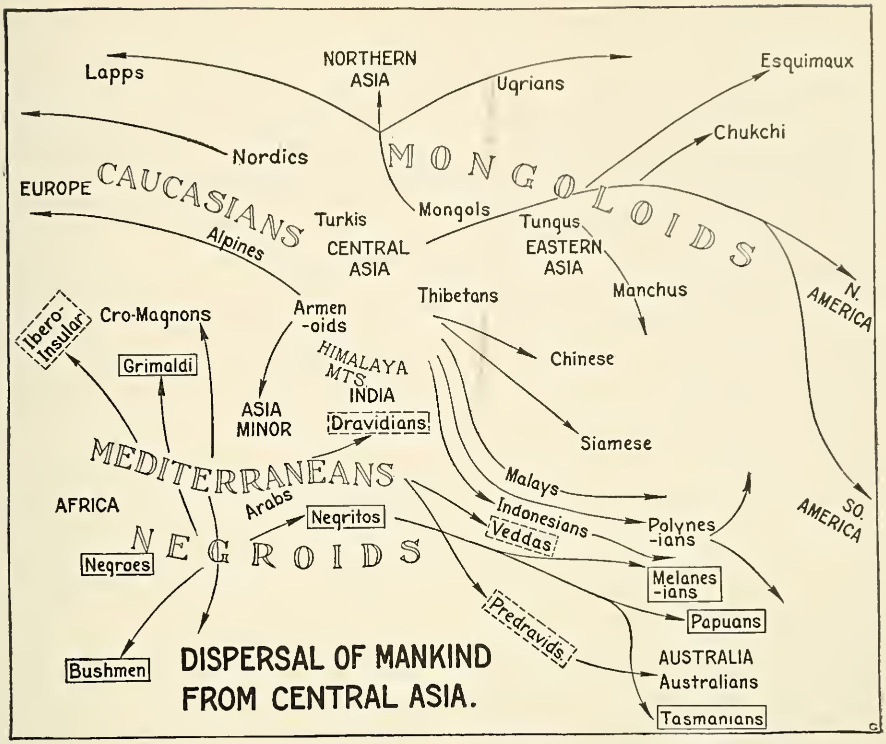
New Evidence for Central Asia

The hunt for fossil man in Asia was the slogan which enabled Roy Chapman Andrews to arouse a nation-wide interest in his great project of Mongolian exploration; no other appeal for financial backing was nearly as strong as this, and it finally enabled him to start his first expedition in the season of 1921. But the Andrews party was not destined immediately to attain its goal of fossil or cultural human remains. During the two entire seasons of 1922 and 1923 the party journeyed for 6000 miles, skirting the western region of the Gobi without finding a single trace of fossil man, although encouraged by the discovery of a new continental life, of a new theater of mammalian evolution, which stimulated renewed and more intensive search for evidences of human occupation in the geologic past.

It was at the dramatic moment of the close of the season of 1923 when the discovery of the dinosaur eggs gave our expedition a world-wide fame, that the writer joined Andrews' party in the east central Gobi and began to visualize the life environment of Tertiary time as ideal for the early development of the dawn men or the direct ancestors of the human race.

This high plateau country of central Asia was partly open, partly forested, partly well-watered, partly arid and semi-desert. Game was plentiful and plant food scarce. The struggle for existence was severe and evoked all the inventive and resourceful faculties of man and encouraged him to the fashioning and use first of wooden and then of stone weapons for the chase. It compelled the Dawn Men—as we now prefer to call our ancestors of the Dawn Stone Age—to develop strength of limb to make long journeys on foot, strength of lungs for running, and quick vision and stealth for the chase. Their life in the open, exposed to the rigors of a severe climate, prompted the crude beginnings of architecture in their man-made shelters, and the early use of fire for bodily warmth and for the preparation of food.

This conception of the early development of man in a high plateau country accords with all principles of human evolution, and is well-established by observations in the Holocene or recent period of the Age of Man. In support of this view we may note: *First*: That the evolution of man is arrested or retrogressive in every region where the natural food supply is abundant and accessible without effort; in tropical and semi-tropical regions where natural food fruits abound, human effort—



Since remains approximately half a million years old, identified as those of man, have been found in England, in Germany, and in Java, it is apparent that early man was a great traveler. Did an ancestral race live in central Asia? Mongolia and Tibet are a favorable upland region for the beginning of man who is usually held to have originated in one place and branched widely. Figure by W. K. Gregory, 1924

individual and racial—immediately ceases. *Second*: That all precocious intelligence and early civilization in mankind were fostered in open regions where the food supply is scarce and impossible to obtain without individual effort and resourcefulness. The corollary of these two principles is the *third*: That during Tertiary times all the lowlands of Asia were relatively well forested and well watered, with a relatively accessible food supply—conditions altogether favorable not to man but to the continued development of the great anthropoid apes, as well as to the retention of arboreal or semi-arboreal habits of life. In brief, while the anthropoid apes were luxuriating in the forested lowlands of Asia and Europe, the Dawn Men were evolving in the invigorating atmosphere of the relatively dry uplands.

Mongolia

This line of thought led to the writer's extemporaneous address delivered October 8, 1923, before the association of the Wen Yu Hui or 'Friends of Literature' on returning from the Mongolian plateau to Peking. This address, entitled "Why Mongolia May Be the Home of Primitive Man," expressed as logical the hope that fossil remains of the very earliest human beings may be found on the great Central Asiatic Plateau and perhaps in

Mongolia itself. It continued with the following argument:

Before and after cave times men lived mainly in the open, along the river-bottoms, or river-drift, or on the uplands or plateaus. Such a mode of life is conducive to the development of the finest physical and moral qualities of the race, for in the open, in intertribal competition, in resistance to and conquest of a natural environment, and in the opportunity for free migration lies the stimulus that carries man up the ladder of advancement. Life in the open preceded by 400,000 years the period of life in the caves, and when a race which has developed under the stimulating influence of an open, broad and varied environment is temporarily forced by the exigencies of the climate to seek shelter in the caves, its latent energy turns to new endeavors, its evolution follows a new direction. Such men are benefited spiritually and intellectually by a life in caves, for such a life of relative isolation turns them to reflection and to contemplation. Thus the period of cold and rigorous climate in Asia and Europe was one of vast importance in the spiritual and mental development of the race, just as the period of life in the open was one conducive to its physical and moral development.

* * * * * *

Thus the three fossil races, the Trinil, the Piltdown, and the Heidelberg, must themselves be distant descendants of an earlier ancestral race. Where did this race live and have its origin? This brings us to the question involved in the title of this address as announced, "Why Mongolia May Be the Home of Primitive Man." We observe that early man was not a forest-living animal, for in forested lands evolution of man is exceedingly slow, in fact there is retrogression, as plentifully evidenced in forest-living races of today. Those South American Indians who live in the forests are backward in development as compared with those living in the open. Of the latter, those living in uplands are more advanced than those living in the river-drifts.

Mongolia was probably not a densely forested country—this is indicated by the animal remains found there in the earlier deposits. An alert race cannot develop in a forest—a forested country can never be a center of radiation for man. Nor can the higher type of man develop in a lowland river-bottom country with plentiful food and luxuriant vegetation. It is upon the plateaus and relatively level uplands that life is most exacting and response to stimulus most beneficial. Mongolia always has been an upland country, through the Age of Mammals and before. It was probably a region forested only in part, mainly open, with exhilarating climate and with conditions sufficiently difficult to require healthy exertion in obtaining food supply. * * * * *

In the uplands of Mongolia conditions of life were apparently ideal for the development of early man, and since all the evidence points to Asia as the place of origin of man, and to Mongolia and Tibet, the top of the world, as the most favorable geographic center in Asia for such an event, we may have hopes of finding the remote ancestors of man in this section of the country. However, this Mongolian idea must be treated only as an opinion, it is not yet a theory, but the opinion is sufficiently sound to warrant further extended investigation.

The first evidence in support of the writer's belief that man inhabited the high plateaus of Asia at a very early stage of his development was afforded by the great discovery of Père Teilhard de Chardin and Père Licent, who found deposits of Mousterian artifacts associated with the fossilized bones of animals at three different sites in the province of Ordos, northern China, in 1923. A full account of this by Père Teilhard de Chardin himself will be found in this issue of NATURAL HISTORY.

ANDREWS STRENGTHENS THE CENTRAL ASIA THEORY

Reinforced by a highly trained and experienced archæologist, Mr. Nels C. Nelson of the American Museum staff, the expedition of 1925 started out more determined than ever to secure either negative or positive evidence bearing on the Central Asiatic theory of human dispersal. The brilliant positive results are already known to readers of NATURAL HISTORY and to the world at large through cablegrams and later reports from the leader of the expedition. The first cablegram dispatched by Mrs. Andrews announcing the discovery of the existence of fossil man in Mongolia in the closing phase of the Old Stone Age reads as follows:

11:48 P.M, PEKING, June 1, 1925.
MUSEOLOGY, New York.

Roy wires Berkey continues well. Great success. Immediately discovered more dinosaur eggs and Late Palæolithic culture corresponding European Azilian. Thousands flint artifacts. Work just begun.

ANDREWS.

This discovery is described by Mr. Nelson in his article in this issue entitled "Dune Dwellers of the Gobi." Subsequent discoveries included artifacts of Mousterian type, thus affording evidence of man's existence in the much earlier Mousterian industrial period which, in Europe, coincides with the dominance of the Neanderthal race. Indications of still earlier stone industries are found, which may belong to Acheulean times; and also possible indications of the Dawn Stone or Eolithic Age. The latest evidence in favor of Asia as the home of primitive man is supplied by Turville-Petre's surprising discovery (August, 1925) of a skull of Neanderthal type in Palestine—known as the 'Galilee' skull.

Considering these discoveries—all made in the brief period of three years (1923–25), and all pointing to the 'Mother of Continents' as the homeland of the human race—we are still compelled to urge caution against any hasty conclusions, and a renewed search for the still undiscovered Dawn Man of Tertiary times.

THE DAWN MAN

The descriptive term 'Dawn Man' is adapted from Smith Woodward's designation of the Piltdown race of Sussex, England, as belonging to a genus, *anthropos,* distinct from the *Homo* of Linnæus. The term *Eoanthropus,* derived from the Greek *eos,* signifying dawn, and *anthropos,* man, is, to our mind, more in accord with modern discovery, which gives the human race a line of ancestors of its own, quite distinct from that of the anthropoid apes. Man and all his ancestors should now be embraced within the family *Hominidæ,* as distinguished from the family *Simiidæ,* which embraces all the anthropoid apes. This family distinction naturally carries with it the appellation 'Dawn Man,' as distinguished from the appellation 'ape man,' which will gradually disappear through disuse along with other misleading terms due to our misconceptions and ignorance as to the actual ancestors of man.

In this connection it is interesting to recall that the term 'ape' was first applied to lowly members of the order of *Primates* known to Aristotle and that it is the equivalent of the Greek word *Simia,* which signifies 'snub-nosed'; also to recall that 'ape' and 'simia' have been used from the time of the Greeks and Latins in terms of contempt. Consequently, it is doubly important to substitute the terms 'Dawn Man' and 'Dawn Men' for the terms 'ape man' and 'ape men'; first, because the latter terms can no longer be used truthfully and, second, because these terms bear with them more or less the idea of inferiority—inferiority which in our opinion is not deserved by the Dawn Man.

We prophesy that the Dawn Man will be found in the high Asiatic plateau region and not in the forested lowlands of Asia, but many decades may ensue before this prophecy is either verified or disproved.

A Dissenting Opinion as to Dawn Men and Ape Men

By WILLIAM K. GREGORY[1] AND J. HOWARD McGREGOR[2]

Editorial Note.—To his honor it may be said that Professor Osborn has always welcomed and acknowledged honest criticism of his conclusions by his scientific associates. We therefore print the following note, commenting on Professor Osborn's views as to the distinction of the human and anthropoid families of Primates.

We quite agree with Professor Osborn that even the earliest known races of mankind (*Pithecanthropus*, Piltdown, etc.) were already true Hominidæ and therefore, in spite of certain ape-like features, they hardly deserved the name of "ape men." It is generally recognized that each of the modern anthropoid apes is specialized in certain peculiarities that definitely rule it out of the line of human ancestry. The known facts of palæontology also prove that these two families must have begun to diverge from each other at some period before the Lower Pleistocene, and we agree with Professor Osborn that the human family probably did have a line of ancestry of its own which stretched backward far into Tertiary times. It would also be convenient to call these Tertiary men "Dawn Men" if it be understood that *Eoanthropus* (Piltdown), the one that was originally so named, was one of the latest of the series.

But from Professor Osborn's recent papers the general reader may very well mistakenly gain the impression that it is Professor Osborn's deliberate intention to disclaim for the human race all kinship whatever with the anthropoid apes and to assign man and all his ancestors to a superior line of beings which throughout the whole of geological time preceding the late Pliocene had kept itself aloof from other vertebrates.

In earlier years Professor Osborn in a brilliant series of palæontological papers followed the lines of evolution of the dentition in many mammals. Turning to the fossil primates of the Eocene, he traced step by step the transformation of the upper molar teeth from a tritubercular to a quadritubercular type, and in other papers on the evolution of the human molar teeth he developed Cope's view that the quadritubercular human upper molar had been derived from the tritubercular type of primitive Primates. Developing further the methods and principles of Cope and Osborn, one of the present writers in various publications has shown how gradual is the transition, among the molar types of the numerous known fossil Primates, from the tritubercular upper molars of Eocene Primates to the quadritubercular upper molars of anthropoids and men.

These researches have also revealed with startling clearness the close resemblance in the pattern of the lower molar teeth between certain fossil anthropoid apes and the Dawn Man of Piltdown, as shown elsewhere in this number of Natural History. In his admirable work *Men of the Old Stone Age* (1915, p. 51) Professor Osborn

[1]Professor of Vertebrate Palæontology, Columbia University; Curator, Department of Human and Comparative Anatomy, American Museum.
[2]Professor of Zoölogy, Columbia University; Research Associate in Human Anatomy, American Museum

says: "Among these fossil anthropoids, as well as among the four living forms, we discover no evidence of direct relationship to man but very strong evidence of descent from the same ancestral stock. These proofs of common ancestry, which have already been observed in the existing races of man, become far more conspicuous in the ancient Palæolithic races; in fact, we cannot interpret the anatomy of the men of the Old Stone Age without a survey of the principal characters of the existing anthropoid apes, the gibbon, the orang, the chimpanzee and the gorilla." With these conclusions the great majority of Professor Osborn's scientific colleagues remain, after the most intensive investigations, in hearty accord.

When Professor Osborn speaks of Central Asia as the homeland of the Dawn Men he obviously refers to the source of the later stages of human evolution, when according to his theory even the Dawn Men were already definitely men. But just as in the classical story the great king was reminded daily "*hominem memento te,*" so even *Homo sapiens europæus* is not lacking in reminders of his lowly origin. He may well wear the cruciform pattern on his second lower molar, but his first molar still bears the mark of the *Dryopithecus*.[1] If the family of mankind has *always* been superior to the family of the anthropoids, why do modern anthropoids and men, in spite of their widely diverse specializations still resemble each other so profoundly and in so many directions that even the "man in the street" recognizes the almost human qualities of his despised relatives? And why does the human foetus at a certain stage show such an unmistakable resemblance to the foetus of the gorilla and the chimpanzee in the hands and feet, eyes, ears, nose, lips, teeth, skull, skeleton, and brain?

[1]See page 300

In another part of this journal Dr. G. Elliot Smith, professor of anatomy at the University of London, states in substance that, so far as our present knowledge extends, there is no structure in the human brain which has not also been found in the brain of the anthropoid, and that the human brain surpassses the ape brain only in the quantitative development of certain parts. But if all the ancestors of man have always been superior to the apes, why are the brains of ape and man built upon a common plan and why are several stages in the apparent transformation of the lower into the higher type already known?

After many years of intensive investigation of the subject from various angles, the present writers can state as a fact that by every criterion used to estimate zoölogical relationships, including the data of anatomy, embryology, physiology and pathology, the chimpanzee and the gorilla stand closer to man than to any tailed monkey.

Fig. 1. The leaning statue "Watoe Langko" stands on a long low ridge near the village of Lamba, at the base of high mountains which surround the plain of Napoe. Note the hooks sculptured on its breast

The Stone Images and Vats of Central Celebes[1]

By H. C. RAVEN
Associate Curator, Comparative and Human Anatomy

IN 1917 while passing through the village of Bamba in the district of Bada, Central Celebes, I chanced to see an interesting stone image standing among the bananas close to a native house. I photographed it and inquired of the natives concerning it. They informed me that it was an image of a woman named "Langke Boelawa" (Golden Anklet) who had turned to stone, and that the image until a few years before, when they brought it to its present position, had stood near the foot of the mountain on the northern side of the near-by Tawelia River.

Naturally I tried to find out by whom the image was made and if there were more like it about. My informants told me nothing of importance concerning its origin, but they did tell me that I would be able to see images and other objects of stone in the districts of Besoa and Napoe, both of which I was on my way to visit.

I spent several weeks in Besoa and later in Napoe, studying and photographing all the stone objects in the vicinity. It was easy to reach the sites when guided by natives, but a visitor passing through the districts would certainly never have seen any of them, as they are located some distance from villages and from the main trails. In Besoa I saw an image somewhat similar to the one in Bada and a number of great vats, each hewn from a single

[1]The field notes and pictures for this article were made while the author was collecting natural-history material in the East Indies for the Smithsonian Institution, Washington.

Fig. 2. "Langke Boelawa," meaning Golden Anklet, is the name given by the natives of the Bada district to the legless granite image in the village of Bamba

piece of granite, some having ornamented covers, and a floor made of smooth flat pieces of stone. In Napoe were two stone images and one hollowed-out rock very unlike the vats of Besoa and crude in comparison, though its purpose may have been similar. The only other stone objects I saw in Central Celebes were mortars undoubtedly used in the pounding of grain, as the present inhabitants use wooden mortars. These stone mortars, each consisting of two hemispherical hollows six or eight inches in diameter and a foot or more apart in the rock, the upper surface of which was levelled and smooth, were at Lemo in the Koelawi district. Another was located near the Lake of Lindoe.

From the village Doda in Besoa an old man guided me to Boeleli to show me the stone image there. Boeleli is a low hill covered with long coarse grass and is close to the foot of the high mountain Toewo. Upon reaching the image my companion rode his horse close beside it and leaning over, wiped his hand first across the brow of the image and then across his own. He explained that he did this "to get strength from Tadoe Lakoe," as the image was called by the natives. "Tadoe Lakoe," it is said, was an ancient local war leader, and the natives believe the image to be the chieftain himself and not merely a representation of him. The statue (Fig. 13) stands about seven feet high, is about thirty inches wide, and is made from a single block of granite. The accompanying photographs, showing both front and side views, make detailed description unnecessary but it may be well to call attention to some of the characters which are not so clear, owing to the low relief in which they were executed: (1) the ears are represented by bumps high up on the sides of the head, their lower borders being about the level of the eyebrows; (2) the shoulders, arms, and hands are in low relief, the fingers pressed to the lower abdominal region; (3) the male generative organ in higher relief is upright and to be seen clearly in the profile; (4) the limit of the forehead is marked, evidence that headgear of some sort is represented. The stone of the top of the head, however, appears to be more or less weathered and this may account for part of the asymmetry.

The image in Besoa, "Tadoe Lakoe," on the evidence of the phallus alone represents a man. The image in Bada known as "Langke Boelawa" was said to represent a woman but there is no positive evidence for such a statement. The images in Bada and Besoa resemble each other closely in the matter of the breasts, ears, headdress, and position of the hands, and perhaps in the phallus. The Napoe images (Figs. 1, 11) differ from those of Bada and Besoa in the apparent lack of headgear and the lack of arms and hands. A mouth is not shown in the figures of Bada and Besoa, but my photographs of the Napoe specimens appear to show in each case what may be a slight groove below the nose, suggesting a mouth. The placing of the ears in the Napoe specimens is lower on the sides of the head, thus more normal than in the figures of Bada and Besoa.

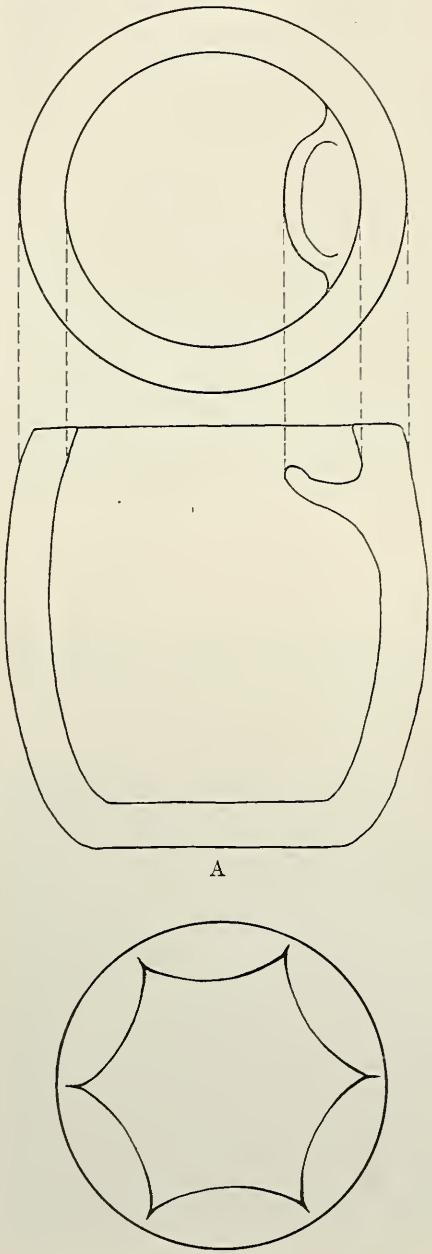
The first stone vats I found in Besoa were near the image "Tadoe Lakoe" where there were four or five together. The most interesting one (Fig. 17) was cracked and had more or less recently been turned on its side. It was of average size, about five feet in diameter by six in height, but its peculiar feature was a concave shelf about eight or ten inches wide inside the vat a few inches from the upper rim, as shown in the accompanying photograph and diagram (Figs. 5 and 17). Except for this shelf the inside of the vat was perfectly smooth and well worked, the outside somewhat weathered and less smooth on that account. The bottom of the vat outside was flat, with the edge bevelled off hexagonally. The vats in nearly every case were encircled by consecutive raised rings, (Fig. 15) and it is possible that in the few cases where these were lacking they had been weathered off, as all were in low relief.

Across the plain nearly five miles from Boeleli were nineteen more stone vats of various sizes, the largest one (Fig. 16) standing about seven feet above the ground and measuring more than that in diameter. I dug under

Fig. 3. Stone vats in Besoa. The outer edges of the rim are rounded, the sides slightly bulging. Note size in comparison with horse and natives

Fig. 4. Elliptical vat at Napoe. Unlike the circular vats of Besoa this one is long, not deeply hollowed-out, and comparatively crude. The natives have referred to it as the "bath place" of a prince

the lower edge of this and made certain that it too was bevelled hexagonally below. On this vat, the only



A

B

Fig. 5.—(A) Diagram of the stone vat pictured in Fig. 17, to show the concave shelf on the inside, a few inches below the rim. (B) Diagram of the bottom of a vat, to illustrate how the edge was bevelled hexagonally

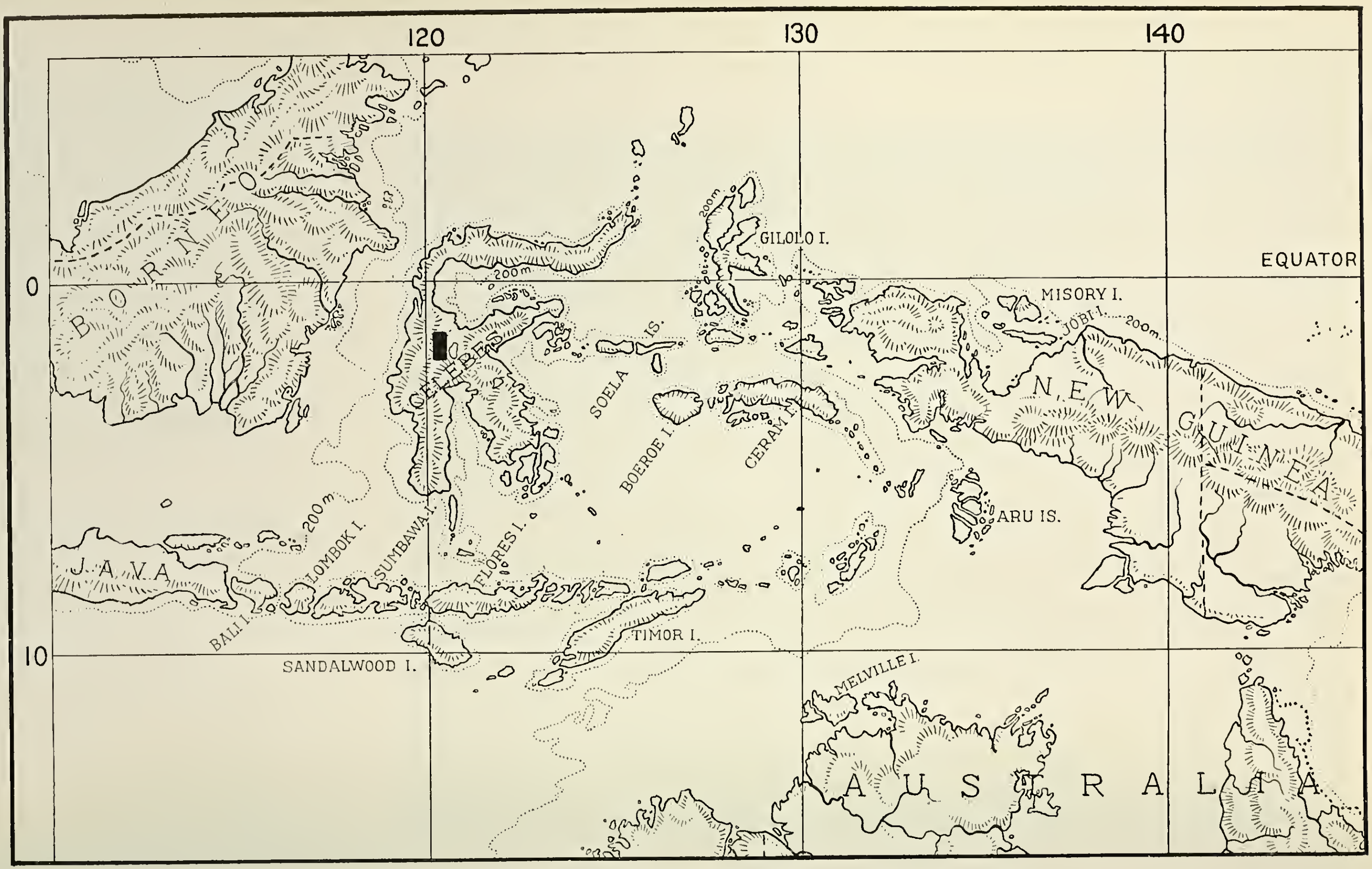
one having any ornamentation other than the raised rings, was a series of faces resembling those of the statues and executed in relief around the upper third of the vat. Each of the faces was separated from its neighbor by a shallow vertical groove and the series bounded below by another groove encircling the whole vat, clearly seen in the photograph. All the vats that still remained upright were filled with mud and water in which there was a dense growth of sedge. I emptied some of these but found only mud and soft earth except in one in which there were in addition wood ashes and fragments of a clay pot. The simplest cover, made for one of the small vats, was smooth and flat below, evenly convex above but somewhat weathered, with a thin edge all around. Near-by was a squat, barrel-like vat much less in diameter at the top than through the middle, which if fitted with this convex cover would have appeared nearly spherical or at least domelike in side view. The three remaining covers were of about the same size, huge stone discs more than six feet in diameter and seven or eight inches in thickness, bevelled so that the diameter above was slightly more than that below. The simplest of these was decorated in the center with a nicely hewn knob more than a foot in diameter and six inches high. Another cover was carved with images of three large monkeys and one small monkey hewn in a row across the middle (Fig. 12). The most elaborate cover was also decorated with images of these black monkeys peculiar to Celebes. The figures were well modeled, arranged symmetrically around the periphery, and in the center was a raised circular boss, flattened on top (Figs. 14 and 15).

Fig. 6. Stone vat near the image "Tadoe Lakoe," Besoa (Fig. 13).—This vat was filled with mud and water in which sedge was growing. Note characteristic granite weathering, partially effacing the horizontal rings

In the nine years since I left Celebes I have occasionally inquired among my friends and colleagues regarding these stone objects. All supposed them to be well known but none could tell by whom they were made, when, or for what purpose. Recently I have searched through much of the literature on the archæology of the Oriental-Indo-Malay-Pacific region in an effort to find out, if possible, to what culture they belong. I am now able to compare them with somewhat similar stone objects in various other localities.

The literature reveals the fact that some of the stone objects shown here were briefly described in 1908 by Mr. J. Th. E. Kiliaan,[1] an official of the Netherlands East Indian Government.

[1] Kiliaan, 1908. "Oudheden Aangetroffen in het Landschap Besoa (Midden-Celebes)," Tijdschrift voor Indische Taal-Land en Volkenkunde, Vol. L, pp. 407–410.



SKETCH MAP OF CELEBES AND ADJACENT EAST INDIAN ISLANDS

(Indonesia, in part)

Fig. 7. The black rectangle on Central Celebes covers an area of approximately 1,000 square miles, including the mountainous districts of Bada, Besoa, and Napoe, where the stone objects herein described are located

Later the same year another brief notice was published by the Reverend Dr. Albert C. Kruyt,[1] who better understood the inhabitants of the country and on that account was able to learn more from them and to correct certain statements made by the original discoverer of the stones as well as to add new facts. Doctor Kruyt also reports three fallen images from Besoa in the vicinity of the vats with the covers described above, and in addition, a mortar at Sigi in the Paloe valley. In a more recent publication he mentions another image at Gintoe in the district of Bada. This image, however, is buried up to its neck in the earth.

The only general work, so far as I know, that treats of East Indian archæology earlier than the Islamic, Buddist and Hindoo cultures, is that of W. J. Perry, 1918, on *The Megalithic Culture of Indonesia*. In this book the attempt is made to show that the stone objects of Central Celebes are part of an early culture that was spread from Burma to Nias, Borneo, Celebes, Sumbawa, Flores, Sumba, Timor, Aru, "Seran" (=Ceram), and adjacent small islands as well as Formosa, by "stone-using immigrants" who imposed this culture upon the indigenous peoples of "Indonesia"; also that these stone-using immigrants, who were in search of gold and other wealth, introduced many other customs, among them terraced irrigation, metal-working and rice-growing. He states further: "Finally, it must be remembered that the existence of megalithic monuments, terraced irrigation, mining sites, the sun-cult, 'children of the sun,' and other elements of the culture introduced by stone-using immigrants has been recorded in all inhabited regions of the earth." Notwithstanding this implication of relationship, the vats and images of Celebes contrast so strikingly in shape and other characters with stone objects in other parts of the Indo-Malayan region that I cannot believe that they belong to the same culture.

Mr. Perry remarks[2] that stone seats occur at Napoe and Besoa and Doctor Kruyt describes as stone seats what I have termed shelves in the inside of the vats. The one at Besoa is shown here both by photograph and diagram (Figs. 5A and 17) and though it may be said to resemble a seat it is, I believe, too small, and is placed where it could not be used as such. Thus if we consider these as shelves there are no known stone seats in Central Celebes to be compared with the stone seats of other places, such as those of Nias, figured by Modigliani,[3] which closely resemble large modern arm chairs.

Just beside the image at Boeleli are two or three small stones to which Kiliaan gave mention as the children of the woman who had, in the native legend, been turned to stone.[4] On this account apparently Perry refers[5] to this as a *cromlech*, but I am unable to see any resemblance to such a structure. These stones are seen in the photograph (Fig. 13a and b) to be simply pieces of rock, possibly used to brace the image, and they are beside it, not under it.

If we look at stone objects made by Buddhists in India, China, Japan, or the East Indies, we find a remarkable similarity among them. The same is true of objects made or introduced by other peoples whose influence and

[1]Kruyt, 1908. "Nadere gegevens betreffende de Oudhedena Angetroffen in het Landschap Besoa (Midden-Celebes)," Tijdschrift voor Indische Taal-Land en Volkenkunde, Vol. L, pp. 549–551.

[2]Perry, W. J., 1918, p. 36.
[3]*Un Viaggio A Nias*, pp. 311, 313.
[4]Kiliaan, 1908.
[5]Perry, W. J. 1918, p. 52.

migrations can be traced with certainty. It is then to be expected that if the stone culture of an earlier day, the remnants of which are to be seen in Central Celebes, was brought by stone-using immigrants who spread their images and structures so widely through Indonesia, all these images and structures would very closely resemble one another. Such, however, is not the case.

Fig. 8. Marquesan stone image. Resembling those of Celebes more closely than anything which is geographically nearer, yet differing in many features. After Linton

A comparison of these objects with all other stone objects of which I could find figures or descriptions has led me to the conclusion that those of Celebes are not closely related to anything of the kind thus far known from the East Indian region.

There has been found on the island of Nias, west of Sumatra, a small statue (about twenty inches high) with a round face and head as wide as the body, similar to the Celebes images in these particulars but differing in the possession of legs and a mouth, and also in the position of the hands and the shape of the eyes, ears, and other features.[1] Thus it is not very close to the images with which we are here concerned. No stone vats are recorded from Nias.

[1]Modigliani, *Un Viaggio A Nias*, p. 308, fig. 63.

Not finding any resemblance nearer, I turned toward the Pacific. In the Caroline Islands[2] prehistoric stone objects are found in the form of large discs three feet or more in diameter with a hole in the center, but no human images or vats are recorded. In the Marquesas many stone and wooden human images have been found[3] which resemble the Celebean statues in general shape, and in fact are closer than anything seen nearer Celebes. I therefore figure one of these Marquesan images (Fig. 8) so that the reader may make his own comparisons. They differ from the Celebean images in the following points: (1) no eyebrows are represented; (2) the nose is short and wide; (3) the mouth and lips are large; (4) the face is flat or convex, not concave; (5) arms are very distinct; (6) the hands rest on the chest, not on the abdomen; (7) the posterior limbs are always present. It is seen then that although the Marquesan images in general form are like those in Celebes, the differences are also striking.

Finally we come to the huge images of Easter Island. Due to the good descriptions and illustrations of these by Mrs. Routledge[4] a very satisfactory comparison can be made with the images of Celebes. The Easter Island images are several times larger than the Celebean and they differ from them in certain respects but in others they bear a marked degree of resemblance. It will be seen in a comparison of the Besoa figure "Tadoe Lakoe" (Fig. 13a and b) with the Easter Island image (Fig. 9) here reproduced, that they differ in fewer characters than do the other images available for comparison.

[2]Christian, F. W., 1899, *The Caroline Islands*, p. 236.
[3]Linton, Ralph, 1925, "Archæology of the Marquesas Islands," Bishop Mus. *Bull.* 23.
[4]Routledge, Mrs. Scoresby, 1919, *The Mystery of Easter Island.*

It seems very probable that ancient sculptors would model their figures after their own people, therefore the features represented in the examples of their art should bear a resemblance to their makers. Turning with this in mind, to the literature on the physical features of the peoples of Polynesia[1] I find three types are recognized: the first or Polynesian is dolichocephalic, hypsicephalic and leptorrhine; the second or Indonesian, brachycephalic, hypsicephalic, platyrrhine Negrito in type; the third and less easily distinguished type, brachycephalic, hypsicephalic and leptorrhine. This third type with short high heads and slender noses has been termed a Malayan type. Its characters are to be seen in the images of both Celebes and Easter Island, although those of the latter have the large long nose, large chin and heavy brow of the Polynesian. All the points of difference between the Marquesan and Celebean images are here points of resemblance. Another interesting point is afforded by the hooklike markings on the breast of one of the Napoe statues of Celebes (Fig. 1) in comparison with designs for tat-

Fig. 9. One of the great stone figures of Easter Island.—Note the arms and hands in low relief, with the hands on the abdomen as in the Celebean images. After Routledge

[1]Sullivan, Louis R., 1923, "Marquesan Somatology with Comparative Notes on Samoa and Tonga," *Mem. Bishop Mus.*, IX, No. 2, p. 232.

tooing formerly used by the natives of Easter Island (Fig. 10).

No vats or anything resembling them are recorded from the Marquesas, but of Easter Island the following statement is made: "There is a roughly constructed ahu [burial place] on the outside of Rano Raraku at the corner nearest to the sea, of which more will be said hereafter, and a quarried block of rock on the very top of the westerly peak was also said to be used for the exposure of the dead. Close to this block there are some very curious circular pits cut in the rock; one examined was 5 feet 6 inches in depth and 3 feet 6 inches in diameter. It is possible they were used as vaults, but, if so, the shape is quite different from those of the ahu."[1] Thus we see that Easter Island also has its circular vatlike pits near the images.

Fig. 10. Tattoo designs used by Easter Islanders within the memory of the oldest natives. After Routledge.
The hooks on the breast strikingly resemble those on the Celebean image shown in Fig. 1

While considering the points of resemblance between Celebes and Easter Island, it may be mentioned that in looking over a glossary[2] of some fifty words, several are the same as words used by the people of Central Celebes, as Rano for lake, Manu for bird, Atua for God, Ika for fish, etc.; and there are others that look as if they might sound like Celebean words if due allowance were made for differences of spelling.

My conclusion is that the similarities in physical features must be largely discounted, due to the great mingling of peoples throughout the whole region. The positive evidence, such as the lack of legs, the placing of the hands, the hooks on the breast (compared with tattoo patterns), the association of circular vats and images, and similarities at the present time in the languages of the two places, may prove to be indicative of rather close cultural relationship. Much further archæological exploration of the whole region, however, is necessary before the questions raised by the stone objects of Celebes can be fully answered.

[1]Routledge, 1919, *The Mystery of Easter Island*, p. 191.
[2]Routledge, p. 123.

THE STONE MAN AT NAPOE

Fig. 11. An image stands among ferns in second-growth jungle not far from the village of Watoe Taoe (= Stone Man) in the Napoe district now inhabited by a happy peaceful Toradja people, who but a comparatively few years ago were warlike head-hunters. Is this image evidence of the artistic skill of their ancestors or of another race?

Fig. 12. Partly buried under earth and coarse grass was the granite cover for a huge vat and across this cover were carved three large monkeys and one small one

Fig. 13. Front and side views of the image at Boeleli Besoa, known to the inhabitants as "Tadoe Lakoe"

Fig. 14. A great vat in Besoa filled with mud and water on which sedge is growing. The cover is to be seen just as it was shoved off

Fig. 15. The same vat as shown above, from another angle affording a better view of the cover and the arrangement of monkey figures on it

Fig. 16. The largest of the Besoa vats, about seven feet high and nearly ten in diameter, is the only one ornamented with faces

Fig. 17. One of the most interesting vats was cracked, of medium size, and provided with a shelf inside; like the others it was hewn from a single block of granite

Man and His Creations

SOME EARLY RESTORATIONS OF ANIMALS OF THE PAST

By FREDERIC A. LUCAS
Honorory Director, American Museum

WHEN Barnum's Museum was one of the institutions of New York, Barnum is credited with having said that "the public likes to be humbugged." Were Barnum on the staff of a modern museum he might say after reading some of the letters of inquiry that man prefers the improbable to the probable and is loath to accept a simple explanation of some fact, or object, if a more extraordinary one seems to fit the case.[1] And this seems to be particularly true when fossils, or things that look like fossils, are concerned.

Now mankind is gifted, or afflicted, with what in the *Elephant's Child* was called "satiable curtiosity" but which he terms thirst for knowledge. So when man began to find fossils he set about for a reason for their existence and sought for some explanation of what they were.

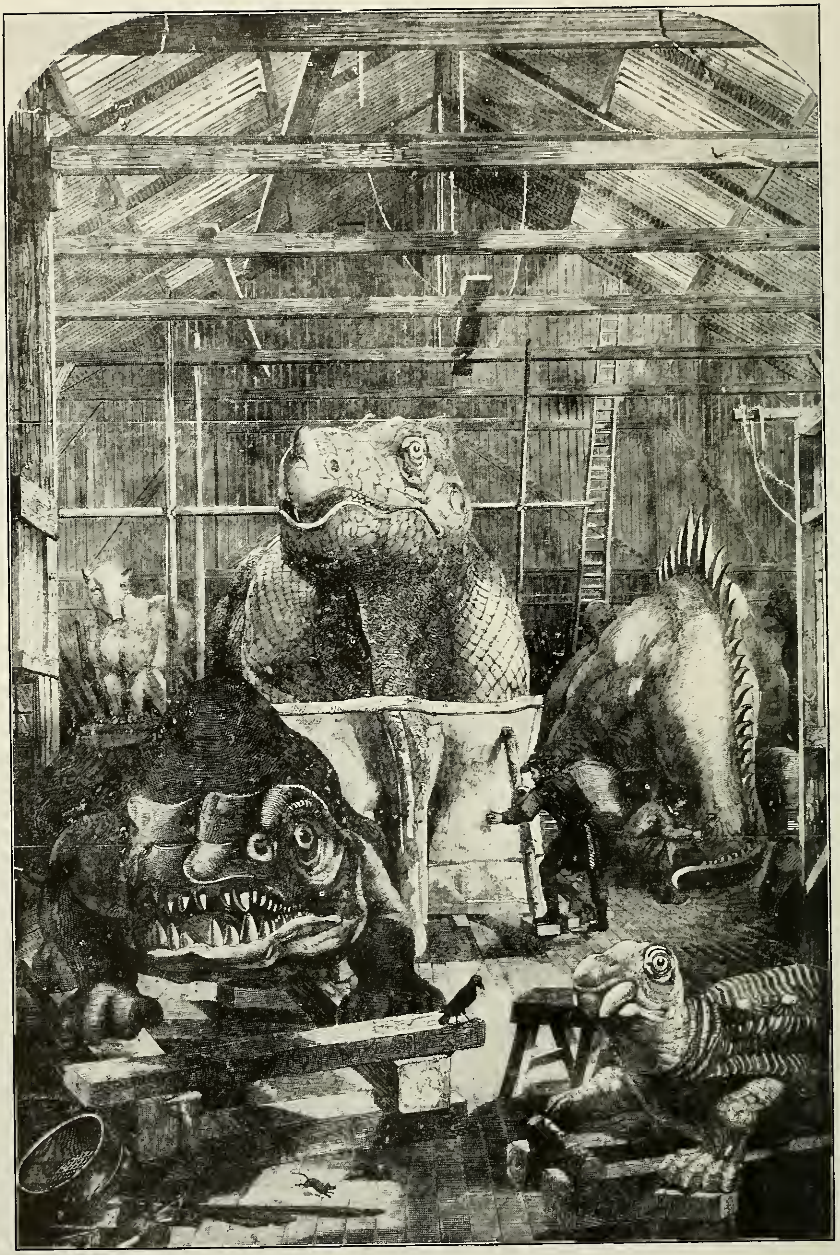
With fossil invertebrates the problem was simple: they were evidences of the flood, when the water covered the face of the earth; that the shell fish increased with astounding rapidity and distributed themselves amazingly in the space of a few months seems not to have troubled these theorists.

Vertebrates, however, allowed more play of the imagination and, after passing through the stages of considering them as "freaks of nature" and later having decided that they were neither jettison from the Ark nor the remains of Hannibal's Elephants, men went to the other extreme of considering that they were animals quite unlike anything living. In many instances they were of course quite right, but having few facts to interfere with their theories, some of the earlier attempts at reconstruction could have been worshipped without violating any commandment, since they resembled nothing in the heavens above, the earth beneath, nor the waters under the earth. One of the most popular ideas concerning them was that they were the remains of giants, not so surprising when based on the leg bones of Mammoth or Mastodon which, to the uninitiated, have a decidedly human look. And mankind dislikes to give up the idea that there were "giants in those days."[1]

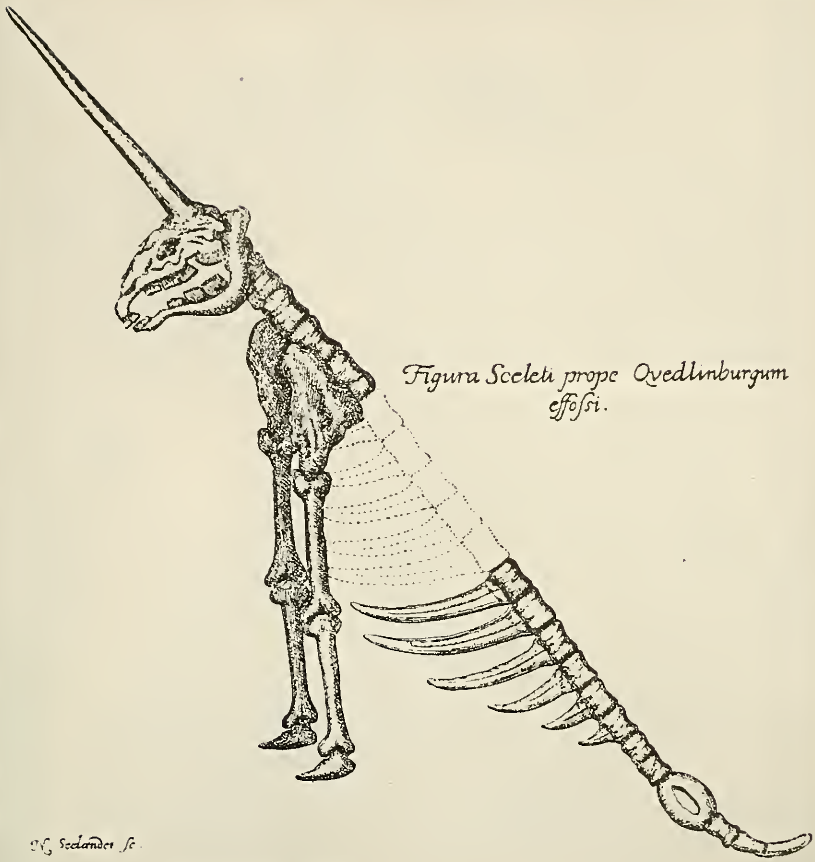
So we have Teutobochus, King of the Cimbri, 19 feet high and the Scotch "Littell John" with a height of 14 feet and other notables. And in America so late as the beginning of the eighteenth century we have the "giant" described at some length in the article on Jefferson, apparently the same specimen noted by the Rev. Cotton Mather and credited with a height of 40 feet. There were no restorations of these early giants probably because they were regarded as having the likeness of men and, so far as we know, the first restoration of an extinct vertebrate was made in 1749 by G. W. Leibnitz in a publication whose Latin

[1]A glowing, or glaring, instance of this occurred to the writer many years ago when he identified an object sent from Kentucky as the breastbone of a horse. The owner was not pleased with this identification, and wrote a most abusive letter in which, among other things, he remarked that it was evidently "an aquatical sea monster" that came up the Ohio and was killed by reaching fresh water.

[1]Does not a recent writer of popular articles on primitive man credit the Cro-Magnons with attaining a height of ten feet!



WATERHOUSE HAWKINS' WORKSHOP, IN WHICH WERE MADE THE MODELS FOR THE RESTORATIONS AT THE CRYSTAL PALACE
From the *Illustrated London News* about 1852



The earliest known restoration of an extinct animal from a work published in Latin by G. W. Leibnitz in 1749. Rendered into English the title reads "Concerning the Primitive World, the Early Aspect of the Earth, and the Original Monuments of its most Ancient History"

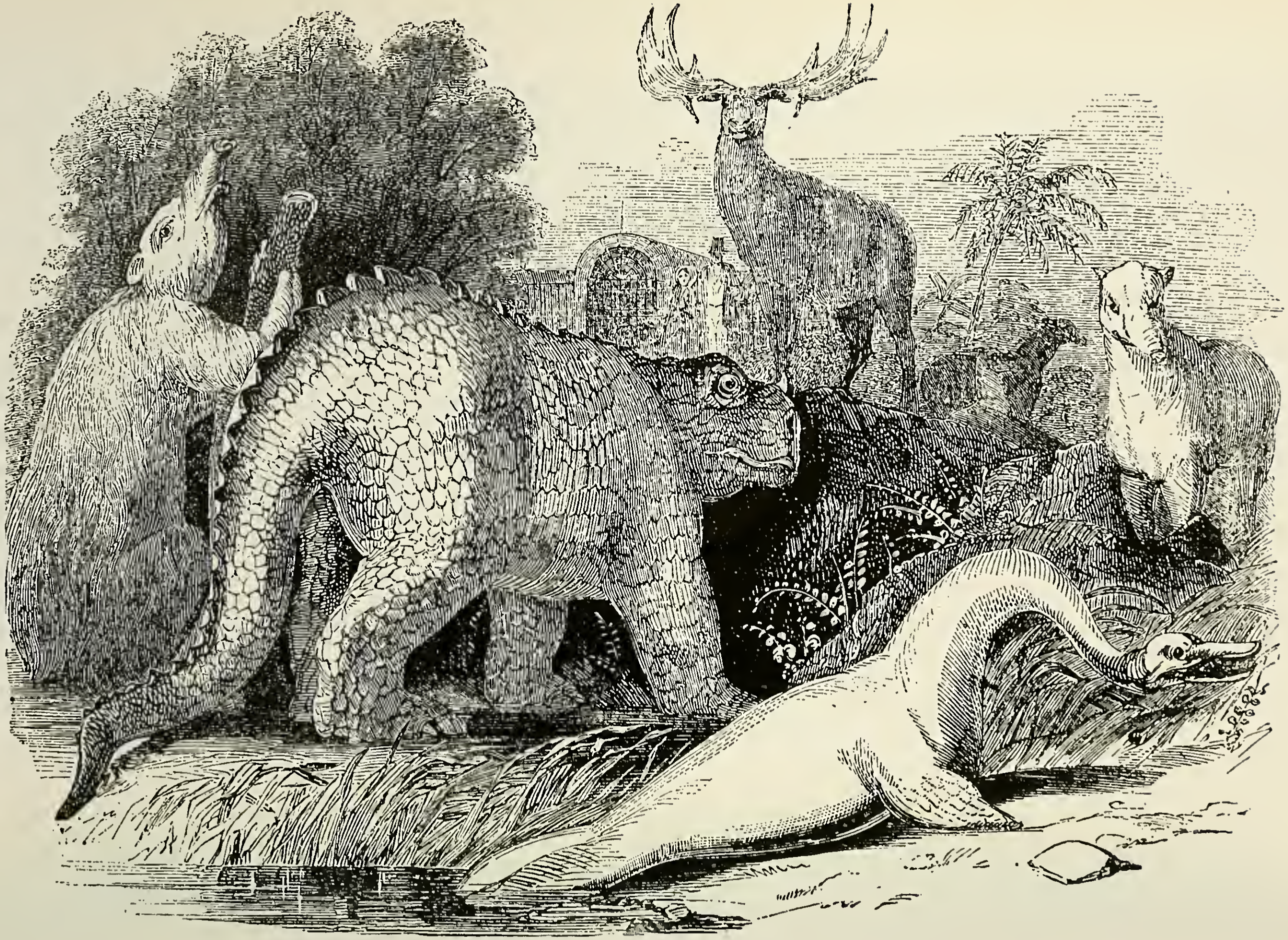
title when translated reads:

Concerning the Primitive World, the Early Aspect of the Earth and the Original Monuments of its most Ancient History.

This appears to have been based on the skeleton of some ruminant, as indicated by the jaws and the curious tail, which is apparently a series of dorsal vertebræ upside down: the long horn was probably thrown in to improve the looks of the restoration.

We may smile at the curious assemblage of bones, but it was scarcely more amusing than the skeleton of the whale shown for many years in the Niagara Falls Museum in which the vertebræ were jumbled together, and often turned hind side before. It is, perhaps, hardly fair to call the Rectangoremus a "restoration" since it was doubtless constructed to deceive, yet many who beheld it may have looked upon it as "the real thing."

Even as late as 1860 Waterhouse Hawkins constructed his restorations



GROUP OF EXTINCT MONSTERS
Restorations designed by B. Waterhouse Hawkins for the Crystal Palace, Sydenham, England.
Reproduced from *The Leisure Hour*, April 20, 1854, London

at the Crystal Palace much on the same principle and, when Owen, master anatomist of his day, told Hawkins that he had put two toes too many on *Iguanodon* (a three-toed dinosaur), Hawkins replied that if they were corns he would gladly remove them but as they were toes they must remain, and there they are.

Hawkins came very near inflicting his restorations on New York in the then new Central Park and when Judge Hinton had the molds destroyed a storm of protest arose. Fortunately Judge Hinton destroyed (not builded) better than he knew.

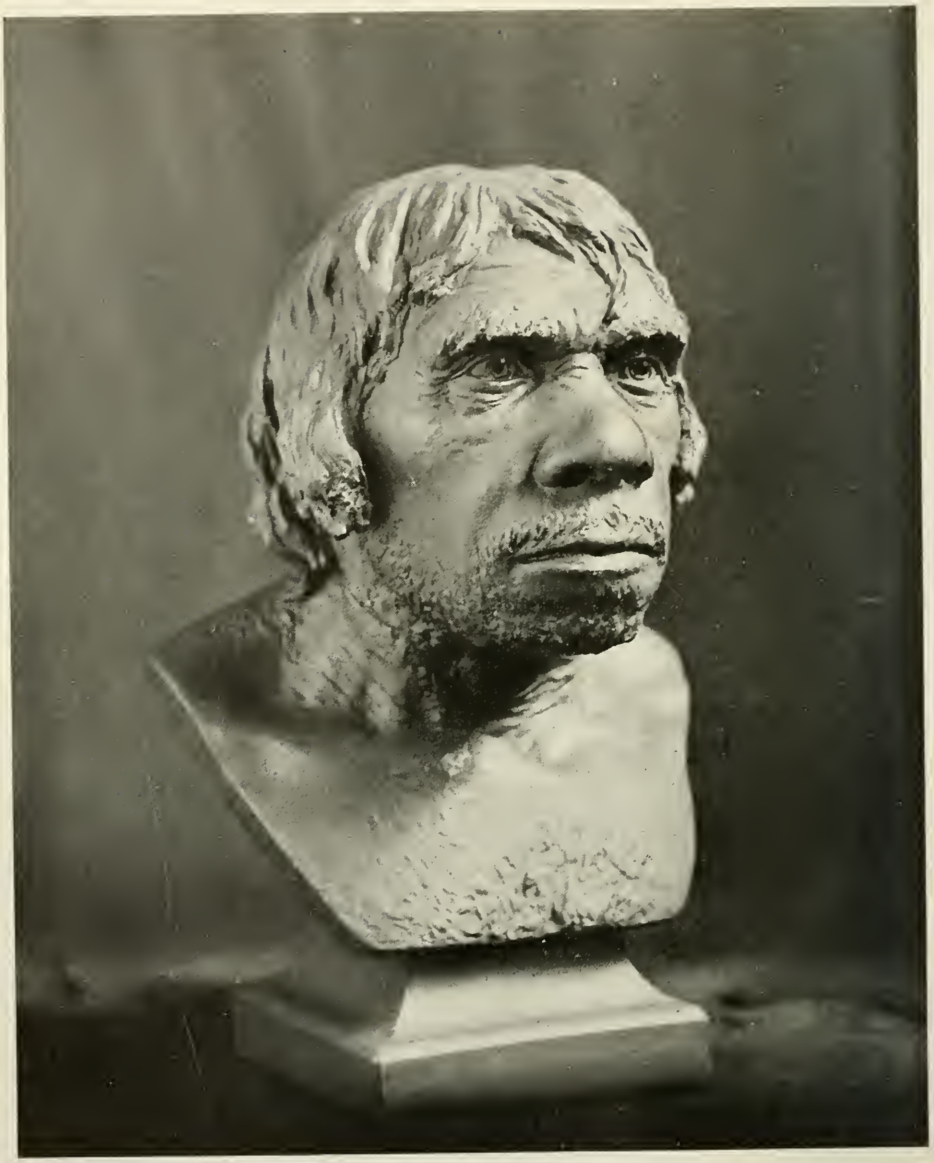
Now Hawkins *did* have some facts to guide him, but some of the names applied to these extinct creatures seem to have stimulated his imagination; thus *Iguanodon* naturally implied iguana and so the first restoration of our duck-billed dinosaur—*Trachodon*, a relative of *Iguanodon*—depicted him with the skull of an iguana magnified many times.

The long, slender ischia—part of the hip bones—were a puzzle—a puzzle that was solved by making marsupial bones of them. Similarly one of the names bestowed upon the big salamander-like creatures known as labyrinthodons was *Megalobatrachus*—giant frog—so Hawkins made him a giant frog, a frog the size of an ox, the dimension striven for by the frog in the fable. Here, too, Hawkins had some thing besides the name to stir the imagination, for the flattened, fossil skull of the animal does look very like the cranium of a huge bull frog. The crushed remains of another fossil salamander, about the size of the existing giant salamander of Japan, suggested to an observer with imagination a flattened human skull, and while its relationships had been recognized by its describer, a writer with less knowledge and more imagination saw in it the remains of one of the victims of the flood and dubbed it *Homo diluvii testis*—man, the evidence of the flood. Assuredly our forefathers believed that natural processes moved rapidly in "the days when the earth was young" and considered that but a few years were required to convert mud into many feet of solid rock.

To realize just how credulous men were one has but to glance over the first descriptions of the *Treasures of the British Museum* and to read extracts from the minutes of the meetings of the Royal Society published in recent numbers of *Nature*.

To say that men *were* credulous is, however, altogether too flattering to the present generation which has an undying belief in petrified men and a real love for living frogs in Carboniferous rocks. And if we smile at these early restorations yet the words Cardiff Giant, Ponzi, and Mrs. Howe's Bank, though painful to some, may cause most of us to smile still more broadly.

These curious creations of days gone by were largely due to the fact that their creators had more imagination than information, few facts to interfere with their theories. As time has passed we have become better acquainted with these inhabitants of the ancient world and in many cases have complete skeletons, and in rare instances their very skin has been preserved. The relation of muscles to bones has been carefully studied, and save in the matter of color, little has been left to the imagination in the restorations shown in the American Museum of Natural History.



NEANDERTHAL MAN

The completed Neanderthal head modeled on the restored skull of La Chapelle-aux-Saints. This is the same as the hairless model, Figs. 5 and 7, with the addition of hair and eyebrows, and a slight suggestion of beard, not sufficient to obscure the chin form. A few wrinkles were indicated, and the iris and pupil incised so that their shadows might lend life to the eyes. Restoration by J. H. McGregor, photographed by A. F. Huettner

Restoring Neanderthal Man

By J. H. McGREGOR

Professor of Zoölogy, Columbia University; Research Associate in Human Anatomy, American Museum of Natural History

IN the Hall of the Age of Man, in the American Museum of Natural History, are several busts modeled on skulls of prehistoric races of man. Some are based on nearly complete skulls, others on crania which are more or less fragmentary. On seeing these heads, the visitor, if he be of an inquiring turn of mind, is likely to wonder how authentic such effigies can be. As the maker of the restorations in question, I have often been asked how much may be inferred regarding the features from the underlying skull. Sometimes the question takes virtually this form,—"Is it possible to model a portrait head on a skull without other data?" My answer is a decided negative, if by a "portrait" is meant a *personal likeness*, and if "without other data" is to be taken literally. In a collection of modern skulls the anthropologist can distinguish race, approximate age, and usually sex, without difficulty, but even if, for example, he knows a certain skull to be that of a middle-aged man of northern Europe, he cannot say how fat or how thin that man was, whether he was bald or whether he wore a beard, yet obviously these are matters of importance in portraiture. Even when these details are known, they afford no index to certain subtleties of facial expression which are essential in a personal portrait.

While therefore I do not consider it possible to construct an individual likeness solely on cranial data, the skull is a great aid in modeling a mask or bust of a *known* individual especially if photographs or other portraits are available. Portrait busts have thus been modeled on the skulls of several famous men, for example Schiller and Bach. But newspaper accounts of the identification of murdered men from the features modeled on skulls discovered long after death, when there was no other clew, are not to be accepted at face value, unless the skull in question possesses some outstanding peculiarity.

Of course skulls exhibit racial characters. The physical anthropologist can distinguish the crania of Negroes, Mongols, and Europeans almost as readily as the layman can identify the living types, and if a sculptor-anatomist were to model the soft tissues on, say, a dozen typical skulls of each of these three races, the layman could doubtless assign most of them to their proper racial groups even in the absence of hair and color differences. Such heads would not be individual portraits, but type models or *racial portraits*. Such racial portraits are all we can hope to attain in reconstructing the soft tissues on skulls of extinct races, where we have no data except the bones, and no information as to hair or complexion, but after all, a racial model has more scientific value than an individual likeness. During the past few years I have attempted such restorations of soft parts on five skulls: *Pithecanthropus erectus*, the Piltdown man or *Eoanthropus*, the male Neanderthal skull of La Chapelle-aux-Saints, the female of the same species from Gibraltar, and the "old man of Cro-Magnon." Of these the data for the first two are relatively incomplete, while the Cro-Magnon is so like certain modern European types that it is not particularly interesting; but the Neanderthal, representing a type distinctly different from our own species, and known from a considerable number of examples, is one which has special interest as a problem in restoration. In the present article I shall, therefore, try to indicate the possibilities and the limitations of restoration as exemplified in *Homo neanderthalensis,* and specifically the man of La Chapelle-aux-Saints. This skull,—on the whole the finest of the race or species thus far discovered,—was found in 1908, in the department of Corrèze in France. The remains, which comprise a considerable part of the skeleton, are widely known through a splendid monograph by Professor Marcellin Boule of Paris.

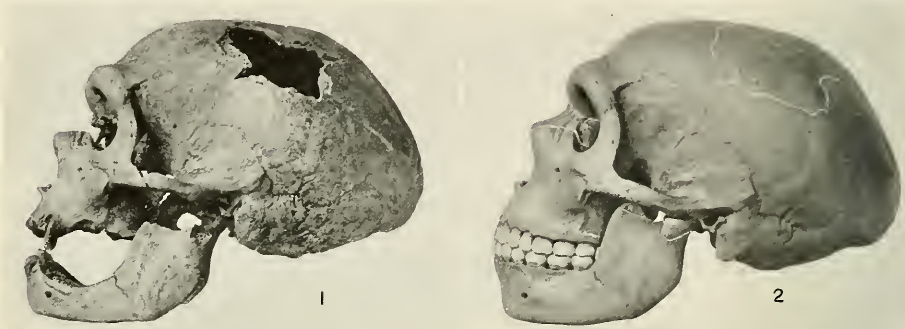


Fig. 1.—The Neanderthal skull of La Chapelle-aux-Saints. From Boule
Fig. 2.—A plaster cast of the same skull with the teeth, nasal bones, and some other missing parts restored from studies of other Neanderthal remains. This photograph was made at too short focus, hence the proportions are not quite accurately represented

The skull, which was broken into a number of fragments, was admirably reconstructed by Professor Boule (Fig. 1). It is that of a man rather past middle life, most of whose teeth had been lost prematurely through a suppurative disease of the gums, so that the jaw is more senile in form than would otherwise have been the case. The lower jaw had become slightly warped (a common post mortem occurrence with fossil jaws), so that it was too wide to articulate properly with the cranium. The skull was so nearly complete that restoration of the missing parts was not difficult. These portions were restored by me on a cast of the skull, and the teeth modeled from numerous casts and photographs of other Neanderthal remains, chiefly those from the rich finds of this race at Krapina, in Jugoslavia. The post mortem distortion of the lower jaw was remedied by a laborious process which involved making, first, a flexible cast in hard plasteline, and from this, after correction, a second cast in plaster. The lower teeth were then modeled to conform to the upper, using again the photographs and casts of other Neanderthal teeth and skulls. The teeth, as restored, are those of a young adult, and not such as would be found in the skull of an elderly man. This placing of comparatively unworn teeth in old jaws may be open to criticism in that it produces an unnatural condition. Had all the teeth been retained the jaw would not have presented quite the senile form which it actually shows. This inconsistency was duly considered in making the restoration, and was deemed justifiable in that it enhanced the value of the restored skull for the demonstration of the typical Neanderthal dental characters. The restoration of the missing nasal bones was a comparatively easy matter as the adjacent structures were mostly present, and casts of two other Neanderthal skulls,—from Gibraltar and Krapina,—with complete nasal regions, were available for comparison. Some other less important gaps were also filled in. The skull, thus restored, represents a nearly perfect Neanderthal skull closely approximating the original condition except for the rejuvenation of the dentition explained above. (Fig. 2.)

The flesh restoration here described and figured was made in 1919. An earlier one was modeled in 1915, not on a cast of the original skull, but on a copy modeled from it by another person. The present restoration—based on an excellent cast—is far more accurate.

The head was modeled directly upon this skull as restored. First the skull was fixed firmly on the so-called Frankfort horizontal or "eye-ear plane," so that a plane passing through the lower margin of the orbits and the upper margin of the auditory meatus would be horizontal. This poses the head in a natural position, and, as all the other heads which I have restored were built upon skulls similarly oriented, comparison of slope of forehead, chin, etc. in the various models, is greatly facilitated. Special attention was devoted to the position and dimensions of the neck. From Professor Boule's published photographs and diagraph drawing of the cervical and anterior thoracic vertebræ, these bones were outlined in natural size, and a mesial section of the neck was constructed, drawing in, not only the vertebræ, but the upper end of the sternum in proper relation, the neck ligaments, oesophagus, hyoid bone, larynx, trachea, and other organs. This mesial section, drawn on card-

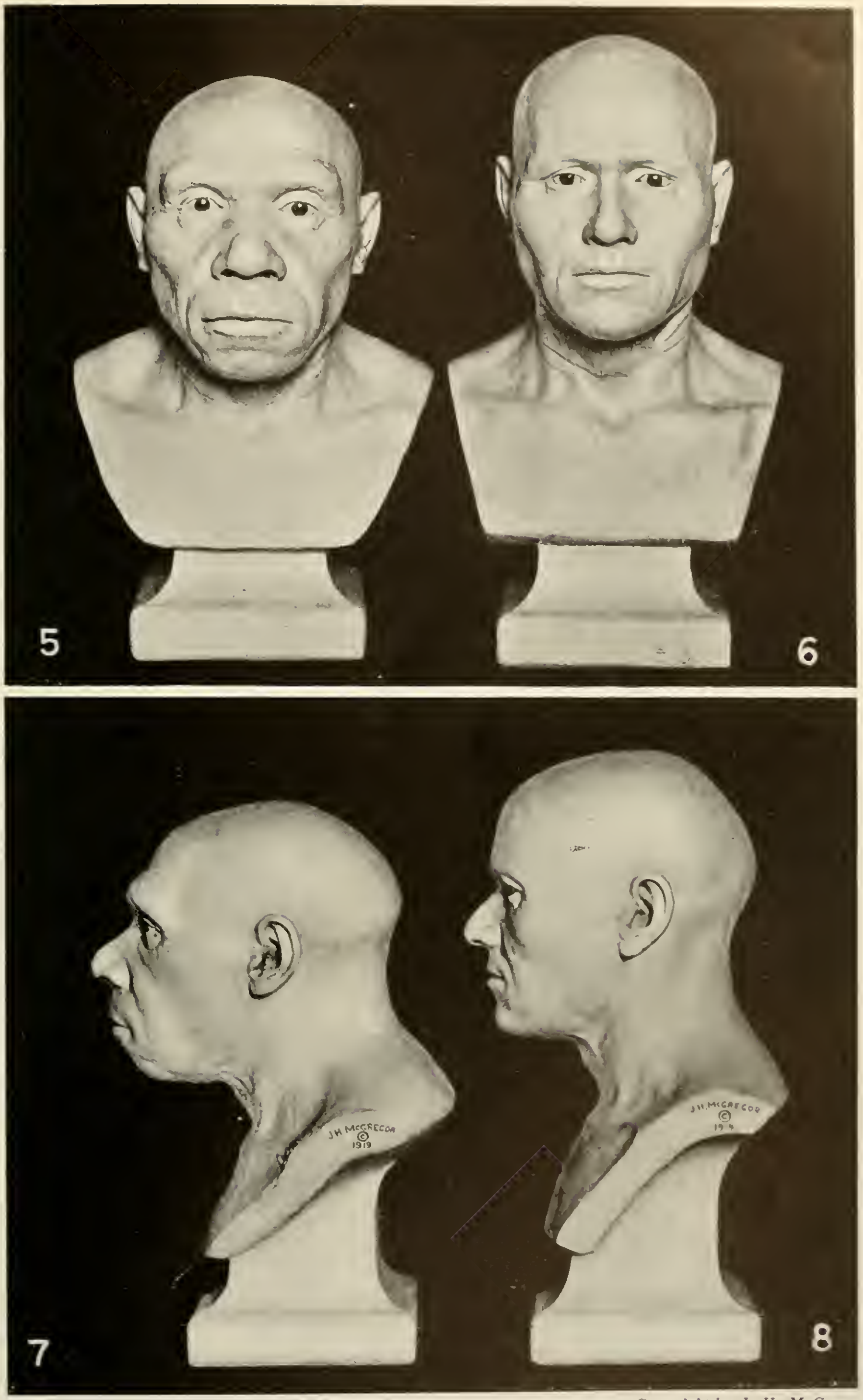
3

4

Figs. 3 and 4.—These figures show the skull posed on the Frankfort horizontal plane, with the large muscles modeled in plasteline, and the plaster eyeballs in place. In Fig. 3 the tarsal plates of the eyelids and the removable nasal cartilages are shown on the left side board, was adjusted to the skull to serve as a guide in modeling the neck. As may be observed from the photographs the neck, as reconstructed, is rather thick, but is far from being the bull neck which certain European restorers have conferred upon Neanderthal man.

Naturally the nose, eyes, and ears are features requiring careful attention. As to the nose it is clear from the nasal aperture of the skull that this feature must have been of great width. It is also certain that it was not flat or depressed, but prominent. Most restorations of Neanderthal man have been at fault in representing the nose as flat like that of certain negroid types. As published researches indicate a surprisingly slight correlation between the width of the nasal aperture and the external nose, the exact width of this organ is uncertain. Though very wide as modeled in the restoration it is not more so than in some Negroes. In order to attain as great accuracy as possible in this feature, the nasal cartilages were modeled in "moldolith," a commercial plastic material which becomes hard when dry. These were further constructed so that the two halves could be removed and replaced separately. (Figs. 3 and 4.) Modeling the eyes required great care. It is known that the centers of the pupils, when the eyes are at rest, are slightly nearer the outer than the inner orbital border, and slightly nearer the upper than the lower border. The size of the adult human eyeball varies but little as compared with variation of the size of the orbits, hence, although Neanderthal orbits are notably capacious, there is no reason to believe that the eyeballs were appreciably larger than in *Homo sapiens*. Eyeballs of the proper size were modeled, cast in plaster, and inserted in the orbits with due regard to their relations to the orbital rim. This is not so simple as might be supposed. There is a normal variation of some 12 millimeters in the prominence of the eyeball in its socket, but in the usual position, which was adopted in this restoration, the front of the cornea is about in the plane intersecting the upper and lower borders of the orbit. The lacrymal sac and tarsal plates of the eyelids were modeled to serve as guides in constructing the soft tissues. (Fig. 3.) It may be remarked that the interpupillary distance is wide, 72 millimeters. Plaster casts of the nasal cartilages in place, and of the orbital region were made as records and for use in checking later measurements. In modeling the ear the point of greatest importance was to observe the normal relation to the bony meatus, or ear opening, in the skull. As there is nothing to suggest that the external ear was remarkable in any way, it was conservatively modeled as to size and form. There is no reason to suppose that the "Darwin's point" of the ear was more frequent or better developed in Neanderthal man than in his modern kin.

Figures 3 and 4 show how the large muscles,—temporal, masseter, and sterno-cleido-mastoid, were modeled, and how heavy bank pins were inserted at critical points to serve as guide-posts. Various investigations have been published, especially in Germany, on the thickness of the soft tissues on various regions of the head and face in cadavers of different races. These studies were invaluable in the present restoration. The thicknesses which I decided to use may be said to approximate the average for well-nourished but not fat individuals.



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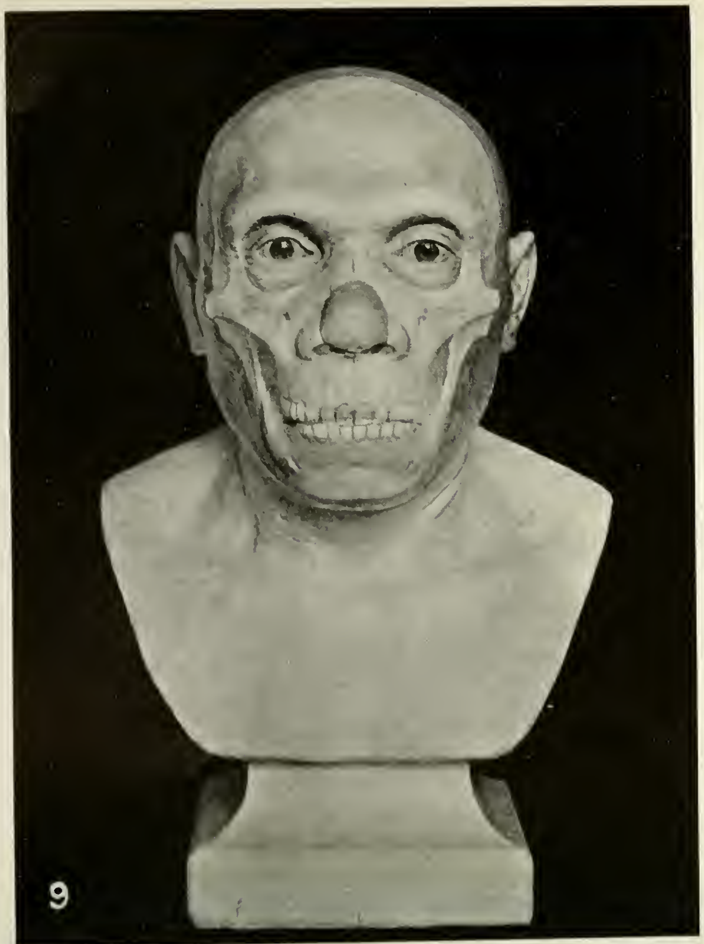
NEANDERTHAL AND CRO-MAGNON: A COMPARISON

Figs. 5 and 7 represent front and profile views of the hairless phase of the head modeled on the Chapelle-aux-Saints (Neanderthal) skull, and Figs. 6 and 8 show a head similarly constructed on a male skull of the Cro-Magnon race for comparison. The contrast facilitates recognition of the characteristic Neanderthal features such as form and relative size of cranium and face, the heavy brow ridge, slope of forehead and chin, wide but prominent nose and retreating cheeks



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NEANDERTHAL HEAD SHOWING RELATION OF FLESH TO SKULL

Figs. 9 and 10.—The Neanderthal "phantom" here shown in front and profile views exists only in the form of double-exposure photographs. The skull (Fig. 11A and the hairless head model (Figs. 5 and 7) were separately photographed superimposed on the same plates to demonstrate the conformity of the restored soft tissue to the underlying skull. The original double-exposure photographs are both elements of stereoscopic pairs, which, when viewed with a stereoscope give the impression of solid but transparent flesh enveloping the bones

It seemed advisable to avoid disguising the skull form by excessive flesh. The local thicknesses adopted were indicated in millimeters on photographs of the skull, and kept as records, and a great number of pins were driven into the plaster skull at corresponding points and cut off at proper heights, and soundings of the depth of the plasteline were made constantly throughout the course of the work. Finally the head without the hair was cast. This model clearly shows the racial head form, shape of nose, chin, etc. (Contrast these features in the hairless heads of Neanderthal and Cro-Magnon men, Fig. 5–8.) It is really more valuable scientifically than the finished bust, in which the head form is disguised by hair, and of course we do not know the nature of the Neanderthal hair. It will be noted that the lips are not thick and everted as in the Negro, as the vertically placed incisor teeth with end-to-end bite render such lips unlikely, and moreover the negroid condition is almost certainly not a primitive character, but a racial specialization. After a mold had been made of this hairless phase, the plasteline was removed from the left half of the skull, leaving the "flesh" on the right side, and a cast of this "half-and-half" model was made. The double-exposure photographs or "phantoms" shown in Figs. 9 and 10 demonstrate the general conformity of the restored soft tissues to the underlying skull.

As a concession to popular taste, the hair was modeled on a plaster cast of the bald phase, and a slight suggestion of beard added, though not sufficient to disguise the form of the retreating chin, an important racial feature. Finally, this finished bust was cast in plaster, as a *racial* model of an adult male *Homo neanderthalensis.* (See page 288.)

The stages of this restoration can be seen in the Museum: first, the cast of the skull before restoration; second, the same with the missing parts restored; third the "half-and-half" skull and hairless head; and, finally, the complete bust. In neighboring cases may be seen casts of the remarkably similar skulls of this same race from Spy, Neanderthal, La Quina, and Gibraltar, and fragments of others, all of which were studied constantly in connection with this work.

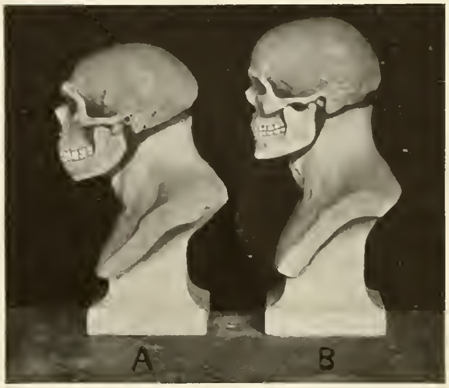

Fig. 11—The skulls of Neanderthal (Chapelle-aux-Saints), A, and Cro-Magnon, B, after removal of the plasteline. "A" and the hairless head (Figs. 5 and 7) were used in making the double exposures shown in Figs. 9 and 10

In every phase and feature of this restoration I have tried to be conservative, to follow only the guidance of anatomical fact, minimizing my personal equation in the work as far as possible, and avoiding any inclination to make the result either bestial or noble. But the Neanderthal species was human, not brute, and though the semblance of the former flesh which clothes this ancient skull, is perforce low-browed and heavy-featured—it is the likeness of a man.

Casts Obtained from the Brain Cases of Fossil Men

By G. ELLIOT SMITH
Professor of Anatomy, University of London

THE interpretation of the brains of extinct members of the human family on the basis of the evidence obtained by the casts of their skulls is a comparatively new field of research. In the first place, the material for such studies has only recently come into our possession, and, in the second place, the problem of interpreting the significance of such data as casts of brain cases afford, has only been made possible of solution by the development of our knowledge of the brain within the last fifteen years. In 1865 anatomists were still disputing as to the nature of the differences between the brains of men and apes, and controverting false assumptions that had been made with reference to certain characters claimed to have been distinctive either of the human or simian brain. Hence when Huxley wrote *Man's Place in Nature* he was not in a position to discuss, except in the most general way, the differences between the human and the simian brain, or to appreciate the features of the cast of the only brain case of fossil man then available,—that is the Neanderthal skull. In 1898 Dr. Eugene Dubois presented to the International Congress of Zoologists at Cambridge a report on the cast of the brain case of *Pithecanthropus*, which perhaps can be regarded as the true beginning of the history of this type of investigation. In that memoir Doctor Dubois concentrated attention upon the left inferior frontal region of the cerebral hemisphere in the attempt to discover whether the brain revealed any features to throw light upon the question of speech. At that time it was commonly supposed by physicians that the ability to speak was entirely dependent upon the integrity of the left inferior frontal convolution, the so-called Broca's area: but it is now realized that the acquisition of speech was an extremely complicated process dependent upon the special development of a large series of widely separated cortical areas involving regions concerned with hearing, sight, and touch, and the combination of the three, as well as the more strictly motor or executive portions of the hemisphere. When the important discovery of a representative of the Neanderthal species was made at La Chapelle-aux-Saints in 1908, Professor Boule, in coöperation with Professor Anthony, began the investigation of the cast of its cranial cavity, and published an important monograph (in *L'Anthropologie*, Tome XXII, No. 2, 1911, page 50), which they further elaborated during the next couple of years. The announcement in 1912 of the discovery of the Piltdown skull aroused considerable controversy as to the nature of this hitherto unknown type of man, and especially as to the question of the possible co-relation between the skull and the jaw found with it. This discussion was responsible for focusing particular attention upon the brain as one of the important factors in determining whether or not the skull was of so primitive a character as to be associated with a jaw so suggestive of simian affinities. The widest discrepancies as to the shape and size of this endocranial cast have been put forward during the last thirteen years, but there can now be no doubt whatever that the capacity of the brain case is very definitely below the average of modern man, and in addition that the cast of its interior reveals a form of brain which is more primitive in type than that of any known human brain, except only that of *Pithecanthropus.*

In approaching the study of the cast of the cranial cavity and attempting from it to interpret the nature of the brain that originally occupied a particular skull, our aims today are of a different nature than those of our predecessors. It is not so much the attempt to identify certain definite fissures and convolutions of the brain, as to determine the relative state of development of different functional areas of the brain. During the last twenty-five years it has been demonstrated that the search which began a century ago for certain features of the brain distinctive either of man or ape was a futile procedure because there are no such distinctive characters. No structure found in the brain of an ape is lacking in the human brain and, on the other hand, the human brain reveals no formation of any sort that is not present in the brain of the gorilla or the chimpanzee. So far as we can judge at the present time, the only distinctive feature of the human brain is a quantitative one, namely a marked increase in the extent of three areas in the cerebral cortex, the parietal, the pre-frontal, and the inferior temporal which are relatively small in the brain of the anthropoid apes and very much more insignificant in the brain of all other mammals. Hence the chief object is to base our conclusions not so much upon the absolute size of any particular brain, as upon the relative size of those particular regions which are of chief significance in phylogenetics.

In a recent number of this Journal Dr. James H. McGregor has given an admirable account of the skull and brain of *Pithecanthropus*, and compared it with the casts of the brain cases of the gibbon, the gorilla, the Rhodesian skull, the Gibraltar skull, and others. In his excellent restoration of the complete form of the cast of *Pithecanthropus*, which I think is as accurate as the facts at present available warrant, he obtained a capacity of 940 cubic centimeters, which, as he pointed out, bridges the gap between the 580 for his gorilla and the 1,280 and 1,300 of other primitive men. The outstanding distinctive feature of the cast of this most primitive human brain case is the extreme flatness, which is due to the imperfect development of the parietal and frontal regions. The disproportionate and precocious overgrowth of the posterior part of the temporal area must be regarded as the tangible evidence of the sudden increase of the importance of the acoustic symbolism, which can have no meaning other than the inference that some sort of speech had been acquired by this most primitive and earliest known member of the human family. The widening of the brain in the posterior temporal area gives the primitive brain its most distinctive feature. The other point of interest in this cast is the fact that the marked asymmetry of the brain, which is peculiar to the human family, is already clearly defined; but as I have pointed out elsewhere ("Right and Left-handedness in Primitive Men," *British Medical Journal*, December 12, 1925) the asymmetry is of the kind which in modern man, and presumably also in primitive man, is associated with left-handedness. Although the three significant areas of the brain, the parietal, the frontal and the temporal, are much larger than they are in any ape, they are, on the other hand, very definitely smaller than those of any other known human brain.

A B C

A′ B′ C′

Fig. 1.—A and A′, endocranial casts of male gorilla; B and B′ *Pithecanthropus*, as restored by Professor J. H. McGregor; and C and C′, Rhodesian man, top and side views. The three casts were photographed together to show the relative sizes. From J. H. McGregor

The cast that I have recently obtained from the restoration of the Piltdown skull, in the completion of which I received valuable assistance from the late Professor John I. Hunter and Dr. John Beattie, reveals a cast which is only about 1,170 cubic centimeters in capacity. The distinctive features of this cast are in the first place, the localized hypertrophy of the posterior temporal area, such as I have already mentioned in *Pithecanthropus*, but with a greater fulness of the three significant areas.

The cast of *Pithecanthropus* in its general form is an anticipation of the peculiar shape seen in a more fully developed condition in the cast of the Rhodesian skull and those of the Neanderthal series. The Piltdown cast, on the other hand, although it reveals the flatness found in all human brains, excepting only the majority of members of the species *sapiens*, displays a form, especially in its posterior part, suggestive of the condition found in *Homo sapiens*. Both in *Pithecanthropus* and in *Eoanthropus* the deep broad notch found at the posterior extremity of the orbital

A B C D

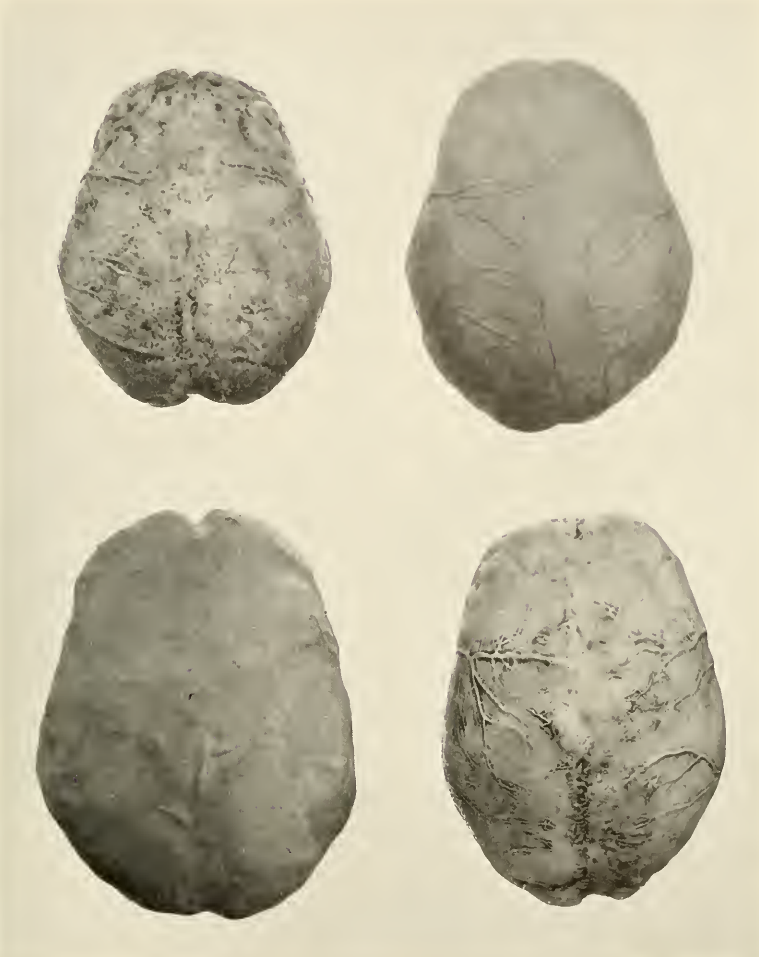

Fig. 2.—A, top view of endocranial cast of *Pithecanthropus;* B, *Eoanthropus* (Piltdown) restored; C, Neanderthal (La Chapelle-aux-Saints); and D, *Homo sapiens* (white man), photographed together to show relative size and form

margin suggests that the Sylvian fissure was widely open at its anterior end, as it is in the chimpanzee and the gorilla.

When we pass to the Rhodesian cast (Fig. 1, C, C[1]) which is a little bigger than that obtained from the Piltdown skull, we find a brain that is considerably altered in form, in the direction which is familiar to us from the series of Neanderthal casts. The uneven expansion of the brain in this process of development is more clearly displayed in this cast than in any other human specimen, and for this reason the Rhodesian cast is particularly instructive. The prominence on the posterior part of the temporal area is still apparent, although this region as a whole is still significantly small, a fact that is most obtrusively displayed in the lateral view. The pre-frontal area,

Fig. 3.—A, left side view of endocranial cast of *Pithecanthropus;* B, *Eoanthropus* (Piltdown); C, Neanderthal (La Chapelle-aux-Saints); and D, *Homo sapiens* (white man), photographed together to show relative size and form. *Pithecanthropus* and *Eoanthropus* as restored by Professor J. H. McGregor

also, although significantly larger than that of the Piltdown cast, and of course much larger still than in *Pithecanthropus,* is still obviously ill-developed in proportion to the general size of the brain. It has an appearance as though in a plastic state it had been taken in the hand and squeezed into a smaller compass. The openness of the Sylvian fissure, to which I have already referred in the case of *Pithecanthropus* and *Eoanthropus,* is still manifest in the Rhodesian cast, but in a less obtrusive form. There is a much greater approach to the closure of this fissure than there was in these more primitive types. In the parietal area there is an obvious expansion in comparison with that of the Piltdown cast, an expansion which affects mainly the inferior part of the parietal area, yet in no cranial cast is the defective development of the upper and posterior part of the parietal territory more distinctly demonstrated than in that of the Rhodesian specimen. One of the interesting features of the Rhodesian cast (to which I have already called attention in the lecture reported in the *British Medical Journal*) is the fact that the lunate sulci are approximately symmetrical on the two hemispheres; a condition that is found only very rarely in modern human brains and then specially in the Negro race.

When we come to the Neanderthal

series of casts, one finds a state of affairs that can be described as a brain of Rhodesian type, in which the great deficiencies found in that cast have been partially filled up. The brain in all members of this species is still exceptionally flat, with the occipital end pulled out in a very distinctive way. The pre-frontal area is still small, both relatively and actually, but is not so obtrusively diminutive as it is in the Rhodesian and the more primitive human casts. Nor does one find that irregularity of the contour of the parietal area which is so striking a feature of the Rhodesian cast. At the same time the parietal area in some of them, especially the La Quina and Gibraltar specimens is not nearly so full as it is in *Homo sapiens,* even in quite primitive representatives of that species like the aboriginal Australian. Hence in some of the Neanderthal casts, especially that of the La Quina specimen, the localized swelling of the posterior part of the temporal region, already noticed in the three more primitive members of the family, is still quite a recognizable feature. In the posterior extremity of the hemisphere one can detect the same sort of asymmetry found in *Homo sapiens,* although perhaps in a less obtrusive form. The great size obtained in certain of the Neanderthal series seems to be due to an increase in the extent of the primary sensory areas and of the parietal territory. There is no significant increase in the sizes of the pre-frontal and inferior temporal areas.

When we come to *Homo sapiens* the most significant change is the alteration in the contour of the brain; an increase in height and a diminution in breadth of the brain. Both diameters, however, share in the secondary expansion that occurs later on in the higher types of brain so as to produce the high-domed and well-filled brain, which is so distinctive of modern man. Perhaps the most distinctive feature of the brain of *Homo sapiens* is the significant increase in the size of the pre-frontal territory, which becomes considerably bigger than it is in any other species of the human family. This leads to the filling out of the fore-head and confers upon modern man a distinctive type of brow which distinguishes him from all other members of the family. In spite of the enormous range of variations in the size and form of the brain of *Homo sapiens,* it never loses this distinctive feature. Although the brains of individual members of the species may be smaller than that of any of the known extinct types, not excluding even *Pithecanthropus,* the brain always differs in form from these types, and the reduction in size may affect other areas than those of the three significant regions that I have mentioned. Hence a very small brain in modern man presents a profound contrast in shape and relative size of areas to the brain of corresponding size in extinct members of the human family.

With the increase of our knowledge of the structure and functions of the cerebral cortex, it is now becoming possible to correlate in some measure the facts of cerebral anatomy in early forms of the human family with the developing powers of manual dexterity and ability to learn from experimentation, upon which man's growing understanding of the world in which he lives ultimately depends.

The Crown Patterns of Fossil and Recent Human Molar Teeth and Their Meaning

By WILLIAM K. GREGORY[1] AND MILO HELLMAN[2]

THE crown of a *second lower molar* (m_2 Fig. 1A) of a white person is very apt to comprise four main elevations or cusps, grouped in two transverse pairs. Two of these cusps, which we will designate by the odd numbers 1, 3, are on the outer or cheek side, and the other two (2, 4) on the inner or tongue side. The outer cusps are more or less flattened, conical, the inner ones when unworn bear low cross crests. These four cusps are separated at their bases by two prominent grooves that cross each other almost at right angles near the middle of the crown: the longitudinal groove starts in front between cusps 1 and 2 and ends behind between cusps 3 and 4; the transverse groove begins well down on the outer side between cusps 1 and 3 and ends on the inner border between cusps 2 and 4. If these grooves were perfectly straight and completely at right angles to each other, all four of the main cusps would be in equal contact at the crossing place on the middle of the crown. But frequently cusps 1 and 4 crowd their neighbors a little and, gaining a small contact with each other, they prevent cusp 3 from being in contact with cusp 2. This whole arrangement of four cusps and two main grooves with the 1–4 contact has been called the "cruciform" or "plus-shaped" pattern of the lower molars.

In the first lower molar (m_1 Fig. 1B) of all human races a fifth main cusp (5) is usually present behind 3 and nearer the midline of the crown. In this five-cusped type the simple plus-shaped pattern is replaced by a more complex arrangement, the most conspicuous feature being a more or less irregular Y, the stem of which is the inner transverse groove between cusps 2 and 4, the fork being formed by the outer half of the transverse groove (between cusps 1 and 3) and by the deep oblique furrow between cusps 3 and 5. There is no 1–4 contact but there is a prominent 2–3 contact. Near the front border of the crown between cusps 1 and 2 there is frequently a prominent transverse groove or crack which has been called the "fovea anterior" (f.a.), while on the hinder inner border, between cusps 5 and 4, a smaller fissure is called the "fovea posterior" (Fig. 1C, f.p.). This whole pattern of five main cusps, with the longitudinal and Y-shaped grooves, the 3–2 contact, the foveæ anterior and posterior, in 1916 was named by one of us the "*Dryopithecus* pattern" of the lower molars, for reasons that will appear later.

While there is a great variation both in the sizes and in the patterns of all the molars in modern races, the first molar is apt to be larger than the second, and it almost always tends to have five cusps and preserves more or less clearly the "*Dryopithecus* pattern" (Fig. 2). The second molar, especially in the white race (Fig. 1A) is apt to have only 4 cusps and the "plus pattern." The third molar, which is

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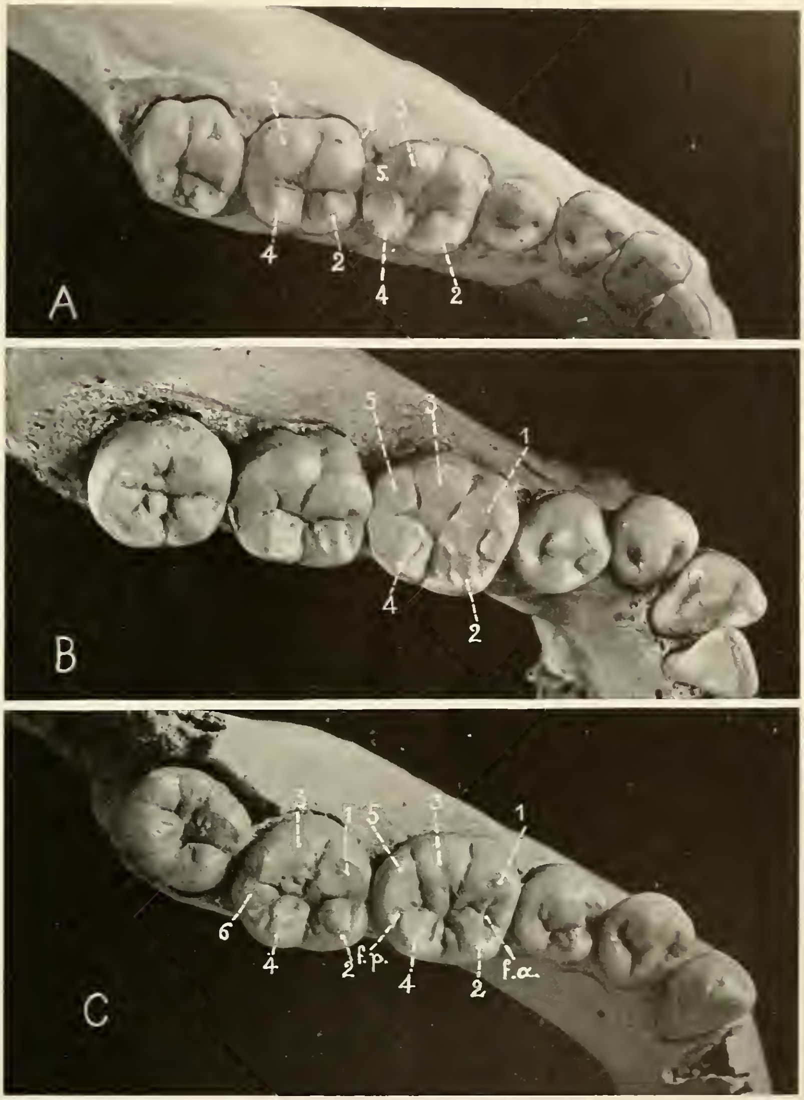

Fig. 1.—Human lower teeth, left side, showing arrangement of cusps in molars. A, White; B, C, Indian. Compare the arrangement of the cusps in the anthropoids (Fig. 2).

delayed in its eruption in the white race (Fig. 1A, m_3), is often smaller than m_1 and more or less irregular in outline, usually with a 1–4 contact and irregular plus pattern. In Negroes the third lower molar usually erupts somewhat earlier in life; it is larger than in the whites and frequently retains five cusps and clearer traces of the "*Dryopithecus* pattern." With minor differences much the same conditions prevail in Australian aboriginals.

On all three molars of some races, such as Negroes, Australian aboriginals and Indians, a sixth cusp (Fig. 3D, 6) often appears on the middle of the

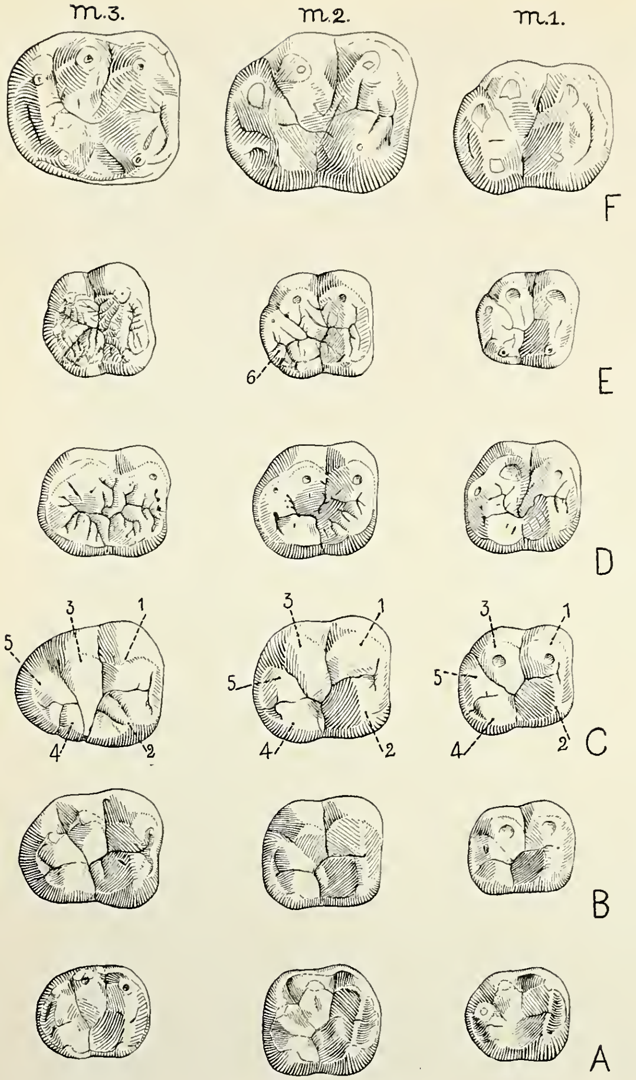

Fig. 2.—Left Lower Molar Teeth of Fossil and Recent Anthropoids. Drawing by Marcelle Roigneau.

F, Recent gorilla, Africa.

E, Recent chimpanzee, Africa

D, Recent orang-utan, Asia.

C, *Dryopithecus frickæ,* Miocene India.

B, *Dryopithecus cautleyi* from the Miocene of India.

A, *Dryopithecus fontani* from the Miocene of France and Spain.

hinder border and lying either between cusps 5 and 4 or in m_2 between 3 and 4.

In the later post-glacial races of prehistoric men (Neolithic) the lower molar teeth, while well developed, do not differ conspicuously from those of recent races, but in the older races from the Upper, Middle and Lower Pleistocene of Europe (Cro-Magnon, Grimaldi, Mousterian, Ehringsdorf, Heidelberg, Piltdown) the lower molars vary from a modernized condition in Cro-Magnon to a decidedly ape-like stage in Piltdown (Fig. 6). The lower molars of the Javan *Pithecanthropus* are unknown, but to judge from the curious mixture of human and orang-like details in its upper molars,[1] the lower molars should also have been more or less ape-like.

The very ancient Heidelberg jaw

[1]The evidence for this statement is given in *Amer. Mus. Bulletin,* Vol. XLVIII, pp. 527–530. 1923. "Further Notes on the Molars of *Hesperopithecus* and of *Pithecanthropus*," by William K. Gregory and Milo Hellman.

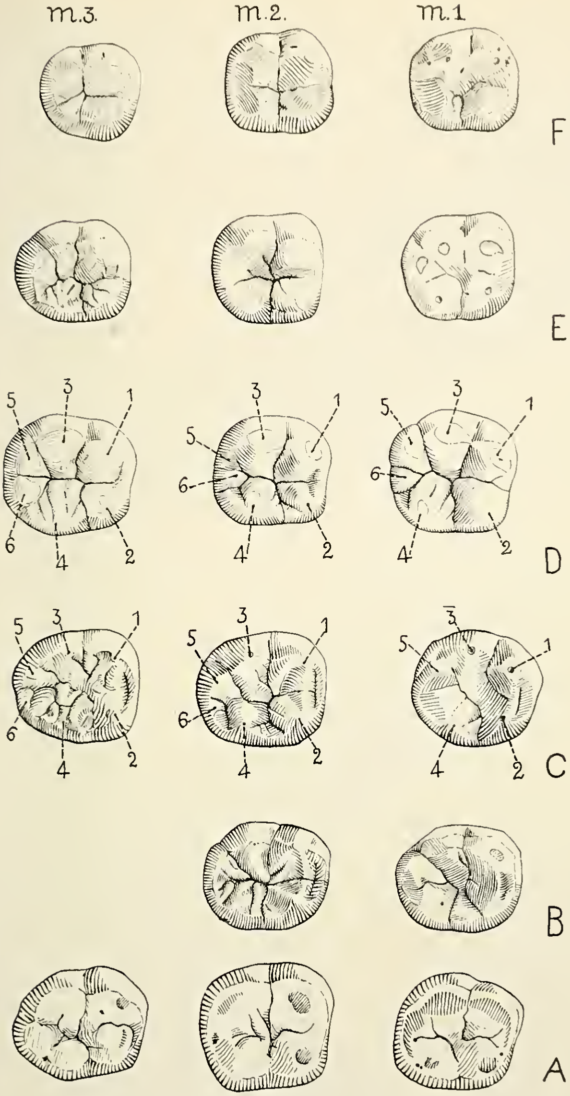

Fig. 3.—LEFT LOWER MOLAR TEETH OF FOSSIL ANE RECENT MEN.

Drawing by Marcelle Roigneau

F, White.

E. Hindu, India.

D, Australian aboriginal.

C, Le Moustier (Neanderthal race).

B, Ehringsdorf child (Neanderthal race)

A, Heidelberg.

from the First Interglacial stage of the Pleistocene epoch, in respect to its retreating chin and extremely wide ascending branch may fairly be termed ape-like;[2] but its dentition is definitely human, although retaining a few primitive features. Thus the five main cusps (Fig. 3A) are present on m_1, m_3, the *Dryopithecus* pattern is intact on m_1, there is a 3–2 contact on m_2. The left m_3, is reduced, with a plus pattern; the right m_3 is more primitive, with a 2–3 contact, with modified *Dryopithecus* pattern. To the palæontologist, possessing an intimate experience with the history of many mammalian lines during the Tertiary period, the fact that the Heidelberg teeth are definitely human while the jaw retains strongly ape-like features, can only mean that the first steps in the transformation of a generalized ape-like dentition

[2]See the diagraph figures of ape and human jaws in plates XII, XIII, of Schoetensack's *Der Unterkiefer des Homo Heidelbergensis. . . .* Leipzig, 1908.

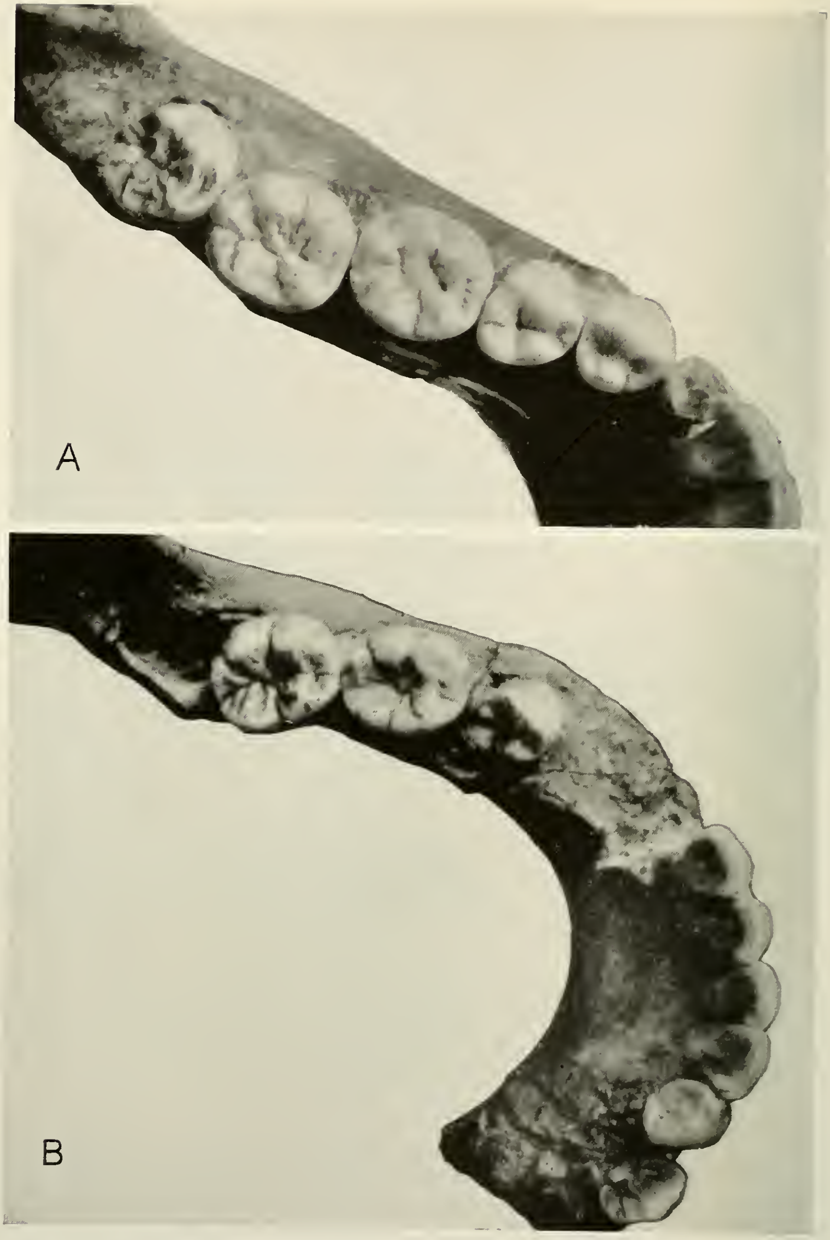

Fig. 4.—Fossil Human Lower Jaws of the Neanderthal Race.—A, Le Moustier. B, Ehringsdorf child. Photographs by Professor J. H. McGregor

toward the modernized human type must have taken place at a period far earlier than the Lower Pleistocene age of the Heidelberg man.

In the beautifully preserved dentition (Fig. 4A and 3C) of the famous "Mousterian youth" of the Neanderthal race, the crown patterns are more or less obscured by the development of fine secondary grooves and wrinkles rather suggestive of the conditions seen in certain chimpanzees and orangs as well as in the extinct ape *Dryopithecus rhenanus*. The modern plus pattern is conspicuously absent. On all three molars there are five main cusps, the 3–2 contact is undisturbed or emphasized, there are well developed foveæ anterior and posterior. A small cusp 6 is present on m_2, m_3. The third molar, just erupting at the time of death, has a prominent fovea anterior; the surface of the crown bears numerous secondary grooves and wrinkles.

In the "Ehringsdorf child" (Fig. 4B and 3B) the first molar crown is decidedly narrower in proportion to its length than is the case in typical modernized molars. The second molar is also relatively very long and narrow. Both molars have a very large conspicuous fovea anterior, a good 3–2 contact, a fovea posterior and an irregular Y-shaped groove. In m_2 there is a small accessory transverse groove and ridge on the inner half of the crown between cusps 2 and 4. Exactly this combination of characters is found in certain lower molars of *Dryopithecus rhenanus* from the Pontian (Lower Pliocene) of Europe (Fig. 9D).

The famous Piltdown jaw[1] from the Lower Pleistocene of Sussex, England, is in general so ape-like (Fig. 5B) that certain authors, including one of us, formerly refused to admit that it belonged with the undoubtedly human, though in some points very primitive, Piltdown skull. But the discovery[2] of a second lot of fragments in the Piltdown gravels, consisting of a lower molar (Fig. 6B) closely resembling the first lower molar of the original specimen, associated with pieces of the forehead and occiput, appear to afford strong new evidence for Dr. Smith Woodward's original opinion that the ape-like lower jaw represents an extremely ancient and primitive species of mankind.

What evidence do the crown patterns of the Piltdown lower molars yield on this interesting question? In both the original specimen and the later-found one (Fig. 6) the crown of the first lower molar shows the much worn surfaces of cusps 1, 3, 5, 2 and 4, and clear traces of the Y-shaped groove. Cusp 4 was not enlarged and is widely separated from cusp 1, the 3-2 contact being well established. Foveæ anterior and posterior are both present. The second lower molar is distinctly longer and larger than the first.

It will be seen that on the human side the conditions in the Piltdown lower molars are perhaps most nearly approached in the Ehringsdorf jaw. But in another direction the crown pattern of the Piltdown molars, as thus described, is identical with that of all the known species of the extinct apes named *Dryopithecus* and allied genera from the Miocene of Europe and of India. Here will be seen (Figs. 2, 7) the identical arrangement of five main cusps, Y-shaped groove, foveæ anterior and posterior, etc., to which the name "*Dryopithecus* pattern" was originally applied. Moreover, all the modern genera of anthropoid apes (Fig. 2) inherit this pattern intact but with diverse modifications.

What is the explanation of the fact that the *Dryopithecus* lower molar pattern, first foreshadowed in the very primitive gibbon-like genus *Propliopithecus* (Fig. 8B) of the Lower Oligocene of Egypt, flowers out during Miocene

[1]See Dawson, C. and Woodward, A. S. 1913. "On the Discovery of a Palæolithic Skull and Mandible in a Flint-bearing Gravel overlying the Wealden (Hastings Beds) at Piltdown, Fletching (Sussex)," *Quart. Journ. Geol. Soc.* Vol. lxix, pp. 117–151, pls. xv–xxi.

[2]See Woodward, A. S. 1917. "Fourth Note on the Piltdown Gravel, with Evidence of a Second Skull of *Eoanthropus dawsoni*." *Quart. Journ. Geol. Soc.* Vol. lxxiii, pp. 1–10, figs. 1, 2, pl. i.

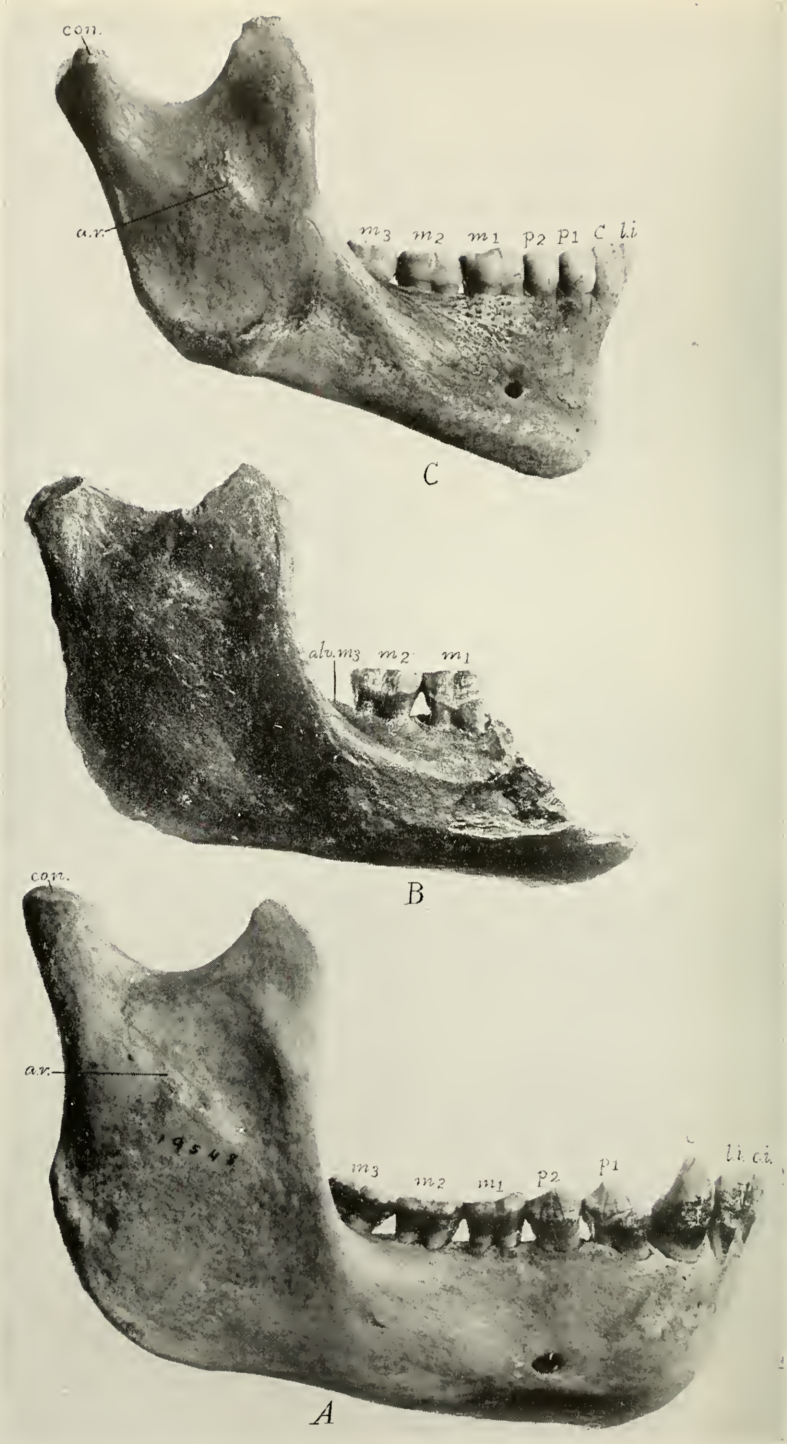

Fig. 5.—Lower jaws of orang-utan (A), Piltdown (B), and modern man (C)

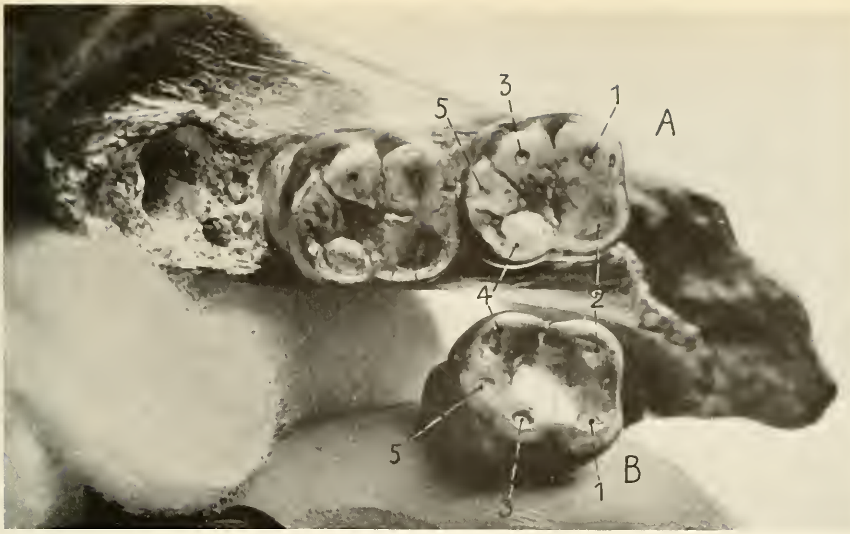

Fig. 6.—Lower Molars of the Piltdown Jaw, Much Worn but Showing the Pure "*Dryopithecus* Pattern."—A, The first specimen. B, The second specimen. The photographs, by Professor J. H. McGregor, are reversed to facilitate comparison with Fig. 7.

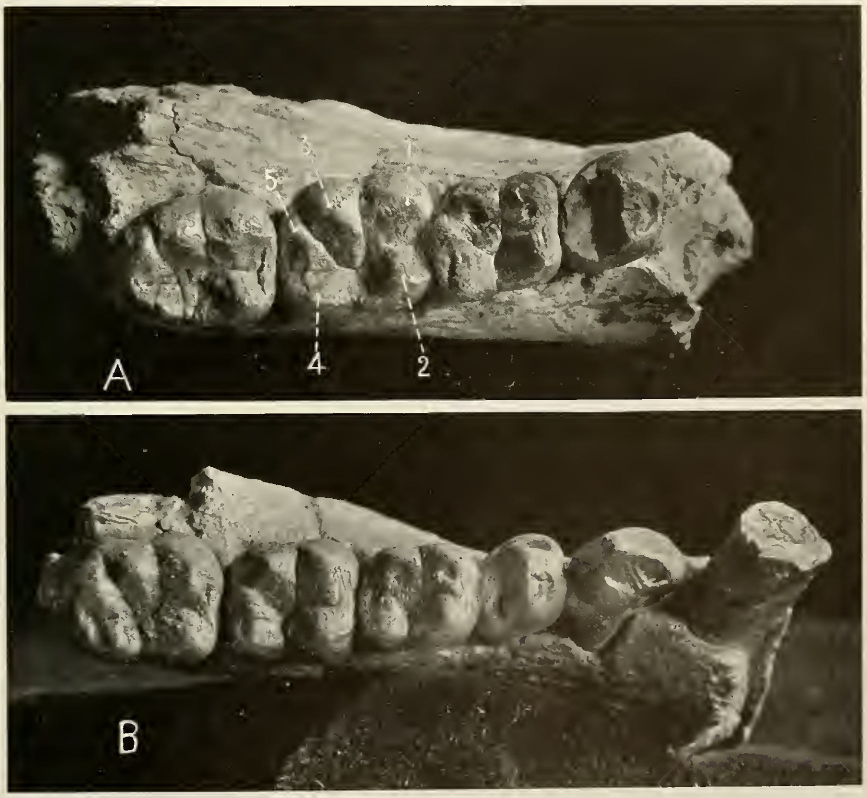

Fig. 7.—Left Lower Cheek Teeth of Fossil Anthropoid *Dryopithecus*.—Collected by Barnum Brown, leader of the American Museum Expedition to the Siwaliks, India. A, *Dryopithecus frickæ*, Miocene, India. X 3/2. B, *Dryopithecus cautleyi*, Miocene, India. X 3/2

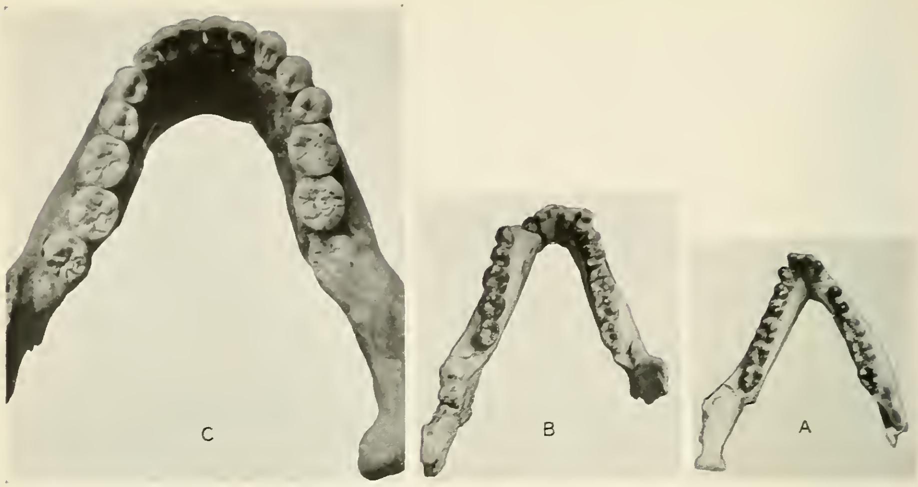

Fig. 8.—Three *structural* stages in the evolution of the human lower jaw. A, Primitive tarsioid stage (*Parapithecus*) with narrow space for the tip of the tongue and converging tooth rows. Lower Oligocene, Egypt. B. Primitive anthropoid stage (*Propliopithecus*) with nearly parallel tooth rows and wider space for the tongue. C, Primitive human stage (Le Moustier) with very wide space for the tongue and reduced and crowded front teeth. Photographs by Professor J. H. McGregor

times in many specific forms in the wide-ranging fossil anthropoid apes of Europe, Asia, and Africa, is present in its completeness in the Lower Pleistocene Piltdown jaw, and becomes more or less obscured in the Heidelberg, Neanderthal and later races of man?

Why do the upper molars of the Mousterian youth (Fig. 9A, B) exhibit such an astonishing agreement in ground plan with the upper molars of *Dryopithecus rhenanus* (Fig. 9C) from the Upper Miocene of Europe? And why are the second lower pre-molars of the Neanderthal and Ehringsdorf jaws most obviously composed of parts that are strictly comparable with those of the second lower premolar of *Dryopithecus?* (Figs. 4, 7.)

Why is it that in some chimpanzees the first lower premolar is a compressed, two-rooted tooth that retains much of the form of the corresponding tooth in the ancient *Dryopithecus*, while in some other chimpanzees the first lower premolar is a transversely widened single-rooted tooth that is strongly like a human first bicuspid? Why does the lower first premolar of *Pithecanthropus* and of some Negroes and Australians retain two distinct roots, and why are these roots fused into one in modernized jaws?

Why is it that the canine tooth of the Piltdown jaw is essentially similar to that of *Dryopithecus?* Why are the lower incisors of the Mousterian and Ehringsdorf jaws comparable in fundamental characteristics of root and crown with those of modern gorillas?

Why are all the milk teeth of even modern man basically identical in their several patterns with those of corresponding teeth of modern anthropoids?

Why is the dental formula $I\frac{2}{2}$, $C\frac{1}{1}$, $Pm\frac{2}{2}$, $M\frac{3}{3}$ (meaning two incisors, one canine, two premolars, three molars on either side and in both upper and lower jaws) exactly the same in all fully developed normal adult dentures of men, anthropoid apes, and Old World monkeys?

And why are the dental formulæ different from this in all other groups of recent Primates?

Why is the formula for the milk teeth ($dI\frac{2}{2}$, $dC\frac{2}{2}$, $dP\frac{2}{2}$) also the same in all human races, in all anthropoid apes, and all Old World monkeys?

All these and a thousand similar questions might fairly be put to those who, ignoring the convergent evidence of comparative anatomy, physiology and psychology, mammalogy, palæontology, and the like, persistently denounce as untrue Darwin's inference that man and the modern anthropoids, in spite of widely divergent specializations, have inherited their innumerable structural and physiological correspondences from some very primitive and early member of the anthropoid group of Old World Primates.

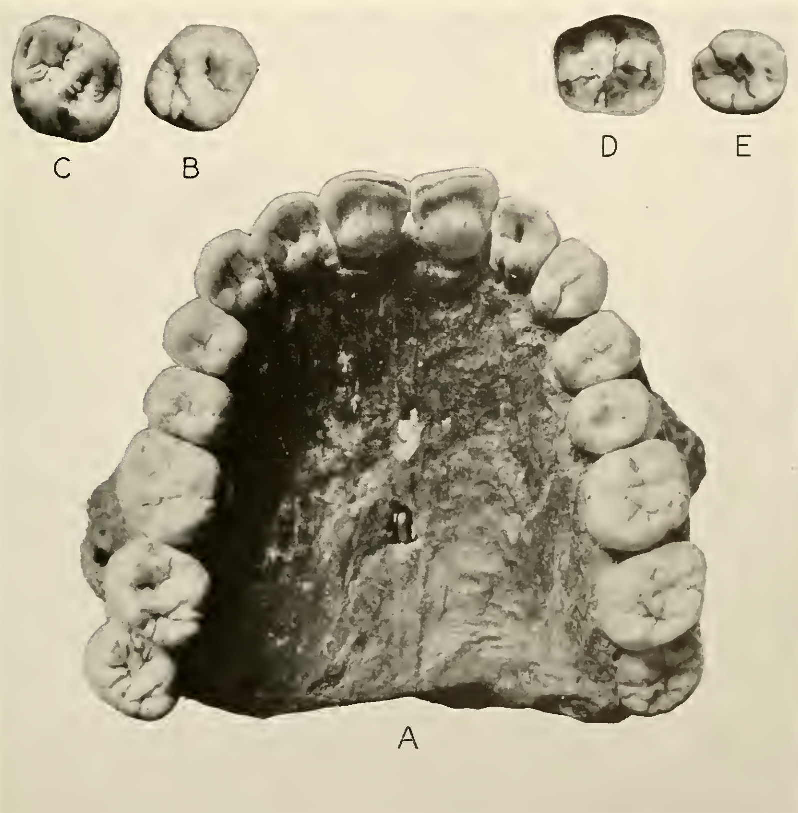

Fig. 9.—Anthropoid heritage in early human dentition.—Palate of Le Moustier (A). Comparison of second right upper molar of Le Moustier (B) with second left upper molar of fossil anthropoid *Dryopithecus rhenaus* (C). Comparison of first left lower molar of *Dryopithecus rhenanus* (D) with first left lower molar of Ehringsdorf child (E)

Significant Characteristics of the Neanderthal Foot

By DUDLEY J. MORTON, M.D.
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Department of Surgery, Yale University, New Haven

THE outstanding characteristic by which the human foot differs from the feet of all other mammals is its large and *distinctive development of the inner border*. Study of the foot structure in all forms of animal life demonstrates that a hypertrophy or increased growth of this nature is always located along the functional axis of the foot. That phenomenon is conspicuously seen in the single metatarsal and digit of the horse, where the functional axis has coincided with the mid-line of the foot; or, in the two-toed condition of cattle and deer, where the functional axis lies between the third and fourth metatarsal bones and digits. In the human foot the presence of a similar increased development along the inner border makes it necessary for us to discover some peculiar structural condition which would cause the centrally-located leverage axis in the primitive type of foot to become displaced upon the inner border.

In all the forms of animal life there is but a single and isolated group which shows a structural arrangement that would fulfill this requirement. This peculiar formation is restricted to the anthropoid apes where it is a constant and well-developed character; the structural character referred to consists of an abrupt inward slant of the calcaneal (heel) joint surface, that is, of the facet upon which the astragalus (ankle bone) rests. The obvious and inevitable effect of such an obliquity, as shown in the gorilla (Fig. 1A), is to deflect the body weight strongly upon and against the inner side of the foot.

But as the slant of this joint surface depends upon the actual position in which the heel bone is held, it now becomes necessary for us to determine definitely the position which this bone occupies in relation to the ground, when weight is borne upon the foot. This, however, presents no unusual difficulty. Examination of the posterior face of the heel bones of monkeys, apes, and other primates, as well as of mammals of other orders, shows that in a functional pose the axis of the posterior surface of the heel bone invariably lies in line with the pull of the attached muscles; and, as these muscles parallel the leg bones, the pull cannot be other than along a vertical plane in direct opposition to the force exerted by gravity.

Thus, when we place the gorilla, the Neanderthal, and the modern human calcanei (Fig. 1) in a position where the posterior heel axes are vertical, although the Neanderthal facet closely approaches the level position it occupies in the modern type of heel, nevertheless, it shows a distinct inward slant suggestive of the anthropoid condition.

Another intermediate character of the Neanderthal foot is the course taken by the tendon of the long flexor of the great toe. (Fig. 2A Fl.h.). In the anthropoid foot, the shelflike projection (sustentaculum tali, Fig. 2A S.t.) which helps to support the ankle bone, points obliquely downward so that the flexor tendon and its groove hug the base of this process; the tendon is continued up behind the astragalus to lie in another groove located well to the *outer* side of the central point on the posterior aspect of that bone. In modern man (Fig. 2C) the under plainly seen, occupying intermediate positions both on the heel and on the ankle bones.

Why and how does the obliquity of the heel facet influence the characteristics of the fore part of the foot? Be-

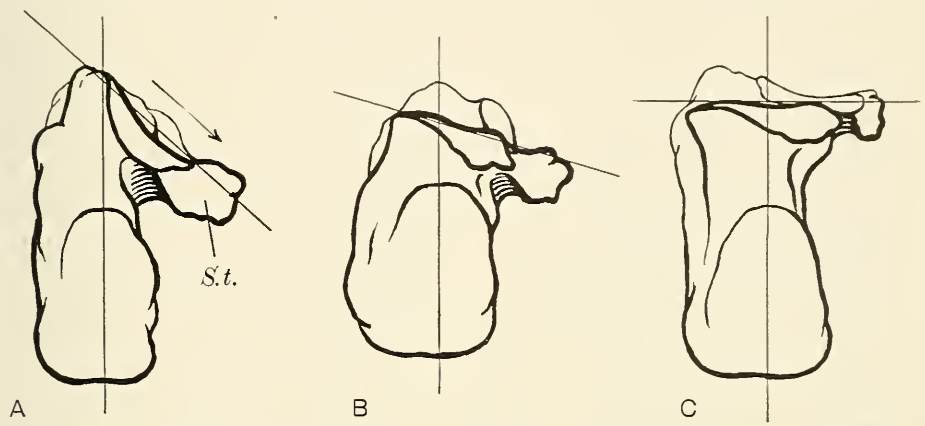

Fig. 1. Posterior view of left calcanei (heel) of gorilla (A), Neanderthal (B), and modern individuals (C), showing slant of sub-astragalar joint and shelflike sustentaculum tali. (S.t.)

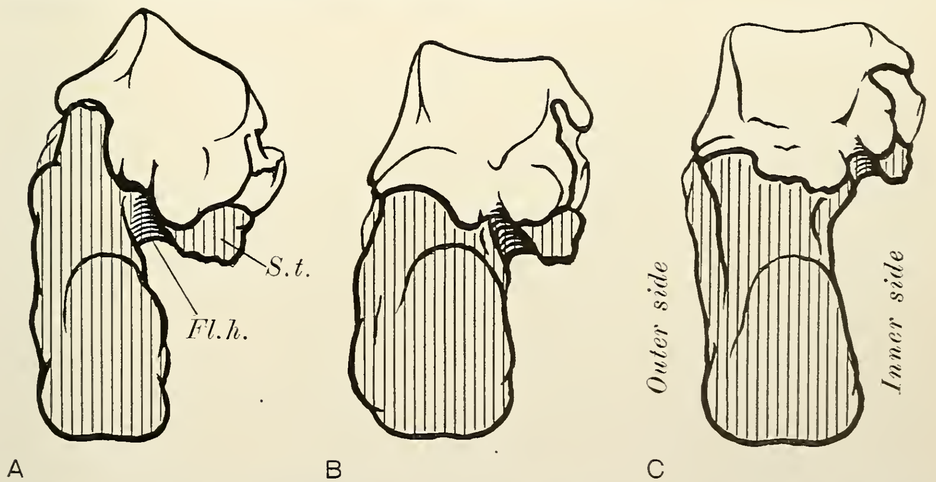

Fig. 2. Left calcanei of gorilla, Neanderthal, and modern individuals, with astragalus (ankle bone) superimposed. Fl.h. groove of long flexor tendon to the great toe

surface of this shelflike process slants upwardly, so that the tendon with its groove has shifted toward the tip of the process; also the groove on the astragalus has moved to the *inner* side of the central point.

In the Neanderthal bones, the grooves for the flexor tendon are cause it determines the manner in which the stresses induced by body weight are distributed throughout the foot; consequently, we may expect corresponding effects to be shown in the proportions and structural relations of all the elements of the foot. This we will now find to be just what happens.

The fact that man shares with some of the larger anthropoid apes, alone among Primates, the peculiar position of the main axis of weight (which lies along the inner border of the foot) is entirely consistent with the view that the human foot has been derived from a primitive anthropoid foot, much like that of the chimpanzee. This view has been abundantly supported by much independent testimony from many sources and is accepted by practically all anatomists who have made a sufficiently thorough analysis of the foot structure in the Primates.

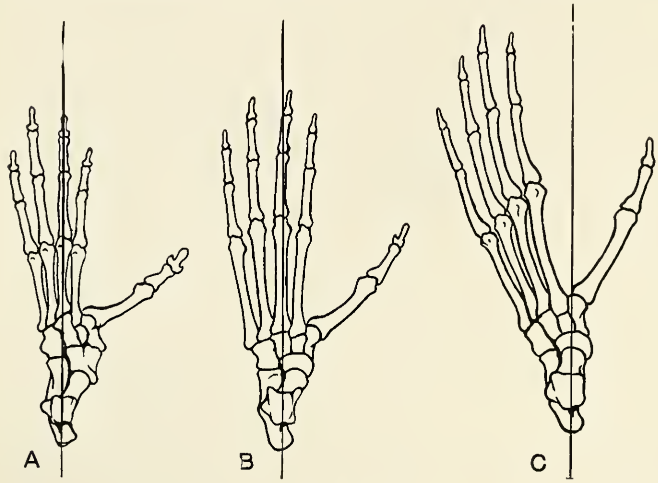

Fig. 3. The primitive functional axis as shown in (A) the lemuroid (*Lepidolemur*) and (B) simian (Macaque) types of feet; also the inward displacement of the functional axis (C) in the gibbon, the most primitive of living anthropoid apes

From *Jour. Bone and Joint Surgery*

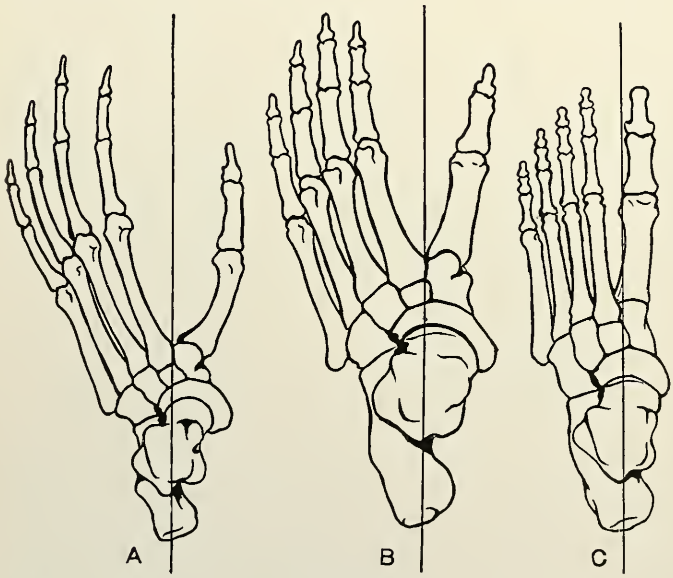

Fig. 4. Foot bones of (A) arboreal chimpanzee, of (B) ground-living gorilla, and of (C) man, showing increased development along the inner border of the foot and more massive heel, as a result of terrestrial usage

From *Jour. Bone and Joint Surgery*

Recognizing that the unique obliquity of the calcaneal facet in the anthropoid ape foot is the only structural condition which would ensure the functional axis being thrown along the inner border, we may provisionally regard the arboreal chimpanzee foot (Fig. 4A) as in a general way representing the type to be found in the ancient primate stock from which the human stem was derived. The short divergent hallux (great toe), the long digits, the slender metatarsal bones, and relatively small heel of the chimpanzee foot, are typical of its arboreal character.

The next stage which was one of the early terrestrial modifications, clearly demonstrates the effects of the sub-astragalar slant. The structural peculiarities of the feet of certain ground-living species of gorilla (*Gorilla beringei*) give unmistakable evidence (Fig. 4B) of the deflection of body weight against the inner border of the foot. The hallux has become notably increased in length and stoutness; the second metatarsal bone also has received a distinctly more robust development than the three outer ones. The reduction of the grasping function of the foot has permitted a shortening of the digits, but the hallux or great toe still retains its wide divergence. In place of the grasping function, however, the hallux, has now found a new, useful purpose in its divergence by acting as a buttress to stabilize the foot against the strong inward deflection of body weight; hence, its divergence would naturally be retained as long as the oblique position of the sub-astragalar joint persisted. The heel has acquired more massive proportions.

It is pertinent to note here that the foot skeleton of a captive chimpanzee which has come under my observation, shows similar gorilloid changes especially in the increased stoutness of the second metatarsal bone. The modifications which have taken place in this pair of feet, clearly differentiate them from the feet of native tree-living individuals, and give strong corroboration to the terrestrial character of the changes in the gorilla feet which I have just described.

The modern human foot presents very different characteristics, but the differences are essentially a matter of degree only. In the absence of a lateral inclination of the sub-astragalar joint, the foot has acquired what medical men call its "balance." Consequently instead of body weight being concentrated upon the inner border, it is more evenly distributed over the entire foot. The previously acquired hypertrophy of the hallux has been retained, even amplified; but in addition, we note a definite increase in the development of the fifth metatarsal bone, especially in its nearly vertical diameter. The characteristic arching of the human foot is the outcome of a remodeling of the bones in such a manner as to produce its balanced posture. At the same time this remodeling gradually eliminated the inward deflection of body weight, and the great toe was brought to its present position parallel to the second toe. Here it assumed more and more of the burden of the second metatarsal bone so that now the latter presents a relatively slight build. The massive heel of the human foot is merely a continuation of terrestrial modifications which had progressed to a notable degree in the gorilla.

The correlation of the position occupied by the anthropoid and human sub-astragalar joints, with the associated characteristics in the forepart of the feet, enables us to predict certain peculiarities of the Neanderthal foot which Professor Boule has either not noted in his writings or has mentioned but briefly. He speaks of the lowness of the arch in the Neanderthal foot—a condition which the slanting position of the shelflike sustentaculum tali would lead us to foresee. This obliquity would indicate a corresponding degree of divergence of the great toe because of the associated inward deflection of body weight. This point also, he has covered by stating that the basal joint of the hallux showed a greater curvature than is present in the foot of modernized man. But accompanying that divergence, there should be a definitely *increased stoutness of the* *second metatarsal bone* which he does not mention; also the fifth metatarsal bone should be of comparatively lighter build and more rounded in its transverse section—*not so vertically ovoid as in the modern foot*—another feature which he does not disclose in his writings.

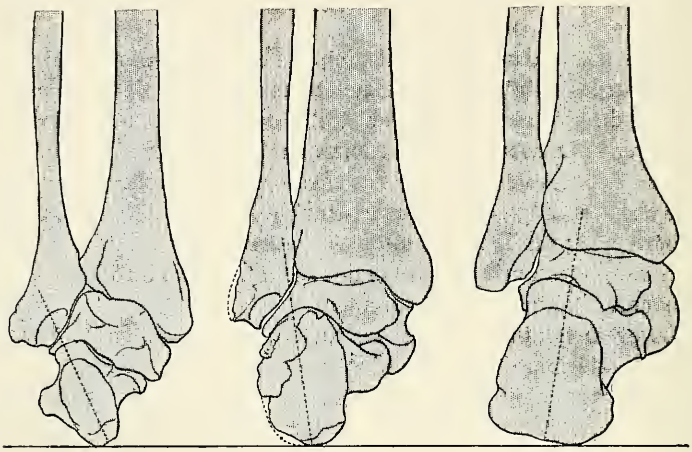

Fig. 5. Posterior view of the heels in (C) chimpanzee, (L.F.II) La Ferrassie II, and (F.R.) modern man, as suggested by Boule. While giving the Neanderthal an intermediate status, Boule apparently determines the position of the calcanei by levelling the sub-astragalar facets instead of placing the heel axes vertically. After Boule

In Professor Boule's illustration (Fig. 5), the axes of the heels are thrown at different angles instead of being placed vertically. His arrangement is very misleading. He shows the human foot in a somewhat abnormal, although a very common, *pronated* posture. Likewise, the position in which he pictures the chimpanzee heel does not represent a terrestrial weight-bearing posture. The position of its axis would indicate that the pull of the calf muscles was obliquely outward—an impossible action. Also, as the posture he gives would have the effect of eliminating the deflection of body weight upon the inner border of the foot through a leveling of the sub-astragalar joint, the functional axis through the foot would inevitably fall upon the outer border. The fact that it is the inner border of the anthropoid foot which invariably becomes hypertrophied under terrestrial conditions and not the outer, is structural evidence which absolutely demonstrates the fault of his premise.

On the other hand, the sequence that I have shown here representing the principal characteristics of four successive evolutionary stages (arboreal anthropoid, terrestrial gorilloid, Neanderthaloid and modern human) is a natural one and seems to be the only sequence which will successfully withstand critical analysis from the standpoint of the mechanics involved. Moreover, it conforms with the great mass of accumulated evidence which definitely unites human origin with an ancient arboreal anthropoid stem.

Taungs and Its Significance

By RAYMOND A. DART
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MAN is an omnivorous, bimanous, and bipedal, almost erect, terrestrial mammal. The highest living anthropoid apes are frugivorous, quadrumanous (or quadripedal), semi-arboreal, semi-erect mammals. It is believed that man arose from a semi-arboreal ancestor, to which the highest living apes are the nearest mammalian relatives, and that this semi-arboreal ancestor sprang, in turn, from an ancestor who was entirely arboreal in habit. Indeed, there are those who believe, that not merely man and all his near relatives, the Primates, but the whole mammalian stock came from ancestors who at one time lived entirely in the trees. We are not concerned here with this more remote origin of the Primates other than to note that they are tree-livers and that their ancestors were tree-livers from the earliest mammalian times.

In order to achieve his so-called erect posture and terrestrial mode of life, the monkey that was to be man had to pass through a severe apprenticeship, of which there were two initiatory phases, before he entered the third phase or true freemasonry of manhood. These two phases were firstly, the semi-arboreal (or semi-terrestrial) which is typified by the living anthropoid ape; and secondly, the entirely terrestrial man-ape phase which has been hitherto typified by one representative only—the man-ape of Taungs, found in Bechuanaland, South Africa.

It has long been recognized by naturalists that two such phases in man's evolution were probable; of the first phase we have in the four living anthropoids and many extinct ones a great deal of information concerning not only its essential characteristics but also its site of operation, i.e., in the tropical or subtropical forest zone. The second phase has been appreciated only as a theoretical necessity, and the scene of its occurrence has been purely a subject of conjecture.

The Taungs remains show that this second phase was a living reality; they demonstrate that man did not arise "Minerva-like in full panoply" as a sudden sport from some semi-arboreal ape, but that the anthropoid achieved human status by laborious passage through the terrestrial man-ape phase; finally they indicate, if they do not actually prove, the quarter of the earth upon which this penultimate act in the drama of humanity was staged.

It is in these matters that the Taungs remains have their significance. They have rendered real what hitherto has been theoretical. We will discuss certain evidence which demonstrates the nature of the body, habits, and mentality of the group of beings the remains have portrayed to us.

THE PLACE AND THE BARRIER

The Taungs limestone deposit is a cliff at whose feet, to the east lies the treeless (save for shrubs) valley of the Harts River and whose plateau crest, equally devoid of forest stretches west into the Kalahari desert. The temerature at Taungs fluctuates from 120° F. in summer to severe frosts and biting cold winds in winter. The

Fig. 1. *Australopithecus*, right side view of the skull

average annual rainfall is about five inches.

It is an area which impresses one, by its heat in summer, and its cold in winter, and by its lack of rain, of woods, of grass, of running water, and all things delectable, as the most inauspicious spot for man's forerunners. It is a region once thickly populated by Bush people and is now a native reserve occupied by a bastard Bush-Bantu race of Bechuanas. But areas such as this, habitable by mankind through his adaptability, his intelligent use of weapons, and his quickness of movement, are not habitable by the lumbering anthropoids of the tropics.

Hence, the appearance of *Australopithecus*, roughly on the latitude of Johannesburg, was most unusual and unexpected and can be explained only by the fact that *Australopithecus* had partaken of those characteristics which separate man from the anthropoids and make it possible for him to exist in such untoward environments. This

Fig. 2

Fig. 3

Fig. 2. *Australopithecus*, right side, cast of skull with restored outline of flesh
Fig. 3. *Australopithecus*, left side reconstruction

belief that *Australopithecus* profoundly differed from modern apes becomes more reasonable when we consider the geographical situation of Taungs. Lying in the Orange River watershed, it is separated from the Zambesi watershed by a vast open tract of country which, to the west, (from Western Rhodesia to the Atlantic Ocean) is the Kalahari desert, and to the north and east (throughout Rhodesia and the Northern Transvaal) is occasionally wooded but is mostly treeless prairie or veldt country. There is no woodland approach to Taungs from the north, east, or west. This open and in large part barren country, interposed between the tropical forest and Taungs is, and has been from Cretaceous times, an effective barrier against the migration of the semi-arboreal anthropoids of Africa—the chimpanzee and gorilla.

The efficiency of this barrier against the migration of the living anthropoids cannot be stressed too greatly when we call to mind the fact that during Tertiary times that barrier of desert and plains has been effectively reinforced by the fearsome carnivorous enemies of Primates, whose possession it was. It is obvious, *prima facie*, that the Australopithecoid group which forced this barrier into the remote Southland had evolved an intelligence (to find and subsist upon new types of food and to avoid the dangers and enemies of the open plain) as well as a bodily structure (for sudden and swift bipedal movement, to elude capture) far in advance of that of the slothful, semi-arboreal, quadrupedal anthropoids. They had thus attained a degree of physical and psychical advancement that sundered them irrevocably from their tropical cousins. It is equally clear that those who had successfully traversed the barrier and established their capacity to live in the latitudes of the Vaal had no serious barrier interposed between them and the southern extremity of the continent.

We may therefore reasonably indulge the greatest hopes of the discovery of youths and adults of the same and allied species in any part of Southern Africa, especially the Eastern coastal areas where the climatic and botanical conditions are so much more amenable for Primate existence.

The formidable nature of the land and animal barrier together with the vicissitudes of life, to which this Australopithecoid group was continually exposed in this country, is the more important to bear in mind since the factors which evoked the thinking and planning powers of the anthropoid, and, with these powers, caused the transformation from anthropoid to man, are to be sought, not in any cataclysmal upheavals of nature, or fortuitous saltations of the germ plasm, but rather in steadily and continuously operating environmental conditions which constantly and increasingly demanded the operation of choice and cunning.

Such an environment is certainly not to be found in any land belt containing the easy refuge of trees where the return to semi-arboreal existence was possible as, for example, throughout Southern Asia and the Eastern Indies.

Just as for the expansion of the brain so, for the evolution of a more erect posture, in which reliance would be placed upon the feet and not at all upon the hands, it was essential that a large territory should be available in order to make it impossible to return to the forest. In this way the anthropoid group should be committed over a countless number of years to the use of their upper limbs for fight and their lower limbs for flight. An environment of this type was present, because of the barrier already mentioned, from Cretaceous times onward in Southern Africa; and Southern Africa is the only country which has elicited, hitherto, an anthropoid individual betraying features such as one might expect to result from the operation of these unremitting and compelling environmental conditions.

I have dealt in some detail with the question of the barrier and the environment it provided, not merely because I was unable to devote more than passing attention to it in my preliminary discussion of the Taungs man-ape, but also because I feel that certain of the criticisms that have been made of my conclusions have been prompted by a failure to appreciate the presence of this barrier and the unquestionable nature of the results which the barrier and the terrestrial life, to which it committed them, must have had upon the bodily form of an anthropoid group which, prior to their leaving the forest, were semi-arboreal in habit. If we had possessed no endocranial cast and, consequently, no corroborative evidence concerning the increased intelligence, the better use of the hands and the more erect stature of this group of creatures from the actual remains themselves, these matters might reasonably have been inferred from a consideration of the geographical site at which the discovery was made.

THE CAVERNOUS FORMATION AT TAUNGS AND THE HABITS OF *AUSTRALOPITHECUS*

It has been suggested that the skull may have been washed into the cave from the surface in comparatively recent times. This view cannot be admitted for several reasons. In the first place the lower jaw is so closely associated with the upper jaw (being

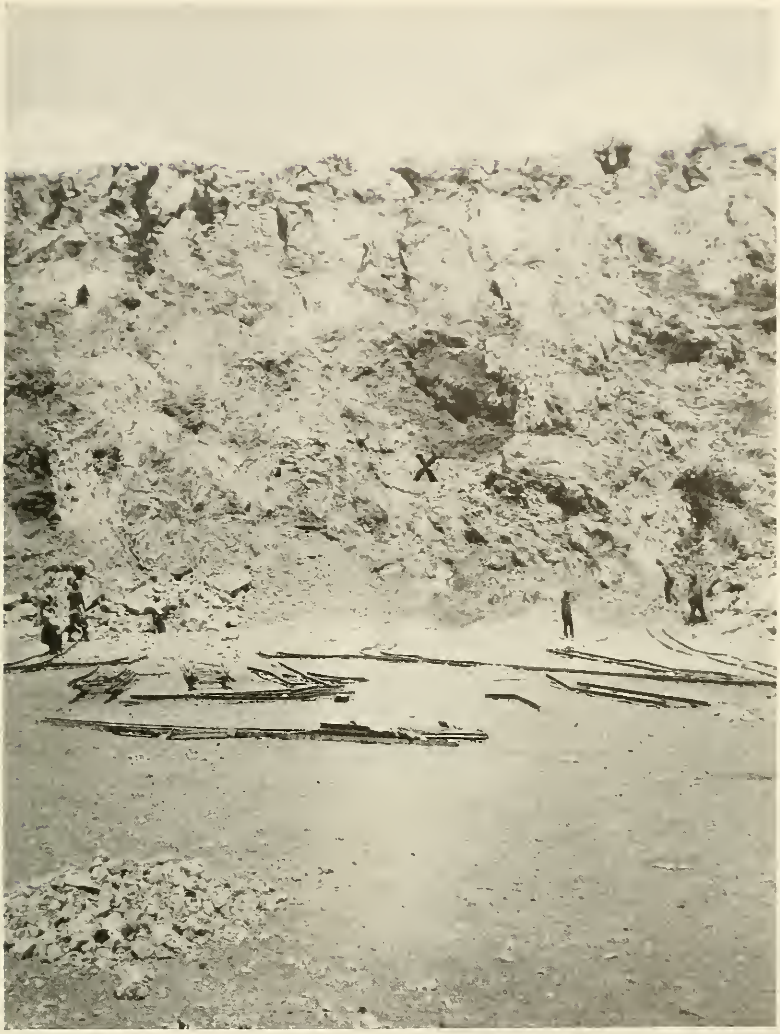


Fig. 4. Face view of the Taungs limestone cliff, showing the cavern in whose solidified floor (X) the Taungs skull was found

only displaced some 2 mm. forward) that a rolling of the remains over a distance and a fall of fifty feet into a cavern, to which no vertical opening has been demonstrated, is not seriously to be considered. Further, fragments of the distal ends of the forearm bones and of the phalanges were present in the rock mass from which the facial fragment was isolated. These proved too fragmentary and too friable to develop but portions are still visible in the stone. These together with the completeness of the skull parts, argue most forcibly against any such conception of the history of the bones.

In the second place the accompanying fossil deposit was a limestone bone breccia containing hundreds of fragments of bone obviously gnawed and constituting a midden heap. It has been suggested by some that the

Fig. 5. Lateral view of the Taungs limestone cliff. The (X) marks the cavern where the skull was discovered

Australopithecus child was itself the prey of some larger carnivorous creature of which this deposit indicates the den. The absence of any bones of larger animals in that recess and the completeness of the Taungs remains is against such an hypothesis. On the other hand the material, which looks like the comminuted bones of turtles, birds, small insectivores, rodents, baboons, and perhaps small bok, as well as birds' eggshells, indicates by its nature, its sparsity, and its searched over and exhausted character, the careful and thorough picking of an animal, which did not live to kill large animals, but killed small animals in order to live.

This conclusion was reached after many protracted searches by the mine operatives and myself for the accompanying fauna. The close association of baboons with the Taungs skull has always been surprising and is still not satisfactorily cleared up. Many of the baboon skulls show signs of fracture before fossilization. Recently I have been successful in isolating, from the breccia, part of the innominate bone of a baboon which was broken, splintered, and probably chewed before fossilization. It is my opinion that we have in *Australopithecus* a troglodytic anthropoid which, in addition to, and probably because of its increased intelligence and its skill in using its hands as hands and its feet as feet, had become sufficiently weaned from its frugivorous tropical diet to vary its table with the fruits of the chase. Today the limestone cliffs are riddled with bees' and birds' nests. Small rodents, turtles, lizards, and other reptiles are plentiful. The Thabaseek "river" pools are filled with rushes drooping with birds' nests, and provide fish, amphibian and reptilian life in profusion. Wild game of the water and the veldt, though not so abundant today, previously existed there in great numbers.

In the third place, these brecciated deposits do not occur under conditions which lend weight to the hypothesis of their being washed in from the surface. They were not found along a tract communicating with the top of the quarry but in isolated and rigidly circumscribed patches like lairs. The small area of breccia in which the *Australopithecus* skull was found has long since disappeared entirely. Recently, in an entirely different area some fifty yards or more to the Southwest at about the same level, another finely comminuted breccia, also circumscribed in extent, has appeared. As there has been an extensive cavernous formation throughout the limestone, the cavities represented by these patches of sand and sandstone probably communicated freely with one another in the remote past during which *Australopithecus* lived.

Considering the evidence impartially, I am led to believe that the man-apes of Taungs were terrestrial and troglodytic in character and that they were omnivorous, having already assumed the diet characteristic of primitive man in such places.

THE AGE OF THE DEPOSIT AND OF THE FOSSIL

With reference to the epoch at which the fossil was embedded in the limestone, there is bound to be much doubt until we know considerably more about the geology of the deposits themselves, and the general question of ageing deposits in Southern Africa. From a consideration, firstly, of the position of this specimen in the cliff; secondly, of the intensity of the infiltration of the lime to form the hard stone in which it was embedded; and, thirdly, of the fact that there is ample evidence in the cliff itself that sand was being incorporated in the cliff during the depositing of the lime, I am of the opinion that the limestone was deposited irregularly leading to the cavernous structure, and that the interstices were filling up with sand from a very ancient period, in large measure contemporaneously with the lime deposition.

In his notes on the baboons found at Taungs which he has kindly placed at my disposal, Doctor Haughton remarks, "It is certain that the sandy patches in the limestone and the bones embedded in them are of the same age as the main body of the limestone."

Since there was a certain growth forward as well as in height during the lime deposition, both the horizontal depth (250 ft.) as well as the vertical depth (50 ft.) at which the remains lay have a degree of significance. In other words I look upon the fossil as Tertiary and embedded while the lime formation was still in progress.

Since that time a ravine about one hundred feet in depth and nearly three-quarters of a mile long has been worn through the hard calcareous tufa when it was the original course of the tiny Thabaseek "river," a sluit or creeklike tributary of the Dry Harts River.

Later the "river" was diverted to its present course northward of the tufa through the softer shales, and has worn its bed to a point some two hundred feet below the top of the cliff. How long it has taken for these processes to become completed it is difficult to say, but in view of the fact that years may elapse without any running water ever passing over the "waterfall" at the head of the gorge through the plateau's edge and along the stream bed, and the further fact that water rarely, if ever, is running during a whole week in any year that rain falls—when of course it may be a raging though small torrent for a couple of days—it is impossible that the work of erosion could have been rapid. It is hardly necessary to say that in the period during which the area has been known, i.e., the last half-century, no appreciable alteration of the conformation of the stream or its channel has been recorded. Assuming for the sake of argument a uniform rate of backward erosion of ⅛ inch per annum, it will be seen that some 125,000 years were necessary for the formation of the dry ravine which is from 50 to 250 feet broad—the cutting of the modern river bed taking perhaps a somewhat briefer but additional period. At all events it is reasonable in the present state of our lack of knowledge to estimate the age of the river bed in terms of hundreds of thousands of years—possibly, as one has suggested, contemporaneously with the uplift of South Africa in the Pliocene. In any case the deposition of the lime deposits took place prior to that period, i.e., prior to the formation of the dry ravine and the present river bed, and so at a very remote period, probably pre-Pliocene. There is no evidence to indicate that the Taungs man-ape did not inhabit the district in those days of lime deposition.

The question must remain an open one on the geological side at present, but it is certainly sheer assumption to regard the deposit and the contained fossils as Pleistocene. Already four definitive human types are known from South Africa as fossils, Rhodesian, Boskop, Bush, and Bantu. All of these are distinctive types of mankind. They are essentially African in distribution and presumably locally evolved. It is true that Rhodesian man has Neanderthaloid affinities and that his geological age is uncertain, but that does not prove that he wandered southward from Europe. The discovery of Neanderthal bones in Gibraltar, Malta, and Palestine, the three gateways from Africa to the other continents, is evidence rather of the reverse migration. All the available evidence indicates that Africa is the fountain-source of her own peculiar stocks, the Rhodesian, Boskop, Bush, and Bantu races. She was probably the source of the Neanderthal stock, and Sergi has always regarded her as the source of the Mediterranean branch of the Caucasoid race. There can be no doubt that the lapse of a great period of time was necessary for the elaboration in Africa of these primitive and modern types. The discovery of the contemporaneity of man with various extinct animals—hippopotamus, mammoth, giraffe, giant pig, and giant buffalo—corroborates this conception of man's antiquity in Southern Africa. The gravels of the Vaal Watershed, which are apparently of Pleistocene age, bear these records. It would be amazing if the Taungs caverns existed in Pleistocene times and were not occupied by man who, as far as can be learned from the study of stone implements, infested the whole Vaal valley during that period.

RHODESIAN BOSKOP BUSH BANTU

Fig. 6. The four African types of primitive man

At Taungs itself, one can find ample evidence of human habitation throughout the vicinity in cave paintings, delicate stone culture and work in bone. But it is all superficial and in no case have human bones or implements of Bush people or of the remoter Boskopoid and Rhodesoid people been recovered from depth in those fissures and caverns in the limestone, for which some suggest a recent age. Until positive evidence of this type is forthcoming, one logically assumes that the deeper filling up of the fissures and the age of *Australopithecus* was anterior to the human period.

Apart from this general type of evidence, the examination of the associated fossilized baboons, which is proceeding here at the present time, promises to reveal the fact that the baboon fauna contemporaneous with *Australopithecus* was a different and more primitive type. Final conclusions have not as yet been arrived at, but it may be stated in general that at least two varieties of baboon were living at that time whose cerebral fissuration pattern was more primitive than that of living forms, and whose endocranial capacity was considerably smaller. There is, therefore, distinct promise that further discoveries and perhaps even those already made will prove that the deposits are of remote age, as the discovery of *Australopithecus* suggests in itself.

AUSTRALOPITHECUS AND MODERN ANTHROPOIDS

I have discussed the general question of the age of the Taungs deposits; it remains to make a few remarks about the fossil in comparison with modern apes. For this purpose I have had prepared three diagrams in which the cranial outline of *Australopithecus* is superimposed upon that of (1) an orang child of the same age, (2) a chimpanzee child considerably younger, in which the milk canines and first permanent molars are not fully erupted,

COMPARATIVE DIAGRAMS ILLUSTRATING THE DIFFERENCES BETWEEN *Australopithecus* AND THE ORANG, CHIMPANZEE, AND GORILLA

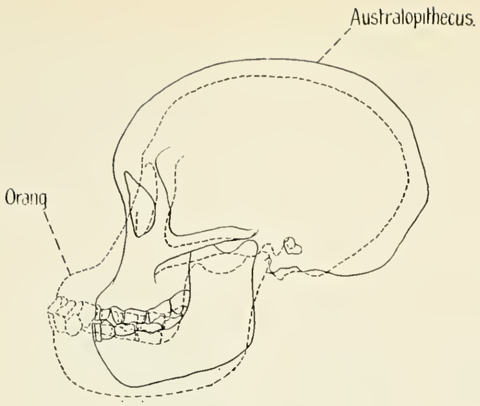


Fig. 7

Fig. 7. Superimposition of *Australopithecus* upon an orang child of the same age. Note the striking difference between the faces and brain cases of both and especially the overhanging forehead of *Australopithecus* as compared with that of the orang

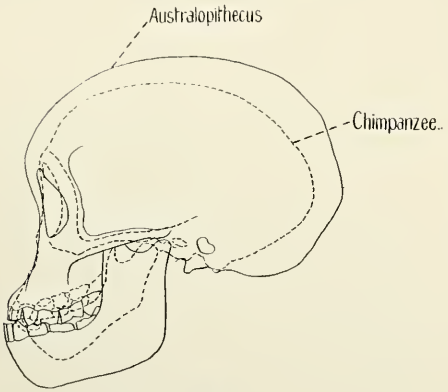


Fig. 8

Fig. 8. Superimposition of *Australopithecus* upon a younger chimpanzee child in which the first permanent molars are not erupted. Note the overhanging forehead and the absence of ridge over the eyes as well as the increased size of the brain case in *Australopithecus*

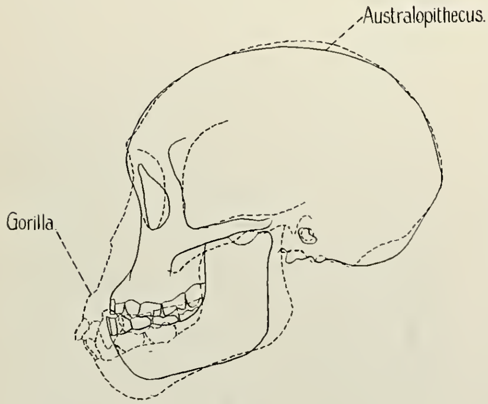


Fig. 9

Fig. 9. Superimposition of *Australopithecus* upon a younger gorilla child in which the first permanent molars are not erupted. Note the smaller teeth and muzzle, the overhanging forhead and the absence of the ridges over the eyes in *Australopithecus*. This gorilla is selected for its unusual size of brain case

and (3) a large-brained gorilla child also younger and in which the first permanent molars are not erupted.

These diagrams are of interest because various scientists, according to individual preference, have claimed *Australopithecus* as an orang, or as a chimpanzee, or as a gorilla. In all the diagrams the skulls are oriented on the same axis (a horizontal line running through the lower margin of the eye-hole and the upper margin of the ear-hole). It is unfortunate that the young chimpanzee and young gorilla are not of precisely the same age as *Australopithecus* but they are sufficiently old to bring out the points I wish to make.

In the first place, in all living anthropoid apes there are definitely marked eyebrow ridges which are entirely absent in *Australopithecus*. All living anthropoids portray a jutting-forward of the muzzle and a falling back of the forehead; while in *Australopithecus* the forehead bulges forward and overhangs the nose and the muzzle to the extent that this feature occurs in some races of man himself.

If we examine the first figure it will be seen how enormously beyond the brain capacity of the orang lies that of *Australopithecus*. In the second figure we are struck once more by the disparity in brain volume between the chimpanzee and *Australopithecus*. The chimpanzee is of course young and its brain would grow a little in size before the first molar was attained but the cerebral disparity would still remain. On the other hand our diagram gives an erroneous impression concerning the small facial parts of the chimpanzee which have not developed to the size they assume when the first molar is erupted, and yet they are already relatively more projacient than the features of the older *Australopithecus*.

In the third figure a large-brained gorilla child is compared with *Australopithecus*. Here, despite the size of the gorilla's brain, there can be seen its brutal overhanging eyebrow-ridges, retreating forehead, massive bones, enormous muzzle, jaws and teeth—features which would be even more pronounced were its first permanent molar erupted.

There is no need to elaborate here the width of the gap that lies between *Australopithecus* and the living anthropoids, for the differences that are seen at a glance spread to every detail of the cranial, facial, and hence also of the bodily make-up. The diagrams show that if *Australopithecus* has any relationships of size and form they are with the chimpanzee rather than with any other living anthropoid. It is consequently only with the chimpanzee that serious comparisons should be drawn in order to assess the nature of this extinct group of Primates.

Certain scientists seem to think that if the brain size of *Australopithecus* was not as great as that of some modern gorillas, *Australopithecus* is not to be thought of seriously as providing any evidence concerning man's ancestry. Nobody would seriously assert that mastodons, mammoths, and whales are more intelligent than man because their brains happen to be larger than man's. Their brains are larger because their bodies are so immense, for the same reason that a man's brain is on the average considerably bigger than a woman's. It is equally foolish to compare the brain volume of a gorilla with that of *Australopithecus*, since the latter was patently a lithe and smaller-bodied creature as compared with the gorilla.

Despite this fact I find the endocranial volume in *Australopithecus* to be 520 ccs. If we add 20 per cent, which is a reasonable amount to allow for subsequent expansion, we find that its adult endocranial volume would be 625 ccs. An adult gorilla has been reported with an endocranial volume of 610 ccs. But the usual range according to Keith is (females) 370–580 ccs. and (males) 420–585 ccs. The average volume for adult gorillas lies therefore in the vicinity of 475–500 ccs. A well-developed female gorilla in Professor Drennan's Department of Anatomy, University of Cape Town, provides an endocranial volume of 500 ccs. and an equally splendid male a volume of 575 ccs. If we look upon the Taungs child as an average specimen of his or her group and allow for adult Australopithecids the range obtaining today for adult gorillas, we may expect in them a fluctuation of from 518–733 ccs. This figure would bring their range of brain fluctuation within the range of fluctuation for Pithecanthropids arrived at in a similar fashion.

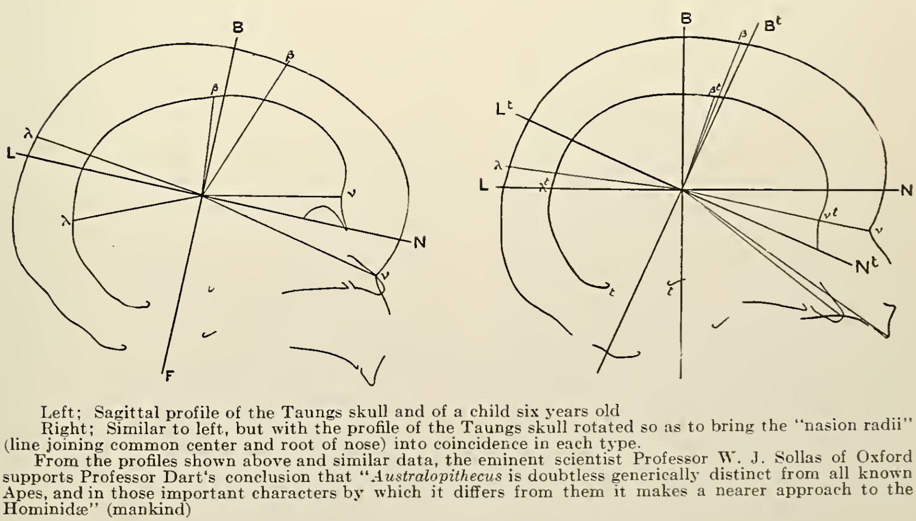
But the brain and intelligence of *Australopithecus* is rather to be compared with those of the chimpanzee which stands nearest to it in cranial, facial, and bodily form. From the data of Bischoff and Ranke it is known that the endocranial capacity in chimpanzees varies from 409–469 ccs. in adult males and from 345—413 ccs. in females, although cases are known where the volume has fallen as low as 290 ccs. Hence the average volume in adult chimpanzees lies in the vicinity of 375–430 ccs., that is roughly 100 ccs. less than in adult gorillas and 200 ccs. less than in the adult *Australopithecus.*

If we take Dubois' figure (850 ccs.) for the endocranial volume of *Pithecanthropus*, then the estimated endocranial volume of the adult *Australopithecus* (625 ccs.) lies about midway between that of the adult *Pithecanthropus* and the average for adult chimpanzees (400 ccs.).

Quite apart from the question of size there are numerous features about the shape and fissure pattern of the endocranial cast of *Australopithecus*, all highly technical, which denote the great advance of its brain beyond that of all living anthropoids.

These features, which concern more particularly the parietal association area of cortex (between the territories for vision, hearing and tactile discrimination) and the pre-frontal cortex (which is concerned with translating into bodily activity the information stored in the parietal memory area) are of such a nature as to lead me to believe that the brain and bodily form of the South African man-apes had attained a stage of organization which lifts them out of the category of the living anthropoid apes and places them certainly in a separate genus and probably in a separate family of beings intermediate between the chimpanzoid group of anthropoids and the most primitive known forms of mankind, the Pithecanthropidæ.

A restoration of the head of *Australopithecus* made by the well-known artist A. Forestier under the direction of Professor G. E. Smith, F.R.S. and published in the *Illustrated London News*



Left; Sagittal profile of the Taungs skull and of a child six years old

Right; Similar to left, but with the profile of the Taungs skull rotated so as to bring the "nasion radii" (line joining common center and root of nose) into coincidence in each type.

From the profiles shown above and similar data, the eminent scientist Professor W. J. Sollas of Oxford supports Professor Dart's conclusion that "*Australopithecus* is doubtless generically distinct from all known Apes, and in those important characters by which it differs from them it makes a nearer approach to the Hominidæ" (mankind)

Thomas Jefferson—Palæontologist

By FREDERIC A. LUCAS
Honorary Director, American Museum

WASHINGTON will ever be known as the Father of His Country, but Jefferson may well claim to be the Father of Palæontology. Others described fossils sent them from America, but Jefferson was among the first to pay them careful attention, and the first and only president to bring them to the White House. "Dolly" Madison, so we are told, found the big east room of the White House convenient for drying clothes; Jefferson used it for laying out the bones which he had secured from the famous Big Bone Lick, Kentucky, and many a palæontologist has wished he had similar space for his material. This may be called the first Palæontological Laboratory in America.

Cotton Mather (1712) may probably be credited with having presented our Mastodon to the world, and he was christened by Blumenbach in 1799, who unfortunately bestowed upon him the name of Mammut, but to Jefferson and Peale belong the credit of really introducing him to the society of his fellow fossils. Jefferson, indeed, seems to have cherished a faint hope that the Mastodon might still linger in the unexplored territory west of the Mississippi, and the Expedition of Lewis and Clark, the predecessor of the later Surveys West of the 100th Meridian, was, we believe, charged to keep an eye out for him.

By the courtesy of Mr. Lewis S. Gannett, we are able to publish a little-known letter of Jefferson's relating to the Mastodon, and the information of which he writes is taken from the *Itineraries and Correspondence of Ezra Stiles,* president of Yale from 1778:

Hartford, June 10, 1784

SIR:

After I had the pleasure of seeing you in New Haven I received information that you were in possession of several facts relative to the huge bones of the Animal incognitum found in America, or of the Mammoth as the Russians call the same animal whose bones they also find in the Northern parts of their empire. Mons.[r] de Buffon the celebrated Physiologist of the present age, who has advanced a theory in general very degrading to America, has in this particular also adopted an opinion which I think not founded in fact. it is that this animal was the same with the elephant of Asia and Africa. I think it certain that it was a different animal, having therefore on a particular occasion drawn his opinion into question I am still anxious of getting every additional information on the subject which may serve either to confirm or to correct the conclusion I had formed. I take the liberty therefore of asking from you a communication of whatever facts you may have become acquainted with as to this animal, as I shall not leave Boston till the 28th inst. any letter to me forwarded thither by post will probably come safe. perhaps it may be new to you that the bones of this animal have been lately dug up in the Salines of North Holston in Lat. 36°–30′ which is much further south than they have ever before been found. I understand from different quarters that the Indians believe this animal still existing in the North & North West tho' none of them pretend ever to have seen one. It is said that the bones abound on the upper parts of the Missouri. to a friend of science I know I need make no apology for the liberty of this application. after repeating your assurance of the pleasure with which I shall render any servies in my power to the institution over which you so worthily preside, as well as to yourself personally, I have the honor to subscribe myself with the most perfect esteem & respect Sir

Your most obedient
& most humble serv.[t]
TH: JEFFERSON

Received June 19, 1784. Ans'd. 21 June.
The reverend Doctor Stiles
President of Yale College, New Haven

And in a letter from Thomas Jefferson to Ezra Stiles, dated Paris, July 17, 1785,[1] he writes:

I thank you for your information as to the great bones found on the Hudson River. I suspect that they must have been of the same animal with those found on the Ohio; and, if so, they could not have belonged to any human figure, because they are accompanied with tusks of the size, form and substance, of those of the elephant. I have seen a part of the ivory, which was very good. The animal itself must have been much larger than an elephant.

Extracts from the Diary of the Rev. Edward Taylor, of Westfield, wc. he kept from 1682 to 1714:

. . . 1705. On the 23d of July "one of the Gentlemen of the Council at York carried thither a monstrous Tooth that weighed four pounds & three quarters, said to be one of the great Teeth of a man, whole & sound on the Top but much decayed in its fangs one of which being hollow contained half a pint of Liquor. It was dug out of a Bank or Hill that rose some 30 or 40 feet above the place, about 26 Miles below Albany, at a place called Claverack. They found another Tooth, that seemed to be a fore tooth that was four fingers broad; and dug up Bones that when they came to the Air turned to Dust, but one Bone they took up, judged a Thigh Bone, of a man, seventeen foot long."

The Diary adds,

This Acco.^{t} was given B^{o} Weekly News Letter for the Week ending August.

In June, 1706, he has this further about the Giant:

On the 14th one Koon, a Dutchman, that came from Albany, brot to my house & shewed me another Tooth of the Monster buried at Claverack, like a Grinder Tooth with three Ridges on its Top & as hard as stone, the fangs much decayed. It was as big as a great Fist & weighed two pounds & an ounce. And he brought two pieces of another Bone conjectured to be of the Wrist, being about a third part of the Bone if split down in its Length. The perfect Bone looking like dull Olivant was nigh an Inch thick and the porous inward part great. The Bone if it had had the other two parts joined to it would it is judged have been as big as the Calf of a Man's Leg of the biggest size. The Dutchman asserted that they took up a Bone judged to be the Knee Bone that was about a foot in its Diameter; and the place where the Bone lay was 25 paces long, according to which the Monster was judged above 60 or 70 foot high. The Indians flocking to see the monstrous Bones upbraided the Dutch with Unbelief in that they would not believe the Report of a monstrous person w^{c}. they had told them from their Fathers, vix. that about 240 years ago there was a monstrous person as high as the Tops of the Pine Trees, that would hunt Bears till they took the Trees, & then would catch them with his Hands, and would go into the River 12 or 14 feet deep and catch 3 or 4 or 5 Sturgeons at a time & Broil them on the Fire for his food. The 17th day two other Dutchmen brought another Tooth as big again that weighed Five pounds; it had three Furrows on the Top four ridges.

Extracted from the original Manuscript, Oct. 20, 1760, in Westfield.

Uncle Eldad adds about the Giant that he remembers hearing his Father conversing about it with the Dutchmen, & that the Tradition among the Inds. was that the Giant "was peaceable & would not hurt the little Indians,'. and the little Inds. would give him meat to eat & he would receive it kindly; tho they said they always was afraid of him. They however want afraid of him when they approached him with a piece of meat or food, w^{c} he would take without hurting them. He would knock the Bears off the Trees with his first or a Club. . . When the Indians first saw Vessels passing in the Sound off against Pancatuck, they said at first it was Weetucks a coming again. . .

About 1705 Mr. Taylor wrote a poetic Acco.^{t} of the Gyant found then at Claveric below Albany—and says that about fourty years before (or perh. 1666) he heard a Story of an Ind. Giant of incredible Magnitude & disbelieved it till he saw the Teeth, which he weighed, one above Two pounds & another full five pounds. He was told by the Dutchmen that the Grave or Extent of the Skeleton was Twenty-five paces, & they dug up a Thigh bone measuring seventeen feet long & a knee pan a foot Diam. The Ind. has often told the Dutch of this Giant who they said was as tall as the Pine Trees & died Two hundred & fourty years before.

[1]*The Writings of Thomas Jefferson*, edited by H. A. Washington. Washington, Taylor and Murray: 1853, I, 364.

The Thigh Bone was found & took up June, 1705, so he died about 1465.—A Tooth weighed four pounds & three Quarters. Grandfather Taylor says: "Two other Teeth after were took up and were Weighed by myself in my house in Westfield; one weighed five pounds, it had three furrows on the Top & was as hard as a stone; the other Two & one ounce. These Bones the Indians about Fort Albany flocking to see upbraided the Dutch of Incredulity for not believing them who told them that about 40 years before that Time they had an Indian as tall as the tall pine Trees, that would hunt Bears till they were treed & then take them with his hands & wade into Water 12 or 14 foot deep & catch Sturgeons 3 or 4 or 5 at a Time & broil & eat them."

The animal associated with Jefferson's name, however, is one of the great ground sloths, a group of animals peculiar to America, where they once ranged from Patagonia to Oregon. The first of these big animals was found in Argentina in 1789; the specimen described by Jefferson was found about ten years later.

In 1797, when Jefferson was packing his "mails" to go to Philadelphia to be inaugurated as Vice President, he included a number of bones from a cave in Green Brier Co., Virginia, on which he based a communication to the American Philosophical Society in which he termed the animal *Megalonyx* (Jefferson 1799 A. Hay), to which the French naturalist, Desmarest, later affixed the specific name *jeffersoni* in recognition of its distinguished discoverer. The title of Jefferson's communication was "A memoir on the discovery of certain bones of a quadruped of the clawed kind in the western parts of Virginia"; the bones themselves are preserved in the museum of the Philadelphia Academy of Sciences.

That Jefferson was not sure of the affinities of his "find," thinking it to be a carnivore and comparing it with a lion, is not surprising; neither were the European naturalists certain of the relationships of Megatherium, and a Spanish zoölogist objected to associating it with the little, sluggish sloth because "all the other edentates could dance in his carcass." Moreoever, to encourage Jefferson in his belief that the claws were from some huge carnivore, there were well authenticated accounts—at least reports from very reliable sources—of the occurrence of some huge beast of prey in Virginia—a beast big enough to kill and half devour a horse. And it shows Jefferson to have been a pretty good anatomist that when he received a description of Megatherium, he added a postscript to his memoir noting the similarity between bones of Megatherium and those of Megalonyx.

Not merely palæontology owes a debt of gratitude to Jefferson, but science in general, and as Doctor Goode says, "Had he not been a master in statecraft he would have been a master in science."

Notes from Field and Museum

ASIA

Central Asiatic Expedition.—Letters telling of the progress of his own work and including the latest news of Mr. Nelson's movements have been received recently from Walter Granger.

Following are a few excerpts:

Nov. 13, 1925.—"I am entering upon my winter's work at Wanhsien. Nelson is with me and both of our wives are along, preferring the cold raw Sze-chuan winter climate to the loneliness of Peking. We are due in Iehang at the lower end of the Ganges tomorrow; I tranship at that point for the upper river and Nelson will engage a small junk and proceed up through the gorges, examining the caves as he goes. His winter promises to be an exciting one and I hope a profitable one. My own district, about Wanhsien, is reported to be unusually quiet just now, but the Gorge region is always infested by roving bands of robbers and discharged soldiers with whom the traveller always has to take a chance. At Yen-ching-kao I hope to add something to the fauna already obtained, to get better specimens of those forms represented hitherto by fragmentary remains, and will especially keep a sharp eye out for further evidence of man and the higher apes."

Dec. 23, 1925.—"Pit-working has been at low ebb this fall, but is starting up now and I am hoping to reap my harvest later in the winter. A pretty fair skull and jaws of *Aeluropus* as well as several jaw fragments and teeth from the same pit are about all I have to date which is worth recording. There were four or five individuals of this bear in this pit, although ordinarily he is a scarce creature. I think I got none of him the second winter. There is no war and no organized banditry hereabouts now, for which I am grateful, for I do not feel quite so secure this year as before when I had Jim Wong with me."

Feb. 21, 1926.—"The fossil pits here are not being worked as extensively as they were both years before, and the great majority of the pits which have been dug have proved either entire failures or have yielded scanty and poor material. I have a small collection and a few choice things and am hoping for better success during this last month. Fortunately I can, and do, turn my hand to zoological collecting, and I now have a fairly exhaustive collection of the birds and mammals of this region, as well as many of the other vertebrates."

April 10, 1926, S. S. 'Kut-wo."—We came down the river without incident, although the Nelsons who preceded us from Wanhsien to Ichang, were shot up a bit, and one Chinese soldier passenger killed. Arriving in Hankow we found the railway cleared to Peking and so I dispatched four of our six boys, trusting to luck and Buckshot's level head that they get through. The other two boys and Nelson and I, with our wives, are going to Shanghai and thence by sea to Tientsin. Shipped six boxes of fossil and artifacts—our winter collection—from Hankow to New York. I never expected to be seasick travelling from Sze-chuan to Peking, but the Yellow Sea is pretty choppy at this time of year and I expect I am in for it. The only redeeming thing about this business is that we have had a chance to see the lower Yangtse. The river is seven or eight miles wide here and at one time this morning we were almost out of sight of land."

Two letters from Doctor Matthew give interesting news as follows:

April 14, 1926, Tientsin.—"I had expected to write you from Peking by this time, but am hung up here for the presen . I had an uneventful trip across, but learned on the way over that the railroad routes to Peking are out of commission, as the bridges were blown up some months ago and have not been rebuilt. I secured passage from Shanghai to Tientsin by steamship—a little cargo boat with accommodations for eight saloon passengers, and arrived here last Sunday, the 10th of April, only to find that the railroad from here to Peking is also out of commission for the last two weeks. Until last Sunday it was still possible to get up by automobile, but since then all autos have been turned back and had to return. Andrews was scheduled to be here today, but a wire from him in reply to my message sent on arrival, says that it is impossible for him to get through, as the roads are too dangerous now for travel. So I am stuck here until I hear from him again or until auto or train traffic is resumed. That may be any day as the Kno-minchun now in control at Peking appear to be on their last legs and are expected to abandon the ci y and retreat to Kalgan very soon. Then whic ever of the "allies" attacking it enters and takes control will probably restore order and communications without delay. A newspaper report says that Andrews had a rather narrow escape from a bomb. He took refuge under a flat car near the station and one end of the car was splintered up by the bomb. However, I do not understand that they expect much if any more of that sort of thing.

"I am much afraid that all this fighting will tend to delay our start and disorganize Andrew's plans more or less. But he will probably have foreseen the situation as possible or probable and adjust his program as far as it could be done. I have had no word from anyone in Peking except for the message from Andrews that I spoke of above so cannot give you any news of the party.

"I hope everything has been going well at the Museum and with best wishes to all the staff. . . ."

April 20, 1926, Peking.—"I reached here last night after having been delayed a week in Tientsin by interrupted communications. The trip of 83 miles took from 8 A.M. to 8:30 P.M. to get through, but they are restoring things to normal quite rapidly. Granger and Nelson have not arrived yet but are expected omorrow night. Hill and Beckwith are here. Young is up a Kalgan, and in his turn incommunicado, as the Knominchun troops are between here and Kalgan now. Andrews hopes at present to be able to get away about the first of May—but he will report to you on the general situation.

"I went over the collections that have been cleaned up by Olsen and his assistants. They have accomplished a remarkably large amount of first-class preparation of rather difficult material, some of it very difficult, and have cleaned up all of last summer's collections except what was sent to New York. The cost figures so far as I have been acquainted with them, are astonishingly low, and certainly vindicate the policy of cleaning up material here. . . .

"The first specimens I saw were the 'Coryphodon' skulls. . . It is, so far as I can judge offhand, identical with the types of *Eudinoceras* in the premolars, hence quite a bit different there from *Coryphodon*. I see no reason for placing the formation in the Lower Eocene or separating it from the Irdin Manha.

"A magnificent big Titanothere out of the super-Shara Murun beds equals or exceeds the largest American skulls—cf. our No. 492. Incomplete unfortunately, only the back of skull arches and part of palate with two molars. Several fine Titanothere skulls out of the Shara Murun (or Irdin Manha) one with lower jaws, neck and fore limbs and feet associated. Two or more long-legged rhinoceroses with skulls that suggest an ancestor of *Baluchitherium* in the *Trigonias* stage of evolution. . . .

"The prize specimen is the *Baluchitherium* legs and feet—not much of the legs, but the feet are extraordinarily fine. The reduction of the lateral digits, especially of the second digit, is greater than in any other rhinoceros and the toes are excessively short. The trapezium and fifth digit, especially the former, are relatively more reduced than in *Teleoceras fossiger;* the forefeet considerably longer than the hind, but not much larger. Separate specimens of *B.* include a femur, an anterior dorsal and some rib fragments. I think that with casts of these specimens and the inferences one can make from their proportions and with the data that I hope to get at Leningrad of Borissiak's specimen, we should be able to make a plaster reconstruction of the skeleton. I can figure out most of it now, except for the character of pelvis, length and curve of backbone and length of ribs.

"Andrews' present plan is to begin with the Shara Murun district and dump us all out there for some three or four weeks of intensive collecting in the new localities found last year and prospecting for other fossiliferous pockets in the extensive exposures that lie to the southward. This will also involve some careful stratigraphic studies which must be tied up closely with the fossil collecting and with previous collections, so that we can clear up the exact relations of these Upper Eocene faunas and fix the true position of the red beds that overlie them and of the underlying red bed (Arshanto). Granger, Beckwith and I can work well together on this problem.

"The fighting in this district has interfered seriously with Andrew's plans for the expedition; indeed it is remarkable to me that he has been able to get through so much with such conditions to face as have prevailed this winter.

"I spoke with Grabau over the phone this morning and hope to meet him and have a talk over some of our problems this week. . ."

A Peking newspaper dated April 13, fully confirms the report in the New York papers that Roy Chapman Andrews had twice narrowly escaped death during an air raid in which bombs were dropped around the Hsi Chih railway station in Peking. Mr. Andrews and his Chinese assistant, Mr. Lo, were in a motor car when a bomb was dropped within forty feet of the car. When a second bomb came even closer they abandoned the car. Mr. Andrews took refuge under a freight car and crouched behind one of the iron wheels. A bomb exploded just on the other side of the car and one of the iron fragments struck the earth within a few inches of his nose. On the margin of the newspaper he writes to President Osborn:

"All well—don't worry. This *was* a narrow escape but bombs don't strike twice in the same place. It was rather amusing after all. Expect we'll get off May 1st. At present we are completely isolated. We watch the battles from the roof of the hotel and have 'Bombing Breakfasts' there in the A.M.

R. C. A."

Under date of April 14, Andrews writes from Peking:

"I havn't time to write just now but I'll tell you the news later. As I write, an airplane is dropping bombs in the city. It is getting to be rather annoying. I got cars a week after we arrived . . . and our stuff and two motors are at Kalgan. At present a terrific battle is going on about us and guns booming all day and night. Matthew safe in Tientsin. Burden due there in few days. Granger and Nelson on the way up from Shanghai.

"I'll get the expedition off but it is about the most difficult job I've ever been up against. However it is *fun* and I never worry."

Mr. and Mrs. Douglas Burden, on their way to a collecting expedition in the Dutch East Indies, called at the headquarters of the Central Asiatic Expedition in Peking at a very exciting time, when the opposing Chinese armies were struggling for the possession of the city. At the latest reports both armies stood between Andrews and Mongolia, and it was doubtful whether he could succeed in getting the expedition through the lines.

Cretaceous Mammal Skulls at Last.—For several generations palæontologists have bewailed the fact that, during the long ages of the Cretaceous in which the dinosaurs were dominant, the mammals, with few exceptions, completely escaped preservation as fossils; at least if they were preserved their remains have been destroyed during the millions of years of subsequent wear and tear on the earth's strata.

The chief exceptions are a few very fragmentary jaws and teeth of small mammals hitherto found in the dinosaur beds of Montana. But last year the Third Asiatic Expedition, while collecting the dinosaur eggs in the desert of Gobi, found in the same formation parts of six skulls and a number of lower jaws of small mammals. These priceless specimens have been worked out of the matrix and have recently been studied by Dr. W. K. Gregory of this Museum and Dr. G. G. Simpson of the Yale Museum. They report that these little skulls fully accord with the inferences of Huxley, Osborn, Matthew, and others that the structural ancestors of all the higher branches and sub-branches of the mammals would be found to be small "insectivores" with primitive brains and "tritubercular" cheek teeth.

The Morden-Clark Asiatic Expedition has successfully met and overcome all the initial obstacles on its journey to the Russian Pamirs by way of Afghanistan. After securing permits from both the British and the Russian governments the expedition got safely over the Burzil pass, which is the most difficult one on the Gilget Road to the Russian Pamirs.

President Osborn has recently received from Colonel Faunthorpe information telling of the accumulation of new and interesting material for the Asiatic Hall of Mammals. Colonel Faunthorpe, who is in the field in India, has secured, among other specimens, the parah stag, the four-horned antelope, and a small series of the hispid hare, a very rare animal. Colonel Faunthorpe is striving to complete the leopard group, for which he seeks a female and two cubs.

AFRICA

Chapin-Sage Expedition.—From East Africa James Chapin, of the Chapin-Sage Expedition reports the successful beginning of the field work. The expedition plans to traverse Central Africa and to ascend Mount Rouwenzori to study the effects of temperature, altitude, and other factors on bird life and distribution.

Carl Akeley writes from Mombassa that the members of his party were recovering from the "flu," that he had met Chapin and that the expedition was proceeding satisfactorily. One of Mr. Akeley's principal objects is to secure material, including photographs and color sketches, for the background of his gorilla group, the gorillas themselves having been collected on his previous expedition and being now mounted and placed temporarily on exhibition. Mr. Akeley's eloquent pleas for the protection of the gorillas against ruthless collectors undoubtedly influenced King Albert of Belgium, who has set aside a great tract in the Kivu district as a perpetual sanctuary for the gorillas and other animals.

After the successful conclusion of the Vernay Expedition in Angola Mr. Herbert Lang proceeded to Southwest Africa and thence to Cape Town, collecting on the way. Some of his material has already arrived safely at the Museum.

The Department of Preparation at the Museum, although handicapped by the necessary absence of several of its members on some of the expeditions mentioned in these notes, is doing its full share toward preparing exhibits for the great halls of African and Asiatic mammals which will be located respectively in the Roosevelt Building and in the new northeast wing.

BAHAMAS

Dr. Roy W. Miner is expecting to sail shortly for the Bahamas to obtain additional material for the new coral-reef group to be installed in the Hall of Ocean Life. The expedition is made possible through the generosity of Mr. John H. Phipps who will accompany the expedition and has placed at its disposal the use of his yacht "Seminole." The personnel of the expedition will include Mr. C. E. Olsen, modeler on Doctor Miner's staff, and Mr. F. L. Jaques, artist. Doctor Miner will leave on June 25 for Nassau, while the main part of the expedition will sail for Miami on July 9. Among other things the expedition hopes to secure sketches for the half-dome cyclorama forming the upper part of the group, as well as casts and models of reef fishes. Diving helmets will be utilized for securing additional observations of coral-reef life.

WEST INDIES AND SOUTH AMERICA

West Indies.—Mr. H. E. Anthony, curator of mammals, recently returned from the West Indies, where he had been collecting and studying the fossil mammals of the islands of Mona and Desecheo. These fossils are of special interest on account of their bearing on the problem of the origin of the mammal fauna of Porto Rico. Mr. Goodwin of the department of mammals remains in the field.

South America.—Mr. Tate is collecting for the department of mammals in Bolivia, and Messrs. Watkins and the Olalla brothers in Brazil.

PANAMA

Dr. Willard G. Van Name, associate curator of lower invertebrates has recently returned from a trip to Panama with a collection of 950 specimens of marine invertebrates obtained mostly on the Pacific side of the Isthmus, particularly at the Pearl Islands and at other points in the Bay of Panama, as well as at Barro Colorado and Gatun Lake. This region has been practically unrepresented in the invertebrate collections of the Museum.

YUCATAN

Thanks to the kindly interest of Mr. George Palmer Putnam and Mr. Gregory Mason, Mr. Ludlow Griscom represented the American Museum of Natural History on the Mason-Spinden Expedition to Yucatan last winter. This expedition, which was primarily engaged in searching for ruined cities of the ancient Maya civilization, left for Belize, British Honduras, on January 6, and sailed north from there along the coast of eastern Yucatan in a specially chartered schooner. The particular interest of the bird department was in obtaining specimens of the peculiar species found on Cozumel Island off the Yucatan coast, and to determine definitely whether they occurred on the adjacent mainland. Mr. Mason afforded Mr. Griscom every opportunity for these investigations. Landings were made at many places along the hitherto unexplored mainland and adequate collections were obtained on Cozumel Island.

More than 200 species were definitely recorded during the trip, and quite unexpectedly seven proved new to science. A number of species were found not previously recorded from Yucatan, and several others were reviously unreported in our collections. A lar e colony of rosy flamingos was one of the most interesting discoveries, as this species is found in only four other places in the world, in most of which it has been rapidly decreasing. A detailed report of the results of the expedition is in course of preparation.

GREENLAND

The Greenland Expedition, under the direction of Mr. George Palmer Putnam and financed chiefly by Mr. Harrison Williams, expects to leave New York about June 20 in an auxillary schooner commanded by Capt. Robert Bartlett. The object of the expedition will be to secure some much needed material for the new Hall of Ocean Life, especially specimens of the narwhal. Mr. H. C. Raven, associate curator of comparative anatomy of the Museum, will be the chief zoologist and Mr. Van Campen Heilner of the department of fishes will be the ichthyologist of the expedition.

GULF OF CALIFORNIA

Mr. Keith Spalding of Pasadena, California, is cruising in the Gulf of California in quest of big game fishes. Mr. Escherich of the Museum's department of preparation is his guest and they are hoping to secure some fine specimens for the new Hall of Fishes.

THE MEDITERRANEAN

Doctor and Mrs. Murphy will be the guests of Mr. and Mrs. Jesse Metcalf on a cruise in the Mediterranean, which will give Doctor Murphy an opportunity to collect birds and fishes.

MEETINGS OF SCIENTIFIC SOCIETIES

Doctor Chapman and Doctor Murphy represented the Museum at the International Ornithological Congress held in May at Copenhagen. Doctor Chapman will also go to England to the Royal Geographical Society meeting in June.

The Society of Mammalogists and the Museums Association held their spring meetings at the Museum.

CONSERVATION

The "Save the Redwoods" movement, actively backed by President Osborn of this Museum, President Grant of the New York Zoological Society, and President J. C. Merriam of the Carnegie Institution has been successful in saving the magnificent stand of redwoods in Bull Creek Flat 200 miles north of San Francisco.

It must be very gratifying to the leaders in this movement to learn that due to their foresight and planning this magnificent forest will be handed down to posterity to enjoy.

UNDERSEA PAINTINGS

Through the generosity of Mrs. William H. Bliss of this city, the Museum has received an addition to the series of beautiful undersea coral paintings made by Mr. Zarh Pritchard in the coral lagoons of the Society Islands. To secure these paintings, Mr. Pritchard donned a diving suit and, seated on the bottom of the sea, made preliminary sketches with oil colors on waterproofed canvas. The finished paintings are most delicately and beautifully executed on sheepskin and give a remarkable picturization of the soft beams of sunlight playing upon the eroded arches and pinnacles of ancient coral reefs, crowned and fringed with living coral colonies.

Mrs. Bliss's donation is one of the finest of the series already presented to the Museum.

Another similar and exquisite painting has recently been presented by the artist himself. Thus the Museum now possesses a fine representation of Mr. Pritchard's work depicting the submarine life of the Pacific islands.

Eventually these reef paintings will be displayed in the Museum's new Hall of Ocean Life, and will be exhibited in connection with the great West Indian coral-reef group, one of the central features of the new hall.

FANCY SAPPHIRES

A notable gift, recently made to the gem collection by Mr. J. P. Morgan, consists of nine corundum gems of the variety known as "fancy sapphires." These are of unusual size and of a rich color and, with the fine series of these gems already displayed, form a magnificent suite.

VON LUSCHAN COLLECTION

Frau von Luschan, widow of Professor von Luschan of Berlin, recently visited the Museum and gave much valuable data pertaining to the great von Luschan collection of human skulls and skeletons, which was acquired two years ago by the Museum, chiefly through the generosity of Mr. Felix Warburg.

PUBLICATIONS

Mr. Childs Frick has recently returned from the Paris Museum, where he studied the fossil mammals of the French later Tertiary formations. His expedition last summer in the Miocene of New Mexico yielded, as an unexpected prize, a well-preserved skeleton of a large extinct mammal that combines characters of the dogs and bears. It proves to be an American representative of the extinct European genus *Hemicyon*, and, together with other new material, has led Mr. Frick to the interesting conclusions—recently published in the Museum *Bulletin*—that the bears were already present in this country before the Lower Pliocene, and that the family is too old to be derived from the extinct European genus *Ursavus* as previous authors have supposed; also that *Hemicyon*, *Ursavus* and some fossil genera from India constitute a natural group, which he names the Hemicyoninæ, distinct from both the dogs and the bears.

Time Measurements of Glacial Clays — More than ten thousand years ago, the margin of a great continental glacier stood over the site of New York City, and adjacent lowlands. At the same time in the Hackensack valley stratified beds of glacial clay were deposited in a fresh-water lake as the ice front retreated slowly northward from year to year. A remarkable feature of these clays is that they are seasonally banded: the "summer" layer composed of fine sand and coarse clay particles, corresponds to the melting period of the ice; the "winter" layer consisting of pure clay, represents the cold season of each year when no streams flowed into the lake from the ice front and the fine clay particles, held in suspension following the summer incursions, quietly settled to the bottom of the lake. In the clay banks the "summer" and "winter" layers alternate in position. Frequently there is a gradation from the summer period into the winter, but the close of the "winter" deposition is sharply set off from the following "summer" sediments.

In *Novitates* No. 209, recently published by the Museum, Associate Curator Reeds gives an interesting account of his studies of this remarkable series of seasonal deposits. He recognized the varve, the amount of aqueoglacial sediment deposited in one year, as the unit of deposition and time measurement. From five clay pits near Little Ferry, New Jersey, Doctor Reeds has established a composite section of 43 feet of clay which contains five thousand seasonal layers, or 2500 varves representing as many years. In a curve of the varves, comprising four graphic charts, he has shown the thickness of the varves which vary from year to year, in fact, they run in series which respresent climatic fluctuations and variable periods of melting of the ice.

Doctor Reeds' report on the Little Ferry district serves as a key section for only the middle portion of the Hackensack valley. When a complete set of clay sections has been secured from other localities in the Hackensack and Hudson River valleys and each locality has been studied and correlated with the present elevations, data will be available for a definite record of the postglacial history of the region.

A New Handbook. "The Story of the Minerals" by Herbert P. Whitlock has recently been published as No. 12 of the Handbook Series. It is in no sense a text book but is intended to increase public appreciation of the Morgan Memorial Hall. Some particularly impressive specimens are both illustrated and described in this handbook

If there are any subscribers to Natural History who feel that they would care to donate copies of the earlier issues to the American Museum Library, the gift would be very much appreciated. There are frequent calls for complete files which the Library is no longer able to fill.

HONORS

The Wollaston Medal, was awarded to Professor Henry Fairfield Osborn at the annual general meeting of the Geological Society of London, Feb. 19, 1926, in recognition of his distinguished services to science as a palæontologist.

When handing the medal to Mr. Boylston A. Beal, councillor of the Embassy of the United States of America, for transmission to the recipient, the president of the Society, Dr. John Williams Evans, C. B. E., F. R. S., addressed Mr. Beal as follows:

"In handing to you the Wollaston Medal, the greatest honor which this Society has the power to bestow, for transmission to Professor H. F. Osborn, I should like to express the admiration which the Fellows of this Society feel for his long record of valuable researches on the Palæontology of the Vertebrates. In his early expeditions to collect mammalian remains from the older Tertiary rocks of Wyoming, he recognized the importtance of ascertaining the exact stratigraphical position in which they were discovered, so as to be able to trace with certainty the succession of extinct forms, and to determine the relative ages of those found in different parts of the world. In 1910 he published his conclusions in 'The Age of Mammals in Europe, Asia and North America.' In a long series of publications he has dealt with almost all groups of Mammals and Reptiles; but especial reference may be made to his important contributions to our knowledge of the Rhinoceroses, Horses, Titanotheres, and Dinosaurs. In his handsome volume on the 'Men of the Old Stone Age, their Environment, Life and Art,' which was first published in 1915, and has gone through several editions, he had made a welcome addition to popular scientific literature.

"He has held numerous important posts, especially in the American Museum of Natural History, New York, of which he is now the President, and has, in connexion with that Museum, organized a complete survey of the geological succession of the higher Vertebrates of North America.

"During recent years he has directed a systematic search for fossils in the Cretaceous and Tertiary strata of Mongolia, and large and important collections of previously unknown forms have been obtained, which he is now studying. Not his least service to Science has been the foundation of a flourishing school of Vertebrate Palæontology, which already includes the names of a number of brilliant men of science, who are working in cordial cooperation under his inspiring leadership."

Obverse and reverse of the Wollaston Medal, the highest honor conferred by the Geological Society of London

The Peking Society of Natural History organized and adopted a constitution on September 21, 1925, and now has a membership of more than one hundred, among whom are many of the leading scientists of China. At their annual meeting held March 12, Honorary Membership was conferred upon Professor Henry Fairfield Osborn. The Society will publish a periodical entitled "The Bulletin of the Peking Society of Natural History."

Professor Osborn, has also been elected Honorary Fellow of the Royal Society, an honor bestowed upon only three other American citizens, Benjamin Franklin, Alexander Agassiz, and Benjamin Thompson (Count Rumford).

We quote from *Nature,* May 8, as follows:

"In the early days of the Society's history, it was the custom, on the election of specially notable philosophical inquirers and workers, not of English birth, to send them an ornate diploma carrying the Society's seal. Birch, the historian, records that, in 1680, 'Dr. Gale was called upon for the diploma to be sent to Mr. Leewenhoeck, and it was ordered that the society's seal should be affixed to it, and that a silver box should be provided for it.'"

"Professor Osborn is among the most distinguished palæontologists of our time. His first publication (1883) dealt with the structure of the brain in amphibia; later memoirs dealt mostly with fossil vertebrates. One of the results of his work is the more precise determination of the relative ages of the extinct mammals of North America. As director [president] of the American Museum of Natural History, Professor Osborn has made the institution world-famous. He has had distinctive influence in establishing a school of younger palæontologists. In 1918 he was Darwin medallist of the Royal Society."

Professor Osborn is the second member of the Museum staff to be thus honored by the Royal Society, Dr. W. D. Matthew, who is a British subject, having been elected a Fellow in 1919.

Doctor G. Clyde Fisher, curator of visual instruction and in charge of the astronomical department of the American Museum, is the recipient of the honorary degree of Doctor of Laws, conferred upon him June 14 by the faculty of Miami University.

Roy Chapman Andrews Receives the Doctorate —The first academic recognition of the scientific accomplishments of the Central Asiatic expeditions of the American Museum is the award of the honorary degree of Doctor of Science to Roy Chapman Andrews by Brown University, at a special convocation on February 24, 1926. On receiving the degree from the hands of President Faunce, Mr. Andrews made a brief speech of acceptance.

This honor gives the greatest pleasure not only to Mr. Andrews but to all of his associates on the expedition and in the American Museum.

The Seventieth Birthday of the famous Belgian palæontologist, Professor Louis Dollo, will be commemorated in a Festschrift volume by fifty scientific colleagues in Europe and America. Professor Osborn, Professor Gregory, and Doctor Matthew will represent the Museum in this volume.

APPOINTMENTS

Prof. Bertram G. Smith of New York University Medical College and Prof. A. B. Dawson of New York University have recently been appointed research associates in the department of herpetology. Professor Smith is well known for his embryological studies on *Cryptobranchus*, while Professor Dawson has made many brilliant anatomical and histological investigations of *Necturus* and other vertebrates.

LEWIS B. WOODRUFF

In the death on November 27, 1925, of Lewis B. Woodruff, two divisions of science lost a conscientious and devoted worker. Although a lawyer by profession, Mr. Woodruff gave his time increasingly to the study of nature, and for many years prior to his death had dedicated practically all of his energies to this pursuit. Originally interested in ornithology, he made a very thorough collection of North American birds and their eggs, and became familiar not only with the appearance but with the notes of all of the summer and winter residents and the birds of passage of this locality. But this early love was in time supplanted by an even more ardent devotion to entomology, and in this wider and less investigated field he found greater opportunity for research. In the course of the years he studied such groups as the beetles, the dragonflies, and the tree-hoppers (Membracidæ), contributing valuable papers as well as building up embracing collections.

At the time of his death he had charge of the assembling of the material for the volume on insects that is to be issued by the New York Academy of Sciences in its series of studies on the flora and fauna of Porto Rico and the Virgin Islands, and he was himself planning to write up one or more of the groups to be considered in this volume. With characteristic thoroughness he prepared himself for the task by visiting the islands last year.

Mr. Woodruff was keenly interested in the activities of the New York Entomological Society and a constant attendant at its meetings. He served it in several official capacities, including that of president. Among the bequests to various institutions that he made was one of $10,000 to that organization. His collections he designated for deposition in the Museum.

NEW MEMBERS

Since the last issue of Natural History, the following persons have been elected members of the American Museum, making the total membership 8937.

Associate Benefactor: Mr. Harrison Williams.

Patrons: Mesdames Isaac H. Dixon and Geraldine R. Dodge.

Fellows: Mrs. Z. Chafee.

Gen. Coleman du Pont.

Messrs. John Edwards Barbour, William du Pont, Clifford Warren Smith.

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ASTRONOMY

JULY-AUGUST

The forthcoming issue of **Natural History** will be devoted to the subject of Astronomy, a most timely arrangement, since the plans for the proposed Hall of Astronomy have just been completed. One article will deal particularly with the plans for this addition to the buildings of the American Museum of Natural History. This has been written by Mr. Howard Russell Butler, adviser to the architects. Another paper on the use of models in an Astronomical Museum has been contributed by Dr. Henry Norris Russell, professor of astronomy at Princeton University and director of the Halstead Observatory.

The three recent total eclipses of the sun visible in the United States are vividly described by one of the leading authorities in this branch of Astronomy, Dr. S. A. Mitchell, professor of astronomy at the University of Virginia and director of the Leander McCormick Observatory. This is especially fitting since the American Museum now has on exhibition in the Pro-Astronomic Hall oil paintings of these eclipses arranged as a triptych. This series of eclipse paintings had its inception in the engagement of Mr. Howard Russell Butler, N. A., by Mr. Edward Dean Adams, to paint the solar eclipse of June 8, 1918, at the Station of the U. S. Naval Observatory at Baker, Oregon, and the subsequent gift of this painting to the American Museum. A physicist by early training and an artist by life training, Mr. Butler is probably the best qualified man in this country, if not in the world, to undertake the painting of this thrilling phenomenon which lasts at most only a very few minutes. Mr. Butler has prepared an article telling how he paints eclipses and lunar landscapes.

Other astronomical topics will be treated in this number by men who are leaders in their respective fields. Dr. William Wallace Campbell, president of the University of California and director of the Lick Observatory, will have an article on the American Museum's Collection of Meteorites; Dr. George Ellery Hale, honorary director of Mt. Wilson Observatory, will write about Electrical Vortices of the Sun; Dr. Charles P. Berkey, professor of geology at Columbia University, will contribute an article on The Early History of the Earth; and Dr. W. J. Luyten of the Harvard College Observatory will discuss Outer Universes.

Dr. Clyde Fisher, in charge of astronomy at the American Museum, will describe the new Zeiss Projection Planetarium, which he examined last summer in Jena and in Munich. It is now a part of the proposed plan to include this wonderful piece of apparatus in the Astronomic Hall.

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THE THREE SOLAR ECLIPSES SEEN IN THE UNITED STATES IN 1918, 1923, AND 1925

FROM THE PAINTINGS BY HOWARD RUSSELL BUTLER

[illegible] eclipse paintings [illegible] in the engagement of Mr. Butler by Mr. Edward Dean Adams to paint the eclipse of 1918, and Mr. Adams' subsequent gift of the painting to the Museum. The present Triptych has been designed by Mr. Butler for the Proposed Hall of Astronomy, plans of which are now exhibited for the first time, and represents the first example of American Museum methods of education applied to Astronomy.

THE OREGON ECLIPSE, 1918

Totality Lasting 112 Seconds

As seen by Mr. [illegible] Russell Butler at Baker, Oregon, on June 8, 1918. The eclipse reached totality at 4 04 [illegible] at an altitude [illegible] 45°, and since it was in the afternoon, the long axis of the corona was inclined to the right. The time was near the period of maximum sun-spots, and as was to be expected, there was a diminished [illegible], but with more polar streamers than were expected. The prominences reached exceptionally large proportions, the "Brontosaurus" measuring 47,000 miles in height.

Gift of Mr. Edward Dean Adams to the American Museum of Natural History

THE CALIFORNIA ECLIPSE, 1923

Totality Lasting 120 Seconds

As seen near Lompoc, California, on September 10, 1923. This eclipse reached totality at 12 59 P.M., and since it was almost a noon-day eclipse, the long axis of the corona was practically horizontal. The time was nearer the period of minimum sun-spots and as was to be expected, the corona was more extended.

Mr. Butler's painting shows the first Baily's bead of the third contact, that is, the first appearance of a speck of the photosphere, evidently between two volcanic peaks on the rough surface of the moon.

Gift of the Morris K. Jesup Fund to the American Museum of Natural History

THE CONNECTICUT-NEW YORK ECLIPSE, 1925

Totality Lasting 110 Seconds

As seen at Middletown, Connecticut, on January 24, 1925. This eclipse reached totality at 9 12 A.M., and consequently the long axis of the corona was inclined to the left. The time was near the period of maximum sun-spots and not only was the outline of the corona surprising to astronomers, but some of the streamers were much longer than was expected. The prominences, while many (19 were recorded by camera), were so small that they could not be seen by the naked eye.

Gift of the Morris K. Jesup Fund to the American Museum of Natural History

Supplement to NATURAL HISTORY, July-August, 1926

THE AMERICAN MUSEUM OF NATURAL HISTORY

FOUNDED IN 1869

MEMBERSHIP MORE THAN EIGHTY-NINE HUNDRED

For the enrichment of its collections, for the support of its explorations and scientific research, and for the maintenance of its publications, the American Museum of Natural History is dependent wholly upon membership fees and the generosity of friends. More than 8900 members are now enrolled who are thus supporting the work of the Museum. The various classes of membership are:

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FREE TO MEMBERS

NATURAL HISTORY: JOURNAL OF THE AMERICAN MUSEUM

Natural History, published bimonthly by the Museum, is sent to all classes of members as one of their privileges. Through Natural History they are kept in touch with the activities of the Museum and with the marvels of nature as they are revealed by study and exploration in various regions of the globe.

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A room on the third floor of the Museum, equipped with every convenience for rest, reading, and correspondence, is set apart during Museum hours for the exclusive use of members. When visiting the Museum, members are also privileged to avail themselves of the services of an instructor for guidance.

THE AMERICAN MUSEUM OF NATURAL HISTORY has a record of fifty-six years of public service, during which its activities have grown and broadened, until today it occupies a position of recognized importance not only in the community it immediately serves but in the educational life of the nation and in the progress of civilization throughout the world.

Every year brings evidence—in the growth of the Museum membership, in the ever-larger number of individuals visiting its exhibits for study and recreation, in the rapidly expanding activities of its school service, in the wealth of scientific information gathered by its world-wide expeditions and disseminated through its publications—of the increasing influence exercised by the institution. In 1925 no fewer than 1,775,890 individuals visited the Museum as compared with 1,633,843 in 1924 and 1,440,726 in 1923. All of these people had access to the exhibition halls without the payment of any admission fee whatsoever.

The **EXPEDITIONS** of the Museum have yielded during the past year results of distinct value. The collections being made by Mr. Arthur S. Vernay in Angola, Africa; the studies of Andean avifauna pursued by H. Watkins in Peru; the three fossil expeditions in the western United States, in New Mexico, and Nebraska and Montana; the extensive survey of Polynesian bird life conducted by the Whitney South Sea Expedition; the work pursued in selected faunal areas of Venezuela by Mr. G. H. H. Tate; the field observations and collections made in Panama by R. R. Benson; the studies of microscopic pond life of Mt. Desert Island by Dr. Roy W. Miner and Mr. Frank J. Myers; the archeological excavations at two important sites in Arizona; and the continuation of the brilliant work of the Third Asiatic Expedition during the past season—these (and the list might be extended) are among the notable achievements of the past twelve months.

The **SCHOOL SERVICE** of the Museum reaches annually about 6,000,000 boys and girls through the opportunities it affords classes of students to visit the Museum; through lectures on natural history especially designed for pupils and delivered both in the Museum and in many school centers; through its loan collections, or "traveling museums," which during the past year circulated among 410 schools, and were studied by 977,384 pupils. During the same period 672,479 lantern slides were loaned by the Museum for use in the schools, the total number of children reached being 3,941,494. 1,076 reels of motion pictures were loaned to 48 public schools and other educational institutions in Greater New York, reaching 333,097 children.

The **LECTURE COURSES**, some exclusively for members and their children, others for the schools, colleges, and the general public, are delivered both in the Museum and at outside educational institutions.

The **LIBRARY**, comprising 100,000 volumes, is at the service of scientific workers and others interested in natural history, and an attractive reading room is provided for their accommodation.

The **POPULAR PUBLICATIONS** of the Museum, in addition to NATURAL HISTORY, include *Handbooks*, which deal with the subjects illustrated by the collections, and *Guide Leaflets*, which describe some exhibit or series of exhibits of special interest or importance, or the contents of some hall or some branch of Museum activity.

The **SCIENTIFIC PUBLICATIONS** of the Museum, based upon its explorations and the study of its collections, comprise the *Memoirs*, of quarto size, devoted to monographs requiring large or fine illustrations and exhaustive treatment; the *Bulletin*, issued since 1881, in octavo form, dealing with the scientific activities of the departments, aside from anthropology; the *Anthropological Papers*, recording the work of the staff of the department of anthropology; and *Novitates*, devoted to the publication of preliminary scientific announcements, descriptions of new forms, and similar matters.

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ASTRONOMY NUMBER

NATURAL HISTORY

JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

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THE AMERICAN MUSEUM OF NATURAL HISTORY

Scientific Staff for 1926

NATURAL HISTORY

THE JOURNAL OF THE AMERICAN MUSEUM

DEVOTED TO NATURAL HISTORY, EXPLORATION, AND THE DEVELOPMENT OF PUBLIC EDUCATION THROUGH THE MUSEUM

ASTRONOMY NUMBER

CLYDE FISHER, EDITOR

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Chaucer's

Troilus and Cressida.

Book V

"And there he saw, with full advisëment,
Th' erratic sterrës heark'ning harmony,
With soundës full of heavenly melody
And down from thennës fast he gan advise
This little spot of earth . . . ."

Photograph by John A. Miller

THE LATEST PHOTOGRAPH OF THE SOLAR CORONA

Taken by the Swarthmore College Expedition in Sumatra on January 14, 1926, with a camera of 15-feet focus. The shape of the corona is nearly circular, exhibiting the type associated with a maximum of sun-spots

NATURAL HISTORY

VOLUME XXVI JULY–AUGUST, 1926 NUMBER 4

Personal Experiences at Eclipse Expeditions

BY S. A. MITCHELL

Director of the Leander McCormick Observatory, University of Virginia

WITH A SUPPLEMENT IN COLOR OF THE THREE SOLAR ECLIPSES SEEN IN THE UNITED STATES IN 1918, 1923, AND 1925[1]

THE observation of a total eclipse of the sun is one of great excitement and nerve-racking tension. The life of an eclipse astronomer may be likened to that of a hunter after big game. Many months and even years are spent in quietly investigating the problems, a costly equipment is accumulated and each piece of delicate apparatus is carefully tested at home to see that it will properly perform its designated functions at the critical moment. After some weeks spent in the field erecting the instruments and most carefully adjusting the cameras and spectroscopes, the eventful day approaches. Each and every one of the observing party becomes more and more intense and keyed up for the great event. A successful attack lies only in taking care that every one of the possible chances of failure is obviated. When the "zero-hour" arrives, bringing with it the total eclipse, will the attack be successful or will some little blunder spoil everything or will cloudy skies render of no avail all the long months of preparation and show only the eclipse entirely eclipsed by clouds?

Today, as never before, our daily life follows its course surrounded by the wonders of science. But amongst all the wonders of all the wonderful sciences there is no science which deals with such a gorgeous spectacle as is exhibited by the queen of the sciences, Astronomy, at the moment when the earth is gradually shrouded in darkness and when around the smiling orb of day there appears the matchless crown of glory, the beautiful corona. Nor can any science duplicate the wonderful precision shown by the work of the astronomer in his capacity to predict hundreds of years in advance the exact hour and minute at which an eclipse will take place and the locality on the earth's surface where such an eclipse will be visible.

These predictions are not the product of clairvoyance or necromancy, but come only as the result of long continued series of observations carefully carried out by astronomers of all ages and of all climes, and hence are the direct consequence of the faith kept by one generation of astronomers in handing down the torch to the succeeding generation.

If no high degree of accuracy is necessary, the predictions can be carried out with sufficient precision by means of the Saros, an interval of 6585 days, known to the Chaldeans three thousand years ago. An eclipse of the sun can take place only at the time of the new moon, and also when the moon is near the plane of the moon's orbit, called the ecliptic, i. e., when the moon is near her node. Owing to the rotation of the axis of the moon's orbit, the sun passes the moon's node after an interval of 346.620 days which is known as the "eclipse year." Nineteen eclipse years amount to 6585 days and the same number of days are found in 223 ordinary lunar months. After this interval

[1]Extra copies of this Triptych, flat and without lettering, suitable for framing, may be obtained for Fifteen Cents each from the LIBRARIAN, AMERICAN MUSEUM OF NATURAL HISTORY.

the distance from sun to earth and from earth to moon (on which the conditions of the eclipse depend) are repeated very nearly the same as at the preceding Saros with the result that the length of the totality is nearly the same as it was at the eclipse 6585 days earlier. This interval amounts to 18 years, 11 days, if four leap years intervene, or 18 years and 10 days if the 29th of February has come five times.

By means of the Saros it is possible to trace the conditions which cause an eclipse. A partial eclipse of the sun is followed after eighteen years by a partial eclipse, a total eclipse by a total eclipse with a duration nearly the same as that of the eclipse preceding it in the Saros. In such an eclipse series there are anywhere from 68 to 75 solar eclipses depending on conditions, extending over some 1200 years. Of these 25 are partial eclipses, while 45 are central eclipses, of which only 18 are total and 27 annular.

The first eclipse in the cycle which includes that of January 24, 1925, appears to have been a partial eclipse visible on May 27, 933, only in far southern latitudes on the earth, while the last eclipse of the cycle will be on June 25, 2177 in high northern latitudes. The first total eclipse of the cycle was on June 8, 1564.

After the occurrence of three total eclipses of the sun in the United States in the short space of seven years, it is very surprising to find that in the remaining years of the twentieth century total eclipses visible under good conditions appear to shun both the United States and Canada. The next total eclipse in this part of the world will be on August 31, 1932, but totality will be witnessed only along a short track in the United States in the state of Maine.

THE ECLIPSE OF JUNE, 1918

In Natural History, Vol. XIX, 244–263, an account is given of the first of the three American eclipses, that of June, 1918, and only brief reference need be made here to the scientific results sadly hampered by thin clouds that almost everywhere greeted the observing parties. The novel feature at this eclipse owes its inception to Edward Dean Adams of New York, a patron of science and art, who became a member of the eclipse expedition on the condition that he be "given a job." Mr. Adams took upon himself the responsibility of trying, by some method, by photography, by a drawing, or by a painting, to procure a reproduction which would show the gorgeous beauty of the corona, and which should be true not only as to form but more especially as to color. Mr. Adams was very fortunate in finding Howard Russell Butler, a portrait painter of note who was well equipped for the task by having developed a shorthand method of noting both form and color. Unfortunately, the artist had never seen a total eclipse. When he arrived in Oregon ten days before the eclipse he had rather lurid ideas, obtained from reading astronomical books, of the appearance of the corona. It was necessary to take him in hand, tone down somewhat his vivid impressions, and show him the colors of the red and blue hydrogen lines in a powerful spectrograph and then criticize the trial paintings of a typical eclipse that he made in the days before the eclipse. He was an apt pupil and had his plans so well laid that he took full advantage of the 112 seconds of totality furnished him. His painting which Mr. Adams has presented to the American Museum of Natural History is exquisitely beautiful, a work of fine art in which the painter has not forgotten that scientific accuracy is the first desideratum when recording an astronomical event. Accordingly, the scientific world owes a great debt of gratitude to Mr. Butler for his painting, but even a still greater debt to Edward Dean Adams, through whose conception, generosity, and enthusiasm the painting of the corona became possible.

THE ECLIPSE OF SEPTEMBER, 1923

On September 10, 1923, the moon's shadow touched the earth's surface at sunrise in the Pacific off the coast of Japan. The shadow traversed the ocean at a speed well over a thousand miles per hour and appeared off the coast of southern California somewhat after noon. After crossing lower California, Mexico, and Yucatan, the eclipse ended at sunset in the Carribean Sea somewhat north of British Guiana.

Fortunately the total eclipse track in 1923 passed over a portion of southern California where one naturally expects superb conditions of weather. According to a well-known American humorist, "When the scientists said that Los Angeles was only to get a 99 per cent eclipse (that is about the only thing I ever knew Los Angeles to fall down on, they are usually 100 per cent) it rather hurt their pride. It was the first time that Nature had ever handed them a mere 99. I don't really think they would have gotten over it but San Francisco only received some 85 or 90 per cent, so that somewhat salved things over. But the Chamber of Commerce has held a meeting and voted resolutions to apply for the next eclipse in its entirety. They claim that it was due to the Club's not giving the matter more thought that they lost the 1 per cent on this one." Everyone, indeed, has heard of the boasted climate of southern California, the "land of sunshine and flowers."

As the result of all the information available about the weather, the best spot for the University of Virginia eclipse expedition seemed to be San Diego, the only large city in the United States inside the path of totality. Within the memory of the oldest inhabitant there had not been a single cloudy day on the tenth of September. To make matters almost ideal, the total eclipse came at one o'clock when the danger from sea-fog was reduced to a minimum. A conservative estimate placed the chances of perfect conditions at about 90 per cent. In fact, the chances appeared so high that it seemed poor business to insure against clouds (which one of the insurance companies was willing to write).

On arrival at San Diego we found that arrangements had been made for the McCormick Observatory party to locate within the military reservation at Fort Rosecrans. Six weeks before the eclipse we found ourselves in a furnished house of ten rooms and two baths, the former home of a major. Meals were sent in from the company kitchen,—and Rosecrans boasted of the "best cook in the Army!"

San Diego has every reason to be proud of her city, located as it is in one of the finest spots of the globe and blessed with an agreeable climate that might well be the envy of any city in the world. We from Virginia, a state which has never been backward in painting a halo around everything connected with the Commonwealth, were much interested in the spirit of civic pride and aggressiveness, which at times may have bordered upon boastfulness. Our six weeks' stay was filled with pleasant memories and we only wish that each and every total eclipse might be observed under the congenial surroundings of Fort Rosecrans.

Many are the problems that may be attacked at the time of a total eclipse. One of the most important is the confirmation of the bending of the rays of light from a star as these rays pass close to the edge of the sun, as predicted by Einstein. We had no equipment for this research and we preferred to let others tackle this problem while we devoted ourselves to following up the line of attack carried out at four previous eclipses. It was therefore decided to have two stations for observing the eclipse, each equipped with a powerful spectrograph for ascertaining the constitution of the gases forming the sun's atmosphere and also the heights in miles that each of the vapors extend above the surface of the sun. One of these was located on Point Loma, near our temporary home, the other at Lakeside, twenty-five miles inland, and near the edge of the shadow cast by the moon. The essential part of the spectrograph was a concave grating ruled by Rowland of Johns Hopkins. Each of the gratings used was made by ruling on a spherical concave mirror of speculum metal 15,000 lines to each inch. The Point Loma grating was four inches in aperture and thus had 60,000 ruled lines. This grating was used by the writer at the eclipse of 1905 in Spain. The Lakeside grating of 90,000 lines was used at the 1918 eclipse.

The sun is the nearest of the fixed stars, and it is the only star which permits us to examine its atmosphere in detail at the time of a total eclipse. A knowledge of the heights attained by the solar vapors gives information regarding the pressures under which the spectroscopic lines take their origin. At very reduced pressures in the sun's chromosphere and at the high temperature found there it is readily possible for an atom to lose an external electron and become ionized. The spectrum of the ionized atom differs very much from that of the neutral atom which has not lost an electron. In the ionized spectrum certain lines are enhanced in intensity and these are the lines which are stronger in the spectrum of the electric spark than in the electric arc. Knowledge of these things are of the very greatest importance in furthering our knowledge of the chemical atom, a quest in which astronomy, physics, and chemistry are vitally interested.

Other problems of the eclipse are connected with the investigation of the corona. What is it? and whence comes its light? Its feeble light has been traced to the enormous distance of ten millions of miles from the sun's surface. It cannot be a true atmosphere consisting of gaseous particles for, if it were, the pressure at the sun's surface would be colossal, and we know for certain that such pressures do not exist. As a further proof we know that occasionally comets come close to the sun's surface, dashing by the sun at the rate of a hundred miles per second,—and yet the comet goes through the corona without any friction and without any perceptible impeding of its velocity, which would be impossible if the corona contained much matter. The only true atmosphere possessed by the sun is the chromosphere which stretches up to a maximum height of 10,000 miles.

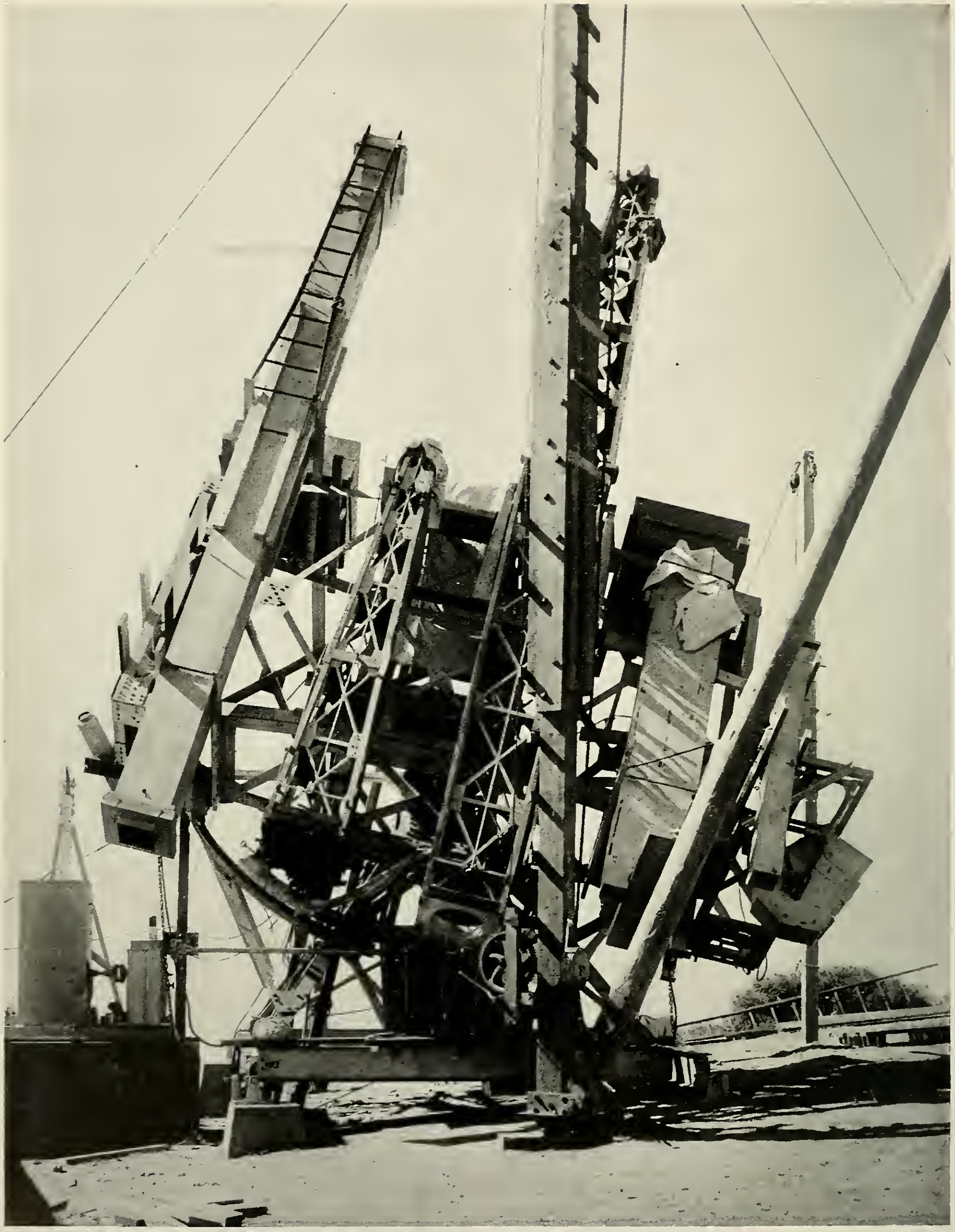
We must rely mainly on the spectroscope to give information on the constitution of the corona. On account of the feebleness of its light it is almost impossible to use a dispersion exceeding that of a single prism. None of the lines in the spectrum of the corona, amounting to about forty, has been identified with terrestrial sources. The strongest line in the whole spectrum is in the green, at wave length 5303. This belongs to the mysterious and unknown element "coronium." Part of the coronal light takes its origin from the gaseous coronium which gives a spectrum of bright lines, and part by sunlight reflected from the molecules of the corona, since a dark Fraunhofer spectrum is observed. It has always been difficult to decide whether the reflection and scattering of the ordinary sunlight is in the corona itself or whether it takes place in our terrestrial atmosphere.

Soon after our arrival, the San Diegans discovered us, and before long, invitations began to roll in upon us to address the University Club, Rotary and Kiwanis, the Lions' Club, etc., at their weekly luncheons, and to give public lectures at night illustrated by lantern slides. At the first of the public lectures, given in one of the city schools, more than fifteen hundred people were turned away for lack of room. The following week a lecture was given in the Civic Auditorium in Balboa Park to an audience of five thousand.

As the day of the eclipse approached the interest aroused in the gorgeous spectacle was very great. If we had been so inclined, we might have spoken morning, noon, and night. But there was work that must be done, work that could not wait,—and much as we like to speak in public, we had to try and transfer to some other visiting astronomer the doubtful honor.

An unusual opportunity awaited science at this eclipse. At North Island was the powerful battle squadron of the Naval Aircraft forces. Here was a chance to employ photography from the air on any of the problems that could be solved by this method. It is manifestly impossible to use any but comparatively small cameras from an airplane and to give any but very brief exposures. On account of the short exposures permitted, no spectroscopic work could be attempted from the air, no investigation of the Einstein effect and no photography of the corona that demanded large focal scale. Airplane photographs could not compete with those taken from a fixed installation on terra firma. In the event of clouds and the possibility of soaring above them in a machine, airplane photographs might be taken, but there would be little of scientific value in photographing the corona on such a small scale. There seemed only one direction in which airplane photography could assist the astronomer, and that was in the attempt to find the position of the moon in the sky with greater accuracy, for in spite of the many refined researches of the mathematical astronomer, the motion of the moon is far from being known with the precision desired. The moon is erratic in her motions and quite in keeping with her feminine gender. The position of the moon affects the time of the prediction of the eclipse and the projection of the moon's shadow on the earth's surface.

The program finally adopted consisted in the attempt to photograph from five separate stations along the northern edge and one at the southern edge on the shore of Mexico, the edge of the shadow of the moon. For this purpose it was necessary to use the best of mapping cameras known to the photographers and to choose special sites to photograph where the terrain would offer as great contrast as possible between a point just inside and one just outside the moon's shadow. Incident-



MT. WILSON INSTRUMENTS BEING ASSEMBLED FOR THE ECLIPSE OF 1923 ally it must be admitted that so little was known of the amount of light to be expected a few feet outside of the moon's shadow that there was some doubt as to the final success of the investigation. But there was nothing to do but to "try and see what happened."

During the erection of our apparatus it was interesting to watch the gradual installation of the gigantic equipment to be used on eclipse day by the astronomers from the Mt. Wilson Observatory. This great observatory, the best equipped and most famous in the whole world, is located on Mt. Wilson near Pasadena. Being therefore only about 140 miles from the eclipse site, it was possible to transport all of their instruments by motor truck from observatory to eclipse camp.

In planning the work for the eclipse, Director Walter S. Adams utilized the interferometer mounting on which to place the cameras, spectroscopes, photometers, etc., of the eclipse program. The longest camera was thirty feet in focal length, used to photograph the Einstein effect. Another camera half this length was for the same purpose. There were cameras to portray the beauties of the corona in various scales and in different colors of light, spectroscopes to ascertain the constitution of the corona, instruments to photograph and to measure visually the intensity of the light of the corona at various angles from the edge of the sun. The instruments numbering fifteen made the most complete equipment that had probably ever been assembled in one place for photographing a solar eclipse. The personnel included about thirty members of the Mt. Wilson staff, while an auxiliary party of twenty computers and friends of the staff were prepared to watch and measure shadow bands, etc.

Between this site and the Spanish lighthouse was the installation of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Captain Ault, Mr. Johnson, and many assistants were prepared to measure the magnetic and electric elements connected with the coming of the eclipse. Fortunately for them they could look on the weather with unconcern for it made little difference to their measures whether the weather was clear or cloudy on eclipse day.

The most of us could have no such smug satisfaction as the day of the eclipse approached. The weather indeed seemed "unusual" (we understood this is the first word that a California baby learns at its mother's knee). At any rate the cloudless skies that we had been led to expect at 1:00 P.M. were not always forthcoming. During the first two weeks of our stay at Point Loma high fog at noon was the rule rather than the exception. Still it was a long time to the eclipse, and conditions would undoubtedly improve,—and they did. The next two weeks gave perfect skies, an absence of wind and altogether ideal conditions. Would this last, or would another cloudy spell come? We were optimists and believed implicitly what our friends the Californians told us.

Saturday, September 8, was a gloomy day and the eclipse would have been under poor conditions. Sunday was even worse. What would Monday bring? At eight-thirty Monday morning we were off on our trip to Lakeside. As we got inland from the Pacific, out of reach of the high fog, and where ordinarily we got out of clouds, the conditions improved but little. At ten o'clock at Lakeside we found high cirrus and the conditions looked hopeless. But there were three good hours until the time of totality and much to be done in the final preparations! By twelve o'clock we heard the airplane aloft which was to observe over Lakeside and the pilot waved to us in friendly greeting. The clouds were not very heavy but there were no clear patches anywhere. We kept a stiff upper lip and refused to believe that after so much bragging California was going to get a black eye.

Still the clouds were not too thick to prevent us watching the diminishing crescent of the sun as totality approached. Nature was hushed but the cocks were crowing lustily as if night were falling. At the very second when expected, the sun was blotted out and a faint trace of corona appeared. But what a bitter disappointment! We carried through our program, exposing eight plates in the seventy seconds of totality, knowing full well that the developed plates would show not the slightest trace of light.

Well, there was no use crying over it (although one was tempted to). We had done our best and the fault was not ours. If misery likes company, it was evident that the clouds were general and not local. As quickly as a high-powered car could take us to San Diego we telephoned to Point Loma only to find as we expected, that conditions there were even worse and practically not a trace had been seen of the corona. Radio told us that the Yerkes party on Catalina Island had suffered a like fate and that the usual luck of the Lick party had deserted them, for conditions where Doctor Campbell and the Lick expedition were located at Ensenada were as bad as could be.

And this was the record for "sunny California"! Not a single expedition greeted with good conditions, and the whole scientific work a dismal failure! There was nothing left to do but pack up and go home,—and then begin to get ready for the next eclipse, that of January 24, 1925. It seemed foolish to expect good weather conditions at nine o'clock of a winter's morning in New York and New England and with the sun low down toward the horizon. But nothing venture, nothing win!

THE ECLIPSE OF JANUARY, 1925

The day before the eclipse of January 24 was one of gorgeously perfect blue skies. Would the morrow provide as good skies? After all the long weeks of preparation and of hard work in installing the instruments, would the work be all of no avail by clouds blotting out the eclipse? As always we were optimists. We astronomers located at Middletown, Connecticut, at Wesleyan University, were all so keenly interested in what we were planning to accomplish that each of us slept the night before the eclipse with one eye open. At six o'clock on eclipse morning my friend Professor Slocum, the director of the Van Vleck Observatory, in whose home Mrs. Mitchell and I were staying, looked out and saw the stars on a brilliant clear sky. He gave voice to his elation by saying "We greet you, sunny California." But this boasting was almost our undoing, for inside of quarter of an hour the sky was thickly overcast with very dense clouds.

What a dejected crowd of astronomers we were at eight o'clock when we had gathered at the Van Vleck Observatory to observe "first contact," the beginning of the eclipse. There was nothing but clouds everywhere!

A quarter of an hour later a ray of hope appeared, there was a blue streak of sky low down in the northwest,—and the clouds were coming

Solar eclipse of January 24, 1925, photographed by Frederick Slocum, Van Vleck Observatory, Wesleyan University, Middletown, Connecticut.

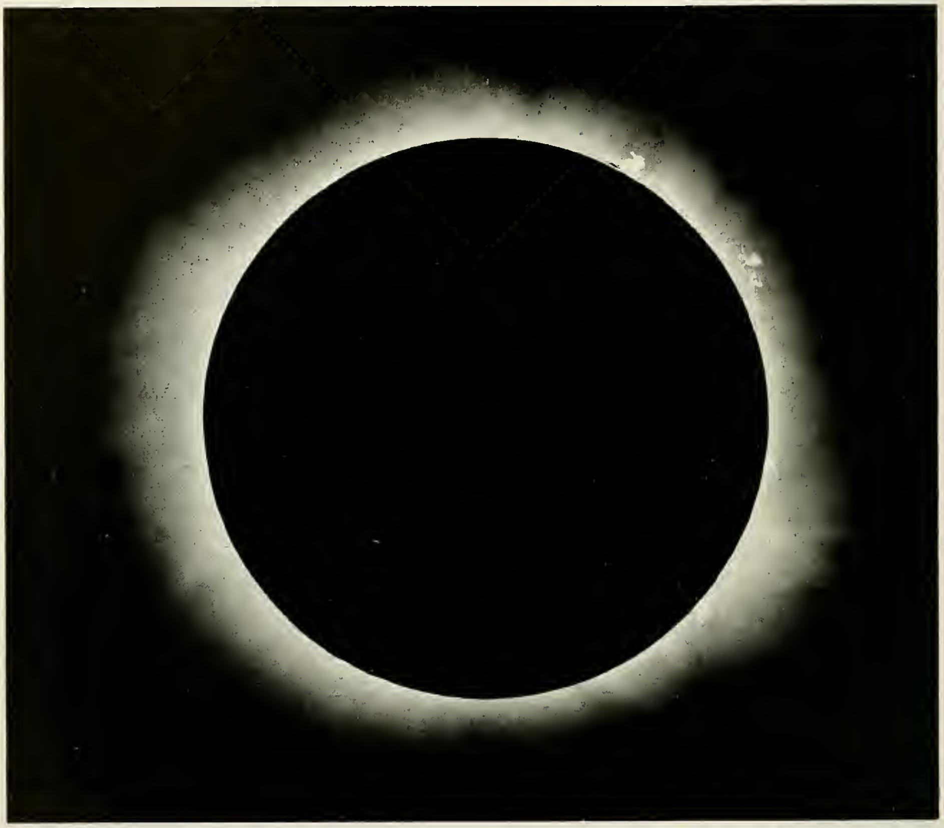
from that quarter. Would it clear off in time! Luck was with us. Fifteen minutes before totality the sun broke through the clouds. Five minutes before totality each observer was at his station and we waited in great expectation. A cloud, very thin and very fleecy, now hung over the sun. It was not thick enough to do much damage and it was moving slowly. We hoped it, too, would go. When the timers called out "Two minutes," the cloud was almost gone. By now it was beginning to get quite dark, a weird and unnatural pall coming over the landscape. The observers outside noted shadow bands flickering over the snow. At one minute before totality, with the thin crescent of the sun growing very small, the atmospheric conditions seemed perfect, the thin cloud had gone.

The signal "Thirty seconds" rang out. Everything was hushed while we waited for the zero hour, the beginning of totality. In my right hand I had a pair of binoculars over the right glass of which was a grating for observing the flash spectrum visually. When I saw it flash out, I gave the signal, "Go"; totality had begun; and with my left hand I opened the shutter to begin the first exposure.

As a spectacle, the 1925 eclipse suffered from its taking place so early in the morning. If the darkening had come on during the middle of the day with the sun high up in the sky the psychological effect would have been all the greater. Still it was a gorgeous sight!

It will be impossible in this short article to give in detail an account of

of the full moon, and half the total light of the corona comes from a zone extending only 3′ from the edge of the sun.



Photographed by John A. Miller

Photograph of the inner corona at the 1926 Sumatra eclipse. Taken by the Swarthmore College Expedition with a camera of 63-feet focus pointed directly at the sun. Note the prominences and the curved hoods covering the prominences

the scientific discoveries from the 1925 eclipse. Valuable information was gained about the intensity of the corona whose total light is about equal to the light of a standard candle at the distance of a meter. Compared with full-noon sunlight the corona gives one-millionth of the light of the sun and about half that of the full moon at its average distance from the earth. The surface brightness of the corona at the limb of the sun is about 1.4 times that

So far in the history of astronomy it has been impossible to detect the corona without an eclipse. The difficulty is that the coronal light has superimposed upon it the enormously greater illumination near the sun produced by the scattering of sunlight in our atmosphere and in the telescope. The effect of the illuminated atmosphere is ten thousand times more intense than the corona near the sun's limb, and hence the astronomers hold out no hope of detecting the corona—at least with present observational means—at any time other than at an eclipse.

With the passage of time additional knowledge of the corona will be accumulated with great slowness due to the paucity of time available for observations. There are a few astronomers in the world who have been on more eclipse expeditions than I have been on, but I do not know of any astronomers who have actually seen the corona more frequently than I have. My first eclipse was that of 1900, and in the quarter of a century that has elapsed I have traveled fifty thousand miles in order to witness six eclipses. The total time afforded for observations during the periods of totality of all of these eclipses has made altogether a paltry fourteen minutes. If in the balance of my active career as a professional astronomer I am permitted to observe each and every total eclipse visible anywhere in the world (a condition of affairs that is not at all likely) I would then be the one astronomer throughout the ages that has had the opportunity of observing total eclipses of the sun for the total length of time of one half an hour.

Astronomy, the grandest and most perfect of the sciences, exerts an appeal to the popular imagination that has no equal in any other science. The reason for the universal interest in astronomy is not because it teaches us that this earth of ours is a tiny and insignificant speck in the cosmos but rather for the opposite reason, that man, though he is so small and infinitesimal in size, is gifted with powers which are almost infinite. From this earth of ours the astronomer's brain intelligence can reach out across millions of miles of space and can ascertain what the sun is made of, what its temperature is, what the conditions are in the solar atmosphere, and acquire this information with so much of certainty that we know more of conditions in the solar atmosphere than we do of the terrestrial. Nor are the investigations of the astronomer confined to ninety millions of miles of space. Light from the sun, traveling at the rate of 186,000 miles per second reaches the earth in 499 seconds, a little over eight minutes. Light from the nearest sun outside of our solar system takes more than four years to reach us. But still the astronomer reaches out farther and even farther and he tells with great positiveness and certainty that the nebula in the constellation of Andromeda is so far away that its light takes one million years to reach the earth!

The earth has existed all of this time and even very much longer, for the most competent authorities are confident that Mother Earth existed substantially in the condition in which she now is for at least one thousand millions of years. Truly it is a great stretch of time, measured by man's standards, when we reach back far enough to be able to say, "In the beginning God created the world."

Painting Eclipses and Lunar Landscapes

By HOWARD RUSSELL BUTLER, N.A.

ECLIPSES

WHEN asked if I would accompany the United States Naval Observatory party to Baker, Oregon, and try my hand at painting the solar eclipse of June 8, 1918, I stated that, as a portrait painter, I generally asked for ten sittings of two hours each. But all the time they would allow me on this occasion was $112\frac{1}{10}$ seconds. As it turned out I got a trifle more, for their calculation was short by $\frac{3}{10}$ of one second.

Of course no actual painting was possible in time so limited and I therefore employed a method of shorthand sketching (which I had been developing and practicing for about twenty years) for recording sunsets and other transient effects. The method is simple, but *does* require practice. I will describe it:

The artist regards his subject as composed of a limited number of what he calls *masses*, in each of which there is a general uniformity of value, i. e., of the position of the *mass* on the scale of brightness—or the scale from black to white.

The shorthand method consists simply in

First.—Quickly drawing the outline of the masses.

Second.—Writing in, on each mass, the formula of its color.

Third.—Locating accurately the points of highest and lowest value.

Fourth.—If time permits, subdividing the masses.

Applying this to the painting of the eclipse of 1918, I realized that drawing the masses would be easy except for the corona. The moon is round, the shapes of the hydrogen prominences could be obtained from photographs, but the corona would be difficult. No photograph gives its full extent. Plates are not equally sensitive and times of exposure vary in length, hence twenty photographs of the same corona give as many different outlines, though a general agreement exists as to the beginnings of the arms or main projections as well as the variations in value, such as arches, etc. The polar rays are so intricate that detail can only be suggested in the rapid drawing but an analysis of many photographs of them gives much information. The eye sees the entire corona to the outermost limits permitted by the optic rays. A general outline of these limits must therefore be striven for, and afterward details from photographs can be advanced to these limits. In 1918 I failed to complete the entire outline in the 20 seconds allotted and so I gave myself more time in 1925. By using my own outline and many photographs of what may be regarded as contours of luminosity I obtained a composite drawing of the 1918 corona.

Next comes the question of determining the formulas of the colors of the masses. This is somewhat difficult and requires practice. My system is based on the "color spindle," as developed by the modern psychologist. As is generally known every color has three constants or dimensions. We will first consider the constant of brightness, or value as the artist calls it. This is represented in the spindle by a vertical axis, neutral as to hue, running from black at the base to white at the top. From this axis, at varying altitudes,

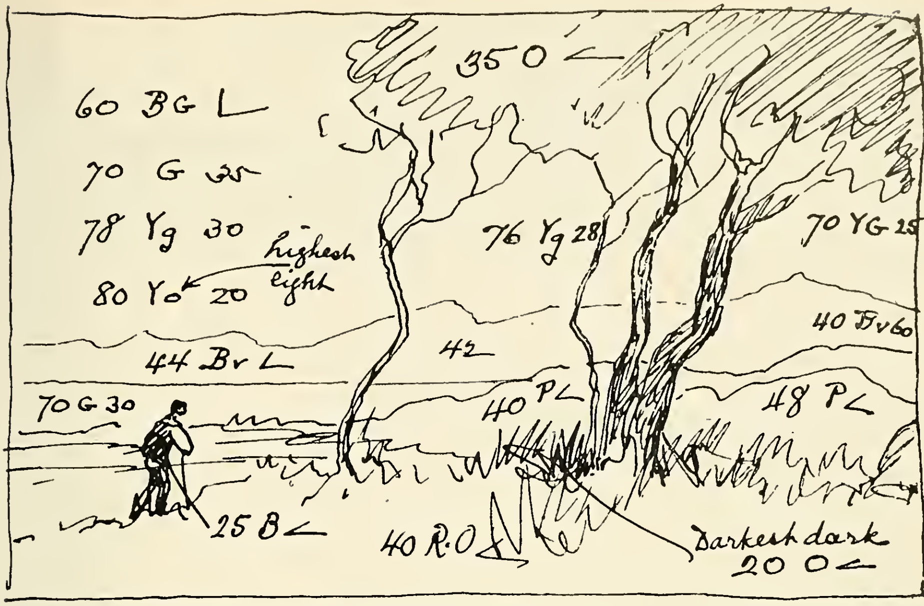


Fig. 1.—Shorthand sketch of sunset, El Capitan Point, near Santa Barbara. Dark blueish-violet mountains seen against a light sky graded from yellow-orange to Robin's-egg blue

radiate spokes representing the second constant or the prismatic hue: red, orange, yellow, green, blue, violet, and purple. The distance out on these spokes gives the third dimension—chroma or saturation. The psychologists tell us there are 30,000 colors which can be differentiated by the average human eye. Each is represented by a point in the spindle and each can be designated by a formula: Thus R.$^{40}/_{60}$ means a red with saturation of 40 per cent and a brightness of 60 per cent. Saturation can be quickly expressed by a sign—a right angle meaning full saturation, an angle of 45 per cent meaning half saturation, acute angles meaning little, down to a straight line meaning none. Where a color becomes neutral, only the brightness or value remains to be recorded. In sketching, it is well to think of the brightness first, then the hue, and lastly the degree of saturation.

Next we consider the lightest and darkest notes in the picture. These may be the masses themselves, as in the case of the eclipse pictures, or they may be accents within the masses.

The key of any picture is determined by the portion of the scale of brightness used. If black is 0 and white 100, a picture low in key might run from 10 to 50; a high-keyed picture, like some of Besnard's frescoes, might run from 70 to 100; a wide key say from 5 to 90.

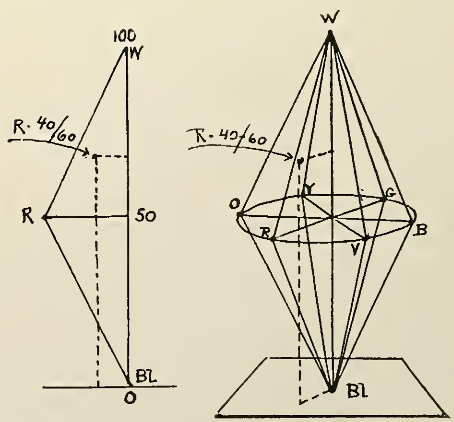


Fig. 2.—Diagram of a "color spindle." The red section is shown separately

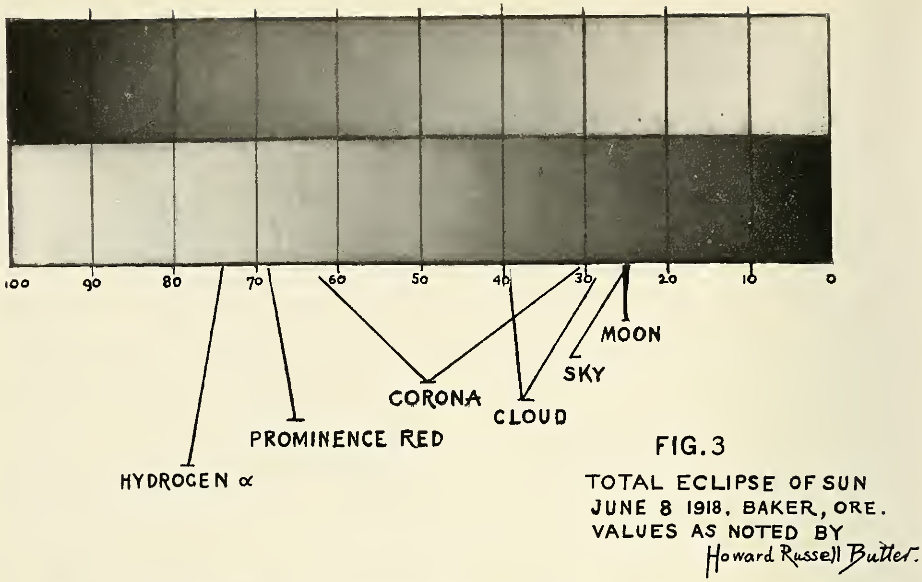


Fig. 3.—A graphic representation of the scale of brightness values of the various colors found in the eclipse phenomena. Varnished ivory black is taken as zero and the best white lead (silver white) as 100 for the points of reference. The most brilliant shades were found in the prominences which consist for the most part of incandescent hydrogen gas with a color approaching that of the red hydrogen line of the spectrum. By careful painting the brightness of the reds used in portraying the prominences was forced up to 67, and a very fiery quality given to them. The brightness of the sky was pitched at 25, as was the moon, while it was estimated that the clouds ranged from 30 to 40, and the corona from about 30 to 60

The addition of any color to white reduces its value, thus, if red be added to white the value descends rapidly.

I realized that in an eclipse picture the key would be very important—a section of the sky with an eclipse going on in it would have a definite key. I wanted to secure the effect of looking through a window at such a section of the sky. So the key would be determined by the extremes of value used. The imaginary window gave an angular dimension to my picture of 2½ degrees, and 20 seconds were to be devoted to looking through Zeiss binoculars giving about that field.

Now the highest light was the mass, very small but very important, of the hydrogen prominences, rich in red almost up to the hydrogen alpha line. To secure this redness I was compelled to reduce the value of my highest note to between 60 and 70. The darkest dark was the blue sky. The moon was about the same. At the time of the eclipse I estimated it at 30. So the range of the values was small and midway in the scale,—a narrow middle key. The formula for the blue sky was 30 B.V.—with a sign meaning strong saturation.

My regular shorthand plan called for more time than was allowed in eclipse painting and so certain modifications were introduced, making the operation a shorthand of a shorthand method.

Thus—realizing that the corona was bound to be brilliant at the edge of the moon and die out into the sky, exhibiting progressive changes in value, I used a rapidly drawn curve between coordinate axes as shown in the illustrations. So much for the values of the corona.

Next for the prismatic hues; expecting that they would be of very low saturation, I painted a sample of pearl-gray on a piece of canvas and tacked it

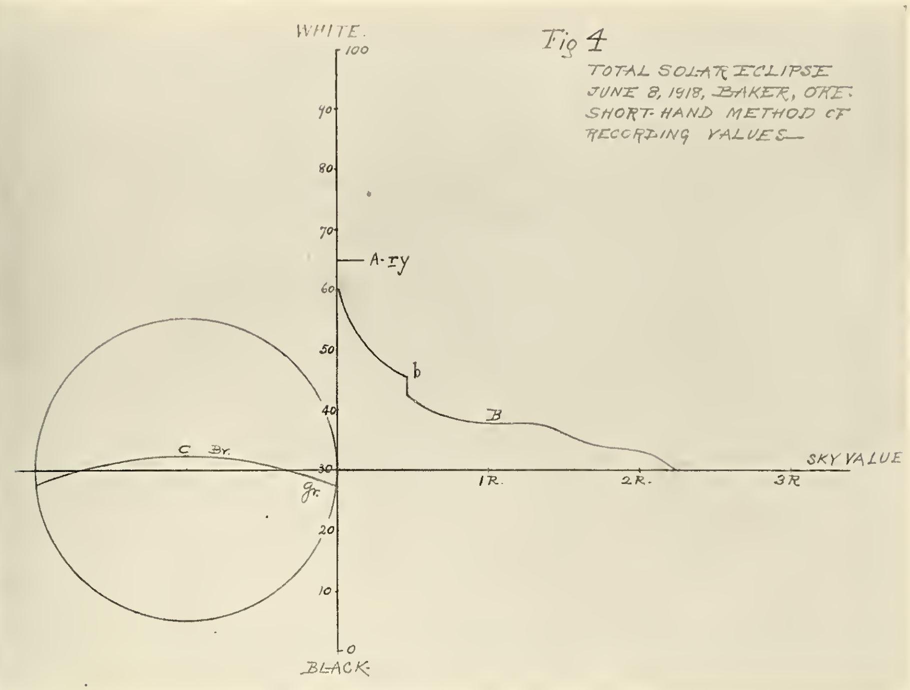


Fig. 4.—Two diagrams combined, one illustrating the artist's shorthand method of recording during the few seconds of the eclipse the brightness of the colors in the corona, the other a method of noting the depth of shadow on different areas of the moon's disk. One diagram consists of the two perpendicular lines or axes, and the curve B. The vertical axis represents a scale for measuring the brightness of a color, considering ivory black as zero and silver white as 100. Distance on the horizontal axis measures distance on the sky beyond the moon's edge measured in radii of the moon ("1 R" equals a distance of one radius or half the moon's diameter from the moon's edge). This horizontal axis is drawn through 30 on the brightness scale, that being the estimated brightness value of the sky during the eclipse. A curve drawn between the axis shows the variation in brightness of the corona at any given point, beginning at the inner edge of the corona and passing outward to the dark sky; that is, the color in the inner corona close to the moon is 60 on the scale (or in other words the tone of the inner corona is about three fifths as bright as silver white). From the curve drawn downward from 60 we see that the corona at 1 R (one radius distant from the moon's edge) had fallen to a brightness of about 40, and slightly beyond the length of 2 R it disappears, blending with the sky. The line A is the artist's shorthand to indicate that the prominences had a brightness value of 65 and "ry" is a quick way of recording it if they were "very rosy, tinged with yellow." These two axes were drawn in advance, on the cardboards on which the eclipse was to be drawn, on two sides of the circle of the moon (see Figure 5), being represented as tangents to the moon's circle (see right hand and upper left hand of figure). By means of the curves drawn in on these axes with great speed during the eclipse, we can read off the brightness of the corona's colors at any distance from the moon.

The line G in the other diagram (the moon's disk at the left) is a shorthand way of indicating that the moon was lighter in the center than at the edges and that these edges were darker than the sky. The "Br." and "Gr." indicate a tinge of brown and green respectively

alongside of the white cardboard on which the record was to be drawn. If the gray seemed correct no entry was to be made; parts that seemed yellower were marked with a Y; greener with a Gr. In my haste being unable to see any color in the brightest part of the corona I wrote in the word "whitish."

To aid in the drawing, concentric circles, radii, and tangents were drawn in advance on the cardboard.

A program was tacked to the easel, reading as follows:

	Seconds
Note value and color of sky	10
Draw value line on moon	10
Note colors of moon	10
Draw outline of corona	20
Use Zeiss binoculars	20
Record position of prominences	10
Note color and value of prominences	10
Note color and values of corona	20
	110

In 1918 an officer of the Navy called the seconds. About ten drills were held in advance and at each a finished

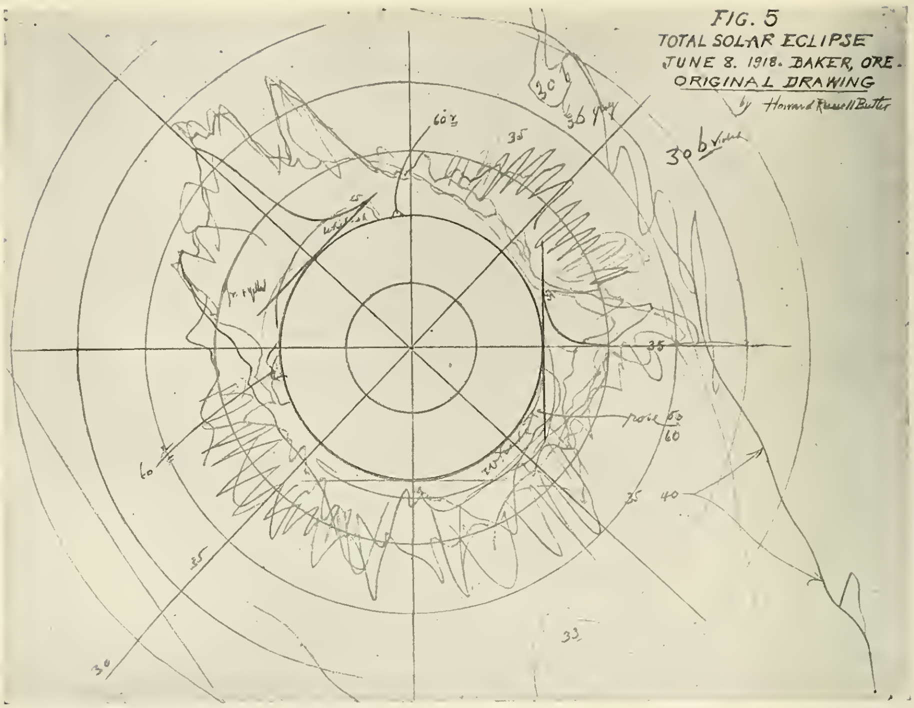


Fig. 5.—This is a reproduction of the actual original sketch, made at the time of the eclipse, on a cardboard on which the radial lines, circles, and tangents had been prepared in advance. This is the artist's record, not only of the general outlines of clouds and corona, but also of the colors which are indicated by initials or words (underscored when the color is intense), and of the brightness of the various parts of the corona, indicated by numbers and by curves such as are explained in the preceding figure. The artist had painted previously a picture of the way in which he "expected" the eclipse to appear and no time was wasted putting in colors or tones which were approximately correct in the prepared sketch

drawing of an imaginary eclipse was made.

When the instant of totality came, the astronomer at the telescope shouted "Go," and I turned (having kept my eyes to the dark northwest to avoid retina-fatigue) and saw the eclipse through a thin film of cloud with blue sky to the right. No time allowance had been made for this cloud and it was necessary to rush matters to gain time for that.

In 1925 at Lompoc, California, I used practically the same method. I could think of no better plan. As the first "Baily's Bead" of the third contact was very beautiful, appearing like an orange ball on the rough edge of the limb of the moon, and as it did not obliterate for several seconds the corona or Venus (slightly over one degree above) I concluded to make that effect the subject of my picture, adding it to the notes previously made.

In 1925 I devoted much time to drawing the corona, realizing at once the similarities of the color to previous eclipses. The sky was very clear and deeply saturated.

LUNAR LANDSCAPES

The Lunar Landscape, from which the colored plate was made, is the joint work of Dr. Henry Norris Russell and myself. It is a view of the earth as seen from the bottom of a lunar crater, the observer standing near a lofty "spine."

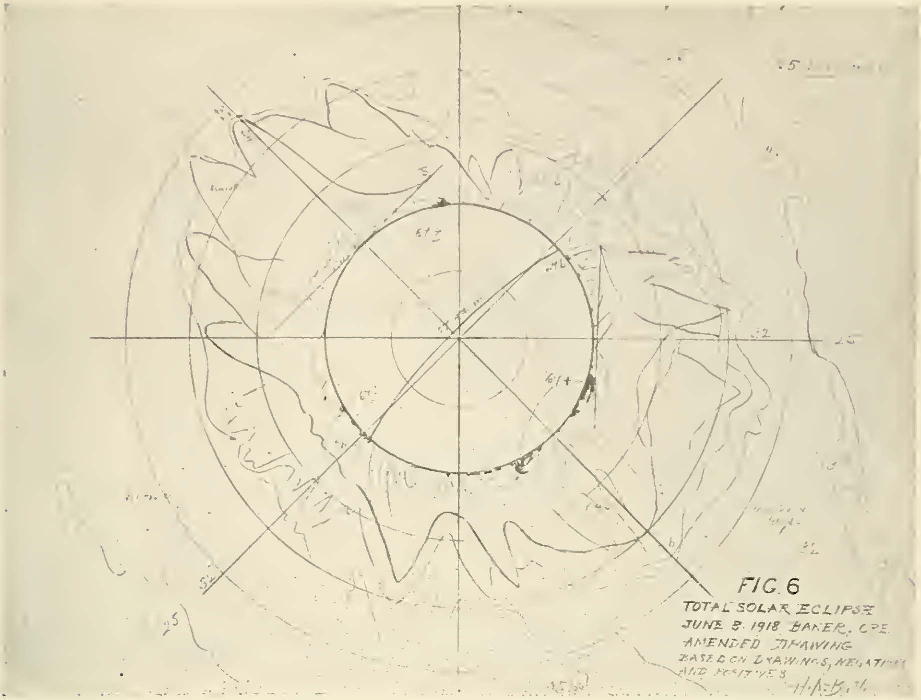


Fig. 6.—The artist's original drawing as amended later by reference to photographs made of the corona. The details of the polar rays and of the prominences had been left for the cameras to record. Careful drawings of these features and of the variations in shading of the corona resulted in this composite picture on which was based the painting of the corona (see color plate of triptych accompanying this issue). The lines outlining the corona in this figure may be regarded as contours of luminosity, showing the range and extent of certain degrees of brilliancy around the disk.

Note: Finding it possible, by process painting, to raise the value of the prominence red, without diminishing its redness, from 60 to 67, the artist adopted the latter figure as his highest light. He also concluded to lower the value of the sky from 30 to 25, thus obtaining a range of 42 points instead of 30, an increase in the ratio of 7 to 5. In this new scale the other values take their proportional places. This is a case of transposition of key. The final painting was made from the transposed key as shown in this figure.

I had long wished to paint a lunar landscape but did not dare to attempt it, realizing my own ignorance. I mentioned this one day to Doctor Russell and he kindly offered me the benefits of his great knowledge. We began by studying the moon's surface through his telescope when it was at the first quarter.

The picture subtends an angle of about 10° laterally and the earth about 2°. The focal distance of the picture is 24 feet—looked at from that point you see the earth only a few degrees above the horizon. It is a daylight picture, the slant of the sun's rays giving a "gibbous" earth and a partial illumination of the mountainous rim of the crater, silhouetted against the black sky. The spine is high enough to catch the sun's rays and has, like many of the lunar cones or spines, an apparent crack or opening at the top. The floor of the crater has been broken into fragments by the upheaval of the spine and these are more or less imbedded in solidified lava flows, with volcanic pits here and there.

The earth is seen with its north pole uppermost and inclined very little from the vertical but showing the north polar ice cap. The Atlantic is toward the observer, presenting a convex mirror in which the sun is reflected near the coast of Morocco. The earth is supposed to be seen in the month of

June. The equatorial cloud belt is shown and a storm is crossing the North Atlantic. Other storms are scattered here and there. Unfortunately these details are not well shown in the color plate, owing to the great reduction.

The earth is seen in the constellation Scorpio and is shown near the serpent's head. Antares is seen to the left of the point of the spine, and Mars, also red, is near the top of the canvas.

In this picture the sky is the darkest mass,—varnished ivory black was used for it. The highest light is the white accent representing the sun's reflection in the Atlantic. The entire range of values—0 to 100—is thus used, depriving the picture of tone and greatly emphasizing contrasts.

We proceeded on the theory that there was no atmosphere on the moon and consequently there would be no diffusion of light. There would, however, be reflected light, especially if surfaces are at all glazed. One-half of the high mountain wall surrounding the observer would be in sunlight and would reflect back into the shadow, giving more or less of sparkle.

Without an atmosphere the values would be unaffected by distance and as the "albedo" of the earth is as a whole far greater than that of the moon, the earth values are made higher than the moon values, so that the earth becomes the most brilliant mass in the picture. All of the earth values however had to be kept below that of the sun's reflection in the convex mirror of the Atlantic.

The apparent surface of the earth as seen from the moon is about fourteen times that of the moon as seen from the earth. The crescent of shadow on the earth would receive so little reflected light from the moon that its value would not differ appreciably from that of the sky.

The colors of the various surfaces on the earth would be seen by light rays penetrating the earth's atmosphere twice (directly and by reflection).

This would probably enhance the blues. Greens would be visible. The outer surfaces of clouds would be as white as the snow caps.

Many times, while making this painting, I longed to be at the spot and see how it really looked. But when Doctor Russell mentioned that the temperature there would be about 70° below zero I was content to abandon that desire. All criticisms will be thankfully received.

THE EARTH AS SEEN FROM THE MOON

Mr. Howard Russell Butler has painted a lunar landscape with the coöperation of Professor Henry Norris Russell, director of the Halsted Observatory at Princeton. It shows the earth in the sky as seen from the moon, the observer being located in one of the rugged lunar craters near a spine thrust up from the crater floor, similar to that which was formed during the great eruption of Mt. Pelée on Martinique in 1902. The earth is represented as in the month of June with the Atlantic toward the observer. It is passing through the constellation Scorpio, Antares appearing near the point of the spine. Mars is seen near the top of the canvas.

Gift of the Morris K. Jesup Fund to the American Museum of Natural History

Solar Tornadoes

By GEORGE ELLERY HALE
Honorary Director, Mt. Wilson Observatory of the Carnegie Institution of Washington

EVOLUTION may be considered to begin with the formation of the atom, the constitution of the chemical elements, and their union into the various kinds of matter. For the origin of matter we must look to the stars, which recent researches have taught us to recognize as the cosmic crucibles in which the chemical atoms are built up from the elementary electrons and protons. The nearest of the stars—in fact, the only star near enough to the earth to reveal its disk, and thus to permit of study in detail—is the sun, the ancestral body of the solar system. Out of the original substance of the sun, the earth and all the other planets were formed, and they are still dependent upon it for light and heat. Thus from the evolutional standpoint the sun is of double interest to us, both as the nearest celestial laboratory for the production and transformation of matter and as the parent and sustainer of the earth, where after a period of tempestuous youth the seas and land surfaces slowly took form, rose and subsided through the centuries, and became the abode of the many forms of life which finally resulted in the origin and development of man.

The sun is a mass of vapor 865,000 miles in diameter, with an average density about 1.4 times that of water. Toward its center, where the temperature reaches several million degrees Centigrade, its density is far greater than this, but the gases which form its brilliantly white surface (the photosphere) are much less dense than water. Their temperature is between 6000° and 7000° Centigrade. Thus there is a great drop in temperature from the interior of the sun, where most, if not all of the atoms are doubtless split up into electrons and protons, to the surface, where we observe the chemical elements as they appear in the electric furnaces and arcs used in our laboratories. We therefore have every reason to believe that by some process not yet clearly understood the elements are formed from electrons and protons below the photosphere, through which they rise in the gaseous state to constitute the atmosphere of the sun.

The year 1859 was made notable by two outstanding events, which marked the origin of the modern study of organic and inorganic evloution: the publication of the *Origin of Species* by Darwin, and the discovery of the chemical constitution of the sun by Kirchhoff. This first use of the spectroscope for the interpretation of astronomical phenomena showed the existence in the sun of the familiar elements sodium, iron, calcium, magnesium, chromium, nickel, barium, copper, and zinc, identified by the coincidence of the lines in their spectra with the dark lines in the spectrum of the sun. Many other terrestrial elements were recognized later, and it soon appeared that the earth and sun are closely similar in chemical composition.

The vapors thus identified in the sun form the lowest stratum of its atmosphere, a thin sheet closely embracing the photosphere. Above this shallow layer certain gases rise to much greater heights, constituting the filmy corona and the brilliant red prominences, familiar to observers of the totally eclipsed sun. Ordinarily the corona,

FIG. 1.—QUIESCENT SOLAR PROMINENCE 80,000 MILES HIGH
Photographed by Ellerman with the 13-foot spectroheliograph of the Mount Wilson Observatory

whose streamers extend more than a million miles from the photosphere, and the prominences, which in rare cases rise to altitudes of several hundred thousand miles, are hidden from view by the brighter light of the sky around the sun. But when this glare is completely cut off by the moon at a total eclipse, they suddenly become visible.

The spectrum of the prominences was observed by Janssen at the total eclipse of 1868 in India. He found no continuous rainbow band, crossed by dark lines, like that given by the photosphere, but merely three or four bright lines due to hydrogen and a single yellow line, shown later to represent the gas now well known as helium. These lines were so brilliant that he was able to see them after the eclipse was over. Thus arose the method, previously suggested by Lockyer and successfully tested by him just before the news of Janssen's discovery reached Europe, of observing the prominences on any day in full sunlight. By widening the slit of the spectroscope, placed tangent to the edge of the sun, the forms of the prominences can be clearly seen. The most suitable line for this purpose is the red line of hydrogen, with which the prominences appear like brilliant red flames.

Among all the variety of celestial objects none can be found more striking than these. Most of the prominences resemble clouds, which change slowly in outline (Fig. 1). Others are of a very different type, and their forms can be seen to vary from minute to minute. Most spectacular of all are the violent eruptions, which put to shame the greatest outbursts of terrestrial volcanoes. One of these, which rose 120,000 miles in 18 minutes, is shown in Figures 2 and 3.

As the sun rotates upon its axis, the prominences thus observed around its circumference naturally come between us and the disk. In this position they cannot be seen through a spectroscope with widened slit because of the extreme brilliancy of the direct sunlight, so much more intense than the light of the sky. I have recently perfected a simple instrument (the spectrohelioscope) for viewing them against the disk, the principle of which was suggested by Janssen, Lockyer, and Young in the early days of solar spectroscopy. In fact, Professor Charles A. Young, then of Dartmouth College and later of Princeton, built an instrument closely similar to the one now in use in my Solar Laboratory in Pasadena (a branch of the Mount Wilson Observatory). This was used with some success in observing prominences on the sun's circumference, but apparently it was not tried for the purpose of detecting them in projection against the disk. The method was abandoned in favor of the widened slit, when it was shown by Zöllner and Huggins in 1869 that this would suffice to show the prominences against the sky.[1]

The principle involved is easily understood. An image of the sun is formed on the slit of the spectroscope. The hydrogen line Hα, near the red end of the solar spectrum, is like a very narrow window directed toward the sun's disk. The width of this line, and therefore the width of the window, can be increased by opening the slit of the spectroscope, but the delicate details of the prominences projected against the disk are then lost in the resulting glare. This difficulty can be overcome by rapidly oscillating the narrow

[1]Professor Young's original spectroscope still exists in the Dartmouth College Observatory, and at my suggestion Professor Poor is replacing the parts necessary to restore it for use as a spectrohelioscope.

Fig. 2.—Eruptive prominence, 162,000 miles high. Photographed by Ellerman with the spectroheliograph of the Kenwood Observatory at 10^{h} 40^{m}, March 25, 1895

Fig. 3.—The same prominence, 18 minutes later, when it had attained a height of 281,000 miles

spectroscope slit and with it a second slit, which excludes from the eye all light except that of the oscillating hydrogen line. We thus acquire what we may call a hydrogen window, which permits us to observe all the changing phenomena in the hydrogen atmosphere of the sun, both in profile about the circumference and in projection against the disk.

The views thus afforded on any clear day are far too varied to describe within the limits of this article. Some impression of their nature, however, can be obtained from the illustrations (Figs. 4, 5, 6). These are from photographs made on Mount Wilson with the spectroheliograph, an instrument devised by the writer in 1889 for photographing the sun in monochromatic light, and since applied in a long series of investigations. The spectrohelioscope (as I have called the new instrument with oscillating slits) now enables us to *see* all of the hydrogen phenomena in the course of their rapid changes, and not merely to photograph them blindly, without knowledge of what is happening at critical moments, as we have been compelled to do in the past. Moreover, the new instrument, though inferior to the spectroheliograph in some respects, has certain important advantages of its own.

One of these is its instant power of distinguishing between gases moving at different velocities. In fact, our hydrogen window not only excludes from view all solar phenomena except those of the hydrogen atmosphere: it also automatically confines our observations to hydrogen clouds moving at certain velocities.[1] By the turn of a screw in the hand of the observer the velocity limits can be instantly changed, permitting the parts of a prominence which are at rest to be distinguished at once from those that are moving toward or from the earth. This device is of great value in the study of solar vortices, the great whirling storms, like terrestrial tornadoes on an enormous scale, which we discovered on Mount Wilson in 1908 to center above sun-spots (Figs. 5 and 6).

As everyone knows, the characteristic storms of the earth's atmosphere are cyclonic in nature, and the direction of the wind in these cyclones is always

[1]Except in cases where the hydrogen line is considerably widened by pressure or other causes.

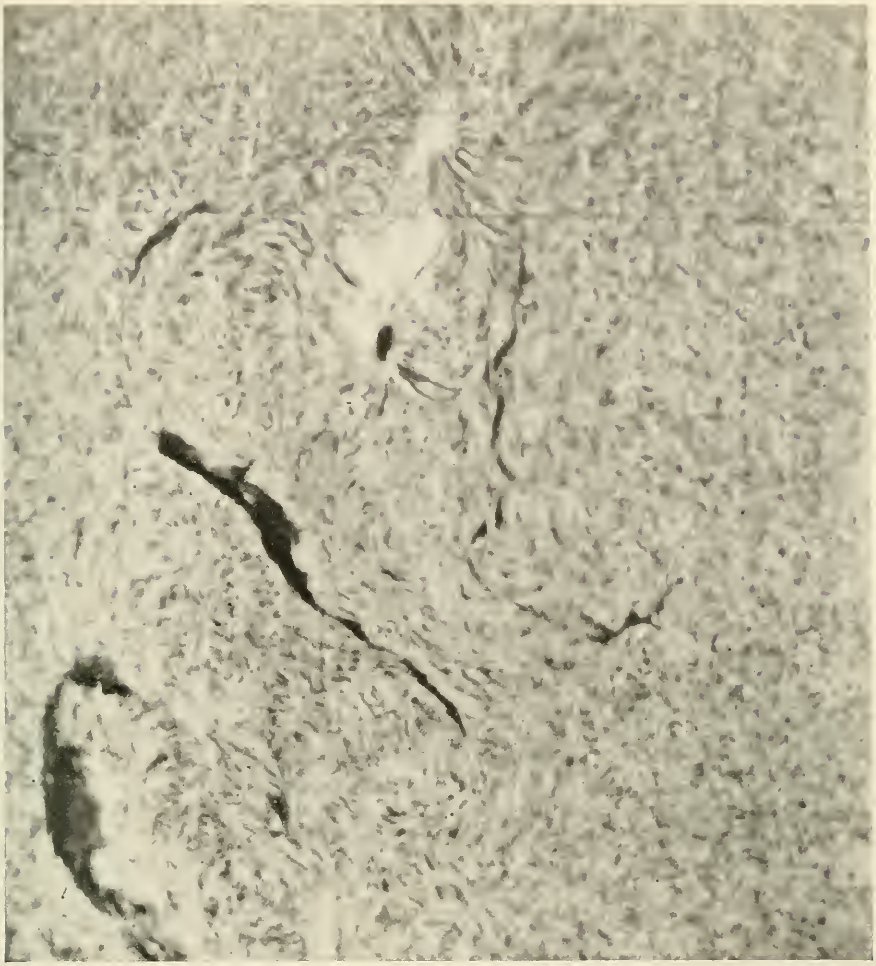


Fig. 4.—Prominences seen in projection against the sun's disk

such as to correspond to a left-handed or counter-clockwise whirl in the northern hemisphere, and a right-handed or clockwise whirl in the southern hemisphere. Tornadoes are much smaller, but far more violent storms, which whirl in the same direction as cyclones. After discovering similar storms in the hydrogen atmosphere over sun-spots, of a diameter many times that of the earth, we naturally endeavored to learn whether the terrestrial law will also serve to define the direction of whirl in these solar tornadoes.

We at once encountered two difficulties. Sun-spots generally occur in pairs, and the hydrogen structure above the two spots usually indicates opposite directions of whirl. But even if we confine our attention to single spots, our difficulties do not all disappear. The hydrogen pattern above some single spots, like that (in the southern hemisphere) in Fig. 6, unmistakably reveals the direction of whirl, in this instance clockwise, thus corresponding to terrestrial storms But the interpretation of the structure above the largest spot in Fig. 5 is far less certain. Here the long, slightly curved filamen

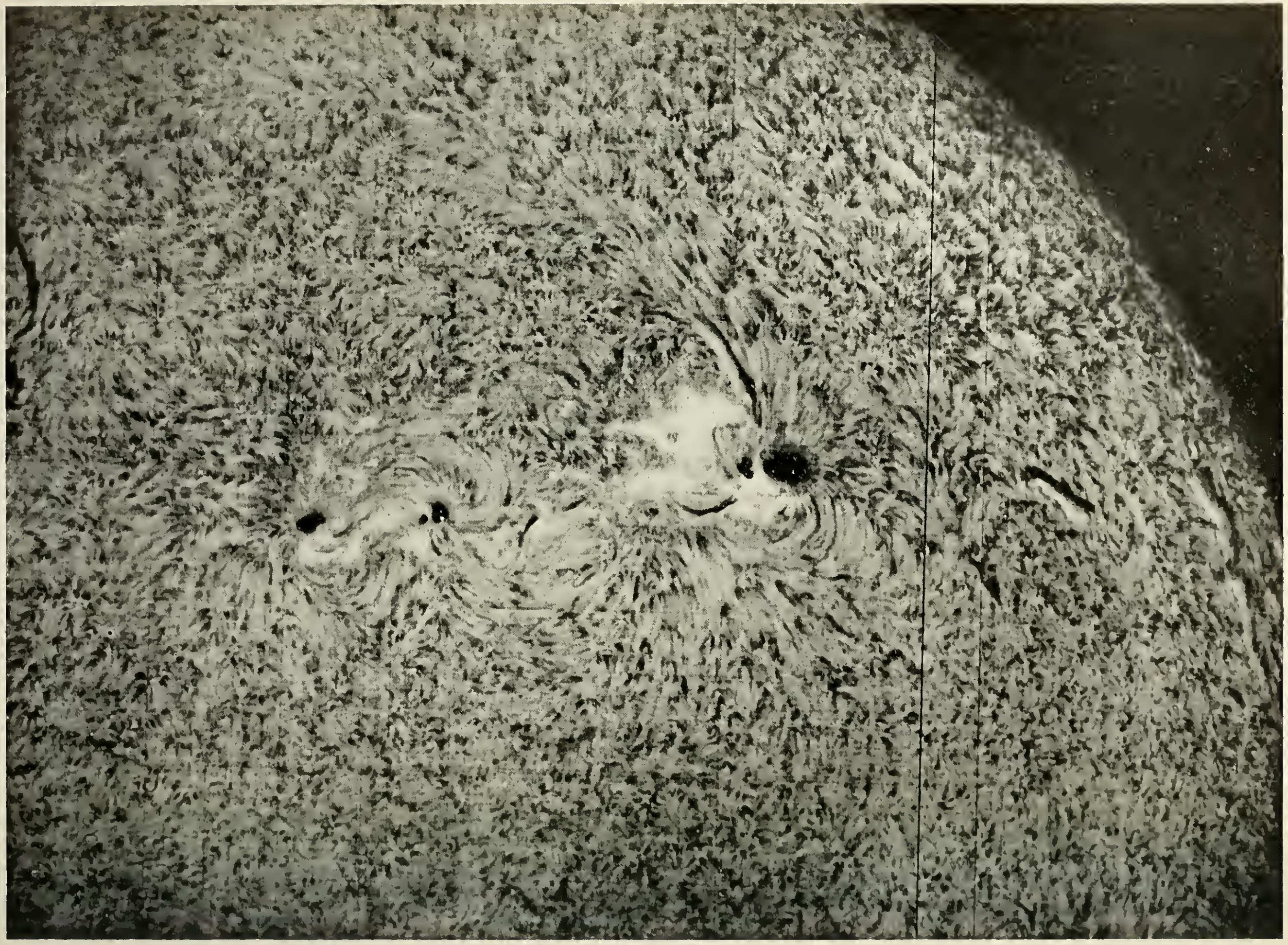


FIG. 5.—HYDROGEN VORTICES OR TORNADOES IN THE SOLAR ATMOSPHERE ABOVE SUN-SPOTS

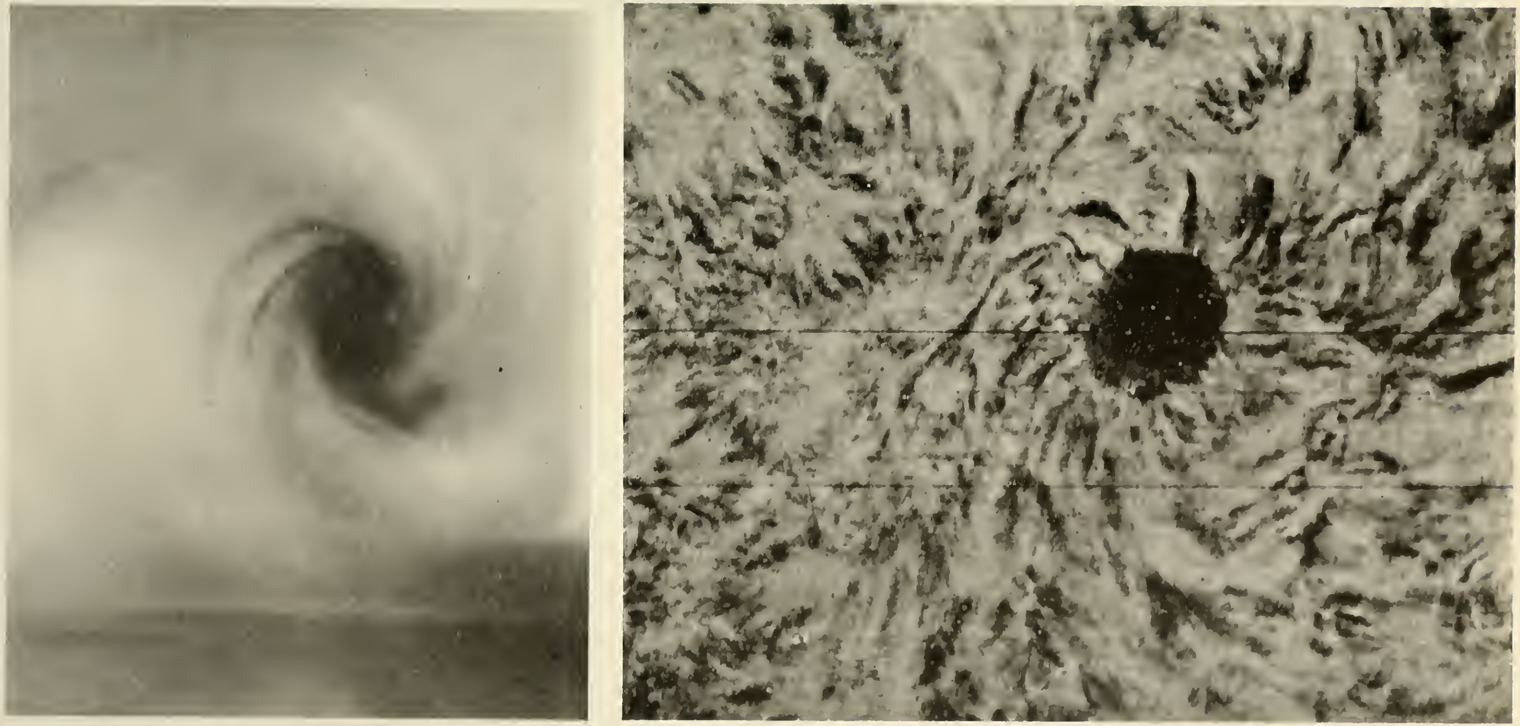


FIG. 6.—(LEFT) A SMOKE VORTEX PRODUCED BY THE METHOD DESCRIBED IN THE TEXT. (RIGHT) HYDROGEN VORTEX IN THE SOLAR ATMOSPHERE ABOVE A SINGLE SUN-SPOT

above the spot (which is in the northern hemisphere) suggests a clockwise whirl, while the vortex structure below the spot is clearly counter-clockwise.

I concluded last year from a study of many photographs that such confusion often results from the presence of two very different classes of phenomena: (1) true vortex structure, where the comparatively cool hydrogen at high levels flows inward and downward toward the spot, and (2), arched prominences, representing hydrogen shot upward from eruptive centers outside the spot, ultimately falling back toward the photosphere after describing a long curved trajectory like the path of a projectile. In such an eruption the hydrogen, when leaving the surface, is so hot that it appears bright against the background. But it rapidly cools as it rises, and the arch which represents the higher parts of the trajectory, though in fact composed of hydrogen so hot that it would appear bright against the sky at the edge of the sun, is cool enough to absorb the light from below and thus seems dark. Evidence of several kinds favors the existence of such eruptive arches, and suggests that the slightly curved filament above the largest spot in Fig. 5 is of this nature. But further proof was needed and this has been supplied, at least in one instance, by the spectrohelioscope. The observation is worth citing, not only because of its value in showing the nature of an interesting class of solar phenomena, but also as an illustration of the power of a newly acquired instrument.

A few days ago (on May 31, 1926) I was observing a sun-spot through the hydrogen window of the spectrohelioscope. I had seen a sharply curved dark filament of hydrogen leading to the spot, recorded its curvature, and had passed on to examine other regions of the disk. At $10^h\,11^m$ I looked again at the spot and was struck by the presence of a brilliant hydrogen outburst near it on the east, which was not visible a few minutes before. Changing steadily in form, the new bright clouds continued to glow brightly for about ten minutes, and then faded slowly. I was then able to see that the curved dark filament had disappeared, as though the comparatively cool mass of hydrogen which it represented had been swept down into the vortex, reappearing at a lower level in the form of the brilliant clouds which had so suddenly come into view. At $11^h\,05^m$ the spectacle was over, though one of the regions near the spot continued to glow less brightly. The nearest parallel to this phenomenon in our daily photographic record on Mount Wilson dates back to June 3, 1908, when a great mass of hydrogen was swept into a spot vortex within a few minutes. This in itself is a good illustration of the value of the spectrohelioscope in rendering visible a phenomenon never seen before. But what followed was even more striking.

In the afternoon, I looked again at the spot and noticed near it a small area still faintly glowing. Then I detected the end of a bow-shaped dark arch, resembling that above the largest spot in Fig. 5. This could not be seen as a whole, but came into view in parts, as the second slit was moved from the violet to the red side of the hydrogen line. A mass of gas coming at high velocity toward the observer shifts the lines in its spectrum toward the violet, and therefore cannot be seen through one of these lines unless the oscillating second slit is displaced toward the violet to receive it. Similarly, in order to see a rapidly receding prominence, the second slit must be moved toward the red. Thus our hydrogen window has a marvelous power of discrimination, not invariably permitting passage to hydrogen light characterized by the Hα line, but only to such light coming from a source moving in a stipulated direction at a velocity corresponding to the distance of the second slit from the normal center of the line.[1]

Having my hydrogen window under instant control, I could thus see exactly what was happening in the arch. The hydrogen was shooting upward (seen with slit to violet) from the point near the sun-spot, moving along the higher part of the trajectory nearly parallel to the solar surface, and therefore nearly normal to the line of sight (slit central), and descending rapidly at the farther end of the arch (slit to red). The nature of the arch was clear, and the distinction between it and the vortex structure unequivocal.

Mount a vertical shaft in a small glass tank half full of water, bearing a paddle (a flat piece of brass or a quarter inch twist drill) almost reaching the surface. Spin the shaft with an electric motor, and a vortex will be produced in the water. By proper adjustment of the paddle, the flow will be upward and spirally outward along the surface. This is our artificial sun-spot. Cover the tank with a sheet of glass and fill the space above the water with smoke, which must not be too dense or too uniformally mixed.[2] Spin the paddle and illuminate the smoke with sunlight through a horizontal slit in a sheet of cardboard covering one side of the tank. Look down into the smoke through the cover of the tank and a beautiful smoke vortex will be seen, closely resembling the hydrogen vortex above a sun-spot (Fig. 6). By moving the slip up and down, cross sections of the vortex can be observed at different levels. When the slit is placed in a vertical position, a vertical section of the vortex can be seen through the side wall of the tank. If two paddles are used, rotating in opposite directions about three quarters of an inch apart, the characteristic vortex structure often photographed in the solar atmosphere above double sunspots can be approximately imitated.

After a long study of solar vortices, utilizing the daily photographs made with the spectroheliograph on Mount Wilson since 1908, and taking into account our daily observations of the magnetic fields in sun-spots and the valuable investigations of Evershed and St. John on the motions of the gases above spots, I believe that these smoke experiments give a very good idea of what actually happens in the sun.

When we first discovered the hydrogen vortices in 1908, I inferred that they pointed to the vortical nature of sun-spots and the probable existence within them of magnetic fields. The reasoning was simple A magnetic field is produced in the laboratory by an electric current flowing through a coil of wire. If, in harmony with modern physics, free electrons could be assumed to be present in the hot gases of the sun, a whirling mass of them in a sun-spot vortex should set up a magnetic field. If sufficiently intense, such a field should split the lines in the spectrum of the spot vapors into two or more components, exactly as the same lines are split in the laboratory when

[1]This method is most effective in the case of the rare hydrogen at high levels, which usually gives a very narrow dark Hα line. The hot hydrogen rising from lower levels gives a wider bright line, but its velocity in the line of sight can often be measured with the spectrohelioscope by determining the position of its maximum of intensity.

[2]Tobacco smoke slowly entering through a small brass tube like an inverted ⊥, its horizontal member perforated with small holes and supported about two inches above the water and the same distance to one side of the shaft, will serve very well.

these vapors are observed between the poles of a powerful magnet (the Zeeman effect). The components are polarized in a distinctive way, so that one or the other can be cut off by a Nicol prism and quarter-wave plate. Thus the existence of magnetic fields in sun-spots should be unmistakably recognized.[1]

law of sun-spot polarity.[2] (Fig. 7).

The typical sun-spot consists of two spots or group of spots, one of north polarity, the other of south polarity, the axis of the pair usually making only a small angle with the sun's equator. From day to day the spots are carried westward across the solar disk by the sun's axial rotation. During

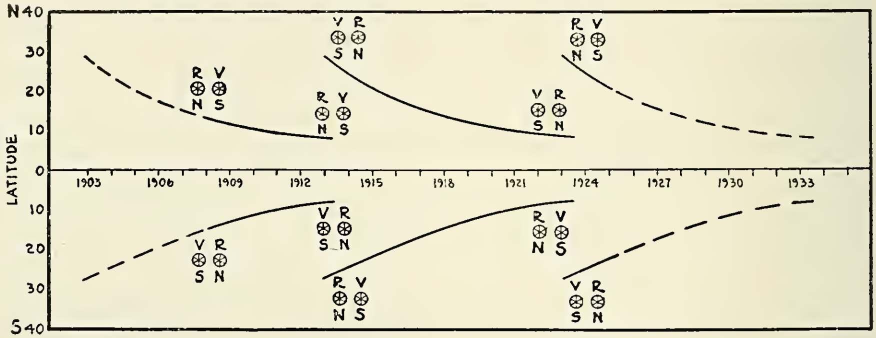


Fig. 7.—The law of sun-spot polarity. The curves represent the approximate variation in mean latitude and the corresponding magnetic polarities of spot groups observed at Mount Wilson from June, 1908, to January, 1925. The preceding spot is shown on the right

The immediate application of this test revealed all the characteristic phenomena of the Zeeman effect, and demonstrated the presence of a magnetic field in every spot examined. It also proved to be an easy matter to determine the polarity (north or south) and intensity of each of these fields. Thus it became possible to undertake on Mount Wilson a systematic study of the magnetic properties of sun-spots. The 150-foot tower telescope is used daily for this purpose, and each spot in every spot-group present on the sun is examined with the 75-foot spectroscope. In this way the polarities and approximate field-strengths of the members of about 2200 sun-spot groups were recorded between 1908 and 1925. A study of these results has yielded the

the 11½ year sun-spot cycle beginning in 1901 the leading (western) spots in the northern hemisphere were found to be of south polarity, while the leading spots in the southern hemisphere were of north polarity. As usual, the spots gradually increased in number from the minimum in 1901, reached a maximum a few years later, and gradually decreased in number until the minimum in 1912. Meanwhile their average latitude steadily decreased, the last spots of the cycle appearing near the equator.

The beginning of a new 11½ year cycle is marked by the sudden appearance in both hemispheres of spots in comparatively high latitudes. To our surprise, these new spots were opposite in polarity to those of the preceding

[1]Although the magnetic fields are certainly present, the problem is less simple now than it seemed in 1908, because of the difficulty of accounting for the strong electric currents necessary to produce such intense fields.

[2]See Hale and Nicholson, "The Law of Sun-spot Polarity": Contributions from the Mount Wilson Observatory, No. 300; *Astrophysical Journal*, Vol. LXII, pp. 270–300, 1925.

cycle, i. e., the leading spots in the northern hemisphere were now of north polarity instead of south, while those of the southern hemisphere were of south polarity instead of north. Moreover, as the spots of the new cycle begin to appear in high latitudes about two years before the last of the spots of the old cycle disappear near the equator, there is a period during which the sun exhibits two zones in each hemisphere, in which the spots are of opposite magnetic polarity (Fig. 8).

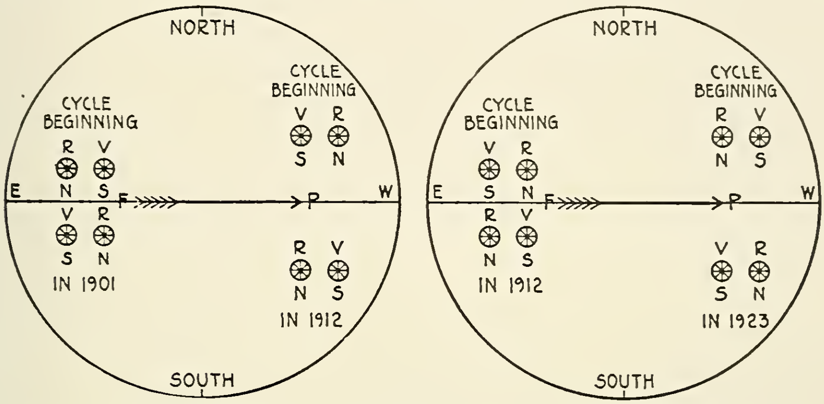


Fig. 8.—Sun-spot zones during the minimum of solar activity. Two zones in each hemisphere, in which the spots are of opposite magnetic polarity, exist for about two years at the time of each sun-spot minimum

Without going into further details, it may be considered probable that the electric current that produces the magnetic fields in sun-spots is always of the same sign, either positive or negative. If so, the reversal of polarity which we have now observed at two consecutive sun-spot minima, those of 1912 and 1923, must mean a reversal in the direction of whirl in the great tornadoes which constitute the spots. Thus the law of storms at the level in the sun where spots are formed is far more complicated than the terrestrial law, and probably points to recurrent changes of circulation, still beyond the range of both observation and theory, within the body of the sun. The hydrogen vortices in the solar atmosphere, though apparently set up by the effect of the underlying spot vortices, nevertheless seem to follow the law of terrestrial storms. At least, the great majority of those above single spots correspond with terrestrial storms in direction of whirl, and show no tendency to reverse this direction at sun-spot minima. There is no theoretical difficulty about this, as Bjerknes has shown. Even in a small tank of water, it is possible to maintain for some time a clockwise or counterclockwise vortex at the surface by means of a paddle whirling in the opposite direction a few inches below.

The broader bearing of the results mentioned in this article are easily recognized. They suggest a curious law of circulation within the sun which orginated in an earlier period of its career and must also operate in many other stars at a similar stage of development.

GIANT SPIRAL NEBULA, MARCH 23, 1914

Illustrating a distribution of matter similar to that assumed to have characterized the material out of which, according to the planetesimal hypothesis, the solar system was made. It is assumed that in the course of time, the central mass became the sun and that other denser knots of planetesimal matter were collected to form the planets which still occupy outlying positions. Photograph from the Lick Observatory

Early History of the Earth

By CHARLES P. BERKEY

Research Associate in Geology at the American Museum; Professor of Geology at Columbia University

TO an inhabitant of Mars the earth would look like any other planet; from a real star it could not be seen at all. Yet it is close kin to the stars,—the offspring of one of them, the sun, almost too insignificant to notice except for the momentous fact that it happens to be the place where the human race lives. On this account, the earth, its origin and history, is of special interest to us.

Although it is the geologist's task to read the history of the earth, he has to admit that the early part of it is almost hopelessly beyond his reach. Compared to the stars, the earth must be quite young, yet its readable history indicates an existence of hundreds of millions of years. There may be myriads of similar bodies associated with the other stars. It hardly seems reasonable that our sun should be the only one to be accompanied in this way by bodies in some respects like our earth.

It may be, of course, that some very unusual happening was responsible for the earth and the other planets of our solar system. They may mark an accident that almost wrecked it. Astrophysicists say that if two suns were to approach each other near enough, the ordinary stability due to gravitation would become so deranged that the one with less mass would explode. Great streamers of disrupted matter would be expelled as the bodies pass each other and would become separated into particles and scattered to prodigious distances. It is claimed that such an accident would not necessarily destroy the whole sun in this manner, or utterly scatter the ejected material beyond control, but that a comparatively large mass would still be left as a central sun, around which the expelled matter would continue to revolve. One must visualize, therefore, a central sun, part of whose original material has been expelled and cooled to become planet dust, occupying the surrounding space to as great distance as the farthest planet, and moving under the control of the sun itself.

Then the work of building begins—the building of planets out of the explosion débris, for, in this view, the earth was not made out of nothing, no matter what can be said of the stars, but directly out of substantial physical material, every particle of which was gathered up from the swarm of fragments revolving around the sun. These particles, no matter how large or small, had their own orbits, differing somewhat one from another, but each following a course as orderly and as definitely under the control of gravitational law as the earth follows today. These are the so-called planetesimals of Chamberlin.

With the myriads of planetesimals, all belonging to a single revolving system, there must be attractions also among themselves. Gravitation is universal. All bodies exert a gravitational pull on all others, and the more massive a body is the more gravitational power it exerts. The tendency is for them to be drawn together with many collisions since they are all moving around the central sun in the same general direction. Under such conditions it is held that the larger planetesimals would grow by accretion. The smaller planetesimals would be gathered up gradually, one at a time, year after year, century after century, age after age, until the sky was swept clear of them.

Thus a few large masses built up by smaller planetesimals came into existence. Among them was the earth and its satellite, the moon. The earth grew by addition of planet dust, or sun matter, from a much smaller size to its present proportions. Thus it had a history of growth before its history as the finished earth began. At its birth and while it was small, it was quite incapable of supporting many of the activities that are now characteristic of it such as those depending on atmosphere, and water, and life. So it grew, slowly, to greater and greater competence until, after millions upon millions of years, it finally became great and stable enough to be the scene of one of the great cosmic happenings,—the introduction of life and the evolution of organisms.

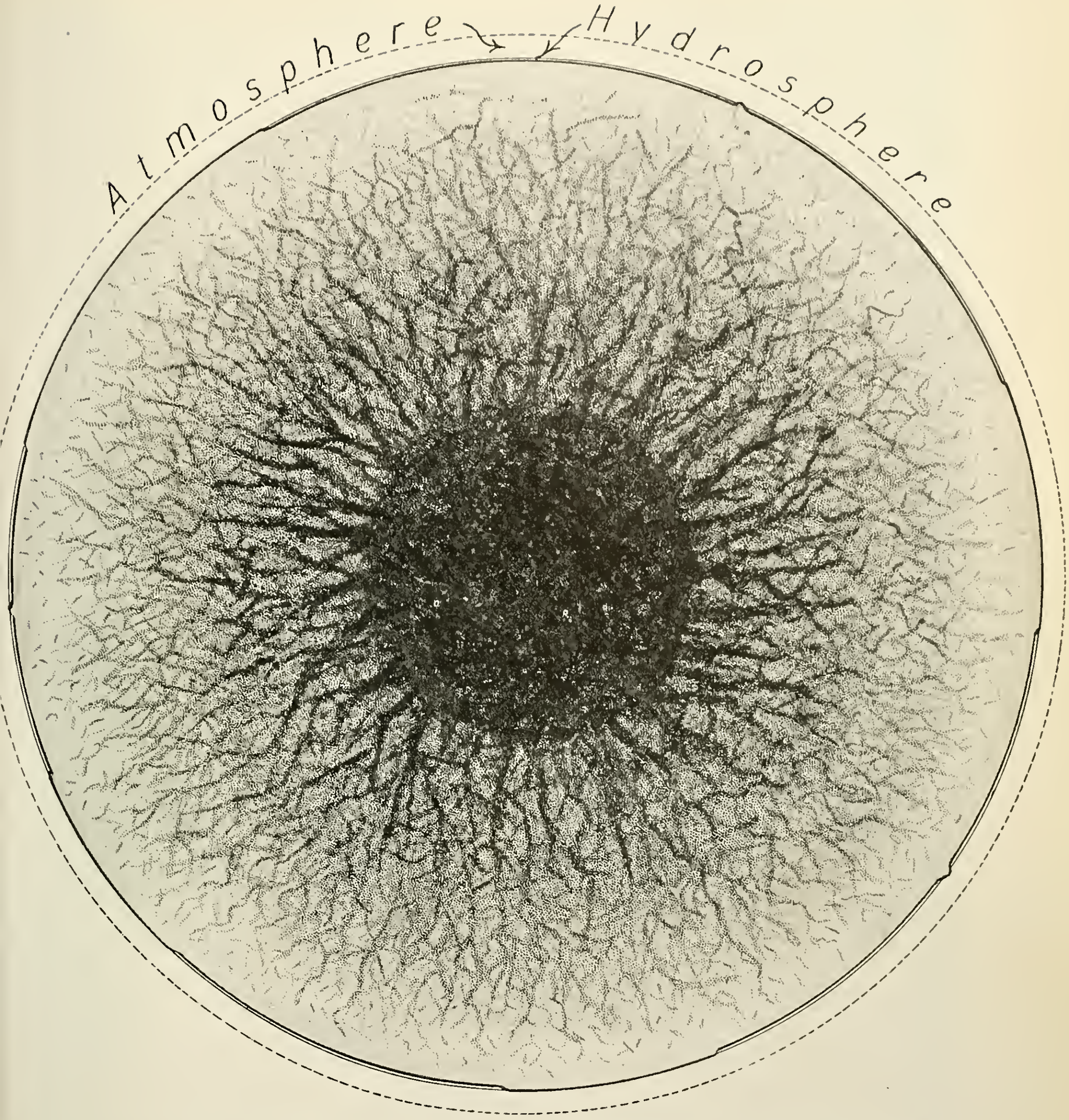
There are, of course, other hypotheses of the origin of the earth. The nebular hypothesis of La Place is older than the planetesimal hypothesis of Chamberlin and in some respects a little simpler. It postulates an enormously extended hot gaseous mass which in the course of time condensed and contracted and separated into rings and finally formed the solar system. Under this hypothesis, the earth passed through a gaseous, then a liquid stage, and finally by cooling reached a solidifying stage with the formation of a crust and a molten interior. Long cooling has made it more stable.

There are minor modifications of both hypotheses, and there are supporters of all of them, but perhaps it is fair to say that most geologists find some form of planetesimal hypothesis of earth origin more satisfying than the other type.

The original heterogeneity of composition, due directly to growth by addition of particles, would make an earth with heavy and light material mixed throughout the mass. It would also bring quite unlike materials together into close contact where their native tendencies to reaction could operate. Thus a series of reactions and processes were inaugurated, the end of which will not be reached until the substance of the whole earth is reduced to essential stability. It may be that this original heterogeneity is chiefly responsible for its long dynamic history. Indeed it may have been the mainspring that has kept the internal processes going and has made the earth almost a live thing to the present day.

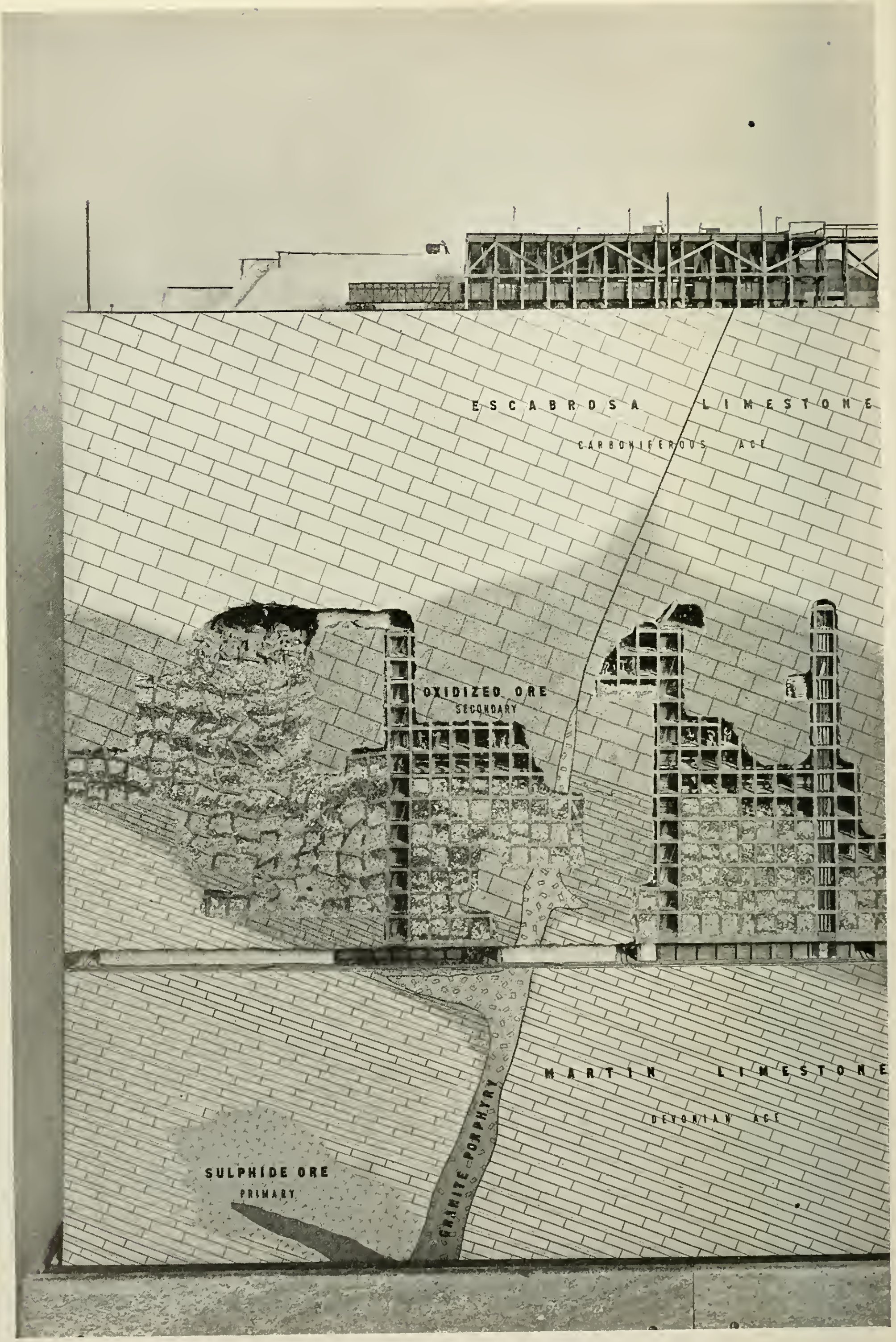
Geologists who regard the earth in this way think of it as undergoing profound internal changes in the course of which many substances have been formed that were not present on the surface in the beginning. Some of these are of immense importance in the economy of life, such as water and air.

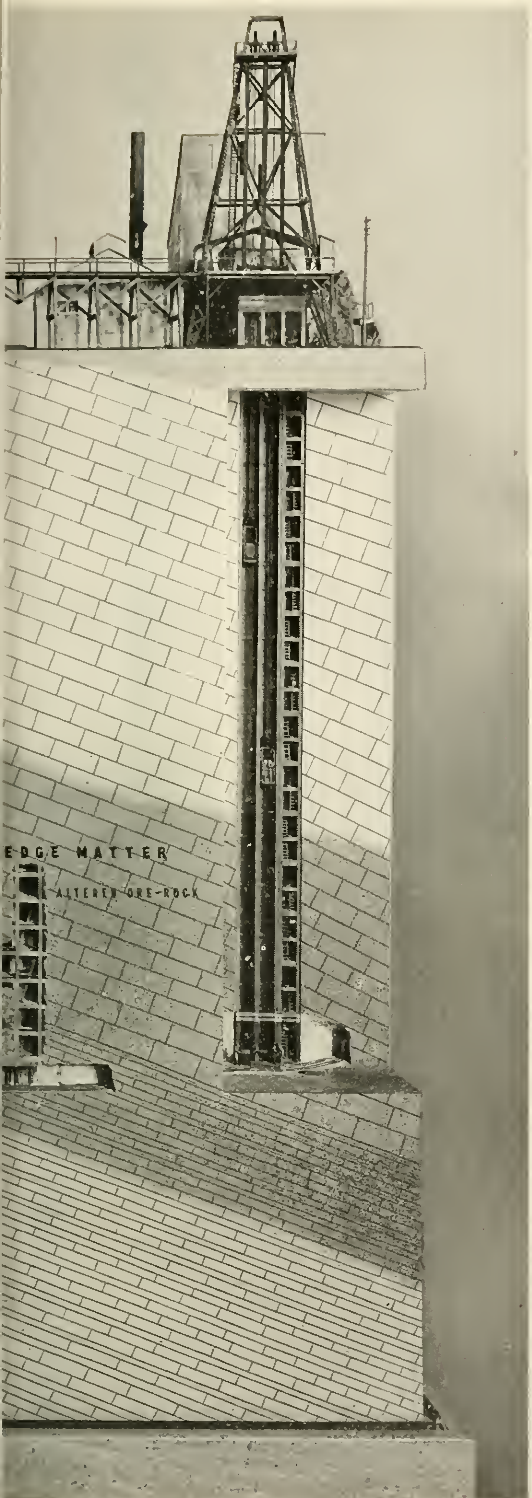
The original porous mass has become much condensed and essentially solid. Physical crowding, due to weight and gravitation, aided by chemical reaction, caused portions to fuse and thus molten rocks were produced and volcanism became established. Probably every portion of the original earth matter has been repeatedly fused and solidified again, but not all portions at the same time. By means of these repeated fusions the substances of the earth have been reorganized and its elements redistributed, the heavier substances settling down toward the



A CONCEPTION OF THE ZONAL CHARACTER OF THE INTERNAL STRUCTURE OF THE EARTH

Following Dr. Henry S. Washington's suggestion and the generally accepted judgment of geophysicists that the central portion is made up largely of metallic substances, probably iron alloyed with nickel, and that the outermost zone is stony, making the rocks that we know more about, while the intermediate zone carries a mixture which becomes more heavily metallic in depth and more stony and non-metallic in the higher levels. According to the planetesimal hypothesis, this zonal condition has resulted from a much more mixed distribution of constituents through a long series of earth transformations under the control of gravitation


ESCABROSA LIMESTONE
CARBONIFEROUS AGE
OXIDIZED ORE
SECONDARY
MARTIN LIMESTONE
DEVONIAN AGE
SULPHIDE ORE
PRIMARY
GRANITE PORPHYRY



center and the lighter ones rising to become a part of the outer shell. Thus, the earth has become zonal, with the heavy material largely concentrated in the central portion.

Of course, internal reorganization of material commenced as soon as the earth began to grow and has been in progress ever since. As the earth grew to larger and larger size, it took on the physical behavior that we know and that has been so important a factor in its readable geologic history. A very small earth would not have gravitational pull sufficient to hold light gases in control and maintain an atmosphere. Such a condition is even now represented by the moon. But the earth came, by and by, to have mass enough to retain an atmosphere, produced and freed through the reactions of the interior. By and by, also, water was formed and rose to the surface, filling the interstitial spaces between the fallen particles. Ultimately there was so large an amount that it filled the lowest depressions in the surface, and these areas have increased in size until now nearly three-fourths of the surface of the earth is covered with water.

Heat is one of the products of such reorganization as the earth had to go

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MODEL OF THE COPPER QUEEN MINE, BISBEE, ARIZONA

Prepared by the late Dr. E. O. Hovey for the American Museum of Natural History

The general surface features are shown with location of the mine shaft and the position of some of the underground workings. In the foreground, the earth is shown as if cut open so that the underground relations can be seen. The ore body is in the overlying sedimentary rocks where it has been introduced by the upward moving mineral-bearing solution derived from the igneous mass beneath, thus showing the intimate relation between mineralization and volcanism

A VIEW IN THE GRAND CAÑON IN ARIZONA

A trench, nearly a mile deep, has been excavated by the Colorado River, exposing a magnificent section of sedimentary strata and representing several different geologic ages. The lowest of these formations must date back to near the beginning of life. All known fossil-bearing strata throughout the earth are younger than the base of this column in the Grand Cañon. Only a portion of the entire history is represented here, but that is made up by combining the data of many similar sections. V, Archeozoic (Vishnu schist); U, Proterozoic (Unkar formation); T, Ba, M, early Palæozoic; R, Ss, Ssh, C, late Palæozoic. (The figure chosen here is the one used as a frontispiece in *A Textbook of Geology*, Part II, Pirsson and Schuchert, 1924, John Wiley and Sons, Inc., New York) through. Early in these formative stages, volcanism was inaugurated through the development of heat in the depths of the earth. Then began the long train of processes that depend on molten rock,—out-pouring lavas, volcanic outbursts, and escaping gases that have been in operation ever since.

Volcanism also set free some of the volatile substances of the interior, which escaped to join the accumulating atmosphere and water of the surface zone. On their way to the surface through other rocks, these escaping gases and mineral-bearing solutions left a trail of effects that is of special interest in itself, for in this manner many of the ores of the metals first found a place in deposits rich enough for mines. Of course, this process has kept on to the present time so that there are deposits of all ages.

As soon as the earth came to have an atmosphere and water, an immensely important train of surface processes was inaugurated, beginning with the weathering and decay of rocks, followed by erosion, and ending with deposition of sediments in beds that later hardened into rock again. It is this series of processes more than any other that is responsible for the long story connected with sedimentary strata, which became the cemeteries for the organisms that represent the life history of the earth. Thousands upon thousands of feet of such fossiliferous sediments have been formed. These formations are so important in the later history of the earth with its ever-increasing complexity of life that it is easy to get the impression that earth history began with them. On the contrary, probably when the earth began, it was a comparatively small body having none of the external features that we now know. More time was represented in the accumulations that then helped to build the earth to its present size and form than in all its subsequent history. This early history is largely speculative because the records are almost wholly destroyed by later changes; but it is of fundamental importance that the earth came through such transformations to the stage that we know more about, else we should probably not have an earth so beautifully suited to the uses that have been made of it.

Finally, in the fullness of time, after the atmosphere and the waters were produced, poured out from the earth's own internal laboratories, and the lands and the seas had separated, and some of the present surface conditions were established, there came a day when a new entity appeared. How it happened no one knows. Why, no one can tell any better than he can tell why the earth itself or the stars came to be. Just when it happened is quite impossible to say, but it is certain that after ages, during which there was no life on the earth, there came a day when life appeared. There was a tiny living thing in the waters of the deep. The most momentous step of all was thus taken, for from this obscure beginning a wonderful train of results has been evolved. From it and its kind has come that long line of living things known as animals and plants. Each succeeding epoch saw advancement to greater complexity and competence, each new step apparently growing out of the preceding one, in a strikingly orderly and persistent manner, so that one who follows the story from its beginning to its conclusion can hardly escape the conviction that the whole series is genetically related. The conclusion seems inevitable that in some way which we do not fully understand the later and higher forms of life have been evolved from the earlier and simpler ones.

With this part of the story we are not now concerned. It is enough to see its beginning. Two or three hundred million years ago, after the earth had passed through its formative stages to comparative stability, it became a fit place for living things. Thus, in due time, the earth became the home of Man.

Born of the stars, formed of star dust, and nourished by sunlight, the earth has undergone a metamorphism so severe that there is probably not a particle of the original material left in its primitive condition. It has been entirely remade. The whole mass has been molded into form and its original potential energy has run down to comparative stability. So it has become possible for the earth as a wonderful mother to preserve and nourish the delicate thing that was first life, and transmit, undiminished and in manifold form, the vital spark that is the glory of the organic world.

TABULATED STAGES IN THE HISTORY OF THE EARTH

THE FORMATIVE ERAS covering an enormously long time. (Almost no records; history largely speculative, based on inferences.)	1. The nuclear stage, when the earth was small 2. The atmosphereless stage 3. Initiation of volcanism 4. Development of atmosphere and water 5. The establishment of oceans and continents
The Advent of Life	
THE ERAS OF LIFE from little known to well known times, covering probably a thousand million years. (Geologic records more and more complete; history based on interpretation of earth structures and forms of life.)	6. The Archæozoic Era (dawn life) 7. The Proterozoic Era (primitive forms of life) 8. The Palæozoic Era (ancient forms of life) 9. The Mesozoic Era (intermediate forms of life) 10. The Cenozoic Era (modern forms of life)

Ancient Concepts of the Universe

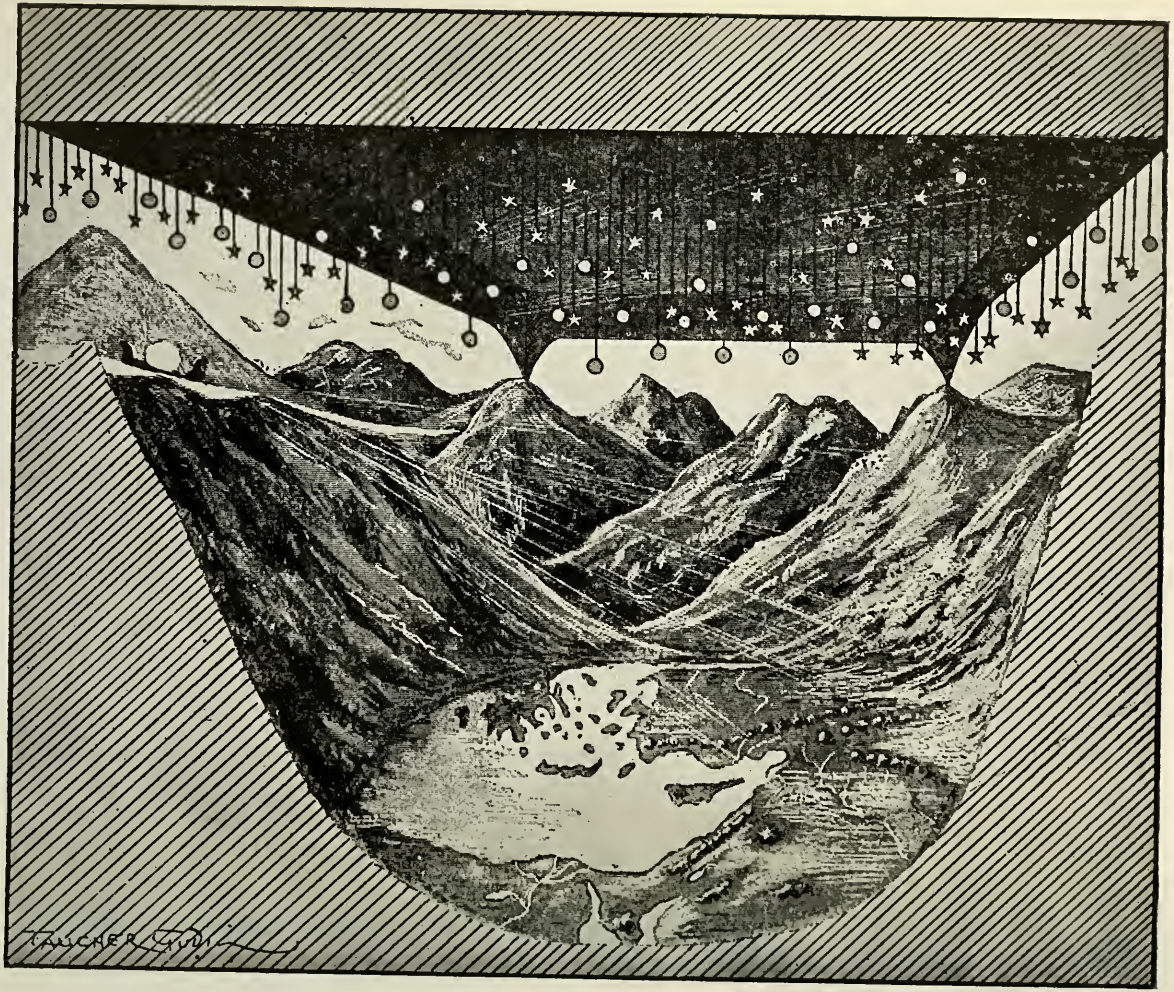
THAT astronomy is as old as civilization is well authenticated by the records of the science among early nations. According to the Greek historians, the earliest traces of astronomical science were found among the ancient Chaldæans and Egyptians, and Maspero in his *The Dawn of Civilization—Egypt and Chaldæa* gives two interesting accounts of the structure of the universe as imagined by these peoples. The following excerpts, together with the illustrations on pp. 384–85 describe graphically their respective beliefs.

AN ATTEMPT TO REPRESENT THE EGYPTIAN UNIVERSE

The Egyptians "imagined the whole universe to be a large box, nearly rectangular in form, . . . The earth, with its alternate continents and seas, formed the bottom of the box; it was a narrow, oblong, and slightly concave floor, with Egypt in its center. The sky stretched over it like an iron ceiling, flat according to some, vaulted according to others. Its earthward face was capriciously sprinkled with lamps hung from strong cables, and which, extinguished or unperceived by day, were lighted, or became visible to our eyes, at night. . . . The sun was a disc of fire placed upon a boat. At the same equable rate, the river carried it round the ramparts of the world. From evening until morning it disappeared within the gorges of Daït, its light did not then reach us, and it was night, . . . "

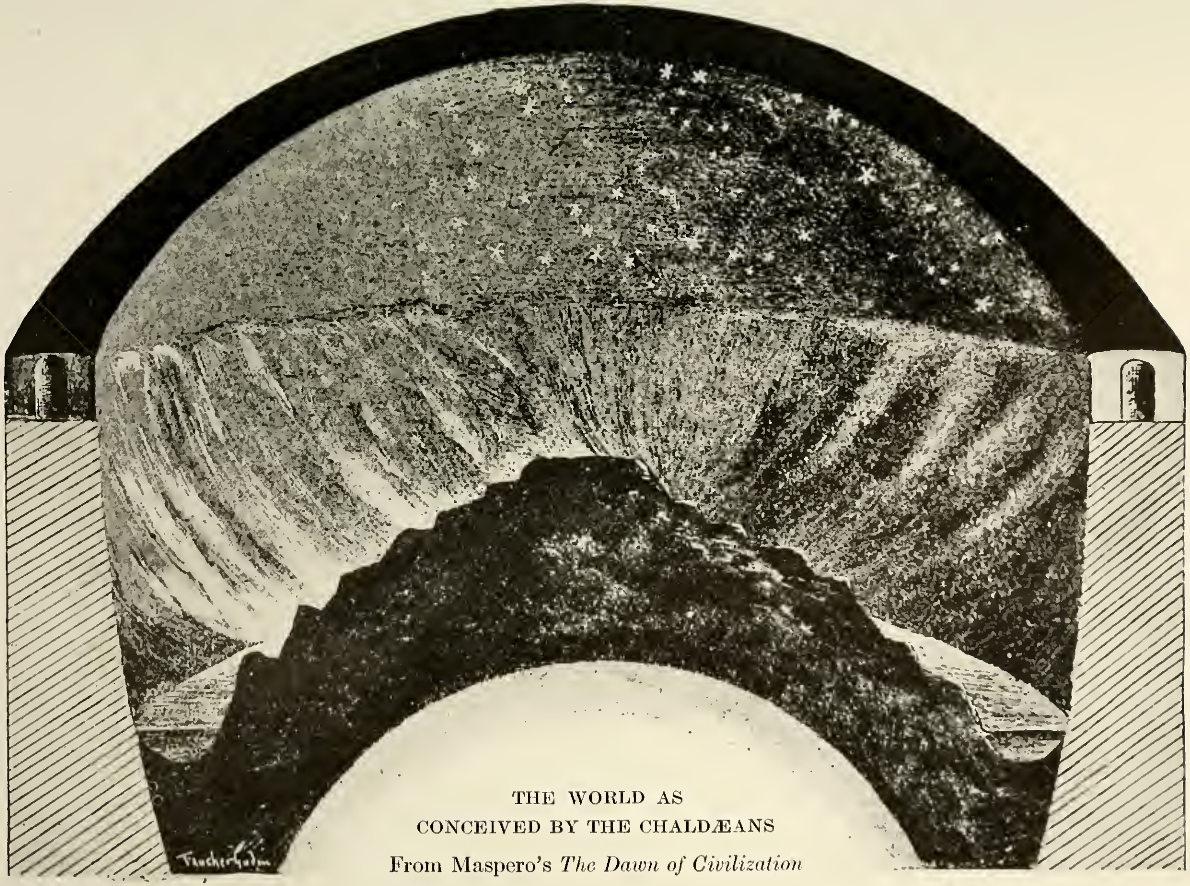
THE WORLD AS CONCEIVED BY THE CHALDÆANS

"As in Egypt, the world was a kind of enclosed chamber balanced on the bosom of the eternal waters. The earth, which forms the lower part of it, or floor, is something like an overturned boat in appearance, and hollow underneath, not like one of the narrow skiffs in use among other races, but a kufa, or kind of semicircular boat such as the tribes of the Lower Euphrates have made use of from the earliest antiquity down to our own times. The earth rises gradually from the extremities to the centre, like a great mountain, of which the snow-region, where the Euphrates finds its source, approximately marks the summit. . . . Near the foot of the mountain, the edges of the so-called boat curve abruptly outwards, and surround the earth with a continuous wall of uniform height having no opening. The waters accumulated in the hollow thus formed, as in a ditch; it was a narrow and mysterious sea, an ocean stream, which no living man might cross save with permission from on high, and whose waves rigorously separated the domain of men from the regions reserved to the gods. The heavens rose above 'the mountain of the world' like a boldly formed dome, the circumference of which rested on the top of the wall in the same way as the upper structures of a house rest on its foundations. . . . He [Merodach] left it quite solid in the southern regions, but tunnelled it in the north, by contriving within it a huge cavern which communicated with the external space by means of two doors placed at the east and the west. The sun came forth each morning by the first of these doors; he mounted to the zenith, following the internal base of the cupola from east to south; then he slowly descended again to the western door, and re-entered the tunnel in the firmament, where he spent the night. . . . "



AN ATTEMPT TO REPRESENT THE EGYPTIAN UNIVERSE

Section taken at Hermopolis. To the left is the bark of the sun on the celestial river. From Maspero's *The Dawn of Civilization*



THE WORLD AS
CONCEIVED BY THE CHALDÆANS
From Maspero's *The Dawn of Civilization*

Island Universes

By W. J. LUYTEN
Of the Harvard College Observatory

"He is no longer a slave who can choose his master"—Henri Poincare

INASMUCH as universe means ALL, it is perhaps a little difficult to understand its use in the plural. By a change of meaning which is as intelligible as it is illogical, universe, to the astronomer, is now limited to meaning all that was once thought to exist, instead of what really does exist. When the astronomer speaks of "other universes," he is not guilty of megalomania, nor should he be accused of usurping the divine prerogative. To the man of science the term "other universes" simply indicates that the material reality of present-day astronomy has far surpassed our original conception of the universe. What, fifty years ago, we thought of as *the* universe, has now been demoted to the rank of *a* universe, merely one out of many. With one stroke of the pen, the spiral nebulæ have been given their freedom—they are no longer of an inferior order in the Milky Way but free and independent citizens of the Cosmic Commonwealth—Island Universes.

The "eternal silence of infinite space" which so frightened Pascal has ceased to exist for us. We see space aglow with light-messages from numberless universes, we are seeing their history, looking into their past—which may be our future.

From the anthropocentric world-conception of primitive man to the modern ideas about island universes is a long step, and one which has taken time. Ever since the beginning of science our measurements have progressed in two directions—toward the infinitely small and toward the infinitely great. In daily life we measure in inches, feet, and miles. When we are measuring light waves in the laboratory, we descend to microns, or thousandths of a millimeter. X-rays make us use Ångstrom units, of the order of one-billionth of an inch. When we speak of electrons and protons, we are thinking of material bodies a quadrillionth of an inch in size. The astronomer, although he uses these small units in his analysis of the light of the stars and studies the behavior of the electrons and protons throughout the cosmos, finds that he must extend the longest units because they are far too short for him. The moment we leave the earth behind us and consider the solar system, we are dealing in millions of miles and begin by calling the distance sun-earth, 93,000,000 miles, *one* astronomical unit. Outside the solar system, for distances between stars, this unit, too, becomes insignificant: the nearest star, Alpha Centauri, is almost three hundred thousand astronomical units away. While looking for larger yardsticks with which to fathom the depths of the cosmos, we naturally think of calling in the assistance of light, with its tremendous speed of 186,000 miles a second. And we adopt as a new unit in the stellar universe, a light-year, the distance traveled by a ray of light in one year, and equal to about five trillion miles. For the nearer parts of space this light-year is a convenient unit; Alpha Centauri is now 4½ such units distant, Sirius about 10, the Pole

Star 200, the Orion nebula about 500. A sphere with the sun at its center and a radius of one thousand light-years would take in most of the stars we can see with the unaided eye. Twenty-five thousand light-years would reach practically all the stars in our Milky Way system; the globular clusters would still lie outside it. But in order to reach the island universes we must go to millions of light-years, distances great enough to suggest the adoption of a new unit, equal to one million light-years, a light-æon. For the present at least one thousand light-æons would suffice to measure the distance of all known objects, of all island universes.

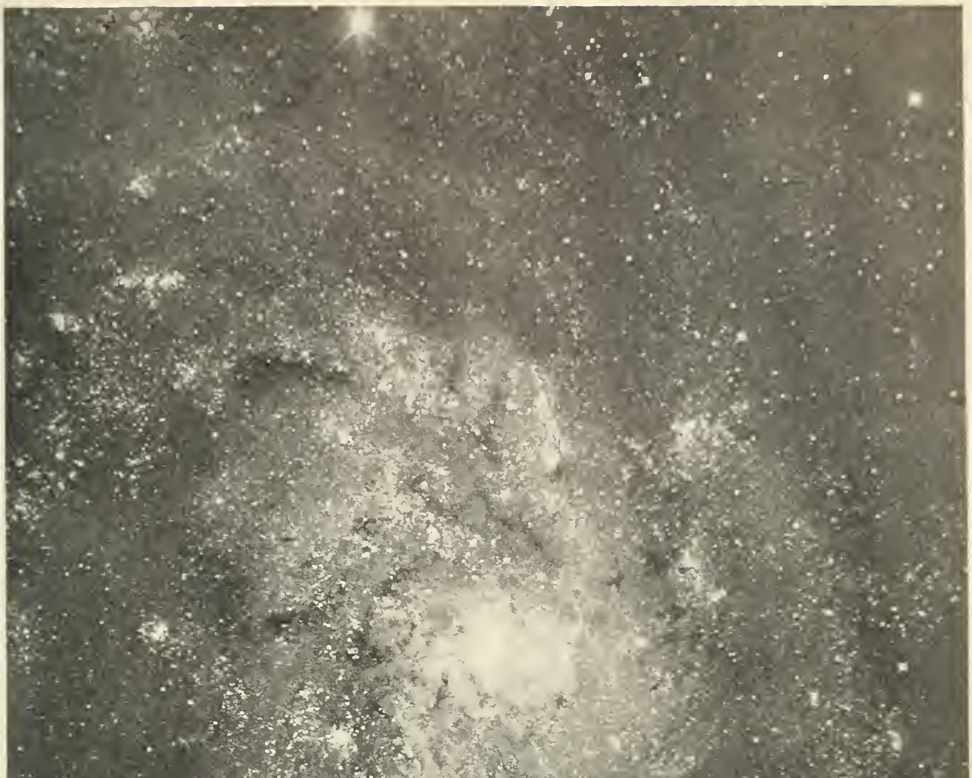
The existence of nebulæ had been known for centuries, even before the invention of the telescope, and nebulæ have always been the object of much speculation. We may say, however, that the new era of island universes was inaugurated in 1845. Its beginnings were very humble and small; at first there was just Lord Rosse's discovery that a nebula in the constellation Canes Venatici showed a spiral shape. Gradually, as telescopes grew larger, and especially as photography, that most powerful ally, was introduced into astronomy, reinforcements arrived, spiral after spiral was discovered and joined the ranks until at present spiral nebulæ form a well-recognized class of celestial objects. Not only that, they are also very numerous in some parts in the sky, as in the constellations Coma Berenices and Virgo, where a long-exposure photograph may show many hundreds of them on one plate.

For some time astronomers speculated about the nature of these spirals. Were they gaseous, like the Orion nebula, or were they great aggregations of stars, only appearing nebulous on account of their enormous distances? The spectroscope soon put an end to this uncertainty; the Orion nebula proved to be a genuine nebula, composed of incandescent gases, the spiral nebulæ were clearly conglomerations of stars. Long before we knew anything about the distance or the size of these spirals, long before we could distinguish the individual stars in them, the spectroscope had shown us that the behavior of atoms and electrons in these far distant systems was the same as in the stars and on earth,—an apt illustration of the power of spectroscopic methods. One might almost be tempted to say that at these infinite distances we can study only the infinitely small. *Les extremes se touchent.* The next difference of opinion arose about the size and the distance of a spiral. Was it an object comparable in size to the whole Milky Way, or was it simply a good-sized star cluster? Easton, of Holland, a supporter of the former alternative, went so far as to propose a spiral structure for our own Galaxy. On the other hand, a strong argument in favor of the small size of the spirals was afforded by the quick rotation measured in some of the larger specimens. Evidence more certain yet was derived from the new stars which had been observed to flash up in the spiral nebulæ, and from the variable stars which have been discovered in two of them during the past five years. From the reasonable assumption that the new stars in spirals are comparable to similar objects which appear in the Milky Way, Lundmark and Curtis came to the conclusion that the spirals must be millions of light-years away. This conclusion, which was confirmed by Hubble from observations of the variable stars in the spirals, afforded a much more decisive means of estimating the distance. It is now universally accepted that the spiral nebulæ are millions of light-years distant. The angular size under which they appear to us then indicates that they must be tens of thousands of light-years in size, large enough to merit the name "island universes." The latest edition of the social register of the Cosmos includes, therefore, all these spirals as full-fledged universes entitled to all rights and privileges of a universe.

As for the rotation of spiral nebulæ, the great distances recently derived have made rapid rotation impossible, and the quick internal motion measured some years ago is now universally regarded as an optical illusion. Although it is obvious from a mere inspection of the structure of spirals that they must be rotating, it is inconceivable that they should revolve so rapidly as to make one complete turn in eighty-thousand years. The large linear dimensions indicated by the present-day distances of millions of light-years would result, for the outlying portions of the spirals, in a speed greater than that of light. Such a thing was immediately condemned as unconstitutional; the modern constitution of the cosmos, the doctrine of relativity, does not permit any material object to move faster than light. Consequently the speed of rotation of spiral nebulæ has been assigned an upper limit; one revolution in a million years or more is all that is allowed them.

The best known of all island universes is undoubtedly the Andromeda nebula, a great spiral, just one million light-years away, and about fifty thousand light-years in diameter. It contains millions and possibly billions of stars, the vast majority being too faint to be seen individually. The only stars we can see are thousands of times brighter than the sun, indeed, the sun could not possibly be seen or photographed at a distance of a million light-years.

During the time that the Andromeda nebula has been under observation, a great number of new stars have been seen to appear in it. The first one to be observed burst out in 1885; it reached the seventh magnitude, which means that, in reality, it was one hundred million times brighter than the sun, one tenth as bright as the whole Andromeda universe! During the few days of its maximum splendor it reigned supreme in the cosmos, it was the brightest star we have ever observed. It was also the most wasteful, for at that time it was radiating so much light and energy into space that, according to the theory of relativity, it was losing more than two hundred trillion tons of matter every second. Yet it could have gone on at this rate for over a year without losing as much as our earth weighs. In addition to this phenomenally bright nova, almost fifty other new stars have been discovered in the nebula, most of them being of the fifteenth or sixteenth magnitude. On the average, the Andromeda nebula seems to produce more than two novæ a year, a little more than our Milky Way system seems capable of. So frequent are these outbursts of novæ that they make us worry what their cause is. It does not seem reasonable to suppose that the past fifty years have been any different in the Andromeda nebula and in the Galaxy from the past fifty billion years, and we have every right to suppose that in that time at least fifty billion new stars have appeared on the scene. To this we must add that fifty billion years is but a short interval in the life of the average star and certainly small compared with the life of a universe. Our Milky Way system contains about fifty



SPIRAL NEBULA MESSIER 33 IN TRIANGULUM. EXPOSURE EIGHT HOURS, THIRTY MINUTES, AUGUST 5, 6, 7, 1910. SIXTY-INCH REFLECTOR

Photograph by Mount Wilson Observatory

CENTRAL PORTION OF THE GREAT NEBULA IN ANDROMEDA, MESSIER 31. EXPOSURE TWO HOURS, OCTOBER 13, 1909. SIXTY-INCH REFLECTOR
Photograph by Mount Wilson Observatory

SPIRAL NEBULA MESSIER 101 IN URSA MAJOR. EXPOSURE FOUR HOURS, FIFTEEN MINUTES, FEBRUARY 5, 1910. SIXTY-INCH REFLECTOR
Photograph by Mount Wilson Observatory

A UNIVERSE SEEN ON EDGE. SPIRAL NEBULA H.V. 24 IN COMA BERENICES EXPOSURE FIVE HOURS, MARCH 6 AND 7, 1910, SIXTY-INCH REFLECTOR.

Photograph by Mount Wilson Observatory

billion stars; we conclude therefore that during the past fifty billion years there have appeared as many novæ as our Galaxy contains ordinary stars. We are faced with the alternative, either that all stars have once been novæ or will become so in time, or, that "once a nova always a nova." Either the nova stage is one of the follies in the life of every ordinary star, or it is a disease, a habit, which, once contracted, recurs again and again.

The Andromeda nebula is not the only spiral that has new stars to its credit. These outbursts have been observed in about other eight spirals. Only very recently, in May, 1926, a new star of the fourteenth magnitude was discovered in the small spiral nebula Messier 61, in the constellation Virgo, —a fourteenth magnitude star,—in appearance an insignificant event, yet it was the echo of a powerful explosion which happened ten million years ago, transforming a perfectly normal-looking star into a veritable blast furnace, ten million times brighter than the sun.

Though the nearest of all spirals, the Andromeda nebula is not the nearest universe. Three others are known to be nearer, viz., the two Magellanic Clouds, situated at a distance of about 100,000 light-years, and a small star-cloud, (technically known as N. G. C. 6822) 700,000 light-years distant. These three are universes in vest-pocket edition, the size of the largest being no more than fourteen thousand light-years and that of the smallest only four thousand light-years.

It was from the Magellanic Clouds that the first clue to the distances of island universes came, for it was here that Miss Leavitt at Harvard first discovered that a relation exists between the apparent brightness of variable stars and the time it takes them to complete one cycle of their variation. Hertzsprung was the first to realize the extreme importance of this relation and to use it for determining distances in the cosmos. Later on, much use was made of it, in a modified form, by Shapley in his extension of the limits of the Galaxy from twenty thousand light-years to two hundred thousand. Now it has provided the basis for fixing the distance of the spiral nebulæ, extending our knowledge of space to tens and hundreds of millions of light-years.

In practically all respects the Magellanic Clouds are similar to our Galaxy; they contain star-clusters, nebulæ, variable stars of different types, blue stars, red stars, in short all the essential features of a universe. They are singularly lacking in one characteristic, however; they have never shown any new stars. Our Galaxy, the Andromeda nebula, and probably all spirals abound in them, but in spite of the close scrutiny with which the Magellanic Clouds have been watched, no new star has ever been observed in them. The same holds for N. G. C. 6822. Why this is so we do not know but, at any rate, this deficiency is not considered sufficient cause to cross the names of these three universes off our books, or even to put them on probation.

We do not know much about the constitution of these far-distant universes (outside the few mentioned specifically) but there is one thing which we know accurately about many of them, their speed in the line of sight. Observations with the spectroscope made principally at the Lowell and the Mt. Wilson observatories have shown us that the Andromeda nebula is approaching us with a speed of 200 miles a second, the Magellanic Clouds are receding from us at the rate of 170 miles a second. Most of the other spirals seem to be running away from us, all have great velocities, hundreds of miles per second. One spiral is even known to hurry away from us at the speed of 1100 miles a second. With reference to the whole system of spiral nebulæ, our Galaxy, and the sun with it, seems to be moving toward the constellation Cassiopeia, with a speed of 250 miles a second.

In addition to the spirals, we know thousands of small, amorphous-looking nebulæ, nebulæ which might be spirals so far distant that the most powerful telescope cannot reveal their structure. Yet it seems that these nebulæ, although obviously related to the family of spirals, are not identical with them; they are, perhaps, embryonic universes. The fact that so many of these amorphous nebulæ seem to crowd together in the sky, has given rise to speculations concerning possible collisions. Now collisions are things the astronomer does not worry about very often. In our Milky Way system a collision between two stars would not happen more than once in a trillion years on the average. But among these nebula the case is different. Charlier has calculated that nebulæ may collide once in a thousand years. And what is a thousand years in the life of a universe? When two such amorphous nebulæ meet or come very near each other, it is quite possible that a spiral nebula will result. At present we possess photographs of many cases where, in a few million years a spiral nebula may be generated. We have never witnessed the birth of a universe, nor are we likely to. The process involved is too slow and does not at all compare as a spectacle with that of the birth of a new star. All that happens is that two swarms of stars meet, and gravitate around their common center of gravity. Indeed, there are indications that the Galactic system is at this moment in "collision" with another universe, manifesting itself as a swarm of stars penetrating the Milky Way at high speed.

What, then, is the present-day picture of the cosmos? To begin with what, is a star? A sphere of glowing gas, varying in size from a globe not much larger than the earth, to one a thousand times larger than the sun in diameter, large enough to take in the entire orbit of Jupiter. In density it may vary from a thousand times rarer than our atmosphere, to fifty thousand times denser than water. Next comes, what is a universe? One answer would be: a vacuum. Take our Milky Way system, e. g., although it contains more than 50 billion stars, the space over which these are scattered is so enormous that we may compare the whole Galaxy to a cubic foot of normal air, spread out over ten cubic miles!

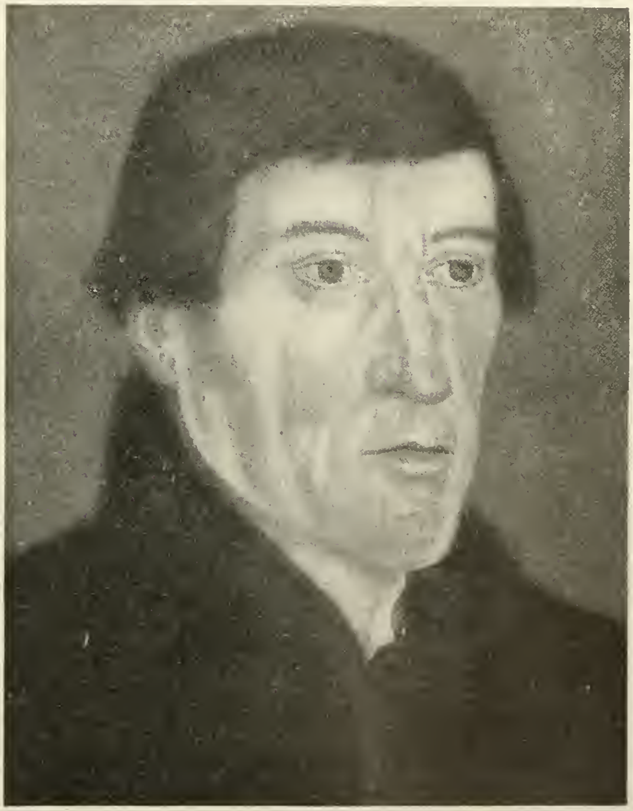
In size, the lens-shaped core of the Milky Way system is about fifty thousand light-years in diameter and no more than ten thousand light-years thick. Outside this nucleus there lie the globular clusters, at distances up to 200,000 light-years, and perhaps some of the more distant Milky Way star-clouds. The first strangers we meet beyond are small islands, the Magellanic Clouds, and N. G. C. 6822, then, at one million light-years, the spirals in Andromeda and Triangulum, not more than fifty thousand light-years in size. So far we have struck only real "Island" universes; a continent as large as our own we have yet to find. But who knows what Space beyond contains? Universe upon universe, some small, some large, and undoubtedly some very large.

Following the tendency of all science

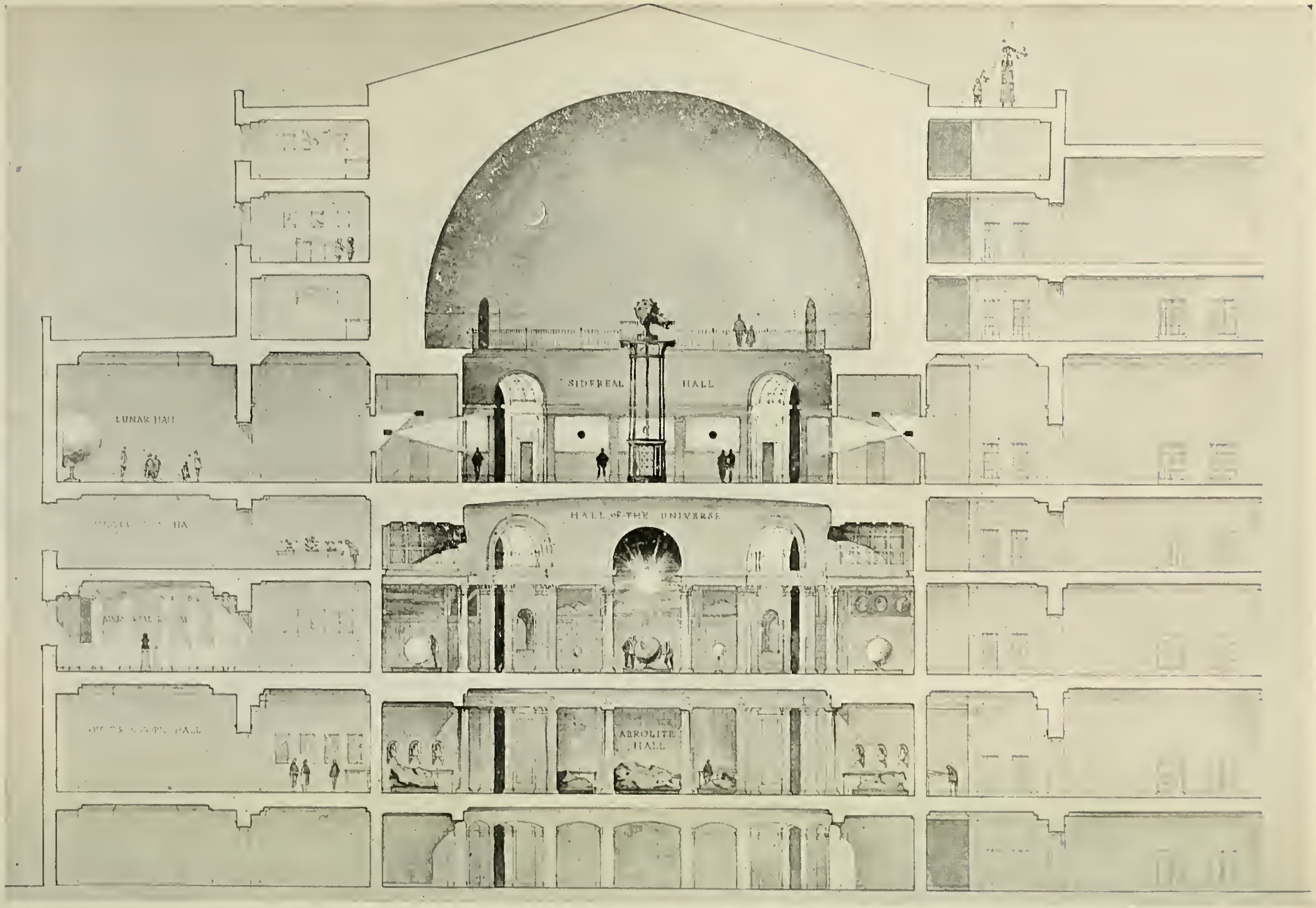
toward "unity and simplicity," astronomical opinion has repeatedly considered everything as part of "our" universe. Equally frequently, however, the dual tendency toward "diversity and complexity" has led us to views like those held now, supposing the existence of numberless universes. Perhaps the future will see us again returning to the Single Universe. Again, everything material will be contained in one system, of much increased dimensions, of course, billions of light-years in size perhaps.

But no matter how far we may go, we shall never reach the end, neither in space nor in time. No matter how far we proceed in space or in time we never advance against infinity and eternity. The ubiquitous myriads of scintillating flashes confront us everywhere, they stagger the mind and overwhelm the intellect—an *infinitas in aeternitate.* And yet, as Pascal, we may feel satisfied with our accomplishments:

> We are little, almost the least and weakest of things; but we know that we are little and therein we are great.

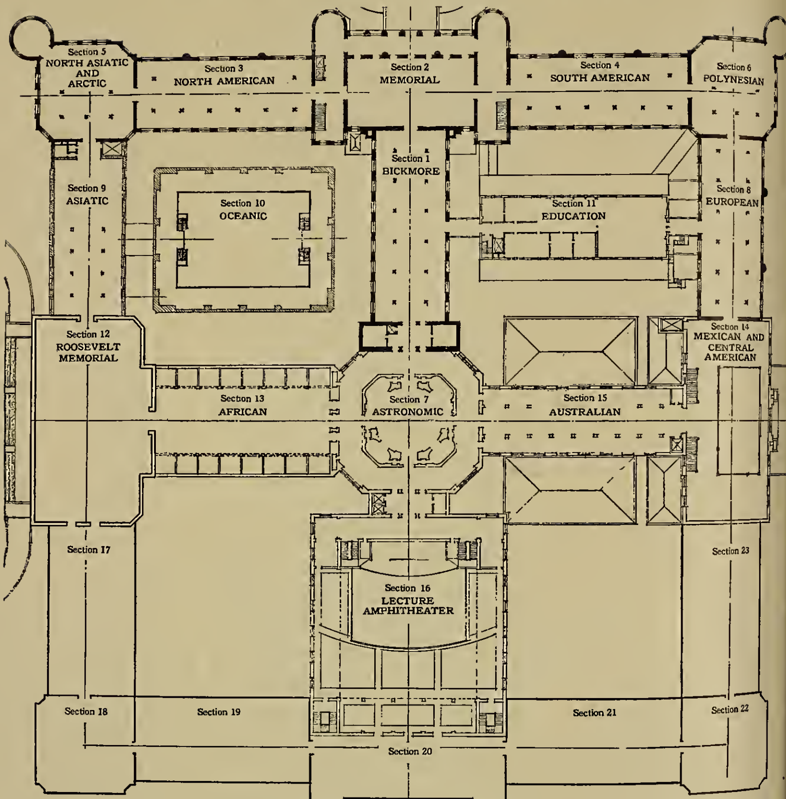


NIKOLAUS COPERNICUS
From the original in the Royal Observatory at Berlin.
After *Weltall und Menschheit*



PROPOSED ASTRONOMIC HALL
Longitudinal section, looking southwest

General Building Plan of the American Museum of Natural History



An Ideal Astronomic Hall

By HOWARD RUSSELL BUTLER

THE proposal of the American Museum of Natural History to construct a hall to be devoted to astronomical and kindred subjects has been conceived at the right time, for it can now be made far more serviceable than would have been possible had it been erected a few years ago. Advance in the line of astronomical exhibits has been rapid lately. Take for instance the Zeiss Planetarium. This marvelous instrument projects on the inner surface of a dome about 4,500 fixed stars, and even the Milky Way is shown as a starry mist. It reproduces the diurnal and annual motions at any desired speed. It also pictures the sun, the moon, and planets, giving their motions within an error, it is claimed, of less than one per cent. It can show the precession of the equinoxes, not in 26,000 years, but in twenty-six minutes. The enormous educational value of this instrument, which solves the problem by optical means rather than by mechanical, and which has awakened such phenomenal interest in Germany, makes it an absolutely necessary adjunct to an astronomic hall—if not its chief attraction. Had the Museum built its hall ten years ago, provision for this unique device would not have been made, and instead, cumbrous mechanical contrivances for showing the movements of a few of the heavenly bodies would have been attempted, necessarily on a limited scale. So I congratulate the Museum on not having been too hasty.

Again I would congratulate the Museum on the wise decision to locate the Astronomic Hall in the exact center of its great system of exhibition buildings. It is indeed appropriate that this should be the central unit,—the celestial hub, so to speak,—from which all the halls containing terrestrial exhibits will radiate. Natural history must begin with astronomy, the earth being but one of the heavenly bodies, and a somewhat insignificant one at that.

The plans, as recently completed, show a building octagonally shaped, with a diameter of 126 feet and a height of five stories, surmounted by a dome. The ground dimensions having been fixed, the Trustees and their architects, Messrs. Trowbridge and Livingston, evolved a general plan along broad and practical lines. Interior divisions were not finally determined, as these would be dependent upon the uses to which the building would be put.

At this stage, I was invited to the position of adviser to the architects.

Before the plan could be perfected in detail, it was necessary to catalogue so far as possible the long list of exhibits to be housed in the building, and my first effort was to canvass the field. A complete list is of course impossible, and the future will also bring many important additions for which space must now be allowed. A wise principle adopted by the Museum is to admit no exhibits except those approved for accuracy by experts. Sensational effects and shallow exaggerations, not based on facts, would do more harm than good. Nature, unassisted, affords enough thrills.

In making the list, the adviser had the assistance of the late Dr. John Tatlock, president of the New York

Academy of Sciences; Dr. Henry Norris Russell, who made many valuable suggestions; Professor William F. Magie, in regard to the Foucault Pendulum; Dr. Clyde Fisher, of the Museum; and Messrs. Bennett & Bauer, of the Zeiss Company, on the subject of the planetarium.

The next problem was that of classification, and after that came the problem of adaptation of the spaces in the building to such classification. This was really the determining factor in the final plans for construction. The arrangement of floor spaces, (rotundas, alcoves, camera booths, and ambulatories) as well as the size of the dome, have been made to suit the classified exhibits.

The final plan calls for a dome 75 feet in diameter, supported at its circumference by a series of steel columns penetrating the building from the ground to the base of the dome. These leave a space for circumferential ambulatories about 20 feet wide, one on every floor between the columns and the outside walls. Another and inner series of columns strengthens the whole structure, leaving spaces for central rotundas on the first, second, and fourth floors,—all 62 feet in diameter.

The exhibits naturally fall into two classes: those which have to be shown in dark rooms by special illumination, like lantern projections, transparencies, underlit pictures, etc.; and those requiring ordinary diffused light (daylight or full electric light) such as globes, photographs on paper, charts, instruments, etc.

A building of this shape and in this position, surrounded by others, is necessarily cut off to a great degree from daylight. Little daylight can reach the central rotunda, and the same is true of much of the ambulatory space. It is therefore fortunate that its mission is one which calls especially for artificial light.

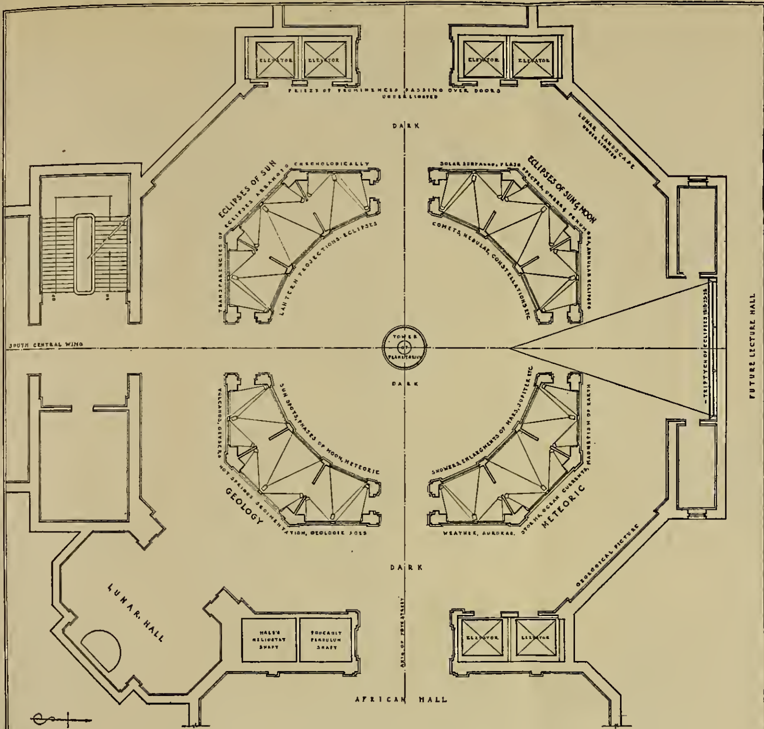
DARK SECTION
SIDEREAL HALL

An early decision was reached in conference to keep the fourth floor (with its dome, rotunda, and ambulatory) dark, and to have diffused light (windows supplemented by electric light) on all the lower floors.

Beginning at the top, as visitors should, and working down, the exhibits of the dark section fall into four classes.

I. Siderial projections on the inner surface of the dome. For these the Zeiss planetarium will be used, a tower being provided to bring it to the proper altitude. The inner surface of the dome is white and the effect of stars is obtained by means of a powerful lantern which throws slides made from drawings based on photographs of the heavens. There are thirty-one of these diapositives, which fitting together, give the complete heavens. Special projections are used for the Milky Way and others for the sun, moon, and visible planets. A gallery on the level of the fifth floor, bringing the eye of the observer to the horizon, encircles the room considerably above the main floor of the rotunda, which is the fourth story of the building. This separates those interested particularly in the projections on the dome from the visitors on the main floor of the rotunda. An alternative to this plan would be to make the fourth floor rotunda only one story high, to abolish the tower and place the lantern of the planetarium in the center of the floor of the fifth story.

II. Twelve panels, carrying trans-

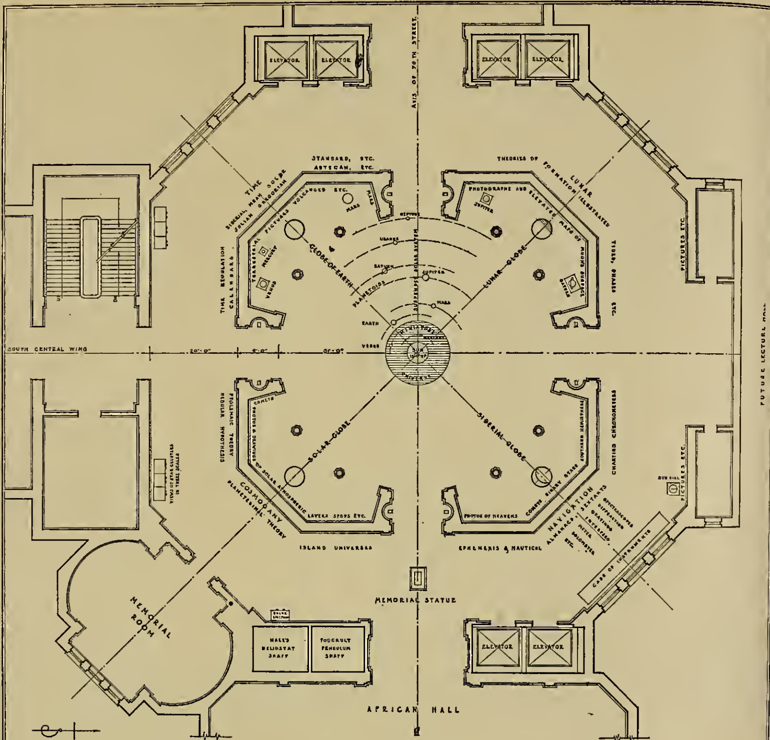


FOURTH FLOOR PLAN

SCALE: ONE INCH EQUALS EIGHT FEET

PROPOSED ASTRONOMICAL HALL

AMERICAN MUSEUM OF NATURAL HISTORY



SECOND FLOOR PLAN

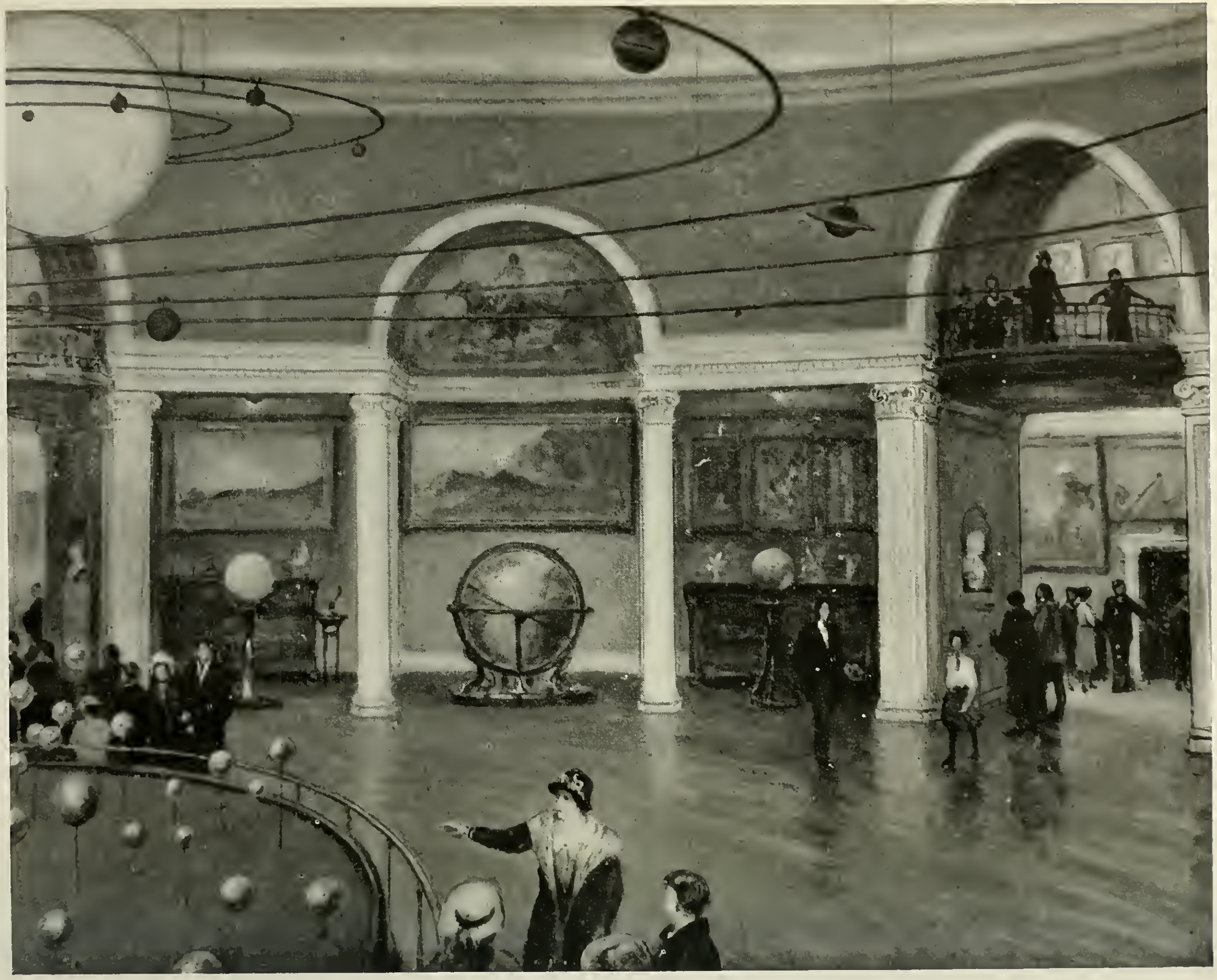
SCALE: ONE INCH EQUALS EIGHT FEET

PROPOSED ASTRONOMICAL HALL

AMERICAN MUSEUM OF NATURAL HISTORY

View in proposed Astronomic Hall showing dome of projection planetarium

lucent screens are arranged around the rotunda. Lanterns, placed behind these screens, in the spaces between the two series of columns, throw projections on the screens of astronomic slides of great variety. These can be shown automatically and rotatively. It was a matter of nice calculation to determine the size of these pictures and the spaces required for the lanterns between the series of columns. An experimental camera booth was erected, and demonstrations made by representatives of the firm of Bausch & Lomb. A wide-angle projector was determined upon and the delimitations of con-



VIEW IN THE HALL OF THE UNIVERSE, SECOND FLOOR
PROPOSED ASTRONOMIC HALL

struction were thus accurately fixed.

III. The inner face of the ambulatory, which surrounds the rotunda and is approached through four openings, is devoted entirely to transparencies, which fall into four divisions, as follows:

(a) Solar eclipses, arranged chronologically.

(b) Solar and lunar eclipse phenomena.

(c) Meteoric division.

(d) Geologic division.

IV. The outer face of the fourth floor ambulatory is devoted to underlit pictures, such as the triptych of eclipses (1918, 1923, 1925) recently placed on view in the temporary astronomic hall of the Museum of Natural History; lunar landscapes; eclipse photographs; a frieze of hydrogen prominences; and such geologic pictures as have astronomic bearing.

A wing on one of the faces of the building provides a space availed of on this floor as a "Lunar Hall," accommodating a lunar globe, ten feet in diameter, with a system of lighting to show phases.

LIGHT SECTION

HALL OF THE UNIVERSE

Second or Main Floor

Everything below the fourth floor is shown by diffused light. A rotunda, two stories high, occupies the space between the second and the fourth floor. Here in the center will be a miniature universe—a number of fixed stars being selected, represented by electric lamps, showing relative distances apart and color, but without any attempt to show relative dimensions. The position of our sun in this group will be a point of great interest. Above this, about fifteen feet above the floor, is a miniature solar system suspended in mid air, somewhat similar to that in the Munich Museum. The illuminated globe in the center represents the sun. The six planets nearest the sun, with satellites, (the planets and satellites all revolving at their proper relative speeds), are shown. The orbits of Uranus and Neptune are left out in order not to diminish the scale too much. The diameter given to the orbit of Saturn would be about 60 feet.

Surrounding the rotunda are four alcoves divided by columns, making three openings in each. In the central openings are large globes;

(1) Sidereal globe.

(2) Solar globe.

(3) Terrestrial globe.

(4) Lunar globe.

Smaller planetary globes are placed in the other openings, and the interior walls of the alcoves are hung with pictures appropriate to the globes.

The inner face of the ambulatory is also divided into four corresponding sections.

(1) Navigation (sidereal globe section).

(2) Cosmogony (solar globe section).

(3) Time and calendars (terrestrial globe section).

(4) Lunar, tides, etc. (lunar globe section).

Around the outer walls of the second floor ambulatory are cases of instruments, above which are hung photographs of astronomical subjects, portraits of astronomers, etc.

Thus the student of navigation will find everything pertaining to that subject in one division—maps, charts, and log tables on the wall and in near by cases, sextants, chronometers, nautical almanacs, etc. The student of cosmogony finds a section giving him information about the Ptolemaic and Copernican theories, the nebular hypothesis, the planetesimal theory and the "island universes." In the "Time Section" the investigator learns about the various calendars, the differences between sidereal, mean solar and standard times, the principles of the sun-dial with examples of the various types near at hand. An investigator of power sources could find out all about tides in the "Lunar Section." The educational value of these sections cannot be overestimated.

A Memorial Hall is provided on this floor designed to commemorate the donor or donors of Astronomic Hall. It would open from the ambulatory of the main floor, while, if the funds should be given by a single individual, a statue of the donor could be placed at the main entrance to the hall as shown in the plans,—this in line with the central entrance to the Museum on Eighth Avenue.

The third story consists of an ambulatory and balconies, giving upon the "Hall of the Universe." This is reserved for qualified students only. Lectures and demonstrations would be given here, and here would be kept all the instruments used in instruction and the many forms of planetaria, such as are seen in the German museums. A hall in the wing is provided for the lectures and for astronomical moving pictures. From the balconies of this hall the student will have an excellent view of the miniature solar system.

AËROLITE HALL

First Floor, Street Level

The arrangement of alcoves here would be somewhat similar to that on the second floor. The aërolites are arranged symmetrically in alcoves, the great aërolites in the largest openings. This arrangement brings the piers necessary to support their weight into positions outside the central hall of the basement, combining these piers with the foundation footings of the steel columns.

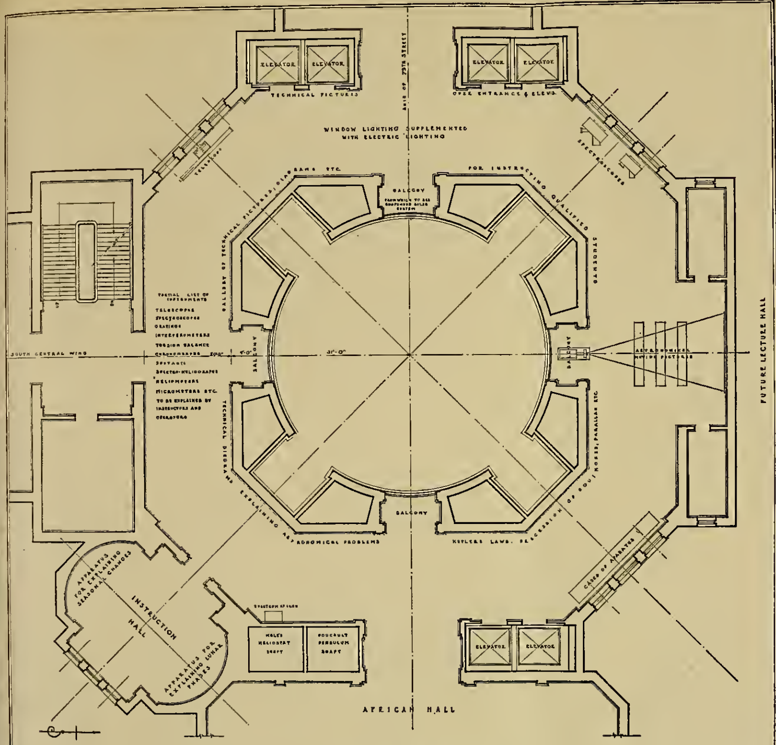
SPECTROSCOPIC HALL

First Floor, Continued

This is under Memorial Hall and is entered from the ambulatory of the first floor. It adjoins the shaft of the Hale Heliostat and here beams of sunlight brought down the shaft can be utilized for spectroscopic projections.

Vertical shafts are provided for the Hale Heliostat and the Foucault Pendulum, terminating on the first floor 120 feet below the roof platform. Adequate elevator service is provided, even to the observation platform on the roof, where a telescope and transit will give opportunity for observation of the heavens themselves.

The time has certainly come for the erection of a great educational hall of the type designed. It is not right that the United States should longer remain behind other nations in a field so important and so absorbingly interesting. The American Museum of Natural History is, beyond question, the organization best qualified to undertake the project. It has an unsurpassable site, situated at the heart of the largest city of the Union. May the means soon be forthcoming and may the opening of the doors of its proposed Astronomic Hall soon be realized.

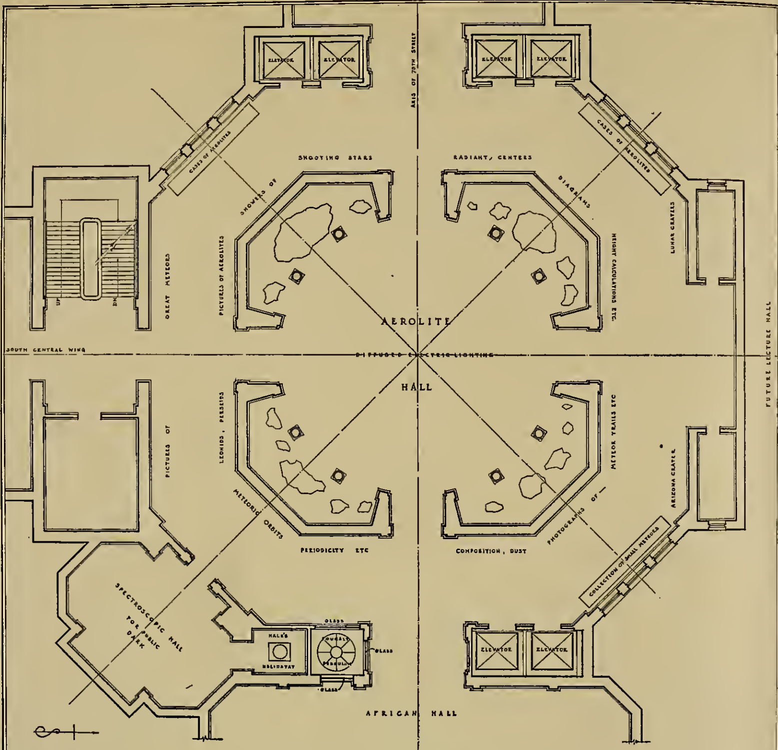


THIRD FLOOR PLAN

SCALE: ONE INCH EQUALS EIGHT FEET

PROPOSED ASTRONOMICAL HALL

AMERICAN MUSEUM OF NATURAL HISTORY



FIRST FLOOR PLAN

SCALE: ONE INCH EQUALS EIGHT FEET

PROPOSED ASTRONOMICAL HALL

AMERICAN MUSEUM OF NATURAL HISTORY

The Use of Models in an Astronomical Museum

By HENRY NORRIS RUSSELL, Ph.D.
Professor of Astronomy, Princeton University; Director of Halstead Observatory

THE words "astronomical museum" might suggest to many astronomers a collection of ancient apparatus which had been relegated to such an environment after they were no longer of practical use in the observatory, but there is no reason whatever why these words should have such a connotation. While a museum cannot be so intimately connected with the work of research in astronomy as it may be in geology, or ethnology, it may perform a distinctive service in connection with its other great function, that of education, both of the general public and of more specialized students of the science.

Direct telescopic observation, which of course has a unique value, is rarely practicable for the public, and suffers under limitations of time even for university students. These difficulties may be considerably obviated by the use of photographs, in a manner very familiar. But it is not generally recognized that suitably prepared models may perform a mission quite distinct from that of even the best photographs.

This principle has long been recognized in the field of natural history, using the word in its narrower sense. The habitat groups which adorn the greater museums convey a wealth of constructive information, even to the casual onlooker, with which no photograph, however excellent, could possibly compete. Is it not practicable to do the same in the case of the heavens?

The more obvious instances, such as the preparation of globes representing the moon and perhaps Mars or Jupiter, have already been frequently attempted. A more ambitious and very successful attempt is found in the modern planetarium. But many other possibilities appear to be open, and it may be worth while to speak briefly of a few, and especially of working models which exhibit characteristics which photographs cannot do.

The chief difficulty in explaining many astronomical problems to the non-mathematical listener is found in the fact that the relations which are concerned are essentially three-dimensional. The power to form a clear mental image of the relations of several bodies in space is somewhat unusual, and pictures in the flat, even the best perspective drawings, do not altogether solve the difficulty; while a model in which the relations are actually represented in three dimensions will often make things clearer.

Consider, for example, solar and lunar eclipses. By a suitable model in a nearly darkened room, in which all the light came from a circular opal glass disk or globe, near one wall, the umbra and penumbra of the shadows of the earth and the moon, the track of the moon's shadow across the rotating earth, and the phenomena of total, partial, and annular eclipses, could all be exhibited. It would be impracticable to construct such a model exactly to scale, but the principles involved could be very clearly illustrated and the mechanical complications need not be at all prohibitive.

Again, in the planetary system, many of the characteristics of planetary motion could probably be best exhibited with the aid of moving pictures. Were it practicable to prepare a film after the manner of the "animated cartoons," which are commercial commonplaces, it would be possible to show the motion of a planet or comet in an elliptic orbit with velocity varying in accordance with Kepler's laws. Such a film, showing for example the motion of Halley's comet, with some indication of the change in brightness and the growth of the tail at perihelion, would be exceedingly instructive. Similar diagrams could be used in the case of binary stars to exhibit both their orbital motion around the center of gravity and the rectilinear motion of this point across the heavens.

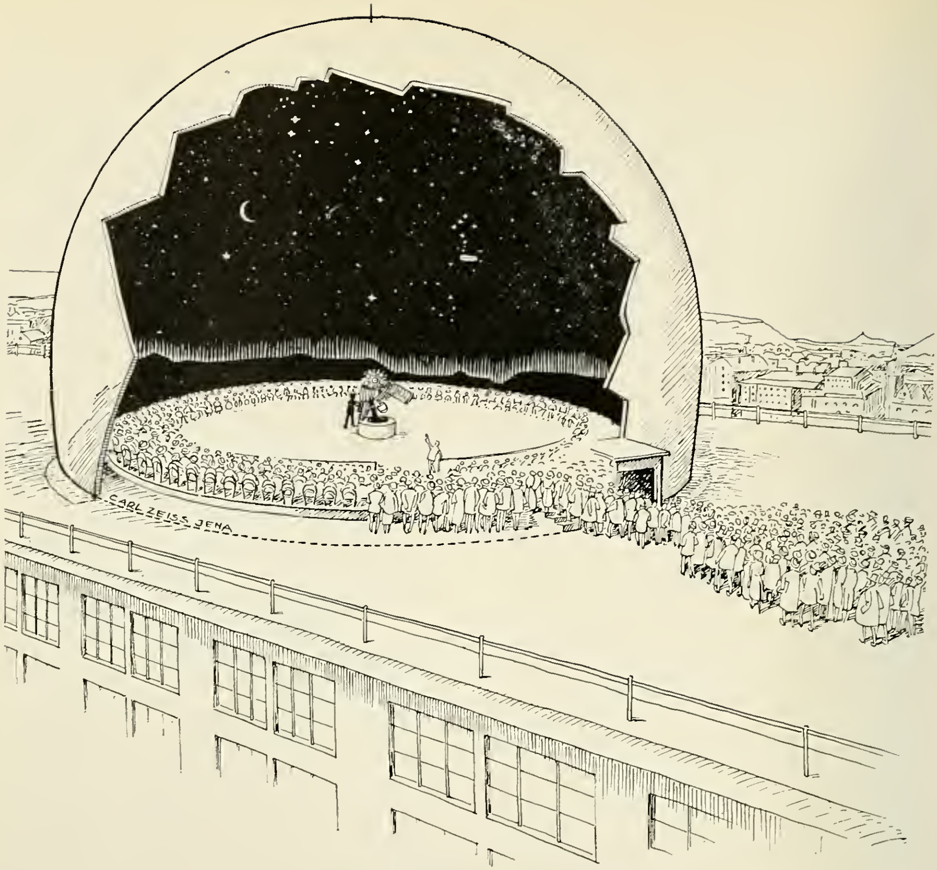
But it is among the stars that the potentialities of the astronomical models are perhaps the greatest. Though they seem to us but dimensionless points of light, our knowledge of the stars is now sufficient to justify the construction of scale models showing their relative positions in space and others exhibiting their true dimensions. The incandescent light here furnishes us with the great advantage that the stars can be represented as luminous points, whose differences both in brightness and in color can be adjusted so that they resemble closely those which actually exist among the stars. A series of lamps, hung by almost invisible wires, could thus form a model representing the position of the sun and the nearer stars in space, and such a model would have the great advantage that corrections or additions could readily be made to it as the discovery of those stars which are our neighbors in space progresses.

It would be entirely possible, also, to prepare models in the form of translucent globes, illuminated by lamps within, which illustrated both the relative size and the relative brightness of such bodies as the sun, Sirius, Arcturus, Rigel, and Betelgeuse. Most interesting of all would perhaps be models of eclipsing variable stars. In this case two such globes of different size and brightness would be set up at a proper distance and caused to rotate about a common center so that each eclipsed the other at regular intervals. There are numerous systems in which the true dimensions are accurately known, and with such a model the visitor might follow for himself the progress of the changes which, as they occur in the heavens, would be exhibited by a photograph annexed to the model.

Still another possibility which occurs to the writer, is that of a graphical representation of the relative magnitudes of astronomical distances, by means of a series of models, maps or diagrams, each on a scale one hundred times smaller than the last. For example, one might begin with a photograph of the room in which the exhibit is placed on 1/100 or 10^{-2} of its actual scale. The next stage might be an aërial photograph of New York City, showing the Museum and its environs, on a scale of 1/10,000 or 10^{-4}. The next, on the scale of 1/1,000,000 or 10^{-6}, could be represented by a sheet of the international map of the world. On this scale the earth is about twenty feet in diameter, as is illustrated by segments of a globe, showing the polar regions, which are now in the Museum. In the fourth stage, scale 10^{-8}, the earth would be about 5 inches in diameter, the moon rather more than an inch, and about thirteen feet from the earth. In the fifth stage the earth and moon would be about one and one-half inches apart and the sun fifty feet away and not quite six inches in diameter. The sixth stage would reduce the sun to about 1/16 of an inch, and put the earth six inches from the sun. The smaller orbits of the planetary system could be well mapped on this scale. The seventh stage would show Neptune's orbit not quite four inches in diameter, and could exhibit some of the larger cometary orbits which are well determined. On the eighth stage Neptune's orbit would have shrunk almost to a dot, some of the cometary orbits would still be visible and the nearest fixed star would be some forty feet from the sun. The ninth stage would bring the nearest star within a few inches of the sun and would be well adapted for a model showing the distribution of the stars in space. Two more stages would be required before a model of the Andromeda nebula could be shrunk to practicable dimensions.

The same scheme reversed, so that objects were magnified instead of diminished, might perhaps be used to exhibit the modern discoveries concerning atomic structure. Magnifications of one hundred- or ten thousand-fold can be reached with a microscope. The third stage might be used to illustrate the ultra-microscopic particles which occur in colloidal solutions. The fourth would exhibit the arrangement of atoms in crystals, the fifth the structure of the inner electron orbits in the heavier atoms; while on the sixth the electron itself would begin to become a visible speck.

Such a series of models, if its preparation should prove practicable, would, in all probability, lead to a realization of the relative magnitudes of the various bodies with which modern science deals, and would be much more vivid than anything that can readily be obtained at present. The writer will confess frankly that the realization of this series is one of his dreams because he would like very much to see it himself.



Sectional view of the Zeiss Planetarium

The New Projection Planetarium

By CLYDE FISHER
In charge of Astronomy, American Museum of Natural History

And that inverted Bowl they call the Sky—The Rubaiyat

SOMETHING new has appeared in the realm of science, something fundamentally different from all achievements of the past years in this particular field. It is an instrument grand in conception and fully realized in its development, an instrument for the purpose of popularizing the great subject of astronomy.

Our prehistoric ancestors were greatly interested in the planets and the stars and in the sun and moon, and made considerable strides in comprehending their movements. The misunderstandings of students before the time of Copernicus and of nearly all persons for more than a century after, were quite natural, for the earth certainly seems to be in the center of the universe, and all the heavenly bodies seem to revolve around the earth. As is well known, the idea that the earth rotates on its axis and that the sun is the center of motion of the earth and other planets was not accepted without great opposition. The vicissitudes of this theory, known as the Corpernican system, the burning of Bruno at the stake, and the punishment of Galileo are common knowledge.

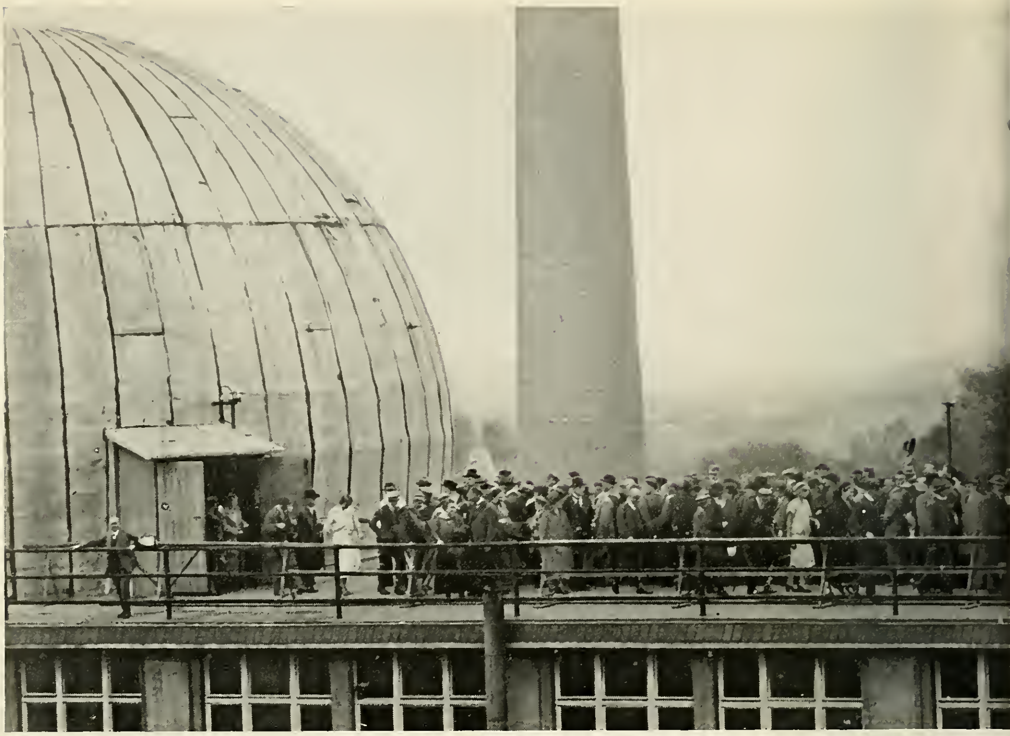
It is true that mechanisms known as planetariums showing the relative motions of the sun, moon, and planets are not new, but have been constructed at various times since the days of Huygens (1629–95) and Roemer (1644–1710). In England a complicated machine of this type was built for Charles Boyle, the fourth Earl of Orrery (1676–1731), which was named for him, thus originating the word "orrery," now frequently applied to such pieces of apparatus. These machines consisted of a series of globes to represent the various bodies of our solar system, each revolving globe supported by a metal rod, the whole system of sun and planets and satellites being connected and propelled by gears so that their relative motions were approximated. The earlier ones had much to do with the final general acceptance of the Copernican system and, ever since their first appearance, these devices have had and still have great value in teaching, the three-dimensional mechanisms capable of simulating the motions of the heavenly bodies being incomparably more effective than flat pictures or pages of printed text.

Some of these mechanical planetariums or orreries have been made with great ingenuity and skillful workmanship. The best ever constructed was made by the Carl Zeiss Optical Works and is installed in the German Museum in Munich. It may be briefly described as follows: A lighted globe in the center represents the sun. The six planets nearest the sun, with their satellites—the planets and satellites all revolving at their proper relative speeds—are shown. The diameter of Saturn's orbit is about forty feet. Uranus and Neptune are left out, I presume because their tremendous distances would make the rest so small proportionately. There is no light except from the central sun, and the walls, ceiling, and floor are painted black. Consequently, day and night are well shown on any of the six planets, and so are the phases of our moon. For the lecturer or demonstrator, a car travels around under the earth, which goes around the sun in twelve minutes, the apparatus being propelled by an electric motor. The phases of Venus and Mercury can easily be observed. The constellations of the zodiac are shown in a belt on the wall, with their names in white letters and with the degrees of the circle marked. The principal stars are shown by lights back of small, round holes in the black wall.

Yet, in view of all this, it is quite plain that these old-fashioned planetariums or orreries were very crude

This way to the Projection Planetarium, at the Zeiss Optical Works, Jena

and unsatisfactory at best. All were built on a small scale and the observer had to watch the various movements of the heavenly bodies from the *outside* of the solar system, and not as one



Zeiss Projection Planetarium on the roof of the Carl Zeiss Optical

observing from the earth. And in all cases the comparative sizes and distances were more or less extremely distorted. And again, the fixed stars, which so enthrall us in the night sky, were always left out, although sometimes shown in an inadequate manner by being painted on the surface of an outside sphere or zodiacal zone or belt. It is true that some of these defects were partially overcome in the large Copernican planetarium in Munich, described above, but all of the old type are conspicuously inadequate in comparison with the new projection planetarium.

One of our American astronomers, in a recent number of a magazine devoted to astronomy, says "it has been reserved for Dr. Bauersfeld of the Carl Zeiss Optical Works in Jena to make the first complete solution of this problem, so significant in the ultimate popularizing of the noblest of the sciences, thus enabling for the first time in history the 'man on the street' to comprehend quite as fully as the learned professor, the seemingly intricate, though actually simple workings of the celestial mechanism."

Before the outbreak of the World War, Dr. Oskar von Miller, director of the German National Museum at Munich, approached the Zeiss firm regarding the construction of a planetarium which would show the movement of the heavenly bodies according to the Ptolemaic system on the interior of a hemispherical dome in the same manner as they appear in the heavens to an observer on the earth, that is, to one *inside* the universe. The first idea considered was to represent the stars by small electric bulbs attached to the dome which would have to be rotated around an axis parallel to the earth's

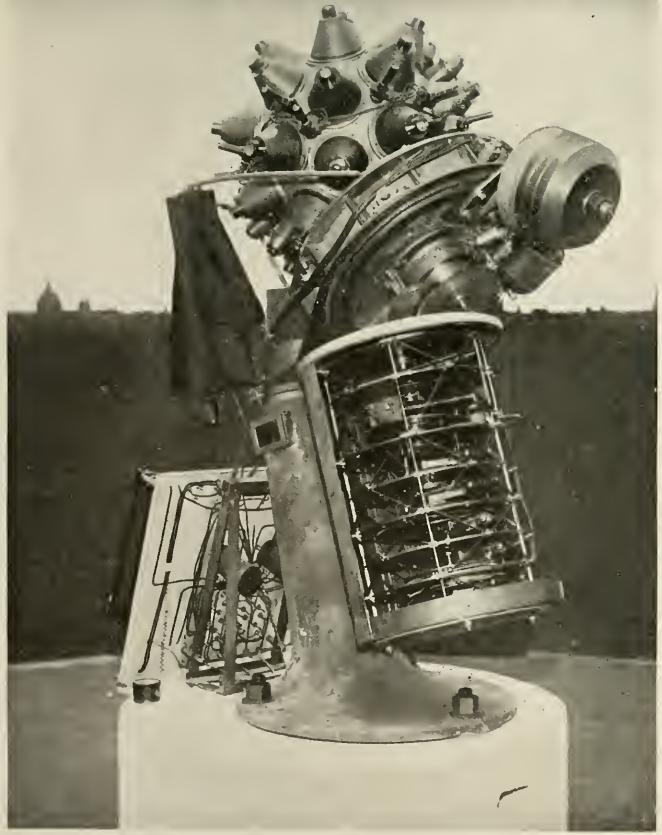
Works, Jena, Germany. Crowds arriving to witness a demonstration

axis. The sun, moon, and planets were to be represented by illuminated discs driven by suitable gearing in such a way that the epicycle orbits of the heavenly bodies would be truly represented. It soon became evident, says Dr. Ing. W. Bauersfeld, that it was impossible to solve the problem in this manner, and the outbreak of the war put a stop to the work. It was taken up again after its close, but the problem was attacked from an entirely different point of view.

The basic idea of the solution was to have the hemispherical dome fixed and to throw images of the heavenly bodies on the dome by means of a projection apparatus located at the center of the dome, the apparent movements of the sun, moon, planets, and stars to be accomplished by the mechanism of the projection apparatus.

In 1924 the first projection planetarium was completed and installed in the Munich Museum. In September, 1925, it was my good fortune to be sent to Germany by the President and Board of Trustees of the American Museum of Natural History, for the purpose of examining this apparatus with a view to its suitability for our proposed Hall of Astronomy. There is no museum of astronomy or department of astronomy in the world that compares with that in the German National Museum at Munich, and the most impressive and consequently the most popular piece of apparatus in the whole astronomical department was the new Projection Planetarium. The available space allowed only ten meters for the inside diameter of the dome. The Museum had two lecturers, who together gave nine demonstrations a day. I attended one of these, at which a part of the audience was made up of a large class

INTERIOR OF ZEISS PLANETARIUM AT JENA
The dome is about 50 feet in diameter, with projection apparatus and artificial horizon



LEFT.—Zeiss Planetarium Projection Apparatus in summernight-winterday position, lowest portion of ecliptic above horizon.

RIGHT.—Zeiss Planetarium Projection Apparatus in summerday-winternight position, highest position of ecliptic above horizon.

In the center of a hollow brass ball at the top, is placed a Nitra lamp of 200 watts, which furnishes illumination for thirty-one projectors that are attached to the outside of this hollow ball and so placed that each one projects a part of the starry heavens. Together they form a continuous picture on the inside of the dome.

The diapositives for these star projectors were made photographically from drawings executed on a large scale which showed every star up to the sixth magnitude. Four thousand five hundred stars were thus located, which is about the number visible to the naked eye. Part of the diapositives are hexagonal in shape and part pentagonal.

To project the Milky Way it was necessary to provide a number of small projectors with the diapositives more or less diffused; it was also necessary to have additional small projectors showing the names of the different constellations.

It was much more difficult to produce the movement of the sun, moon, and planets. This s accomplished by the cylindrical part of the apparatus extending to one side and below the hollow sphere of star-projectors.

ZEISS PROJECTION PLANETARIUM IN PRINZESSINNEN GARTEN IN JENA.
Photograph by Clyde Fisher, September 11, 1925

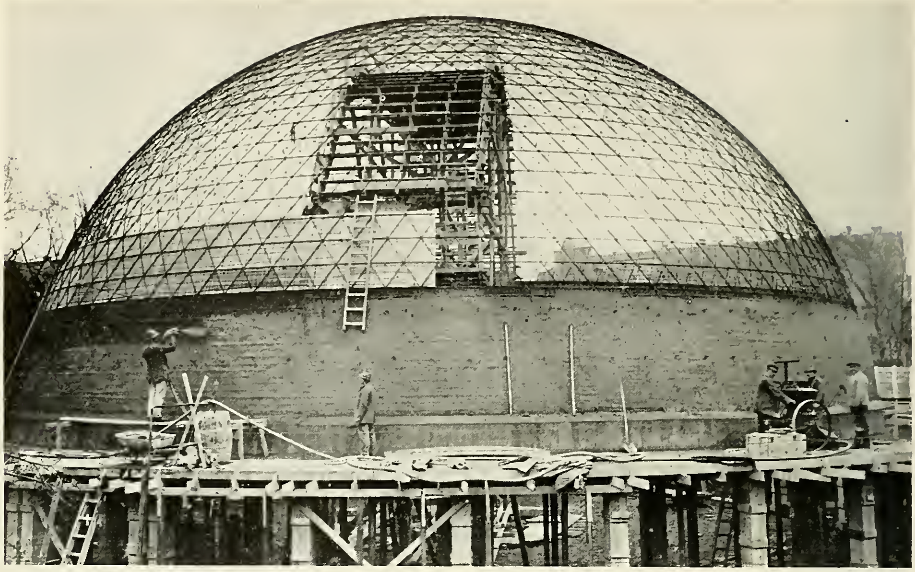
of pupils from a parochial school accompanied by two or three nuns.

The second Projection Planetarium to be built was located upon the roof of the buildings of the Carl Zeiss Works at Jena, and it was here, before going to Munich, that I first saw the apparatus in operation, and it was here that I made a careful study of the mechanism and its working. The dome is larger than the one at Munich, being sixteen meters or about fifty feet in diameter, and affords seating room for 280 persons, although in the excitement of the first days as many as 600 persons, more than half of them standing, were packed into this dome, and as many as twelve lectures and demonstrations a day were given. The dome is hemispherical in shape and is white inside. In the center is an optical projection apparatus which throws on the inside of the dome images of the sun, moon, all the planets which are visible to the naked eye, and the 4500 fixed stars that are visible to the naked eye, including the Milky Way. These projected images move as the real bodies appear to move in the sky, with the time accelerated due to rotation of parts of the central apparatus, which is so accurately made that it takes care of the precession of the equinoxes. The erratic motions of the planets in the sky as seen by the naked eye from the earth are visualized much more satisfactorily than by the old-fashioned planetarium.

The phases of the moon are just as clearly shown, but most impressive of all is the realistic appearance of the fixed stars, including the Milky Way. In the public demonstrations at Jena the audience was sometimes composed largely of school children. Whether the audience was made up of children or of adults, when the fixed stars appeared, an involuntary "Ah" swept over the assembly and they were spellbound. It seems that no one is prepared for such a realistic representation, and I was no better prepared than others. In short, I was astonished, overwhelmed. The illusion of the immensity of space is perfect. One feels that he is in the great outdoors under a clear night sky. Due to some subconscious imagination, perhaps—at least for some psychological or physiological reason, this artificial sky seems to possess the deep night blue seen in the real sky, and yet there was no blue color on the inside of the dome and none in the projection apparatus. On being congratulated upon the mechanism, Dr. Ing. W. Bauersfeld, the inventor, admitted that the illusion of the immensity of space and the realistic representation of the fixed stars, including the Milky Way, had exceeded even his expectations. And Dr. W. Villiger, head of the department of astronomy in the Zeiss Works, was an unbeliever until the apparatus was finished and demonstrated.

By means of a special set of projectors the names of the constellations can be shown in the sky, and with a flashlight showing an arrow-shaped light the lecturer can point out any star, planet, or other body in the sky.

During several days spent at the Carl Zeiss Works I was afforded every facility for examining this new invention, including several private demonstrations, besides the opportunity of attending a number of public demonstrations. For the latter they have five lecturers, young men with technical training who during part of their time are otherwise engaged in the Zeiss Works. Full notes were made concerning the apparatus, its installation, its demonstration, and its adaptation to our astronomical



Spraying liquid concrete on skeleton of dome of Zeiss Planetarium

hall at the American Museum.

In early September eleven of these planetariums had been sold to cities in Germany, and negotiations were in progress with other cities of Europe. Within a few days they expected to close a contract with Vienna. One of the domes in the process of building was seen and photographed in Prinzessinen Park in Jena. In this the dome is twenty-five meters, or a little more than seventy-five feet in diameter, almost exactly the same diameter as the dome planned for our astronomical hall. In the one at Düsseldorf the dome will be thirty meters or more than ninety feet in diameter. For projectional reasons this is considered the maximum limit in size.[1]

[1]At the present time (June, 1926) three Zeiss Projection Planetariums are in operation besides the one in Munich, viz., in Leipzig, in Barmen, and in Düsseldorf. Others are being completed in Berlin, Hamburg, Frankfort, etc., and will be ready in the course of this year. The Planetarium building in the Prinzessinen Park in Jena has been finished since the writer's visit in 1925

Having read an enthusiastic description of the apparatus, and on account of the confidence inspired by the fact that it was made by the Carl Zeiss Optical Works at Jena, I approached this investigation with a tendency toward a favorable consideration. Determining, however, to hold this inclination in check and to approach the matter with an open mind, I made the examination with care and thoroughness. As a result of this study I am enthusiastically in favor of securing a Zeiss Projection Planetarium for our new astronomical hall. Judging from the experience at Jena and at Munich, I believe it will attract more people to the Museum than anything we have ever had here. When it becomes more widely known, it is sure to come to America. May the first one come to the American Museum of Natural History!

A Nature Trail in the Sky

By FRANK E. LUTZ
Curator, Department of Insect Life, American Museum

FOR more than thirty years I had wanted to be able to recognize at least a few constellations and to call them by name. For more than thirty years I had envied those who could do it, but for some reason or other—either laziness, or an inferiority complex, or lack of proper inspiration, but probably the first—I never really learned any except the two northern "dippers." Then, in March my small boy asked me what a third dipper "up there" was. The question challenged my intelligence and was a call to do my parental best. It does not take as much work as I had thought; even I have learned a few constellations; and it is lots of fun.

"Nature Trail" has come to mean to some of us a path in the woods or fields with labels pointing out a few of the interesting things along it, just as a friend taking a walk with us would do. Let's make a "nature trail in the sky." To fully enjoy this trail, lie flat on your back on Mother Earth, wrapping yourself in blankets if necessary. The effect is often magical, for you seem to float across the sky from one constellation to another.

Before starting on any trail we must get our bearings, and knowing north is very important. Fortunately this is easy in the sky of the Northern Hemisphere, where our present trail is located. Polaris, the North Star, is fairly close to the North Pole of the heavens and will be as long as we live. About 5000 years ago a star in the Dragon's tail was the pole star and 12,000 years from now Vega in Lyra will be the pole star. We shall point out these stars shortly. The celestial north pole moves in a circle that has its center about half-way between Polaris and Vega, one revolution taking about 26,000 years. For our present purpose, however, we may consider that it is a fixed point about a degree from Polaris in the direction of Mizar, the second star from the end of the handle in the Big Dipper; and Polaris is the star at the end of the handle of the Little Dipper. The lip of the Big Dipper points to Polaris.

Mention has just been made of a "degree." Degrees are to the face of the sky, as we see it, what feet or miles are to earthly things, measures of distance. Stars millions of millions of miles apart may seem to us to be very close together and, if one star is nearly back of another from the point at which we stand, the two will to our unaided eyes appear to be one star. From our point of view, it looks as though we are in the center of a huge, hollow glass ball (the sky) that is revolving about us and we can see about half of it at any time. Of course, it is what we are standing on that is revolving but that does not alter appearances. The stars seem to us to be on the shell of this huge sphere.

Do not be discouraged by the following geometry; we shall soon get to sky measuring. There are 360 degrees in a circle. Since we can at any time see about half of any one of the great circles in the sky, the length of a line from some point on the horizon to the horizon opposite the first point is 180 degrees. Clearly, then, if the apparent distance between two stars is $\frac{1}{36}$ of this distance, the stars may be said to be 5 degrees from each other. But most of us find trouble in estimating small fractions of the distance from horizon to horizon. Therefore, small measuring rods here and there in the sky are convenient. One such measure is the depth of the bowl of the Big Dipper. The two stars that mark the side opposite the handle (the two stars that point to Polaris, the North Star) are about 5 degrees apart. The distance from the tip of the handle of the Big Dipper to the far edge of the bowl is roughly 25 degrees.

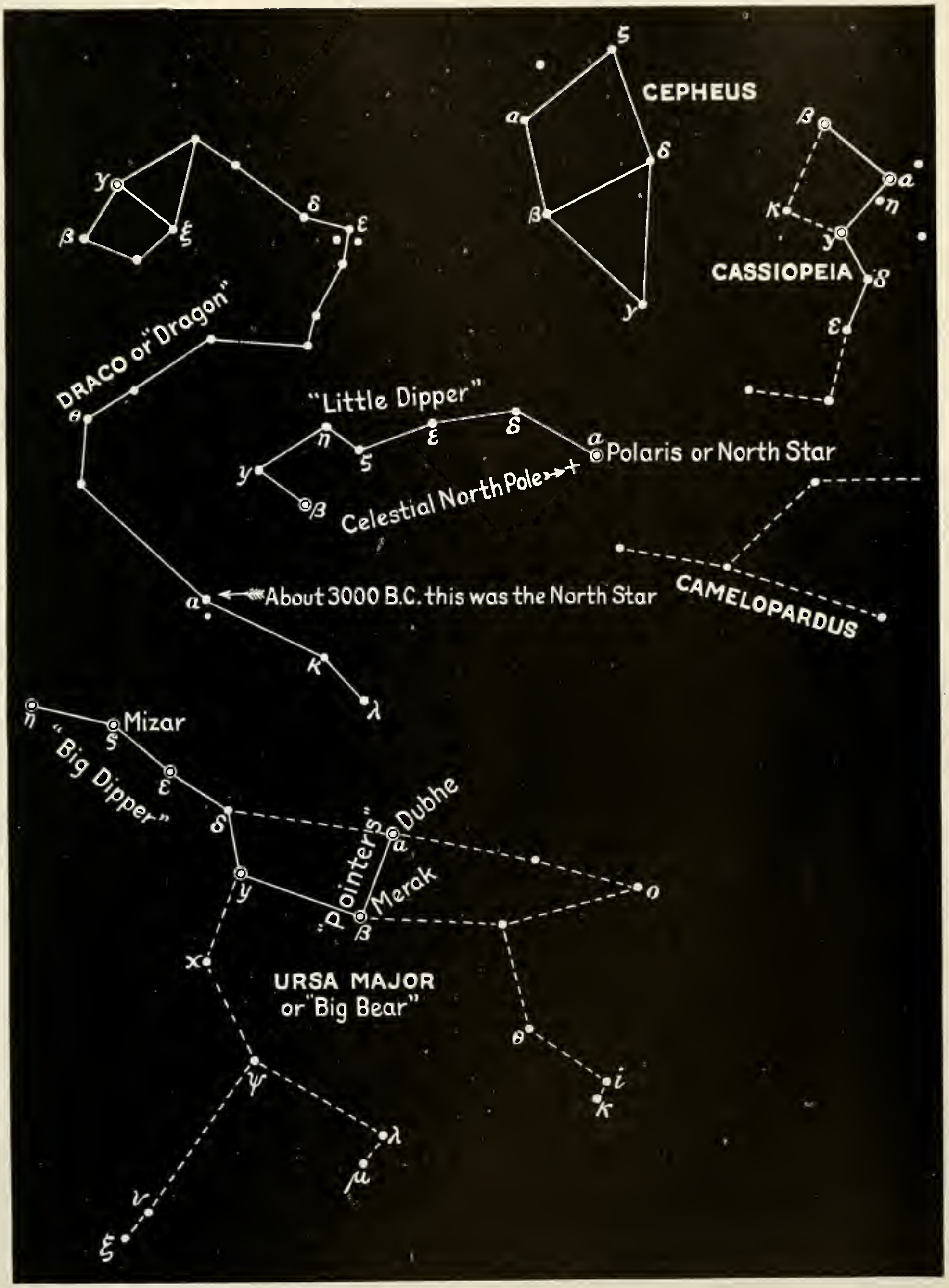
Now, we are ready to take the trail. First, we shall wander about in the region of the Pole and later we shall go to the Zodiac, the celestial menagerie and the stamping-ground of the most far-reaching fraud that ever dignified itself by the name of a "science," astrology. If you must believe in something foolish, believe the stories that I am going to tell you about the Greek gods and goddesses, but do not be so utterly foolish as to think that the positions taken by celestial bodies in their set courses have any connection with the course of your body's destiny, much less of your mind's. The only explanation for the belief in astrology by otherwise intelligent people of the present age is that "Barnum was right."

It so happens that there are five or six rather interesting constellations so near the celestial north pole that people throughout most of the northern half of the world can see them at any hour of a clear night in any season of the year—they do not set below the horizon. To learn these we do not need to wait until certain hours of certain nights, and, knowing them, will help us to find the others. The accompanying map (Map 1) shows approximately the relative positions and distances from each other of these stars. There is no fixed up-and-down to this map because, as our world turns, the map must be turned to keep up with it.

Look at this map, paying special attention to the two "dippers," including Polaris, the North Star. More or less ignore the other stars for the present but turn the map around and around, back and forth, until you can pick out the two "dippers" wherever they are. Then look up in the sky on a clear night in a generally northern direction and there you will see them. That much I have known for thirty years.

Our ancestors either had better imaginations than we have or, being interested in different things, their imaginations took different turns. The constellations that suggest dippers to us suggested bears to them. Accordingly, what we call the Big Dipper is a part of what they called the Big Bear or, in their language, *Ursa Major*. Our little Dipper is their Little Bear or *Ursa Minor*.

Furthermore, the ancient peoples had stories to "explain" the constellations that they recognized. Most of these stories concerned their gods and these gods had some very human traits. Jupiter was king of the Greek gods and Juno was his wife. There was a nymph named Callisto, who interested Jupiter so much that Juno became jealous. Just what happened then is not any clearer than many other family quarrels are. The girl in the case, Callisto, was changed into a bear and the bear was put up in the sky where the stars of Ursa Major, our Big Dipper, mark its position. But, whether Jupiter did it to avoid Juno's jealousy or whether Juno did the changing in revenge and then Jupiter did the rest, is not certain.


CEPHEUS
CASSIOPEIA
DRACO or "Dragon"
"Little Dipper"
Polaris or North Star
Celestial North Pole
About 3000 B.C. this was the North Star
CAMELOPARDUS
Mizar
"Big Dipper"
"Pointers"
Dubhe
Merak
URSA MAJOR
or "Big Bear"

MAP 1

Each of these Bears has an absurdly long tail, the handles of the dippers, and what we call the Big Dipper, for example, is not all there is of *Ursa Major;* other stars belonging to it are shown in Map 1. The letters are the Greek ones by which astronomers designate the different stars of a constellation. In Ursa Major o marks the tip of the bear's nose. The only front foot the beast has (possibly Juno saw to the other one) is at ι and κ; one hind foot is at λ and μ, the other being at υ and ζ.

When stars become very famous they get names as well as letters. Map 1 gives the names of three stars in our Big Dipper. Of these, Mizar, the one next to the end of the handle, is the most important for us. What we call Mizar is itself really a group of stars but to some unaided eyes they look like one; sharper eyes can see two, the fainter of which is called Alcor; and astronomical instruments show others. At any rate, remember Mizar.

Incidentally, Polaris, the North Star, is really a double star, having a companion of ninth or tenth magnitude. The stars that appear brightest to us are said to be of "first magnitude." They are all named in the accompanying maps and marked with rayed dots. Most of the second magnitude stars are marked by dots with circles around them and some are named in these maps. A sixth magnitude star is barely visible to us without a glass.

The Dragon (Draco) lies with his tail between the two "Dippers" or Bears. Opinion is not unanimous as to what dragon this was in life. It may have been the one that Cadmus killed, and then, when he scattered its teeth like seeds, an armed man sprang up from each of them and gave him more trouble. Or, it may have been the one that guarded the golden apples of Hesperides and was killed by Hercules. As we shall soon see, Hercules is now not far away from it in the sky.

The tip of the Dragon's tail is between Polaris and the bowl of the Big Dipper, about eight degrees from the lip of the Dipper (remember that this dipper is about five degrees deep). Following the outline of the beast toward its head we first go parallel to the handle of the Big Dipper until, when just between the bowl of the Little Dipper and the crook in the handle of the big one (the star Mizar) we find the star α of the Dragon. It is the one that was the pole star about 5000 years ago. In other words, the earth is swinging about at such a rate that the end of a straight line continuing its axis until it meets what looks to us to be the face of the sky has moved from near this α star in the Dragon to near the end of the handle of the Little Dipper, our present pole star. The course of the end of this line (that is, the path in the sky of a prolongation of the earth's axis) is a circle. The center of this circle is also the center of the ecliptic, the apparent path of the moon and the location of the Zodiac we are going to see later. But now let us get back to the Dragon or we may get lost.

We followed the outline of the Dragon from the tip of its tail near the lip of the Big Dipper to a point between the handle of that dipper and the bowl of the Little Dipper. Now, still going toward the Dragon's head, we curl around the bottom of the Little Dipper's bowl, then double back so as to make a rough S (turned right for left), as is shown in Maps 1, 2, and 4. The brightest star (γ) of the four which mark the Dragon's head may be roughly located as follows: Imagine a line drawn from Polaris to the end of the Big Dipper's handle. This line may be considered to be one side of a nearly equal-sided triangle of which the other two sides meet at γ. So, γ is about as far from either Polaris or the end of the Big Dipper's handle as they are from each other.

Cassiopeia is our next constellation. Some see in it a sprawly W; others, taking in one more star (κ), have a chair with an uncomfortable-looking back (upside down in Map 1). However, Cassiopeia was a queen and she is not sitting in that chair but the chair is formed by her bright spots. Her husband, Cepheus, and her daughter, Andromeda, are not far from her. We shall meet them soon.

Well, Cassiopeia, the mother, is there on the side of Polaris opposite the Big Dipper and about as far from Polaris as Polaris is from the Big Dipper. Three of Cassiopeia's stars (α, β, and γ) are bright ones, being of second magnitude. Now meet her husband.

Cepheus, once King of the Ethiopians, is between his wife, Cassiopeia, and the bend in the back of the Dragon. That is rather nice of him and the best that I have been able to learn about him. After studying Map 1 you can probably find him up there but, if you need further help, note that five moderately bright stars form a lop-sided square with a triangle on it, the triangle being on the pole-star side of the square. The top of the triangle is nearly on a line between Polaris and β of Cassiopeia. The following is not usually considered a part of this constellation, but, 4 degrees from ζ, somewhat toward α but outside of the square, is one of the reddest stars that we can see without a glass. Like most red stars, it is a "variable," being brighter at some times than at others.

There are other stars in this general region of the north pole of the sky but we must be going elsewhere, and now we get into the trouble that the constellations we are going to learn are not always visible to us, owing to the way our earth turns around and we with it. First we shall take some constellations of the summer skies at fairly reasonable hours of the evening. Most of Cassiopeia and the bottom of the square of Cepheus are in the Milky Way and, for a while, we shall keep either in the Milky Way or on the same side of it as the stars we have been looking at.

The Milky Way, or Galaxy, looks very much like an irregular and in some places a divided streak of hazy light across the sky. It is a region where there are millions of stars too faint or too far away for our eyes to see them clearly. One explanation is that the universe is shaped like an enormously large Ferris wheel. If such a wheel, miles and miles across, were hung full of lights and we were near its center and looked along the axle of the wheel we would see a large number of lights (stars) but if we looked toward the rim of such an immense wheel we would see many more, most of them so far away that they would be indistinct (the Milky Way).

At any rate, in June the Milky Way is along the eastern horizon at about 9 P.M. and nearly in mid-sky at about 1 A.M. (when the Big Dipper is west of the North Star). In August at 9 P.M. it is in about the same position as in June at 1 A.M. At about midnight of about April first or about 9 P.M. of the middle of May, the Milky Way forms a border along the northern horizon from East to West; in other words, when the Big Dipper is above the North Star.

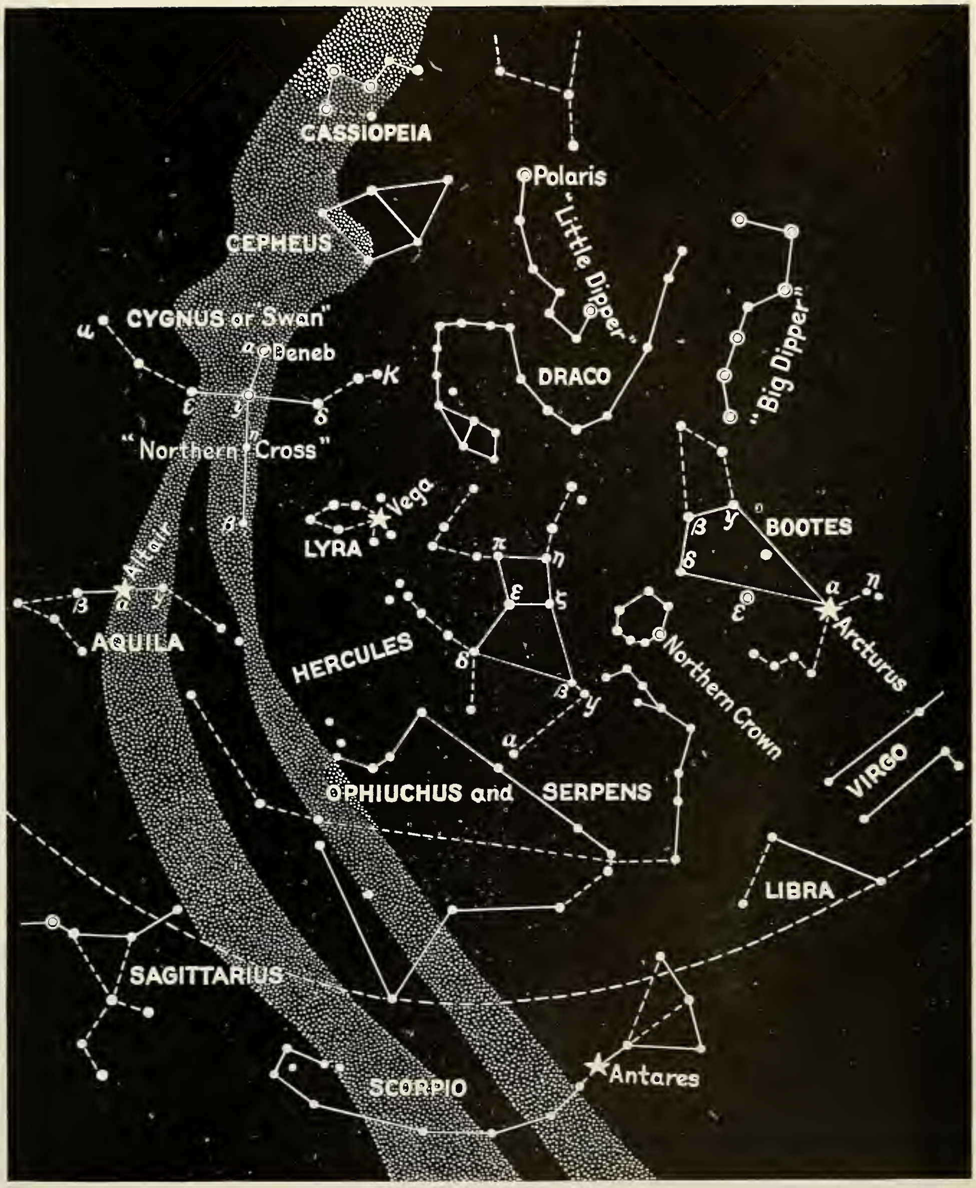
Start at Cassiopeia, then go along the Milky Way past her husband, Cepheus, and you will come to the "Northern Cross," a part of Cygnus, the Swan. The head of the Cross (Map 2, α) is toward Cassiopeia and one arm of the Cross (δ) points through the head of the Dragon to the end of the handle of the Big Dipper. Another way of locating it is that the side of the Big Dipper's bowl nearest the handle points toward the foot of the Cross. (Do not include here the very bright star, Vega, that will be mentioned later in connection with Lyra.) From α to β (the whole upright of the Cross) is about the length of the Big Dipper. Taking in the whole constellation, the bill of the Swan is at β and its wings stretch from κ to μ. It seems that Cygnus was a friend of Phaëton, the boy who went joy-riding with the horses of the sun and got into fatal trouble. Cygnus mourned so much that Jupiter changed him to a swan. They had a great way of changing people into animals in those days, and on almost any excuse.

Having seen the Northern Cross, we shall now skip over two constellations (coming back to them soon) in order to see the Northern Crown (Map 2). It is a small (about the size of the bowl of the Big Dipper) but a fairly complete circle of stars that lies on the other side of the Dragon from the North Star. Imagine one line drawn from the bottom of the bowl of the Big Dipper, through the end of its handle, and then prolonged for about the total length of the Big Dipper. It will end at about the Northern Crown. If that is not enough, imagine a second line drawn from the end of the Little Dipper's handle (the North Star), through the bottom of its bowl, through the back of the Dragon and nearly as much farther. It will end and meet the first line at the Northern Crown. This crown was given by Bacchus to his bride, Ariadne. He probably put it in the sky for safe-keeping.

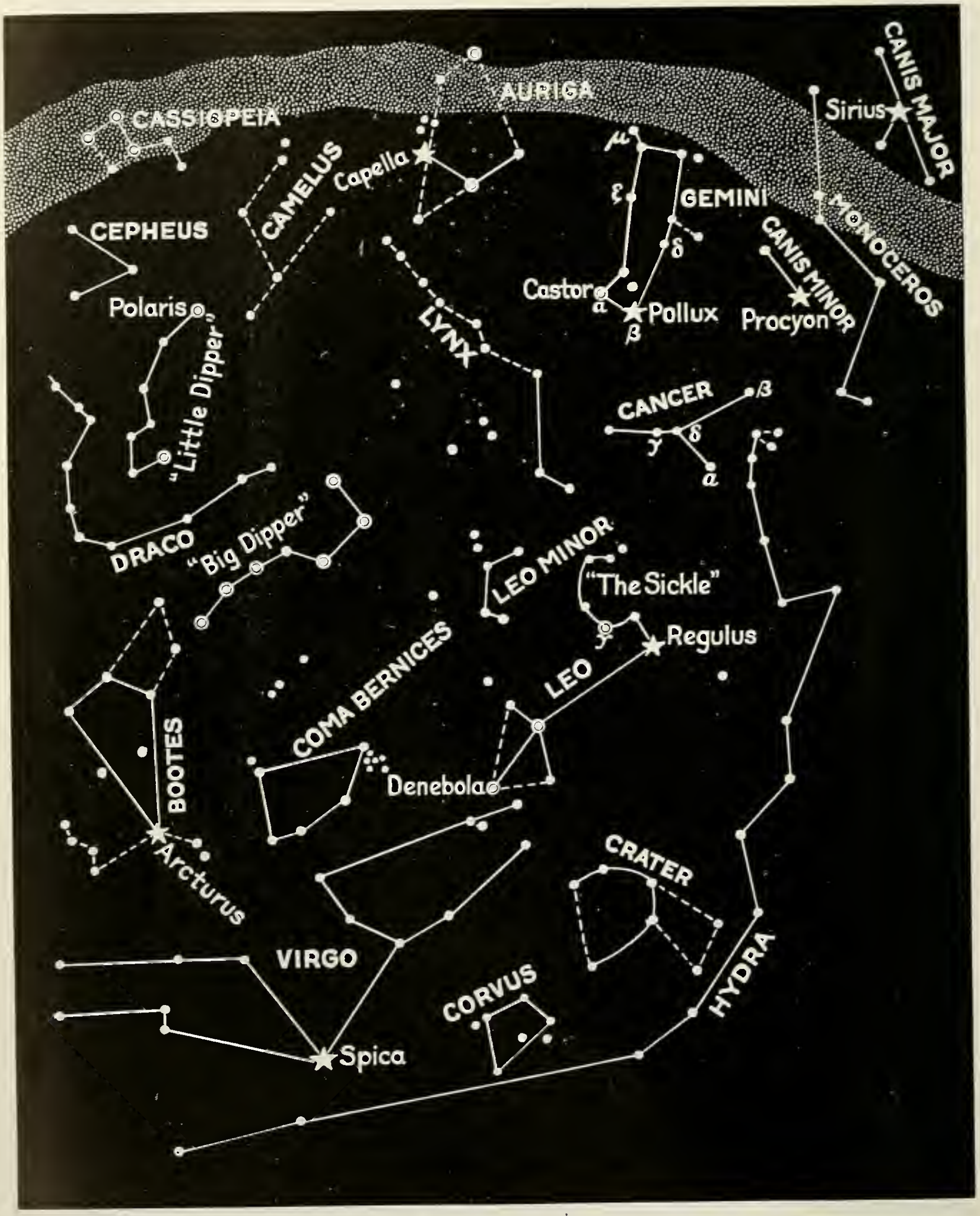
In going from Cygnus to Corona (the Crown) we skipped over Lyra and Hercules. They have not been very easy for me to make out since Lyra seems to me rather indefinite and Hercules rather sprawly.

As for Lyra, let us locate its brightest star Vega and say that the rest of the "Harp" is between it and the foot of the Northern Cross. Vega is very bright (first magnitude) and forms one corner of a nearly equal-sided triangle of which the North Star and the end of the Big Dipper's handle are the other corners. The side of the Big Dipper's bowl that is nearest the handle points fairly close to Vega, as I hinted when trying to locate for you the foot of the Northern Cross. The Harp is supposed to be the one that Apollo gave to Orpheus. Its music not only charmed men and beasts but made even trees and rocks get up and move around. More than that, when the wife of Orpheus died and went "where Pluto held his sway," Orpheus followed her and played so sweetly that Pluto let her out. By the way, it is said that Vega is 160 millions of millions of miles from us but approaching at the rate of 500 miles a minute. It is at least 30 times as bright as our sun and, as was said before, will be our descendants' north star 12,000 years from now.

I cannot help you much with Hercules except to say that a part of him is between Vega and the Northern Crown. Perhaps you will see four stars there that mark the corners of a rough square. The two that are farther from the North Star than the other two are his belt; the closer two are in his legs, and his feet are near the Dragon


CASSIOPEIA
Polaris
CEPHEUS
"Little Dipper"
"Big Dipper"
CYGNUS or "Swan"
Deneb
DRACO
"Northern Cross"
Vega
LYRA
BOOTES
Altair
Arcturus
AQUILA
HERCULES
Northern Crown
VIRGO
OPHIUCHUS and SERPENS
LIBRA
SAGITTARIUS
Antares
SCORPIO

MAP 2


CASSIOPEIA
AURIGA
CANIS MAJOR
Sirius
CAMELUS
Capella
CEPHEUS
GEMINI
MONOCEROS
CANIS MINOR
Procyon
Castor
Pollux
Polaris
"Little Dipper"
LYNX
CANCER
DRACO
"Big Dipper"
LEO MINOR
"The Sickle"
Regulus
LEO
COMA BERNICES
BOOTES
Denebola
Arcturus
CRATER
VIRGO
HYDRA
CORVUS
Spica

MAP 3

that he may have killed in addition to doing many other wonderful things. Perhaps Maps 2 and 4 will help you to get his various parts together.

Going on the other side of the Northern Crown (Corona) from Hercules we find Boötes. Boötes is a plowman and some have called the Big Dipper his plow, but the constellation looks more like a kite with a very bright, first-magnitude star (Arcturus) where the tail would be fastened and with its head lying near and being pointed at by the handle of the Big Dipper. (See Maps 2 and 3). Arcturus is said to be about 250 millions of millions of miles away and approaching us at the rate of 150 miles per minute. It is about a million times as large as our sun. We deal with large numbers in the heavens. Another name of this constellation is Arcas. If you look up the story of Arcas, the son of Callisto, you will see why this constellation is near the Great Bear—why, that is, according to mythology.

Moving farther away from the North Star, we come to a Snake (Serpens). It has its head near the Crown (Corona) and is being held by a man (Ophiuchus) who is at the head of Hercules. The combination is in honor of Æsculapius, the god of medicine (note the emblem of the medical corps in our army), but we shall not stop to see the doctor and there is a much better snake farther on.

Still going away from the North Star in this same direction we come to the Scorpion in the zodiac along the ecliptic; and the ecliptic is a very important thing in matters of the sky. Let me quote from Howe here so that if it is wrong you can blame him.

"The zodiac, or zone of animals, is a belt sixteen degrees wide, which extends around the sky like the stripe on a croquet ball. From antiquity onward much attention has been paid to the constellations in it. Imagine that a line from the center of the sun to the earth's center is prolonged through the earth and extended until it meets the celestial sphere.

"While the earth travels round the sun in its annual journey, the extremity of this line traces a circle on the celestial sphere. The name of the circle is 'the ecliptic.' To an eye situated at the sun's center the earth would appear to travel around the ecliptic. To an eye placed at the earth's center the sun would similarly appear to course along the ecliptic, taking a year to make the complete circuit, passing through the zodiacal constellations in successsion. The ecliptic lies in the middle of the zodiac, which extends eight degrees each side of it. As we watch the sun, moon, and planets, they always appear to lie in the zodiac."

Since the ecliptic is a sort of a circle and the zodiac is a circular zone, they have neither beginning nor end and we can break in at any point. But, since it is not very comfortable to go star-gazing just for the fun of it before about the middle of May, we shall start with that member of the zodiac that sets in the West at about 9 P.M. then, the Gemini or "Twins." However, I suggest that you do not start on this tour of the zodiac and the side trips that will be taken in connection with it until you have become well acquainted with what has gone before, especially with those stars shown in Map 1. We are going to use the constellations already mentioned as landmarks—or "skymarks." When on a new trail, one should be able to recognize such things and, furthermore, if you learn merely what has already been pointed out you will know more about the sky than most people do.

The Twins, Castor and Pollux, may be found as follows. Starting with Mizar, the bright star that is next to the end of the Big Dipper's handle, follow a line from it diagonally across the Big Dipper's bowl to the two stars which lie in the front foot of the Bear (see page 414); then extend this line about 25 degrees (about the total length of the Big Dipper) farther. That will bring you to the Twins. The rest of the constellation is on beyond them (between them and the Milky Way) and may be recognized from Maps 3 and 5.

These boys were interesting brothers. Pollux, represented by the brighter of the two stars, one of first magnitude, was immortal; but Castor, represented by a fainter star (really a double one) near him and on the side toward Cassiopeia, was mortal. Being mortal, Castor died, and Pollux was so grieved that he wanted to die too but, being immortal, he could not do so without special permission. Jupiter refused this permission but compromised by allowing Castor to spend one day with Pollux on Mt. Olympus, and Pollux to spend the second with Castor in Hades, and so on.

The next constellation on the ecliptic, following the order in which they arise in the East, is Cancer. This does not mean that Cancer is always east of Pollux as we see them in the sky—a very confusing thing due, among other things, to the fact that the ecliptic is not parallel to the celestial equator. I am far from understanding this fully, but twirling the disc of the very useful "Barritt-Serviss Star and Planet Finder" has helped much.

Cancer in the sky is not a disease but an animal, a crab. The stock explanation of why this constellation was called a crab does not appeal to me very much and my own private explanation may not be true, so I shall give neither, although I may say that each is connected with the habit crabs have of going sideways. The particular crab which this one is said to be is the one that pinched Hercules when that famous hero was fighting the nine-headed hydra.

None of the stars of Cancer is of more than fourth magnitude. Five of them (Maps 3 and 5) outline a Y and there is a pair by the side of the Y's fork. A line from Polaris (the North Star) through the tip of the Big Bear's nose and prolonged 40 degrees ends near the center of the Y. There is a test for you. The tip of the Big Bear's nose is at the second star beyond the lip of the Big Dipper nearly on a line starting from where the handle joins the bowl, going through the bowl's lip and then prolonged 15 or 20 degrees. Remembering that the length of the Big Dipper is about 25 degrees, you can get that and, clearly, 40 degrees is 1⅗ times 25.

One reason for working hard to find this constellation (March and April are good months in which to start hunting for it; during the summer it sets too soon) is that one of the most ancient of weather signs concerns it. Two stars in the middle of the Y are called the Asses and between them is a cluster of stars—to our eyes often not more than a faint glow of light—properly called Praesepe. It's English names are Beehive and Manger. If the Asses thought that it was Manger and found that it was Beehive, I imagine they would kick, but that has nothing to do with the weather. Here it is from a Greek poet, Aratus:

"A murky manger with both stars
Shining unaltered is a sign of rain.
If while the northern ass is dimmed
By vaporous shroud, he of the south gleam radiant,
Expect a south wind. The vaporous shroud and radiance
Exchanging stars harbinger Boreas."

Boreas is the north wind but I do not vouch for the prophecy any more than I sponser that translation as good poetry. Also, another thing that I merely pass on to you is that here is the "gate of men" through which souls descend into human bodies and return to regions above the sky when they leave those bodies.

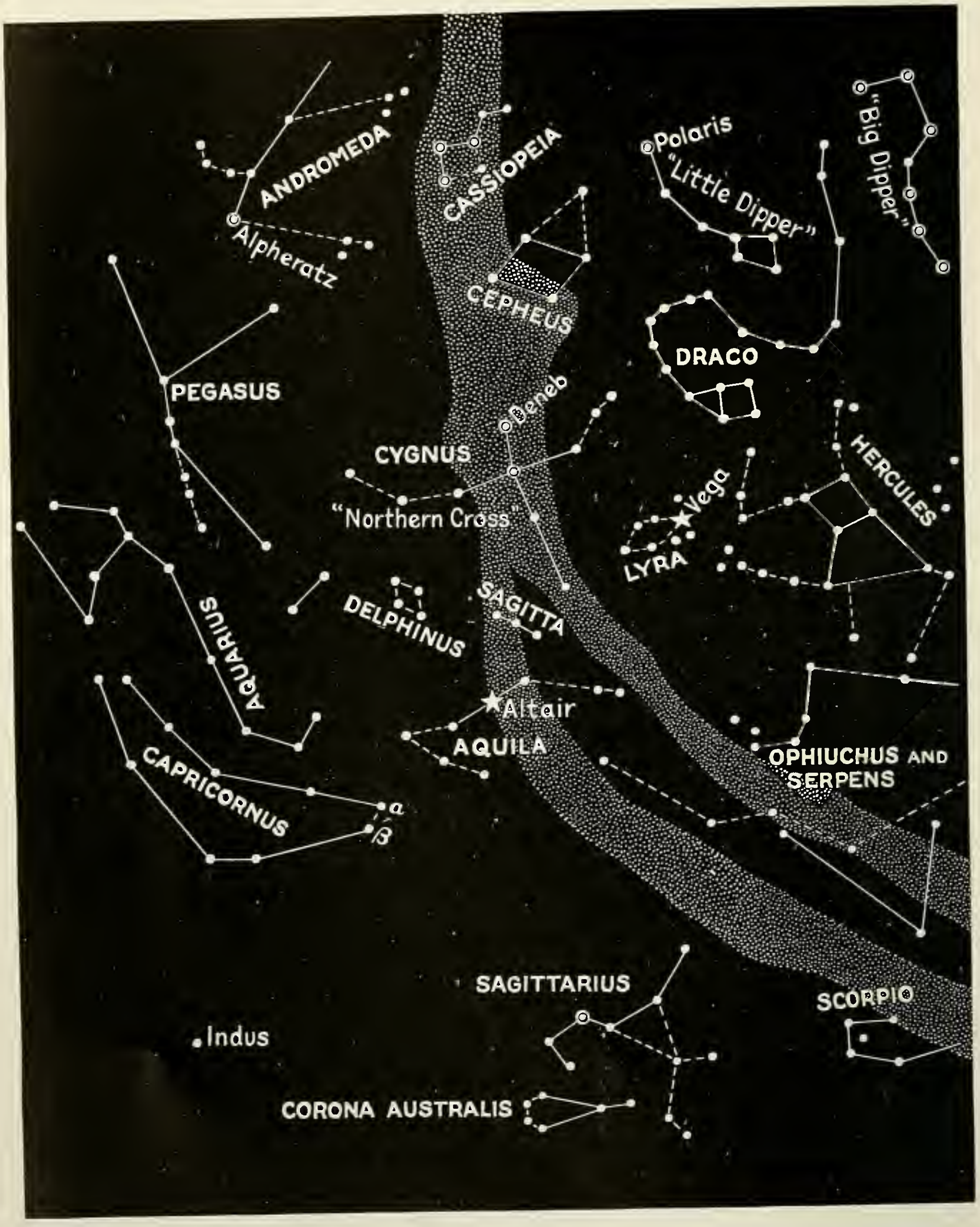
Leo, the Lion, is the next in line as we move along the zodiac. There seem to be two constellations here, a sickle and a triangle (Map 3). A line from Polaris through the bowl of the Big Dipper, and then continued, passes through the triangle, which is more or less (depending on how high up the constellation is) east of the sickle. If you can locate μ in one of the hind feet of the Big Bear (see Map 1) you can imagine a line from Polaris through it which, if extended 22 degrees will meet γ of the sickle but, knowing about where to look for these things, you can probably locate the sickle more easily by the first-magnitude star, Regulus, at the free end of its handle. The star at the corner of the triangle most distant from the sickle is Denebola and the distance from Regulus to Denebola is about 25 degrees or about the total length of the Big Dipper.

The Virgin (Virgo) reclines along the celestial equator about where the ecliptic crosses it on this side of the celestial north pole. Of course, this does not help you to find Virgo but, if you learn to recognize Virgo, you will know about where that point is. Her head is near Leo and she stretches out beyond Arcturus, the Virgin being not far from that famous star (see Map 3). She has one first-magnitude star, Spica, which is really made up of two revolving about each other—many of what seem to us to be single stars are not really so. A line from the North Star through about the middle of the handle of the Big Dipper and continued nearly twice as much farther will end near Spica. An easier way to find it (also a check on the other way) is that the long side of the "kite" in Boötes that is near the Crown points almost directly at Spica. Having located this star, you can probably link up the others by help of Map 3. This virgin's name on earth was Astræa. She was famed for her kindness and is said to have been the last of the immortals to leave the earth at the close of the Golden Age.

Now let us go beyond the zodiac to see the immense snakelike constellation, Hydra (Map 3). Those of us who do not care to stay up after midnight will have to look after the middle of February if we wish to see all of it; by about the end of June it sets too soon to be seen well. The head is near Cancer on the opposite side from the North Star; and the next to the last star in its tail is near Spica, a long stretch roughly parallel to and (in the North) near the horizon. Between it and the Virgin is Corvus, the Crow, pecking at Hydra.

The next constellation of the zodiac is Libra, the Balance (Map 2). It is a small one that used to be considered to be the claws of its succeeding neighbor, the Scorpion, but scorpions can lose claws without much apparent discomfort. A line from the North Star running through the far bottom corner of the Little Dipper's bowl and continued between the Crown and Boötes will finally meet Libra, the Crown being about half-way between it and the bowl of the Little Dipper.

The Scorpion (Scorpio) does not get its tail completely out from under the southeastern horizon before about midnight in May and about nine o'clock in early July. The creature stretches


ANDROMEDA
Alpheratz
CASSIOPEIA
Polaris
"Little Dipper"
"Big Dipper"
CEPHEUS
PEGASUS
DRACO
Deneb
CYGNUS
"Northern Cross"
HERCULES
Vega
LYRA
AQUARIUS
DELPHINUS
SAGITTA
Altair
AQUILA
OPHIUCHUS AND
SERPENS
CAPRICORNUS
α
β
SAGITTARIUS
SCORPIO
Indus
CORONA AUSTRALIS

MAP 4

right across the Milky Way. A line from the North Star running along that side of the square in Hercules that is nearest the Crown and extended more than as much again will just about meet the only first-magnitude star in this part of the sky (Map 2). It is Antares in the Scorpion. With it, the Milky Way, and Map 2 as guides, you can doubtless make out the rest of the Scorpion.

I do not know what to think about the justice of everything connected with this Scorpion's affairs. Orion was a mighty hunter but not a conservationist. He started out to kill all of the beasts of the field. That was not right, of course; and the earth sent the Scorpion to sting him, which it did and killed him. Æsculapius, the mighty physician, was bringing him back to life, but Jupiter hit the doctor with a thunderbolt and that was the end of that. The Scorpion is now in a nice bright place in the zodiac, even though it is rather close to the horizon for us to see, and we shall meet Orion later.

We have now examined all of the principal constellations and some of the lesser ones that are in our northern sky between the arms of the U-shaped Milky Way, the U that stretches along the northern horizon at, say, 9 P.M. in the middle of May or at midnight in the latter part of March. As the season advances, things swing around until all but the tail of the Scorpion is under the western horizon at midnight on the first of August or at 9 P.M. in the middle of September. Then we have an entirely new set of stars which are to be seen on the other side of the Milky Way from the North Star. We shall look at them now.

Sagittarius, the Archer, is in the zodiac near the Scorpion's tail. Some of its stars form what is called a Milk Dipper. (See Map 4.) A line from the North Star through Vega just misses the handle of this, going between it and the Scorpion. A line from the middle of the W in Cassiopeia through the middle of the Northern Cross (Cygnus) meets the bowl of this Milk Dipper.

Incidentally, this last line, just after it left the Northern Cross, went near a first-magnitude star, Altair, in the constellation of Aquila, the Eagle (Map 4). Altair is near the edge of the Milky Way. The eagle is probably the one that stood at the side of Jupiter's throne. It is too bad that it is not in the zodiac. On the other side of Sagittarius, so near the horizon that it is often not easy to see, is the Southern Crown. It is close to the bowl of the Milk Dipper of Sagittarius and looks like a round-headed kite with four stars in the curve. You may be able to see it in the South at, for example, about 9:00 P.M. in the middle of August or about midnight in early July.

The next two members of the zodiac are best studied together because the first of them, Capricornus, the Goat, is overlapped by the rather extensive Aquarius, the Water Carrier. Look at Map 4 and then orient yourself in the following way. A line from the North Star through the star marking where the arms of the Northern Cross join its upright, if prolonged an equal distance, about meets α of Capricornus. Good eyes can see without a glass that this star is double. The one which is near it, β, is also double but it takes a glass to see this. The "pointers" of the Big Dipper form a line which goes through the North Star and, extended, just misses the W of Cassiopeia. Extend it a little more than as much again and you will strike near the far end of Aquarius (Maps 4 and 6). The first-magnitude star in that region but in the direction of Capricornus is Fomalhaut. It is in the constellation of the Southern Fish, not the Fish that is in the zodiac.

As to the mythology of Capricornus, the Goat, Howe says that one who tries to study it "may be pardoned for wishing that Jupiter had given the goat a nice pasture in his back yard and kept it out of sight of mortals." The Water Carrier is said to have been Ganymede, the cup-bearer of the gods, but, according to the stories I used to read, it was not water that Ganymede had in his cups.

Pisces, the Fishes of the zodiac, are not very striking, but they lie along the ecliptic, almost meeting and somewhat overlapping Aquarius (Maps 5 and 6). A line from Polaris (the North Star) through the nearest star in Cassiopeia's W will cross Pisces near the eastern end (the last to rise and set) of it. But perhaps the best way to learn Pisces is to learn the constellations between it and the North Star first.

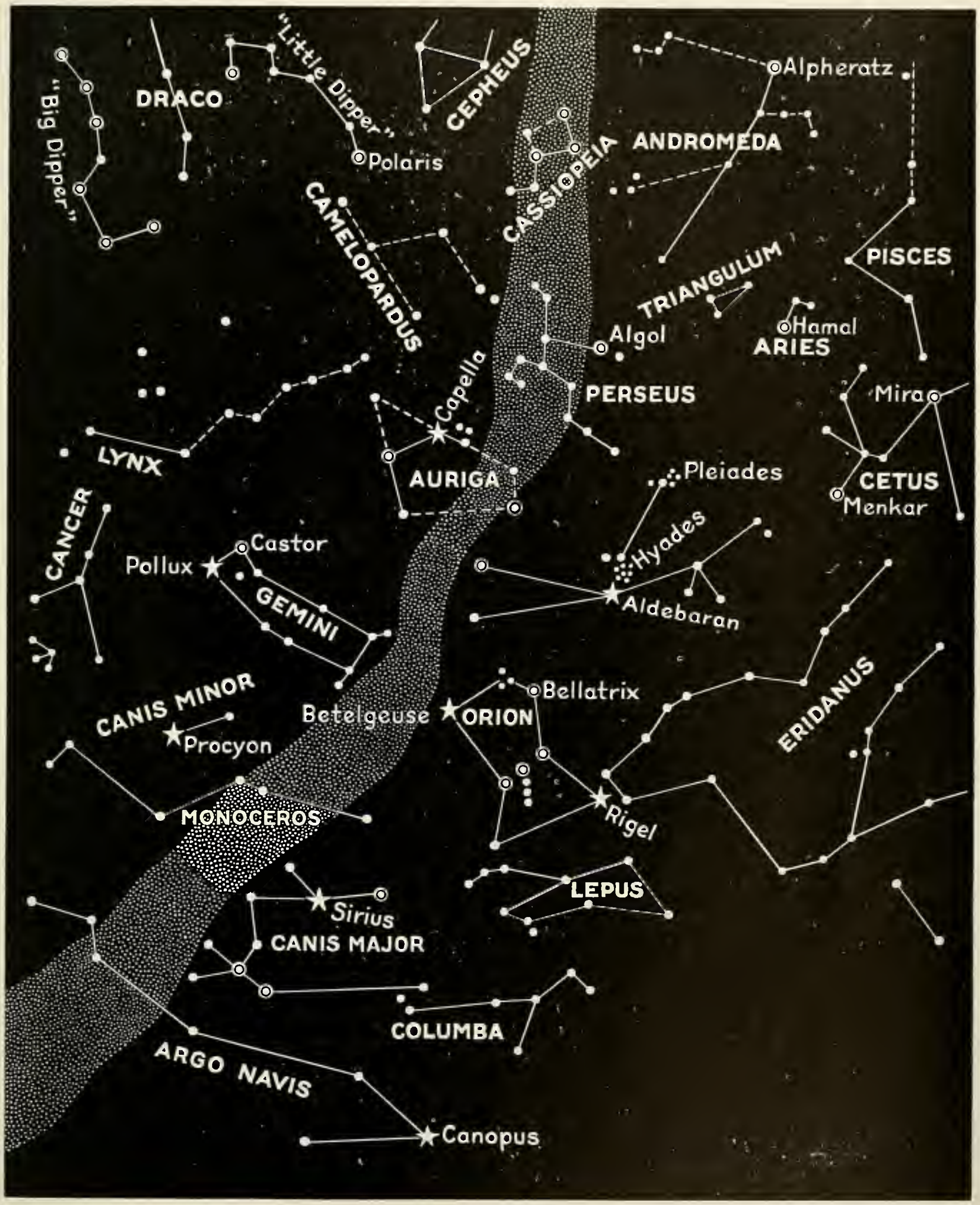
We are now in the eastern heavens at about midnight in the end of July or about 9 P.M. in the middle of September. In that case the Pleiades have not yet arisen. Or, if you prefer cold nights, we are in the western heavens at about midnight in November or about 9 P.M. during the Christmas holidays and the Pleiades are right above us.

First find Andromeda (Maps 4, 5 and 6) and especially locate her α, a star known as Alpheratz, by drawing a line from Polaris through β in Cassiopeia (what would be the right-hand upper star of her W if the W were right side up) and prolonging it an equal distance. A line from Polaris through the left-hand upper star of the W and prolonged an equal distance ends not very far from the other side of Andromeda.

We have mentioned this girl before and pointed out Cepheus, her father, and Cassiopeia, her over-proud mother. If Perseus is still below the eastern horizon with the Pleiades we shall have to wait an hour or so for him to come up but, otherwise, we have all of the actors in a rather interesting drama, the *personæ* of which are shown in Map 6. Read about it in Bulfinch's *Age of Fable* or in some other good book. In bare outline it is as follows.

Cassiopeia had angered the Nymphs of the Mediterranean by saying that they were not so beautiful as her family (herself according to some authorities, and her daughter according to others, but probably both). The Nymphs threatened to kill off all of the Ethiopians of which Cepheus was king, but compromised on having Andromeda chained to a rock so that Cetus, a sea monster, could eat her. This Cepheus did and things looked bad for Andromeda, when Perseus came along on Pegasus, a horse with usable wings. This horse had just been born from the blood that dripped from the head of Medusa, a snaky-headed Gorgon killed by Perseus. Medusa is not in this story except that she unintentionally furnished the horse and that Perseus had her head with him as a trophy.

They did not draw the color-line in those days and Perseus agreed that if he could marry Andromeda, who, being an Ethiopian, was black, he would save her from Cetus. That was what happened, though he had a hard fight. There was more trouble at the wedding, for Andromeda's former suitor, Phineus, came with a large number of his friends. All of them, including Phineus, were turned to stone when Perseus held the head of Medusa in front of them and they did not get into the sky, but the family is there, including Pegasus, the horse. Cetus, the Sea-monster, is also there near that part of


"Big Dipper"
DRACO
"Little Dipper"
Polaris
CEPHEUS
CASSIOPEIA
ANDROMEDA
Alpheratz
CAMELOPARDUS
PISCES
TRIANGULUM
Algol
Hamal
ARIES
Capella
PERSEUS
Mira
LYNX
AURIGA
Pleiades
CETUS
Menkar
CANCER
Castor
Pollux
GEMINI
Hyades
Aldebaran
Bellatrix
CANIS MINOR
Betelgeuse
ORION
ERIDANUS
Procyon
MONOCEROS
Rigel
LEPUS
Sirius
CANIS MAJOR
COLUMBA
ARGO NAVIS
Canopus

MAP 5

the horizon which, on the northern shore of the Mediterranean, is the sea. Even so, the Nymphs had a bit of revenge, for Cassiopeia hangs in the sky head-down obout half of the time.

Now for Pegasus. Perhaps by using Alpheratz of Andromeda as one corner, you can see a rough square about 15 degrees on a side between Cassiopeia and Aquarius (Maps 4 and 6). The other three corners of this square are the principal stars in Pegasus, the rest of the horse being in the direction of the Northern Cross and Capricornus.

Cetus (called a Sea Beast but it must have been more than a whale) is on the other side of the zodiac beyond the Fishes, part of it really coming into the zodiacal region. Map 6 will help you. Mira varies greatly in brightness and, although usually quite faint now, it was a first-magnitude star in the eighteenth century.

Perseus and Cassiopeia are near each other in the glory of the Milky Way near Andromeda, who isn't. A line from the far corner of the Little Dipper's bowl through the North Star nearly meets Algol on the other edge of the Milky Way (Maps 5 and 6). The right-hand line of Cassiopeia's W, continued "below the line" also about meets this star, which is the most interesting one Perseus has. It is also called the Demon and varies from second magnitude to fourth and back again to second in less than three days.

Near Perseus and between him and the Twins, Castor and Pollux, is a first-magnitude star, Capella. It is in the constellation of Auriga, the Charioteer (Maps 3, 5 and 6).

Now we shall return to the zodiac for a bit. Next to the Fishes is Aries, the Ram. Properly speaking, this is where the zodiac starts but it was more convenient for us to start elsewhere. A line from Polaris to Andromeda (see Maps 5 and 6) and prolonged nearly 20 degrees ends at α of Aries, one of the three stars that form the Ram's head. His body consists of faint stars between it and the Pleiades. This is said to be the celebrated ram with the golden fleece that was the reason for one of the first zoölogical expeditions, the Argonautic.

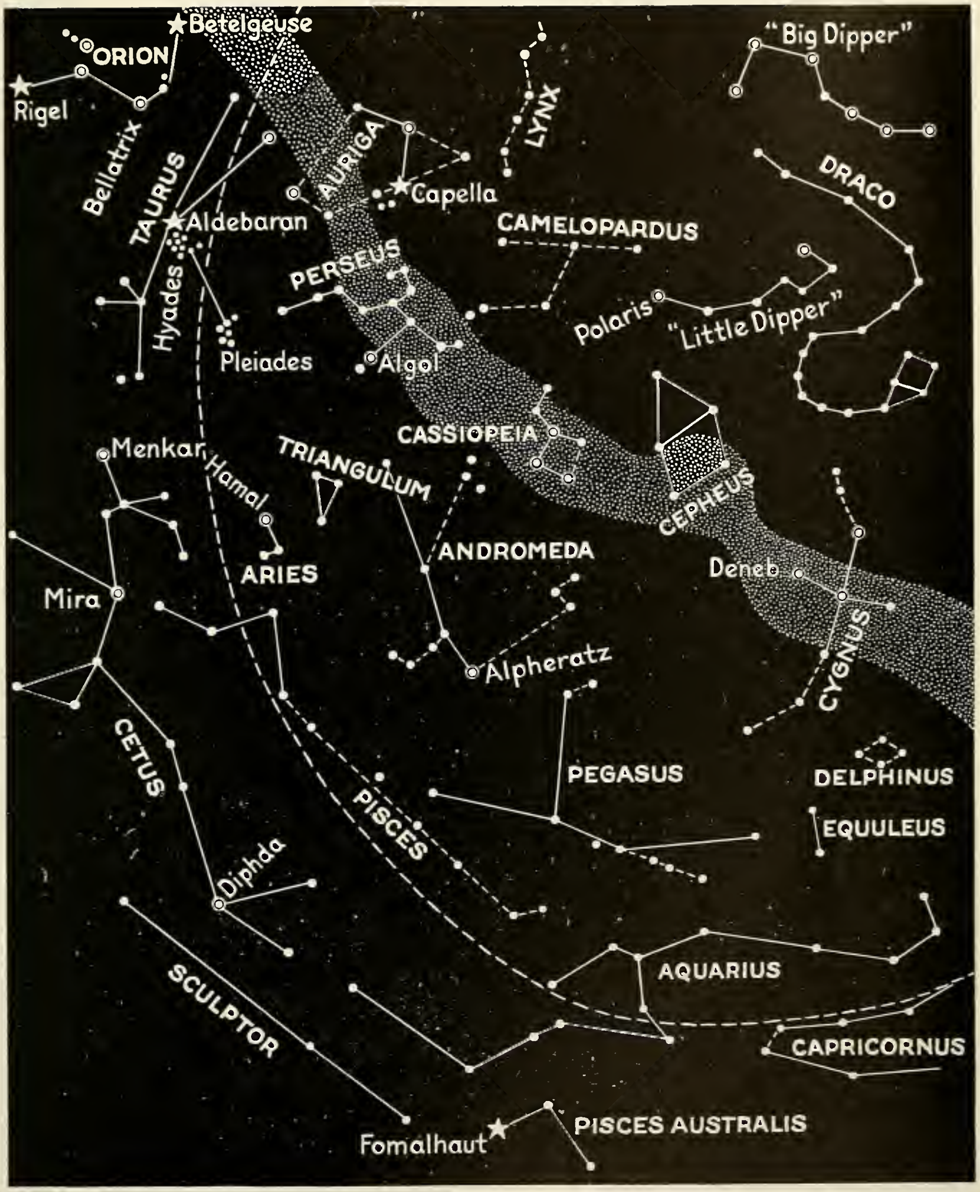
Finally, so far as the zodiac is concerned, we have Taurus, the Bull (Maps 5 and 6). A fine first-magnitude star, Aldebaran, is there. A line starting from the middle of the handle of the Big Dipper, going above its bowl and then through Capella, finally meets Aldebaran. (See Maps 5 and 6 and what follows.)

The Pleiades and the Hyades are two groups of stars that are associated with the constellation of Taurus. Tennyson wrote:

> Many a night I saw the Pleiades, rising through the mellow shade,
> Glitter like a swarm of fire-flies tangled in a silver braid.

Orion is said to have fallen in love with the Pleiades, who were daughters of Atlas, and chased them. To save them, according to this story, Jupiter turned them into pigeons and then put them in the sky. Although there were seven, one is said to have left her place so that she might not behold the ruin of Troy. Another explanation of the missing girl is that she fell in love with a mortal and hid herself in shame. The Hyades were nymphs who took care of Bacchus in his youth.

Whatever may be the facts of the case about the Pleiades, Orion is not far from them now—just the other side of Taurus (Maps 5 and 6). He certainly is well fitted out with fine stars, Betelgeuse, Bellatrix, and Rigel, especially. Pollux (of the Twins), Betel-


Betelgeuse
ORION
Rigel
Bellatrix
TAURUS
Aldebaran
Hyades
Pleiades
AURIGA
Capella
LYNX
"Big Dipper"
DRACO
CAMELOPARDUS
PERSEUS
Polaris
"Little Dipper"
Algol
CASSIOPEIA
CEPHEUS
Menkar
Hamal
TRIANGULUM
ARIES
ANDROMEDA
Deneb
Mira
Alpheratz
CYGNUS
CETUS
PEGASUS
DELPHINUS
PISCES
EQUULEUS
Diphda
AQUARIUS
SCULPTOR
CAPRICORNUS
Fomalhaut
PISCES AUSTRALIS

MAP 6

geuse, and Rigel are about in a line. Another way of locating them is that there is a rough square with the Milky Way going through it. Capella (of Auriga) and Pollux are on the North Star side of the Way and Aldebaran (of Taurus) and Betelgeuse are on the other side. Also, Aldebaran, Betelgeuse, and Rigel form a nearly equal-sided triangle. But in all of this do not get confused with Orion's two dogs, one on each side of the Milky Way, below the Twins and Orion.

Canis Minor, the Little Dog, has but two bright stars, one (Procyon) of first magnitude (See Maps 3 and 5). Canis Major, the Big Dog, is richer in stars and includes *the* Dog Star, Sirius. Sirius is in the dog's head as it faces its master. It is the brightest of the fixed stars and can readily be found by prolonging the line formed by the three stars in Orion's belt toward the Milky Way. Another way of locating it, if you care to go clear across the sky, is that the outer part of the Little Dipper's bowl points to it, the line passing to the west of Pollux and Procyon.

So, we have swung the seasons in the sky and have glanced at all of the principal constellations of the Northern Hemisphere. It is not the purpose of a Nature Trail to tell everything. Perhaps I have told too much here; you may be confused. If so, go back to the beginning and learn the first half-dozen that can be seen at almost any time of any night of any month. Later on, you will be ready to do a nightly dozen and it will be worth while.

NOTES

ADVISORY COMMITTEE ON ASTRONOMY

In developing the plans for the Museum's Great Astronomical Hall and for the exhibits which will interpret this subject to the public, the Museum is receiving invaluable assistance from William Wallace Campbell, Sc.D., LL.D., director of Lick Observatory; George Ellery Hale, Ph.D., Sc.D., LL.D., honorary director of Mt. Wilson Observatory; Samuel Alfred Mitchell, Ph.D., Director of Leander McCormick Observatory; Henry Norris Russell, Ph.D., director of Halsted Observatory; Howard Russell Butler, M.F.A., who have consented to serve as the Advisory Committee on Astronomy

DISTINGUISHED GUESTS

The Crown Prince of Sweden, Gustavus Adolphus, and the Crown Princess Louise visited the American Museum of Natural History on June 8. The members of the Board of Trustees, the director, and the curators, who were on hand to receive the royal party, were much pleased with the genuine interest and wide knowledge which they manifested. Among the halls visited during an intensive two hours' tour were: Morgan Gem Hall, Peruvian Archæology, Preliminary African Hall with especial attention to the Akeley gorillas, Flying Bird Dome, Habitat Groups of North American Birds, Dinosaur Hall, Age of Man Hall, and Pro-Astronomic Hall.

Mr. Robert Woods Bliss, American Minister to Sweden, was a member of the visiting party. The Crown Prince and the Crown Princess have made a deep and favorable impression upon the members of the Museum staff as they have upon the American people generally.

CENTRAL ASIATIC EXPEDITION

Roy Chapman Andrews, leader of the Central Asiatic Expeditions, has cabled the American Museum of Natural History that although he has been able to get the camel caravan safely out of the Chinese war zone and into Mongolia, the Expedition party has not yet been able to take the field. He stated that the camel train had been commandeered three times by the soldiers, but after careful negotiations, was at last passed through with a military escort. The members of the Expedition are at present in headquarters in Peking awaiting a change in the military situation. At a conference the members decided that there was still time for reconnaissance work, and inasmuch as the Expedition is completely organized, every reasonable attempt will be made to carry out the plans for this summer. It is desirable to proceed to the western region south of the Altai Mountains and, if the fossil deposits warrant. a working force will be sent there next year,

While at headquarters, the members of the Expedition have been busy preparing fossil material already collected, so that practically no time has been lost. However, the delay in starting for Mongolia has been a disappointment. Owing to this delay, it is hardly probable that any extensive discoveries can be made this season, but it is hoped that by means of a hasty survey a region may be selected that will next year yield results for which such strenuous efforts have been made.

Mr. Andrews states that representatives of the Mongolian Government have called upon him in Peking with a formal invitation for the Expedition to return to outer Mongolia. They promised to give all possible aid in the prosecution of the work, and most cordial relations were established.

President Henry Fairfield Osborn has been spending the last twomonths in England engaged in palæontological research. In an address before the Geological Society of London, Professor Osborn discussed the geological significance of the discoveries made this spring in the Gobi Desert by the Third Asiatic Expedition under the leadership of Dr. Roy C. Andrews. These discoveries have verified a prediction made by Professor Osborn as long ago as 1900 that the unknown high plateau region in Central Asia would prove to be the chief center of origin and distribution of mammalia from which radiated all animal life to the continents of Europe and North America.

THIRD PAN-PACIFIC SCIENCE CONGRESS

Mr. Walter Granger, associate curator in palæontology, and Mr. N. C. Nelson, associate curator of archæology, have been appointed official representatives of the American Museum of Natural History to the Third Pan-Pacific Science Congress to be held in Tokyo, Japan, October 27 to November 9, 1926.

BIRDS

Dr. Frank M. Chapman and Dr. Robert Cushman Murphy were official representatives of the American Museum of Natural History at the International Ornithological Congress held at Copenhagen, May 24–29, 1926. These American delegates were especially honored by the authorities in charge of the program, who engaged a theater and invited the scientists of Copenhagen to attend a special meeting at which Doctor Chapman spoke on "Bird-Life of Barro Colorado and Chile," and Doctor Murphy spoke on the "Bird-Life of Peru."

Doctor Chapman went from Copenhagen to London, where he addressed the Royal Geographical Society on "Darwin's Chile" (it being just one hundred years since the survey was inaugurated in which the "Beagle" took part). He also spoke before the Zoological Society on "Barro Colorado," and before the British Ornithologists' Club on "Chilean Bird-Life."

Doctor Chapman has recently returned to the Museum, but Doctor Murphy, who does not expect to return until September, will visit European museums for the purpose of arranging exchanges.

EDUCATION

Closer coöperation between museums and schools was one of the topics occupying a prominent place on the program of the National Educational Association, which held its annual meeting at Philadelphia, June 27 to July 2.

The American Museum of Natural History was represented by Dr. Clyde Fisher, curator of visual instruction and Mrs. Grace Fisher Ramsey, assistant curator of public education. On Monday Doctor Fisher gave an interesting talk on "The Contribution of the Coördinating Council of Nature Activities of the Children's Organizations Outside of the Schools" before the department of science instruction. Mrs. Ramsey served as a member of the program committee for the department of visual instruction.

A new feature of the program which attracted much favorable comment was the demonstration classes using different types of visual aids. Doctor Fisher gave one of these lessons on "Change of Seasons" to a class of totally blind pupils, using the uranosphere which has proved such a wonderful aid in the work carried on by the Museum's department of public education with the blind classes from the public schools of New York City. Later that afternoon he gave a talk on "How the Natural History Museum Can Help the Schools." At the close of the discussion several educational films were shown, among them "The Wonderful Work of Water," prepared from the lecture of Mr. George H. Sherwood, curator-in-chief of the department of public education. At the Tuesday afternoon meeting of the School Garden Association, an allied organization of the National Educational Association, Mrs. Ramsey talked on "The Improvement of Nature Teaching."

FISHES

Mr. J. T. Nichols is now on a reconnaissance trip along the coast of Alaska. His object is to obtain personal field knowledge of certain Arctic forms of birds, fishes, and cetaceans that occur on both the Atlantic and Pacific sides. In a recent letter to Doctor Gregory, Mr. Nichols writes:

"One important and very interesting problem which will be opened by a better field knowledge of the Arctic fauna, has to do with the method and extent to which Pacific temperate forms have invaded the Atlantic, or vice versa, through polar seas. It is conceivable, for instance, that our Atlantic sculpins and flounders were of Pacific origin, became adapted to Arctic conditions, and so crossed to the colder waters of the middle Atlantic. A study of the line where the Arctic fauna meets that of the temperate Pacific, I think along the Aleutians, has a particular bearing on this problem. Here oceanographic conditions pertain which are very different from the better known conditions along the corresponding line in the Atlantic.

"That the fresh-water fishes of North America, particularly the carps and their allies, are of Asiatic origin, I am pretty well convinced. This is evidenced by similarity of fishes in the lower Mississippi Valley to those of Asia, for one thing. An hypothesis as to the time and manner of their crossing, which I have had on my table in the Museum for some months, will be helped by a first-hand knowledge of the present physiography of the Bering Sea region. I shall cover sufficient ground on this trip to see practically all types of land there bordering on the sea, and should be able to deduce therefrom how different physiography and climate must have been, to have permitted invasion by any particular form."

HISTORY OF THE EARTH

Dr. W. D. Matthew, acting curator of the department of geology and invertebrate palæontology, arrived in Peking in April to spend the summer months in the field with the Museum's Central Asiatic Expedition under the leadership of Dr. Roy Chapman Andrews. Associate Curator Reeds is in charge of the department during his absence. Mr. E. J. Foyles, who has been assistant in the department since 1916, left the Museum on June 30 to accept the position of director of the Geological and Biological Museum in the University of Rochester, Rochester, New York. Mr. D. D. MacLellan, A.M., Columbia, Mr. G. R. Megathlin, A.B., Amherst, and Miss Althea Lepper, A.B., Ohio, are assisting in the department during the summer months. Mrs. Mary V. Forster, A.B., Ohio, is voluntary assistant.

In June, Dr. C. A. Reeds assisted by Messrs. P. B. Hill and F. D. Matlack, resumed field work on the glacial clays of the Hackensack valley, New Jersey. Sampling tools have been devised in the department laboratory for securing continuous specimens of these seasonally stratified clays to depths of thirty-five feet. Through the generosity of Mr. Childs Frick, a one-half-ton Chevrolet truck has been provided for the transportation of the field equipment of this expedition.

INSECTS

The American Museum's Station for the Study of Insects has opened the 1926 season with Dr. Frank E. Lutz in charge and Mr. F. Martin Brown as part-time assistant in the Nature Trail work. The Station has as guests for the summer a number of boys and two research students in entomology, Mr. Wm. S. Creighton, of Princeton University, and Mr. Brandt Steele, of the University of Indiana. As was the case last year, the Nature Trails are open to the public. They are paths in the woods having labels that point out interesting things along the way. The entrance to the Trails is on the Bear Mountain—Greenwood Lake road, near where this road crosses on a bridge the main highway three miles north of Tuxedo, New York.

MAMMALS OF THE WORLD

Akeley Expedition.—Mr. George Eastman and Mr. Daniel E. Pomeroy have been enjoying some interesting hunting and collecting with Mr. Carl Akeley. Considerable work has been done in the Lukenia Hills in preparation for one of the habitat groups for the African Hall. Early in May the remarkable vegetation of this region was in superb condition for studies to be made. The abundance of flowers in bloom, the rich and varied color of the rocks, and the splendid view of Mt. Kenia to the north and of Mt. Kilimanjaro to the south combine to make this an ideal spot.

Mr. Akeley reports that Messrs. Leigh and Jansson, the artists, are getting excellent results.

The Ruwenzori-Kivu Expedition.—Late in April Doctor Chapin with his associates, Mr. Sage and Mr. Mathews, made a successful hunting trip into the Tanganyika Territory, with the veteran hunter, Mr. A. J. Klein. They secured three lions, two buffalo, and a variety of antelopes.

During May, they climbed Mt. Kenia in order to select a locality for an East African habitat bird group. On Kenia they collected two genera of birds new to the Museum's collection. In all they have collected nearly four hundred birds. On May 27, the date of the most recent letter from Doctor Chapin, they were just about to go to the Kidong Valley in order to gather materials for a bird group.

The Chapin-Sage party has crossed the trail of the Akeley Expedition, giving opportunity for an exchange of greetings and courtesies.

Peru and Bolivia.—Two expeditions sent out from the department of mammals of the American Museum have recently returned from the field. Mr. G. H. H. Tate, who accompanied Mr. H. S. Ladew to Peru and Bolivia, has concluded a successful field season in these countries.

Most of the collecting was done in Bolivia, where material was secured at 24 different collecting stations, ranging from 1800 to 17,200 feet in elevation. The opportunity to acquire museum collections from this district is due to the generosity of Mr. Ladew, who financed the expedition and wished to have a museum representative in his party. Mr. Tate took more than 625 mammals, 200 birds, and 1500 plants, as well as small collections of reptiles and insects. Since Mr. Ladew's primary purpose was to gain as comprehensive an idea of South America as possible, the party was on the move a large part of the time and covered more territory than is customarily visited in five months. Mr. Ladew left South America by way of Buenos Aires for England, but Mr. Tate remained a few weeks longer in order to round out the collections. Because of a delay in the granting of permits for the shipment, the boxes and trunks of the expedition have not yet arrived at the Museum, hence a more detailed statement as to any rarities secured cannot be given at this time.

Virgin Islands and Porto Rico.—The object of the second expedition was to collect the mammals of the Virgin Islands and small islands adjacent to Porto Rico. Mr. Gilbert Ottley, volunteer assistant on the trip, returned to New York on June 7, and Mr. G. G. Goodwin, department assistant, concluded the field work and returned on July 5. The party, which left New York in February under the direction of H. E. Anthony, curator of the department of mammals, visited eleven islands during the course of the expedition, Porto Rico, Mona, Caja de Muertos, Vieques, Culebra, St. Thomas, St. Croix, St. John, Tortola, St. Martin, and Anguilla.

Although the mammal life is very restricted throughout the West Indies, great importance may be attached to its distribution and origin, and to the fact that formerly the mammals were more abundant and are found today only as fossils. Valuable collections were secured both of the present-day mammals (the bats) and of the fossil prehistoric forms. Species new to science were taken on St. Martin and, when the collection is properly prepared for inspection, it is not unlikely that additional discoveries will be made. Anguilla and St. Martin, small islands at the northeast corner of the West Indian group, were formerly the home of a very large rodent, a veritable giant compared to the rodents of today. This animal was described under the name of *Amblyrhiza inundata* and must have been as large as a black bear, with a heavy body and robust limbs. The expedition found many teeth and bones of this great rodent, which is very rare in museum collections. Besides a considerable collection of the fossil remains of mammals, birds, and reptiles, 304 recent mammals and small collections of plants and insects were secured. Photographs were taken and data assembled for a detailed report as a part of the natural history survey of Porto Rico and the Virgin Islands, which is being carried on by the New York Academy of Sciences and affiliated institutions.

The Morden-Clark Asiatic Expedition.—Recent communications received from the Morden-Clark Asiatic Expedition convey very gratifying reports of splendid success in the quest of *Ovis poli*. The expedition has secured the finest series of this spectacular wild sheep that has ever been brought together for any museum. Although none of the specimens taken is reported to have record horns, excellent group material has been obtained, comprising adult males, females, and young. Interesting side lights on the activities of the expedition are given in letters received by Mrs. Morden and Mrs. Clark. The following is from a letter to Mrs. Clark, dated April 21, from Misgar, India:

"Within the last few days we have passed around the end of four big glaciers and one we had to cross which was a mile and a quarter wide. It was most interesting going up and down, but we could see ice only once in a while, as at best the glaciers are very dirty with the sand and rocks brought down by them. Just above us a hundred yards or so, great pinnacles of ice were standing straight up in the air. This glacier is many miles long, in fact, they don't know just where it starts. One man followed it for 12 days and then didn't find the beginning. Misgar is important as it is the end of the telegraph line on the road to Kashgar. It is only a little flat place in a valley where there is enough water and soil to raise crops. There are two buildings or huts—one the telegraph station and the other a government store house.

"Last night was the end of our comfortable and most convenient rest houses, and tonight we are out in the cold in our little six by seven tents . . . "A" tents. We have no beds and sleep on the ground. . . . . "

"In camp in the Russian Pamirs, 14,000 feet, May 3, 1926. We left on the 30th April, riding yaks, and with ponies carrying our baggage we went over Peyik Pass, 15,450 feet, into Russia. Again we were fortunate in having good weather and we did not have it a bit hard on this trip as we rode the sturdy yaks nearly all the way. The snow on the

Chinese side was not very bad except for the last 500 feet, which were steep, and our ponies floundered pitifully, but finally made it. At the top we all took a rest; it was not cold—about freezing. We had a wonderful panoramic picture from this height and took many photos going over the Pass. As we descended the other side, the snow was much heavier and continued down into the valley for a considerable distance. At times our descent was very steep and we had to zigzag down the slippery slopes. We got to the valley bottom and continued along this for several miles with snow everywhere. . . . "

"Everything is going well. It is a wonderfully interesting trip. We are the first whites to be in here in twelve years, and, we think, the first Americans. We are getting some very interesting pictures too. I am still enjoying good health and find no trouble in breathing although we are higher up. We do not mind the cold. In fact, the cold seems of a mild kind and is not bitter as that we get at home. Of course the outdoor life fortifies one for this and we dress for it too."

From a letter to Mrs. Clark, dated May 9, Russian Pamirs, Aktsoi:

"It is 11 A.M. and we are out on a little knoll watching some sheep and waiting for them to move and get behind something so we can go over some flats after them. Have been here since 6:30.

"I think I told you of meeting the Russians who have been very nice to us. After being with them a day and giving them a chance to size us up we returned to our camp just inside the Russian border. We stayed here because in one section of the mountains near by there were some sheep. They seem to be only in patches and when you know where to look you can see a great many. In other places that look the same you will not see a sheep.

"We have had lots of snow from time to time, which has delayed us some. Have had cold weather too—once zero and always down to 10–15 every night. When the sun is out in the day it gets very warm, like a hot spring day. We have had practically no wind night or day, which saves us from the cold. We are camping in yurts all the time, which are very roomy and comfortable with the little fires. These certainly take the raw edge off of camping, as we go to bed and dress by their warmth.

'We are now up where we have no fuel or water. Everything is frozen and no water runs. Our fuel has to be brought to us from the flats below,—many miles, and we melt snow for water. At our last camp No. 29 we saw many sheep and got two fine big ones out of a herd of 20 rams. Bill shot one and I got a good one at the same time. That was the morning of zero weather and it was bitterly cold riding along. We travel on yaks when hunting, as they alone can get through the deep snow and climb the hills over rocks or snow at this high altitude. They are strong and powerful and very good to ride, and carry all you want to tie on them.

"I went out alone one afternoon and saw 33 sheep, rams, and females, but when they are in such numbers they are very hard to hunt, as they scatter out. There are always some that see you and the minute they do off they go over the mountain peaks and you have to hunt them the next day in another valley, hoping always to see them first so you can stalk. This is difficult as the country is all big, sweeping valleys and the sheep nearly always see you before you see them. We chased them so much and there were so many storms that we decided to move to this place that we heard of. We made the 30 miles in two marches, passing Kizil Rabat again and seeing the soldiers, and stopping at the hot springs for another nice hot bath. . . ."

"The skins of the *Poli* are extremely hard to take care of. . . you usually get them a long way from camp, but most of all, the hair is extremely brittle and sensitive to blood stains that won't come out. Then the weather is almost always at freezing and the sheep are hard to wash and skin. You will remember the trouble I had with the caribou—well, these are very much worse. They are still in the fine winter coats of a sort of brown back with cream white legs and underparts. We have seen several foxes but could not shoot them while hunting the sheep. Their fur is not of good color, being sort of a dirty white. Saw one wolf and some rabbits. The marmots are just beginning to come out in the middle of warm days. They are big fellows and the color of a dark red fox. I want to get some if I have a chance. We have to be very careful about shooting in the sheep country, as it scares them too much. . . . "

"Have been through some glorious mountain country and have hunted up to 15,500 and 16,000 feet. We are in camp 34 now, so you we see are moving fast. Have altogether 5 specimens of *Ovis poli*—all 5 are big males—horns measuring from 50 to 52 inches. Have a complete skeleton and 4 skins. The weather is cold at night, going down to about 15 more or less every night. The days when the sun is out are like balmy spring days and at times hot. When clouds come up it is quite cool, but not cold. The Russians are still very kind to us and are doing everything possible to help in every way. As yet we have heard nothing further from Roy and don't know whether we will go out with him or not. We expected something definite before this, but he promised to let us know at Kashgar June first."

Later on other specimens of *Ovis poli*, in addition to the five mentioned above, were secured.

Because of the disturbed political conditions in China, which have upset the plans of the Third Asiatic Expedition, the Morden-Clark Asiatic Expedition will not be able to meet Doctor Andrews as originally planned.

SCIENCE OF MAN

Professor A. Radcliffe Brown recently visited the department of anthropology, en route to Sydney, Australia, where he has been appointed to the new chair of anthropology in the University of Sydney. Professor Brown has long been distinguished for his anthropological work, both in the field and as a teacher. As a preliminary to his work in Australia he has made a tour of American institutions interested in anthropology to investigate their methods and examine museum collections.

Earl H. Morris, who up to the present year, was in full charge of the Museum's intensive exploration of the Aztec Ruin, now the Aztec National Monument, New Mexico, recently spent a few days at the Museum. Mr. Morris has been appointed by the Carnegie Institution of Washington to take charge of the excavation of the famous Maya ruin at Chichen Itza, Yucatan.

The Fifth Bernheimer Expedition.—A report was received during the month from the Fifth Bernheimer Expedition announcing some interesting finds. This expedition spent twenty-three days in the general region of Navaho Mountain in New Mexico to secure anthropological, geographical, and geological data.

A new natural bridge was located, the hemispherical arch of which was 170 feet high. Its spread from base to base was about the same, and its thickness at the top was in the neighborhood of 25 feet. Mr. Bernheimer reported that a remarkable feature about this bridge was its removal about thirty feet from its matrix, which, immediately back of it and almost concentric with the fully developed natural bridge, was in process of forming another natural bridge, while within the center of the latter there was still another round cavity developing. This suggested the eye of a hawk, hence the name, Hawkseye Bridge, was given to the formation.

Shortly afterward the party located a ridge of slick rock about a mile square. This ridge was literally covered with pot holes of all sizes, several of them very deep. Some contained water, and others sand. Vegetation grew luxuriantly in the sand, while some of the sand-filled holes were deep enough to house cedars from two to four hundred years old. A number of holes were from thirty to forty feet deep, and varied in diameter, from ten feet at the base to twenty to forty feet at the mouth. Inasmuch as the watershed was insignificant, it was decided that the action of the wind was mainly responsible for them, perhaps assisted by the rotting of the stone under the influence of water.

PUTNAM ARCTIC EXPEDITION

Friends of the Expedition, which has Mr. Putnam, Mr. H. C. Raven, and Mr. Van Campen Heilner aboard, had an anxious time when they learned that the Schooner Morrissey had run on the rocks, and they were correspondingly relieved at the message that the schooner had been safely floated and was proceeding on its way undamaged. Among the trophies of the expedition are five Greenland sleeper sharks, one of which is ten feet long, as announced by wireless to the New York *Times* July 21.

J. L. WORTMAN

A brief letter from Mrs. Eugenie Wortman of Brownsville, Texas, announces the death of Dr. J. L. Wortman, June 26. Doctor Wortman was one of the prominent palæontologists in America for several years. He collected fossils for the American Museum in 1890, and in 1891, when the department of vertebrate palæontology was organized, he was appointed assistant curator, an office which he filled until he resigned from the Museum staff in 1898. A fitting tribute to this noted scholar, with a record of his achievements, will be printed in the next issue of Natural History.—B. B.

NEW MEMBERS

Since the last issue of Natural History, the following persons have been elected members of the American Museum, making the total membership 9025.

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Messrs: Julius H. Barnes, Joseph Boyer, Herbert L. Burgess, Richard A. Cooke, Craig F. Cullinan, C. W. Dall, Herman L. R. Edgar, Richard Milton Fullé, Howard J. Hamershlag, Theodore D. Helprin, Herman L. Hoops, Robert P. Huntington, Frank L. Jones, Charles W. Kellogg, Achilles Laevens, Edward J. Lewis, H. Morton Merriman, Bradford Norman, Jr., Leonard Outhwaite, William F. Parish, Samuel E. Peabody, J. Stuart Sneddon, Roberts Walker, Rudolph L. Walton.

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Misses: Esther M. Campbell, L. Elizabeth Clark, Marion Clow, Grace Wyatt.

Professors: George I. Hopkins, Nathaniel E. Wheeler.

Doctors: David Cerna, Howard P. Collings, D. A. Dery, Robert W. Gaston, Thomas H. Grosvenor, Milton L. Hersey, A. M. Neff, Daniel W. Rogers, Ross Hall Skillern, F. P. Thompson.

Capt. Wm. E. Menzel.

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THE ROMANCE OF FOSSIL HUNTING

SEPTEMBER-OCTOBER

The September-October issue of **Natural History** will deal with the fascinating experiences of collectors in searching the rocks of different ages for specimens of former life.

Geologic time is very long—perhaps one and a half to two billion years—no one knows the exact length. The fossil record of plants and animals, that once lived in the sea and upon the land, is far from complete and probably never will be fully known, for of the thousands of individuals that lived only the hard parts of a few are preserved in the sedimentary rocks. Oftentimes only a bone, a scale, or a bit of broken shell is the collector's reward for the day's search. Again, he may be overwhelmed with the great abundance of material. Complete specimens are rarely found. It is the duty of a fossil collector to know his science so well that if only a part of a specimen is unearthed he can immediately interpret its relation to the former individual and its significance in geologic time.

The surface of the land and the depths of the sea have not always been the same as they are at present. The plains, hills, mountains, streams, and valleys have had many different settings. The sea during various stages has pushed its strand line inland over the lowlands to a far greater extent than now. As the student of earth history becomes familiar with these varied scenes, he notes that the plant and animal life, on both land and sea, has been ever changing; that the forms are related; that there has been both progressive and regressive evolution, and that living things are what they are because of their connections with the past.

Mr. Childs Frick, trustee and research associate of the American Museum of Natural History, in an entertaining article on "Prehistoric Evidences" contrasts the former life of Val d'Arno and Monte Bamboli, Italy, with the Rancho-la-Brea tar pool of California and the extinct Pleistocene and Miocene faunas found near Santa Fé, New Mexico.

Dr. W. D. Matthew, well-known palæontologist of the Museum, in "Fossil Hunting on the High Plains" tells of some of the methods used in collecting fossils twenty years ago as compared with those of today.

Associate Curator Barnum Brown of the Museum staff and veteran collector in many lands has chosen "The Samos Island Fossil Fields" for relating his fossil-hunting experiences in the Grecian archipelago.

Professor R. S. Lull, director of the Yale University Museum, in "Early Fossil Hunting in the Rocky Mountains" dwells upon the trials and fortitude of the pioneer palæontologists—Marsh,Cope, Hatcher, Wortman, and others.

Dr. Stuart Weller, professor of palæontologic geology in the University of Chicago, reveals his intimate knowledge of the Mississippi Valley rocks and of the fossils found therein.

Professor J. E. Hyde, of Western Reserve University and of the Cleveland Museum of Natural History, contributes an article on the "Fossil Fishes of the Cleveland Shale" and adds a personal touch concerning the collectors who have unearthed these unusual forms.

Dr. Rudolf Ruedemann, Palæontologist of the State of New York, recounts his interesting experiences as a fossil collector. New York State is rich in fossils of the Palæozoic age, and has produced many notable collectors.

Professor W. H. Twenhofel, of the University of Wisconsin, tells of his varied experiences as a fossil collector on the wild and storm-ridden island of Anticosti.

Professor Edward W. Berry, of Johns Hopkins University, one of the few palæobotanists in the United States, relates some of his interesting experiences as a collector of fossil plants.

Dr. Robert Broom, physician and veteran collector of Permian reptiles, tells of "Fossil Hunting in South Africa."

Several members of the staff of the Museum's Central Asiatic Expedition have contributed to "The Romance of Fossil Hunting in Mongolia," which summarizes briefly the essential features of the Expedition's work in the Gobi Desert.

"The Arbuckle Mountains, Oklahoma—The Fossil Collector's Happy Hunting Ground" will be described by Dr. Chester A. Reeds, associate curator of invertebrate palæontology.

Dr. A. Wetmore of the United States Natural Museum and Curator E. S. Riggs of the Field Museum of Natural History will also contribute.

THE AMERICAN MUSEUM OF NATURAL HISTORY

FOUNDED IN 1869

MEMBERSHIP MORE THAN NINE THOUSAND

For the enrichment of its collections, for the support of its explorations and scientific research, and for the maintenance of its publications, the American Museum of Natural History is dependent wholly upon membership fees and the generosity of friends. More than 9000 members are now enrolled who are thus supporting the work of the Museum. The various classes of membership are:

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AUTUMN AND SPRING COURSES OF POPULAR LECTURES

Series of illustrated lectures, held in the Auditorium of the Museum on alternate Thursday evenings in the fall and spring of the year, are open only to members and to those holding tickets given them by members.

Illustrated stories for the children of members are presented on alternate Saturday mornings in the fall and in the spring.

MEMBERS' CLUB ROOM AND GUIDE SERVICE

A room on the third floor of the Museum, equipped with every convenience for rest, reading, and correspondence, is set apart during Museum hours for the exclusive use of members. When visiting the Museum, members are also privileged to avail themselves of the services of an instructor for guidance.

THE AMERICAN MUSEUM OF NATURAL HISTORY has a record of fifty-six years of public service during which its activities have grown and broadened, until today it occupies a position of recognized importance not only in the community it immediately serves but in the educational life of the nation and in the progress of civilization throughout the world.

Every year brings evidence—in the growth of the Museum membership, in the ever-larger number of individuals visiting its exhibits for study and recreation, in the rapidly expanding activities of its school service, in the wealth of scientific information gathered by its world-wide expeditions and disseminated through its publications—of the increasing influence exercised by the institution. In 1925 no fewer than 1,775,890 individuals visited the Museum as compared with 1,633,843 in 1924 and 1,440,726 in 1923. All of these people had access to the exhibition halls without the payment of any admission fee whatsoever.

The **EXPEDITIONS** of the Museum have yielded during the past year results of distinct value. The collections being made by Mr. Arthur S. Vernay in Angola, Africa; the studies of Andean avifauna pursued by H. Watkins in Peru; the three fossil expeditions in the western United States, in New Mexico, and Nebraska and Montana; the extensive survey of Polynesian bird life conducted by the Whitney South Sea Expedition; the work pursued in selected faunal areas of Venezuela by Mr. G. H. H. Tate; the field observations and collections made in Panama by R. R. Benson; the studies of microscopic pond life of Mt. Desert Island by Dr. Roy W. Miner and Mr. Frank J. Myers; the archeological excavations at two important sites in Arizona; and the continuation of the brilliant work of the Third Asiatic Expedition during the past season—these (and the list might be extended) are among the notable achievements of the past twelve months.

The **SCHOOL SERVICE** of the Museum reaches annually about 6,000,000 boys and girls through the opportunities it affords classes of students to visit the Museum; through lectures on natural history especially designed for pupils and delivered both in the Museum and in many school centers; through its loan collections, or "traveling museums," which during the past year circulated among 410 schools, and were studied by 977,384 pupils. During the same period 672,479 lantern slides were loaned by the Museum for use in the schools, the total number of children reached being 3,941,494. 1,076 reels of motion pictures were loaned to 48 public schools and other educational institutions in Greater New York, reaching 333,097 children.

The **LECTURE COURSES**, some exclusively for members and their children, others for the schools, colleges, and the general public, are delivered both in the Museum and at outside educational institutions.

The **LIBRARY**, comprising 100,000 volumes, is at the service of scientific workers and others interested in natural history, and an attractive reading room is provided for their accommodation.

The **POPULAR PUBLICATIONS** of the Museum, in addition to NATURAL HISTORY, include *Handbooks*, which deal with the subjects illustrated by the collections, and *Guide Leaflets*, which describe some exhibit or series of exhibits of special interest or importance, or the contents of some hall or some branch of Museum activity.

The **SCIENTIFIC PUBLICATIONS** of the Museum, based upon its explorations and the study of its collections, comprise the *Memoirs*, of quarto size, devoted to monographs requiring large or fine illustrations and exhaustive treatment; the *Bulletin*, issued since 1881, in octavo form, dealing with the scientific activities of the departments, aside from anthropology; the *Anthropological Papers*, recording the work of the staff of the department of anthropology; and *Novitates*, devoted to the publication of preliminary scientific announcements, descriptions of new forms, and similar matters.

For a detailed list of popular and scientific publications with prices apply to:
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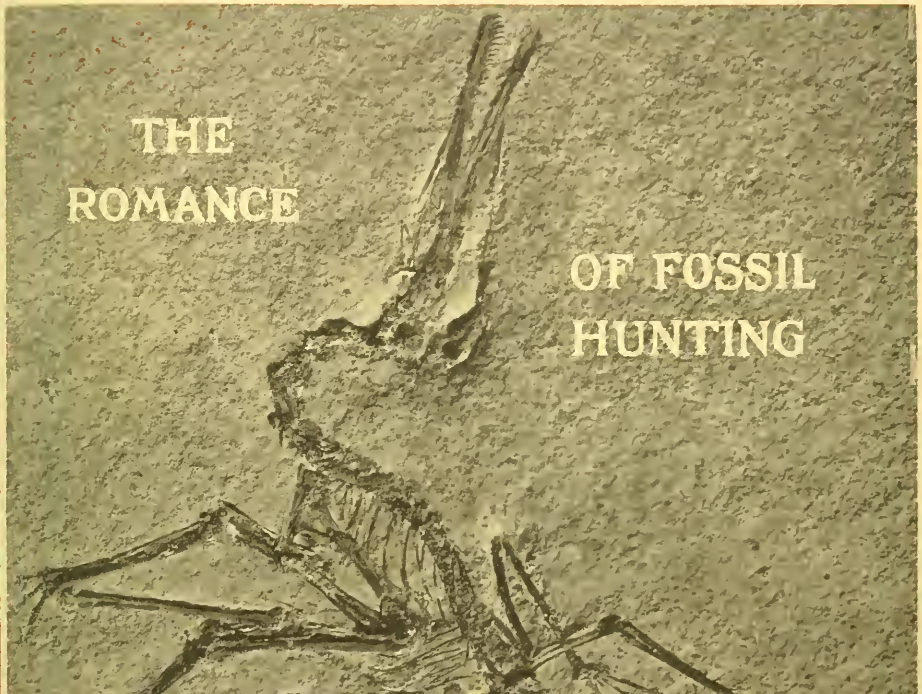
NATURAL HISTORY



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NATURAL HISTORY

THE JOURNAL OF THE AMERICAN MUSEUM

DEVOTED TO NATURAL HISTORY, EXPLORATION, AND THE DEVELOPMENT OF PUBLIC EDUCATION THROUGH THE MUSEUM

THE ROMANCE OF FOSSIL HUNTING

CHESTER A. REEDS, EDITOR

SEPTEMBER-OCTOBER, 1926

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A DINOSAUR SKULL IN THE BEDROCK AT SHABARAKH USU, MONGOLIA

The rock is a fine red sandstone, which, in Cretaceous time, was loose wind-blown sand. An almost perfect skull of *Protoceratops andrewsi* has been chiseled out and cleaned enough for a photograph, showing the curved parrot-like beak and the lower jaw. This is one of the most important types found by the Expedition for it has certain primitive characters and is not known from any other region

NATURAL HISTORY

VOLUME XXVI SEPTEMBER-OCTOBER, 1926 NUMBER 5

Cleveland Hoadley Dodge

1860-1926

BY HENRY FAIRFIELD OSBORN

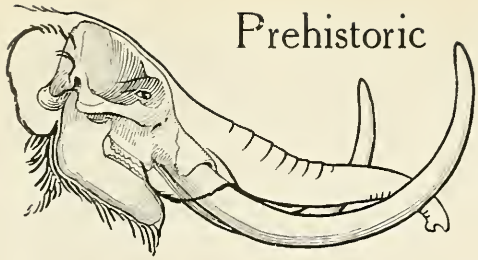
THOSE who recall Cleveland Dodge only in the closing years of his life, will find it hard to picture him in the vigor of his youth at Princeton University and in the confident strength of his young and mature manhood in the life of New York. A classmate of the brilliant Woodrow Wilson, he became his strongest champion in the crisis of the presidency of Princeton University and in the far greater crisis of the presidency of the United States. He backed Wilson at Princeton by his moral and financial support of the Preceptorial System and by his gift of the superb building devoted to Geology and Biology. No president of our country ever enjoyed more unswerving personal support than Cleveland Dodge gave to Woodrow Wilson and to all the great reforms and causes which he espoused.

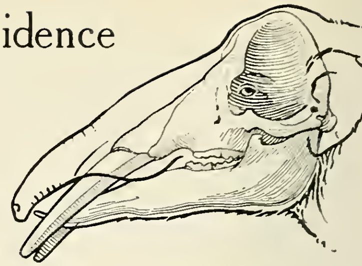
As a philanthropist in New York, his apparently limitless energy led to the development, on a thoroughly modern religious as well as practical basis, of the Young Men's Christian Association, a movement first conceived by his older brother, Earl Dodge, who also was a graduate of the Princeton Class of 1879. In more recent years he took up the apparently hopeless cause of Relief in the Near East and contributed lavishly of his time, his energy, and his means. He also gave strong financial support to the American University of Beirut.

From his entrance into the service of the American Museum of Natural History on January 21, 1898, until the last days of his life in the spring of 1926, he was an ardent and most generous supporter of all the great causes of the Museum which fell within his special field of interest and of taste—from the fossil fishes under Bashford Dean, to the Congo Expedition, to the African elephant group, to the Roosevelt South American Expedition, to the ill-fated Crocker Land Expedition, to the Central Asiatic Expeditions, to the Special Educational Fund, and finally to the Ralph Winfred Tower Memorial Fund. His contributions and gifts exceed $108,000.

At meetings of the trustees, he was at once the most conservative in matters of finance and of economy and the most progressive in matters of exploration and educational advance. For many years a member of the Executive Committee, he rarely missed a meeting and, soon after his election as a member of this central Committee, rose to the rank of vice president in which office he served for the sixteen-year period, 1908 to 1924. He was the first to applaud a piece of meritorious work by a member of the scientific staff, the first to offer a resolution of appreciation of an administrative achievement. To the president and, in fact, to all the members of the American Museum of Natural History, the life of Cleveland H. Dodge is an inspiration. We find new courage, new enthusiasm, and new confidence in our great undertaking when we contemplate his courage, his enthusiasm, and his confidence.

Prehistoric Evidence





Short-jawed low-fronted *Mastodon* from the Pleistocene of New York State, and long-jawed high-fronted mastodon (*Trilophodon*) from the Miocene of New Mexico, reconstructed upon scaled drawings of fossils skulls

By CHILDS FRICK

Research Associate in Palæontology, American Museum

THE wanderer in Florence, thrilled by the glories of the Renaissance and by antiquities of mediæval, Roman, Grecian, and Etruscan ages, is seldom aware of far older relics that evidence the life of earlier prehistoric centuries. Few sight-seers are conscious of the existence, within a stone's throw of the San Marcos cloisters with their Fra Angelicos and Savonarola's cell, of the R. Instituto with its collection of Pleistocene mammals[1] rivaling both in variety and in individual interest those of the far-famed California tar pools of Rancho-la-Brea.[2] Here may be seen and studied the petrified remains of strange, but none the less real, creatures that in relatively recent prehistoric time bred and held sway in what is now the valley of the Arno. Well may we wish that those famed Florentine collectors and princes, the Medici, had themselves but realized the rich evidence buried under foot, and dared the prejudice of the time of Galileo to foster in that early day the gathering together of these mute witnesses of a former era, and thus had advanced the present status of our science by hundreds of years: a science whose aim is the history of animal forms; the tracing back of family trees of the creatures of today and of the extinct creatures of the past, not by generations but by steps of many thousands of years; the causes of their differentiation, and the records and bearing of their migrations on the physical history of the earth: a science whose evidence is the fossilized remains of the great epochs of the past, those different animal assemblages met with in consecutive superimposed layers of the earth's crust,—remains that ere the investigation is complete must represent Life throughout the ages on every continent and in all its faunal zones: a methodical science that deals with the tabulation and description of these varied assemblages and with the intercomparison of all,—the relative levels at which the present-day associates of men first appear, the species from lower levels that suggest the ancestral stems of each of these, the uppermost limits of survival of the extinct forms of ages past, and the light that all this throws on the origin of man.

The current number of NATURAL HISTORY is given to the romance of our hunt for these fossilized remains throughout many lands. In the following pages, therefore, I have sought to illustrate several of the varied ways

[1]Museum Geologico, R. Instituto di Studi Superiori, Director Dr. Giotto Dainelli.
[2]See "Mammals and Birds of the California Tar Pools," Osborn, H. F., NATURAL HISTORY, XXV, No. 6, p. 527.

in which such evidence occurs by telling of three localities visited in the past year. "Where do you hunt?" "How deep do you dig?" are oft-repeated queries. As the first of these three examples I take the Etruscan region of Val d'Arno (Fig. 1A), the home of Dante, that yields a fauna of early Pleistocene age; for the second, another historic Etruscan locality, that of Monte Bamboli (Fig. 1B), with its remnants of late Miocene life; and for the third, the area north of Santa Fé, New Mexico (Fig. 1C), an earlier Miocene accumulation with deposits of Pleistocene age directly superposed.[1]

THE VAL D'ARNO PLEISTOCENE

In prehistoric Val d'Arno time, perhaps a half million years before the earliest civilization of which we have trace, ere the coming of the great cave-bear and contemporary races of men or of the mythological she-wolf of Rome, but long since these lands were raised from the shallow Eocene sea, what is now the valley of the river Arno seems to have been a region of plains, of forest vales, of shallow lakes, of lagoons, and of lignite-forming morasses. Today the morasses, preserved in the thick beds of unaltered tree trunks and forest débris underlying extensive areas of the recent surface, afford one of the chief industries of the region; for, tapped by many shafts, the ancient tree trunks are mined, corded, and burnt for coal. Buried amid this woodland growth, and in the adjoining clay and sand deposits of former lake bottoms, all deeply covered over by accumulations of more recent age, lie the fossilized remains of the creatures of Val d'Arno day. Through later change in the relative elevation of land and sea, that which was then a basin of deposition is now drained by the River Arno, which has cut the present broad valley into these accumulations of ancient time. It thus happens that the peasant repairing a deep rent of the swollen torrent or the miner working underground occasionally comes upon the limbs, jaw, or even skull of one of those creatures of long ago, and brings the trophy to his foreman or village mayor. Little by little the evidence has accumulated, an ever-lengthening list of forms. A few of these are almost indistinguishable from allied species now existing in Etrusca or near-by equatorial Africa, but the great majority are extinct—driven from their former home and off the earth by a complex of causes, among which may have predominated insect-born pestilence and the change of food and clime.

Would that we might see this great host on parade, pair by pair, the female and the male, as a Florentine artist quaintly depicts the cargo of the Ark; that we might check our hypotheses regarding their vanished bodies, muscular adaptations, coloration, and the story of their lives! Mastodons and mammoths, tapirs and boars, lions and sabre-toothed cats, long- and short-faced bears and wolves, in dying, have left their remains mingled here in the old lignite bogs, much as their distant cousins have left theirs trapped in the

[1]Two strikingly different examples of Pliocene deposition, the period that lay between the Pleistocene and Miocene and which is unrepresented at these localities, are: (1) the flintlike ledges, Fig. 3, discovered by the writer, lying high upon the metamorphics of little Mount Eden in southern California (Frick, C., 1921, Univ. Cal. Pub. Dept. Geol., XII, p. 335); and (2) the Coralline Crags of the British Coast, whose fossil-bearing beds occur at the base of cliffs submerged beneath the sea, save at low tide (see Moir, J. R., NATURAL HISTORY, XXIV, p. 640). In the flintlike Pliocene strata at Eden, California, there occurs a fauna exhibiting an interesting admixture of forms now extinct and of forms highly suggestive of animals surviving today. This is exampled in a species of extinct pony of typical Pliocene character (*Pliohippus edensis*) and its more horselike associate (*Pliohippus osborni*) which much resembles the typical horse of the overlying Pleistocene deposits; and is further exampled in the huge, extinct Pliocene cousin of *Hemicyon* (*Hyænarctos gregori*) and its modern-appearing, bearlike contemporary, *Plionarctus edensis*.

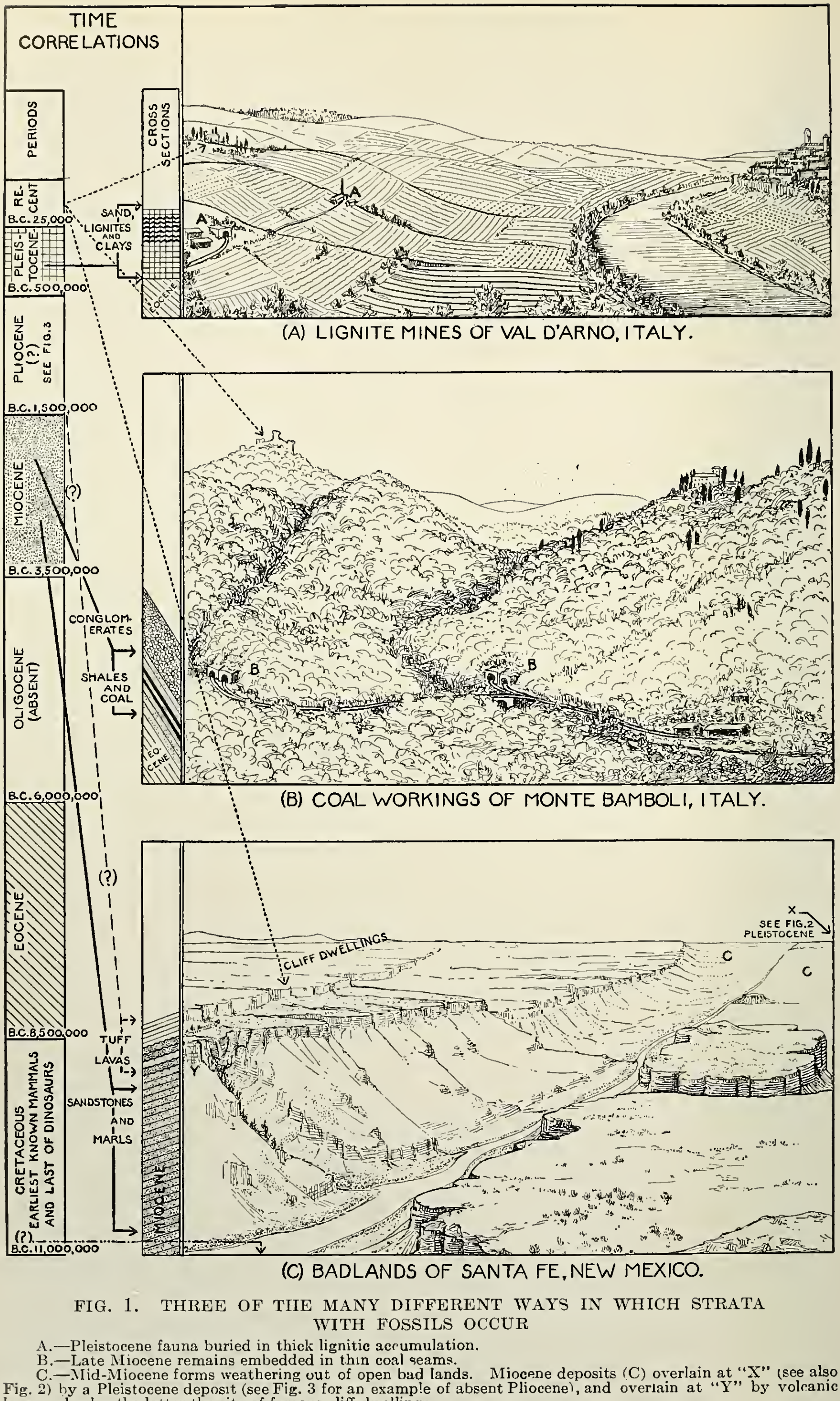


FIG. 1. THREE OF THE MANY DIFFERENT WAYS IN WHICH STRATA WITH FOSSILS OCCUR

A.—Pleistocene fauna buried in thick lignitic accumulation.
B.—Late Miocene remains embedded in thin coal seams.
C.—Mid-Miocene forms weathering out of open bad lands. Miocene deposits (C) overlain at "X" (see also Fig. 2) by a Pleistocene deposit (see Fig. 3 for an example of absent Pliocene), and overlain at "Y" by volcanic lava and ash—the latter the site of famous cliff dwellings.

Time scale adapted after Osborn and others. Compare Lucretia P. Osborn, 1925, "Chain of Life," Chart A, page 16, and table opposite page 84.

California tar pools of La Brea.[1] While the camel and great ground-sloths of the pools were absent, the single species of bison, of antelope, and of deer, of the tar pools, were here multiplied into numerous races of wild oxen, antelope, and noble, antlered stags, marvelous trophies for any baronial wall! Similarly the typical horse of La Brea, much resembling our modern friend, was replaced in the Val d'Arno by two widely differing species. One of these was even more like "Dobbin" than he of La Brea; the other (*E. stenonis*), though of equal stature, had teeth of more primitive form. Here, too, were huge rhinoceroses and hippopotami, hyænas, and baboons that are all unknown in the California pools! As for man himself, actual evidence of his presence with either fauna is as yet insufficient.[2] If present, his different habits and relatively small numbers might well preclude the ready finding of his remains.

THE MONTE BAMBOLI LATE MIOCENE

For a second and far different example of fossil occurrence let us search out the Late Miocene of Monte Bamboli a hundred kilometers to the south of Florence in the vicinity of Massa Maritima. We find ourselves in a rugged land where precipitous heights are crowned by walled towns with ruined towers that give occasional glimpses of the sea, where terraced hill and quiet valley are bound by wild and cedar-studded gorge; a region on which great earth forces have left their imprint in contorted strata and steaming boracic springs. Here, in thin seams of coal outcropping in the deeper brush-grown ravines, occur the scant remains of a fauna that flourished hundreds of thousands of years before that of post-Pliocene Val d'Arno—a million years before the building of Massa's now-crumbled baronial towers. These now thin and steeply pitching outcroppings, before they were buried by the accumulation of untold layers of bowlders and gravels, sands and clays, and compressed to coal by the titanic force of earth movement, were lignitic-forming bogs like those of later Val d'Arno time. Continental subsidence, subsequent to, and perhaps partially concomitant with the accumulation of the same deposits, turned this region into an island archipelago long previous to that gradual reëlevation which, resulting in deep erosion and the present mountainous topography, brought to light in narrow seams the compressed cross-sections of what were formerly open bogs.

The embedded bones of the ancient inhabitants are black-stained and often crushed beyond recognition. Fragments of skulls and jaws of swine and apes, of crocodiles and tortoises predominate. In fact they and certain remains of two species of antelope and of a peculiar hemicyonid (see p. 446), unless we include the teeth of a species of pony and tapir from similar coal seams of a near-by and possibly coeval marine accumulation, are the sole witnesses of an otherwise unknown phase of late Miocene life. These priceless remains were all obtained during the sixties and eighties when the same carbonaceous streaks were worked for coal. Unfortunately for science, economic conditions have long since closed the mines. I have visited the fallen pit heads and wondered to

[1]For interesting reconstructions of La Brea animals see illustrated article by Professor Osborn, *loc. cit.* p. 440.

[2]Note H. E. Anthony's discovery of a human skull in apparent association with the remains of extinct Pleistocene horses, camels, mastodons, and ground-sloths in the Pleistocene deposits near Riobamba, Ecuador. Sullivan, L. R., and Hellman, Milo, "The Punin Calvarium" *Anthropological Papers* of Amer. Mus. Nat. Hist., XXIII, Pt. VII.

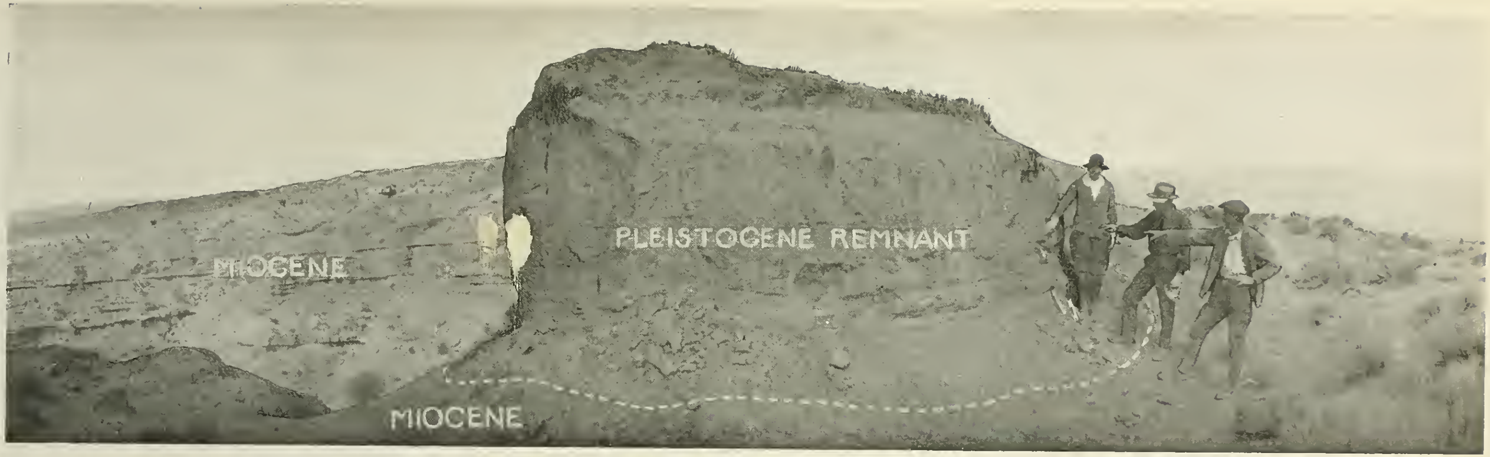


FIG. 2.—PLEISTOCENE AND MIOCENE DEPOSITS OF THE SANTA FÉ BASIN, NEW MEXICO

In the foreground a remnant of the once widespread Pleistocene lies on the deeply eroded Miocene surface. Mrs. Childs Frick and Messrs. Blick and Rak pointing to protruding toes of a large wolf (?*Canis dirus*) as found by writer (view taken at "X" of Fig. 1)

FIG. 3.—PLEISTOCENE AND PLIOCENE DEPOSITS AT EDEN, SOUTHERN CALIFORNIA

Far-flung Pleistocene directly underlain by deposits of Pliocene age which rest upon the ancient rocks of Mount Eden and outcrop about its north flank (see footnote p. 441) what future age is reserved the knowledge of the secrets of this unique Monte Bamboli life buried far within.

Fortunate it is for our understanding of the Miocene that Nature is not always so secretive of her treasure, and permits us to read in certain localities the fuller written page of other phases. Such regions are those great uplands where the fossiliferous strata, instead of being hidden by a deep mantle of soil and vegetation, or buried in narrow seams far within the ground, lie naked at the surface, subject to the erosive action of heat and cold, of wind and rain. Prominent among these are the great bad-land and desert areas of our own West.

THE MIOCENE OF SANTA FÉ, NEW MEXICO

For our third and final example let us visit one such area, the four hundred-square-mile stretch of bad lands which occupies a depression lying 6000 feet above the sea between the Jemez and the Sangre del Cristo ranges to the north of Santa Fé, New Mexico. As in the case of our two former examples this area was once a basin of deposition, but perhaps more a region of water holes and parched wastes seasonally green with the rain, than of forests and dark *estancias*. Since those days it has been elevated by great earth movements, and because of its aridity and the absence of protecting vegetation, much of its once vast content has been carried away. Under the work of the winds, the frost, and the rain, long hidden secrets of the lowest levels are being opened to the eye of man. Trenched by winding myriads of upward-creeping, jagged-walled, and rapidly widening arroyos, the stratified deposits of former centuries season upon season are borne away, here in swirling clouds of dust and there by the turbid waters of the silent Rio Grande. Who knows but that elsewhere deposited as dust and silt upon decaying carcasses and in the lapse of time all deeply covered over, these same sediments, in their turn, may reveal to our descendants of eons hence these very remains entombed today? Beneath pink escarpments of parched and broken uplands, crowned with scattered greasewood, junipers, and piñon pine, stretch the low north- and south-running flats of the great river, and those of its sandy washes from east and west, verdant with the irrigated fields of Mexican villages and Indian pueblos: a picturesque land which on every hand breathes of romance, that settled by the padres many years previous to the coming of the "Mayflower," is rich in quaint Indian ceremonials, in Spanish-American tradition, and in archæological as well as palæontological remains. But of those who have for centuries passed along the Santa Fé trail—priest, soldier, trapper, "forty-niner," archæologist, and engineer—who has noted far and wide Nature now disgorging that which she has held buried since remote Miocene age? Not our stage-driver, who, blind to the fossilized fragments of the bones of real camels that lie about its very base, calls attention to an eroded sandstone butte situated a few miles beyond the city, and widely known as the "Camel." Sphinxlike it crouches by the wayside on a pedestal whose foundations antedate the far-famed Egyptian monument by a minimum of two million years; a freak of erosion carved from some long vanished cliff-bound plateau, the passing remnant of what was once one vast stratified deposit, as are all those far-flung variegated pinnacles, flatcapped domes and buttressed ridges. Each bluff reveals the component strata—layer upon layer of high-piled Miocene deposits that suggest the flat-lying leaves of a volume viewed end-wise, and that form the matrix for occasional petrified remnants of the life of former days. Here and there layers of flintlike hardness, acting as stays to erosion, protrude in prominent bands beyond their softer fellows as do the covers of a pile of books beyond the leaves. All are but so many pages upon pages of a venerable scrapbook—Nature's titanic volume on "The Miocene of Santa Fé."

From such strata we have already garnered the remains of a noble fauna. In variety it exceeds that which we have secured from a rich deposit of somewhat similar age in the Mojave Desert of southern California, and matches the classic horizons of Europe. The majority of the forms are of races non-ancestral and far removed from those more modern creatures found buried in the remnants of a once widespread Pleistocene deposit that here and there still cap the old eroded Miocene surface (Fig. 2). Certain of these forms are of genera common to the Miocene of both the western and eastern hemispheres, while others are found in one hemisphere alone. Amongst those known only from America, and occurring in particular abundance here, are the forementioned camels, a galaxy of lost races varying in stature from diminutive gazelle-like to huge giraffe-like forms; herds of many kinds of delicately horned merycodi, those peculiar antelopine-deer; flocks of four-toed ruminating hogs, "oreodons," and of peccaries; and bands of fleet ponies, dew-clawed and striped perhaps as brilliantly as the zebra—absent in the Miocene of the eastern hemisphere, they are there replaced by representatives of the true deer, antelope, swine, and apes, all absent here. Amid remains suggestive of the Miocene of Europe and in instances of surviving genera of today we have found narrow- and broad-nosed rhinoceroses, a tiny deer *Blastomeryx*, hedgehogs, porcupine-like and peculiarly-horned rodents, primitive hares, gophers, squirrels, and mice; lizards and tortoises; lion- and lynx-like cats; weasels; foxes and coyotes, and heavy-headed wolves. Lastly, we have retrieved splendid skulls and jaws of other and stranger forms that, common to the Miocene of both continents, have since vanished into the medley of the great beyond—huge-bodied, prognostic-chinned mastodons, *Trilophodons*[1] (see foresketch); stout-limbed, three-toed hypohippine ponies that externally may have resembled the tapir almost as much as they resembled the horse; and the rare *Hemicyon*.[2]

It was the hope of finding remains of this so-called "half-dog" that really first brought us to Santa Fé. For seasons past we had been collecting in the above-mentioned Barstow Miocene of the Mojave Desert of California,[3] a task bequeathed me by my friends of the department of palæontology and historical geology of the University of California, who years before had located and made preliminary investigation of these difficult beds. One day I was surprised to discover among other interesting material forwarded from this area by my industrious field assistant, Mr. Joseph Rak, some teeth of the *Hemicyon* above mentioned, a

[1]Nobis, "Tooth Sequence in Certain Trilophodont Tetrabelodont Mastodons." Bull. Amer. Mus., LVI, Art. II, 1926.
[2]Nobis, "The Hemicyoninæ and an American Tertiary Bear." Bull. Amer. Mus., LVI, Art. 1, 1926.
[3]Merriam, J. C., 1919, Univ. Cal. Pub. Dept. Geol., XI, p. 438.

much-discussed, but little-known carnivorous genus of the French Miocene, related perhaps to the peculiar carnivore of Monte Bamboli (see p. 443) and to certain of the huge and inaptly named "hyæna-bears" of the later Pliocene, but heretofore unrecognized in America. Subsequently I happened to note the strong resemblance of a fragmentary lower jaw in the National Museum collection to certain of this new California material, and later was able definitely to determine it, too, as *Hemicyon*. This specimen had been found by Cope, then vertebrate palæontologist of the U. S. Geological Survey, in the vicinity of Santa Fé, a locality that had lain untouched by fossil hunters since his visit in 1874. Was material still to be found there? Might the old locality yield more of *Hemicyon*? Late in the summer of 1924 Messrs. Simpson and Falkenbach of an American Museum field party, en route home from Texas, were wired to stop over at Santa Fé. The first days' exploration brought fragmentary material, and the fourth a disintegrating block which they reported as containing the skull and jaws and parts of the skeleton of a great dog. Months later this block was received and opened up at the Museum. Before us lay a nearly complete skeleton of *Hemicyon*, revealing a beast with somewhat tiger-like proportions and doglike teeth, till lately quite unknown excepting for the few partial jaws and palates from the Mid-Miocene of France. Since then we have worked for many months at Santa Fé, and have secured a splendid series of remains representative of this ancient fauna, but to date, this first great trophy is our most complete specimen of any of those ancient animals, and, save for two fragmentary teeth, our only example of *Hemicyon*.

Among the finest specimens of last season was that found on a Sunday afternoon only a few hours before departing for the East. My wife and two of our little girls had motored out with me to an area that I had long wanted to examine. We had lunched in the scant shade of a small clump of junipers and started up the adjoining hillside for the view of what lay beyond, when suddenly and almost at the same instant we all four noticed scattered fragments of bone. These we traced on up the sandy slope, striking with our picks here and there in the soft débris-littered surface till we came upon their source. Immediately we were all engaged in scraping and brushing aside the soil and treating what lay beneath with thin shellac. Nor did we desist until the fast-lengthening shadows bade us hasten homeward. We had outlined the skull and the limb bones of a large rhinoceros. Hours of work still remained for our stronger, if not more expert successors, before the rocky area containing the bones could be quarried into solid blocks, bound with strips of plaster-soaked burlap, and crated for the eastward journey.

Some months before, marooned one evening by the unwonted collapse of our car high on the tuffs of the wooded Parajito plateau, sixty miles by winding mountainous road to the west of the "Camel," we were forced to spend the night in a little cabin deep within the neighboring Cañon of El Rito de los Frijoles. The reader may recall that this gorge contains some of the most impressive remains of prepueblan people, and is now the Bandelier National Monument. The storied dwellings of the ancient occupants lie partly against and partly within natural excavations in the tuff of the north wall, and represent a civilization the zenith of which some archæologists place as early as 500 A.D.[1]

Turning our backs on ceremonial cave, ancient homes, and trails worn deep into the rock by moccasined feet of prehistoric men—let us follow the small creek, to which the Indian women of old must have repaired for daily household needs, through alders and tall bull pines to the mouth of the little cañon two miles distant. There, amid towering walls of stratified and superincumbent igneous rock, in view of the waterfalls by which El Rito plunges far below into the great White Rock Cañon of the Rio Grande, let us tarry to gaze upon the deep-bedded series of thin-edged layers of sands and clays, their capping of darker bands of lava, and the superincumbent gray wall of ash where the cliff dweller once made his home,—a vast accumulation representing a fraction of that gulf of time, estimated at from two to twenty million years, which separates yonder high abodes of ancient men from the fossilized remains of the mammals found buried in the lowest of those deep-laid clays.[2] Consider the centuries of accumulation represented in all these wide-stretching variegated sediments of the Santa Fé basin, hundreds on hundreds of feet of individual layer upon layer of paper-like shales, fine sandstones, intercalated fossiliferous clays, grits, and cobbles; the erosional interval of unrecorded duration that divides the higher of the sedimentary strata from the dark overlying beds of once molten lava and five hundred feet of gray tuffs; the succeeding years of upheaval and deformation that shattered the former continuity of all these layers and brought the Rocky Mountains into being; the ages necessary for the subsequent cutting of the White Rock Cañon gorge, for the slow reduction by wind and rain of these once vast Miocene deposits to their present remnants, and the preparation of the superincumbent Frijoles cañon to the needs of prehistoric men.

Such are but three of many examples that might be given of the ways in which remains of ancient life, long and deeply buried, are being brought to the light of day. We can but hope that Nature even now holds preserved, hidden away amid the earth's yet unexplored mile on mile of similar sedimentary strata, that longed-for evidence which will crown the coördinated research of some not too distant day and tell of earlier races of human beings—the precursors of such as these cliff dwellers, of their forebears of Val d'Arno and La Brea time, and of their and our direct ancestors of thousands of centuries before, the man-endowed contemporaries of the highly developed beasts of the Miocene of Monte Bamboli and of Santa Fé.

[1] Henderson, Junius, and W. W. Robbins, Bull. 54, Bureau Amer. Ethn., 1913, p. 54.

[2] Northeastward the "marls" are found lying directly upon the metamorphics outcropping in the foothills of the Sangre del Cristo range; northwestward they are separated by sediments of yet unknown age from the red beds of Triassic time; southward they may be in places directly underlaid by parts of the Cretaceous series

Early Days of Fossil Hunting in the High Plains

By W. D. MATTHEW

Curator-in-chief, Division of Mineralogy, Geology, and Geography, American Museum

THE HIGH PLAINS: that is the country that stretches west from the cultivated prairie to the foothills of the Rockies,—a broad level plain covered mostly with buffalo grass and other short grasses, suited for cattle raising and generally used that way, although every here and there one finds an optimistic "nester" or "Kincaider" who has fenced in a homestead and is trying to make a living from it.

This plain stretches from South Dakota to Texas, but the highest and the most typical portion of it lies east of Denver in eastern Colorado and western Kansas. Many rivers traverse it from west to east, running in broad, shallow, flat-bottomed valleys, flanked usually by a line of scarped cliffs, cut in the soft rocks that underlie the plains. These escarpments are carved by wind and weather into strange, irregular, and often fantastic outlines, and broaden out here and there into a maze of gullies and cañons most appropriately called *mauvaises terres*—bad lands—by the early explorers and settlers, for they are bare of vegetation, difficult to traverse whether on horse or on foot. Their maze of winding, waterless gullies form a trap for the inexperienced, either man or animal. There is little or no feed to attract the cattleman or sheep-herder, no chance of finding valuable mineral deposits to lure the prospector to these bad lands. There is just one valuable crop to be obtained there—fossils. They are the happy hunting grounds for the "bone-digger."

In the early days of the West, the "breaks" and bad lands served as a refuge and lurking ground for hostile Indians, and later for cattle rustlers and bandits. Today they are peaceable enough, where still wild and unsettled; their picturesque beauty and fantastic marvels of sculptured rock and cliff make them a place of pilgrimage for visitors. Many of the more remarkable and historic buttes and, cañons, landmarks on the early trails, have been set aside and protected as national monuments or state or local parks, and are visited by thousands of tourists.

The earliest fossils from the Plains were brought in by fur traders from St. Louis, who penetrated as far as the big bad lands of the Cheyenne River, and brought back fossil teeth and bones and battered skulls as evidence of their story of the great cemetery of strange beasts. These were studied and described by Joseph Leidy in 1847–55. Then came the preliminary reconnoissances for the transcontinental railways, and larger parties, usually protected by military escorts, traveled and mapped the various routes and reported upon their topography, geology, and economic possibilities, and incidentally made a more or less systematic search for fossils. This opened up a most promising new field for scientific discovery, and two able young scientists, Cope of Philadelphia and Marsh of New Haven, devoted their energy and resources to its exploration with a success that drew the attention of the whole scientific world, and inspired a large school of American palæontolo-

SLAB FROM EAST BUTTE, AGATE SPRINGS, MIOCENE BEDS, NEBRASKA

This block (5½′ x 8′) contains 21 skulls and parts of skeletons of *Diceratherium*, and is a section of the bone deposit or mass that extended through the east butte, Cook's ranch, Harrison County, Nebraska gists. The sharp personal rivalry between these two men, while it had some unpleasant features, served to spur both to their utmost effort and hastened the development of method and technique in collecting as well as the publication of results.

The building of the transcontinental railroads made the western bad lands accessible for small collecting parties. Indians had ceased to be a danger, and a group of expert fossil hunters, among whom Hatcher, Wortman, and Sternberg were leaders, developed the rather simple technique of collecting and practical handling of a field party to fit the conditions of the western field.

The necessary equipment could be purchased at any considerable trading center. A team and wagon, a couple of saddle horses, tents, camp stove, etc., were the chief necessary equipment; each man's personal baggage and bedding roll were usually brought from home. The latter consisted of camping blankets and "tarp,"—a canvas sheet 6×16 feet of heavy duck, which, when properly folded, protected against anything short of a flood. A newcomer often brought a sleeping bag instead of the regular tarp. With provisions for the party and a few bags of oats for the horses, the outfit would pull out for the bad lands, and camp at some point where water and grass were at hand. Sometimes this was near a ranch house or homestead, more often not, for the important point was to get as far into the bad lands as practicable.

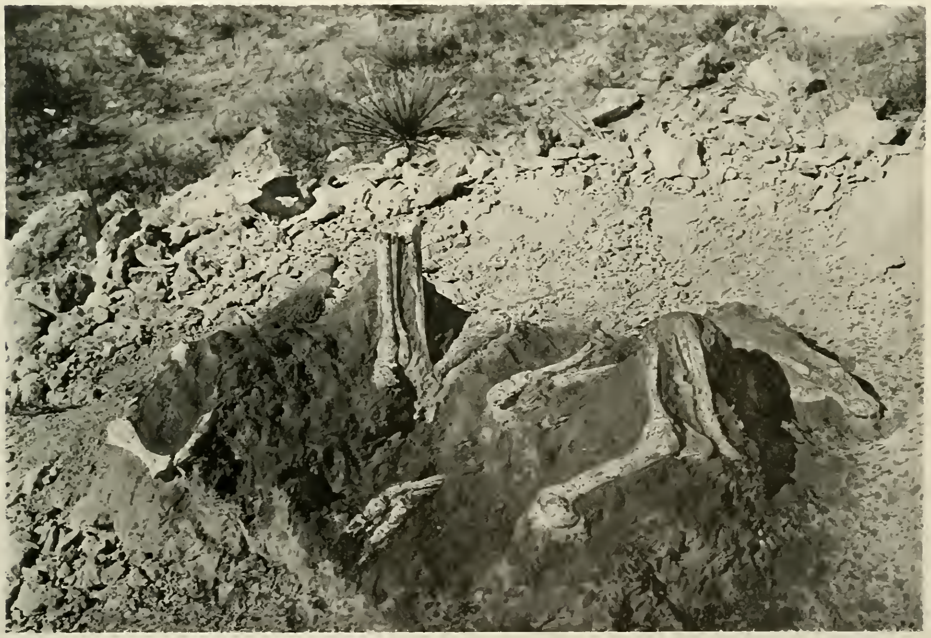
The day's work consisted in "looking out" as much as one could cover of the rock formation exposed in cañons and gullies, prowling over the weathered slopes, and climbing along the steeper cliffs, watching always for the peculiar colors and forms of weathered bone fragments, following up every trail of fragments to its source, and prospecting cautiously with a light pick or digging chisel to see what, if anything, is left in the rock. Such a prospect came often as a blessed relief after hours of climbing and scrambling had reduced one to a state of staggering weariness. If it was a valuable find, it might mean some hours or days of work to prospect and collect. More often, of course, it was a minor find, a jaw or a few bones, and still more frequently nothing worth while would be there. Even at that it was an excuse for a little rest, and one could go on hopefully, praying for better luck next time. Toward sunset one must get back to camp, tired and discouraged by an unsuccessful day, or comparatively fresh and cheerful with a new discovery to report. Perhaps it might be a complete skull or a skeleton of some rare or imperfectly known fossil; perhaps some species altogether new to science,—in any case a prize that paid for much weariness and many disappointments. Then supper, a pipe, and to bed, and the same routine repeated the next day and the next, until all the bad lands within practical reach of the camp—five miles on foot, ten with the help of saddle horses—have been prospected, and another camping site must be found. There the same order of work is repeated, and so on until the season closes or the bad lands area has all been "looked out." By the end of the season a very considerable collection has accumulated, and one realizes with some surprise that what seemed desperately poor pickings has after all yielded an important collection.

Of the technique of collecting and preparing fossils, I need say nothing here; that has been fully explained in other numbers of Natural History.

Bone Cabin Quarry, Wyoming, with camp in background. In the group of workers are Messrs. Lull, Granger, Schneider, and Kaisen

Camp at Hell Basin, Washakie bad lands, Wyoming

Wasatch bad lands near Otto, Wyoming.—This *Coryphodon* skull had entirely weathered out into small fragments. The earth was swept up and carried seven miles to a stream, washed and sieved, and then pieced together in the Museum, forming a complete skull and jaws. The two men are Messrs. Riggs and Brown



Hypohippus skeleton in rock (Miocene-Lower Pliocene). Davis ranch near Grover, Colorado

Stratigraphic studies and exact records of geological level were developed in the nineties, and added a new and fascinating interest to the work, as one could actually trace in the succession of strata the progressive evolution of the different races, verifying in specimen after specimen the primitive characters of those from the lower layers, the progressive character of those from the upper layers, and the intermediate conditions in specimens from the middle beds. No one carries a more solid conviction of the truth of evolution than the field palæontologist. He has seen it with his own eyes, and it is quite useless for learned pundits of the pulpit or the laboratory to tell *him* that evolution is only a hypothesis, or that palæontology does not prove anything about it. He knows better; he has seen it himself ineffaceably inscribed in the records of the past.

The coming of the automobile has revolutionized the fossil-hunting business. For one thing, it has greatly widened the range of practical field work. The old conditions limited it to a radius of five or ten miles from water and feed. A "dry camp" supplied at intervals with food and water might carry the exploration a stage further, but throughout the West, especially between the Rockies and the Sierras, there were enormous areas of bad-land exposures that it was not practicable to prospect adequately for lack of water or feed. With the automobile there is probably no promising exposure so distant but that it can be, and will be prospected for fossils. Moreover, the range of a day's collecting with an automobile is so greatly increased, that most areas in the Plains can be prospected from some near-by settlement, and it hardly pays even to camp out. The old days of the open range have passed; much of the country is fenced up and a good part of it homesteaded, and the residents no longer welcome strangers with the old unquestioning cordial greeting. The bad lands of the Plains, the old hunting grounds of the bone-digger, are not exhausted of their fossils. They never will be, for storms and weathering expose an ever renewed supply. But some of the joys of discovery have passed; the new fossils are apt to be like those previously known. And the collecting methods are a bit more prosaic. The old delightful camping routine, with its pioneer equipment and unhindered freedom of exploration, has shifted and changed to automobile travel in the deserts and plateaus of the Great Basin and intermontane states, a field for discovery which will take many years to cover. The high plains, too, will always be a great fossil field, but the romance of their discovery and exploration by the early fossil hunters belongs to the past.

Early Fossil Hunting in the Rocky Mountains

By RICHARD SWANN LULL
Professor of Palæontology, Yale University; Director, Peabody Museum

IT was in 1868 that the pioneer among American palæontologists, Othniel Charles Marsh, made his first trip to the Rocky Mountains for fossils, a trip that was to stimulate a life-long interest in these relics of the past, one ultimate result of which was the amassing of the great collections at Yale. Of all the material Marsh assembled, none made a greater appeal, both to himself and the public imagination, than did the horses among mammals and the dinosaurs among reptiles, representatives of which he found on this initial trip. The Peabody Museum still treasures the original horse specimen, *Protohippus parvulus*, which Professor Marsh found in western Nebraska, but the identity of the dinosaur bone which he discovered has been lost sight of in the passage of time. The year 1870 saw the inauguration of the first formal expedition from Yale, followed by others in the succeeding years until 1873, after which the work was conducted in another way. The personnel of these early expeditions was made up of Yale men, seniors or recent graduates, who paid their own way, giving their services for the sake of the thrill of big-game hunting, both living and extinct, and the adventure of exploration in unknown fields. Marsh had keen insight in his choice of men, for, while few of the members of his parties became professional palæontologists, they, almost without exception, had worthy careers in other walks of life, two, at least, becoming members of the Yale Corporation and several becoming members of her faculties.

On the material side these expeditions were remarkably successful, especially when one remembers that the vicissitudes encountered were not entirely those of the physical environment. Tons of specimens were brought in, collected from a virgin field and revealing at almost every turn discoveries new to science; species, genera, and new orders of creatures, the very existence of which had been beyond imagination. One only wishes that the methods of collecting had been more refined, but the present technique had not yet been developed, and the extreme value of the specimens compensates for shortcomings of original attainment.

After 1873 the student expeditions ceased, although they had done yeoman service in Kansas, Nebraska, and Wyoming, and from Colorado to Oregon. This was due in part to increasing Indian difficulties and in part, we imagine, to Professor Marsh's desire to collect more intensively in certain regions or horizons, as he was beginning to amass material for his projected monographs on dinosaurs, horses, titanotheres, Odontornithes, and others. To this end he had paid collectors, some of whom had served the earlier expeditions as cook, horse wrangler, or guide, and not only knew the country but had of necessity learned something of the rather crude technique of that day.

Other young men who were regularly connected with the Museum were also sent into the field, and some of these, notably S. W. Williston and J. B. Hatcher, were not only highly productive of material for the Yale Museum, but became, subsequently, men of outstanding rank among palæontological workers. Williston's name is found attached to numerous specimens, principally from the Niobrara Cretaceous, toothed birds, pterodactyls, and marine saurians, while we always think of Hatcher in connection with the Ceratopsia skulls, of which upward of two score were collected largely by himself and Peterson, now of the Carnegie Museum. With Professor Beecher they also gathered the large amount of Lance mammal material seen in the Museum at Yale and the National Museum. Hatcher spent portions of the years from 1886 to 1888 in the field, during which he collected 105 nearly complete titanothere skulls and much associated material.

Midday meal.—Expedition of 1870

It must be remembered that this collecting was financed largely by Professor Marsh himself up to the time of his appointment as Vertebrate Palæontologist to the United States Geological Survey, July 1, 1882. From that time on until Marsh's death in 1899 Government assistance was generally available. Material was therefore collected and paid for jointly by Marsh and the United States and, after the professor's death, was divided between the Peabody and the National museums, constituting the so-called Marsh Collection of each institution, for in 1896 the entire share of the Yale professor was deeded to Yale University to be cherished forever.

Upon the coming of the present incumbent of the Chair of Palæontology twenty years ago, there was a vast and important collection at Yale, second only in extent to that of the American Museum and containing items which are unique and priceless in their importance to science, the fruition of a third of a century of intensive work. There were and are certain important gaps in the series to be filled. Hence it seemed wise to revive the field work, and four expeditions were undertaken

Collecting fossils in the Rocky Mountains, 1871

from 1908 to 1915, when the coming of the war made such matters relatively unimportant. The passing of the old Museum building in 1917 and the lean years which followed up to the dedication of the new edifice were perhaps reasons sufficient for non-activity in the field.

The old-time expeditions were staged in the real West, at a time when lack of means of transportation and the presence of Indian menace, together with the very intimate contact every fossil hunter must have with his physical surroundings—with fatigue, heat and cold, hunger and thirst—made the search for the prehistoric a real adventure suited to red-blooded men. Big game was then abundant, but this good was offset by days of labor through rolling sandhills, with infrequent streams, often alkaline, little vegetation, and the menace of occasional prairie fire and Indian attack, in spite of which material by the ton was collected with unflagging zeal.

One of Williston's letters to Marsh (June 1, 1876) tells how the party narrowly escaped death from water while in Kansas. "The Smoky Hill rose nearly twenty feet in about as many minutes, catching us asleep at half past two in the morning and drowning one of our horses. We swam and waded ashore as we jumped from our beds, but succeeded in saving most of our camp outfit which drifted ashore." This is merely one of the vicissitudes of these romantic days, most of which are unrecorded except in the memories of a dwindling group of men.

Personnel of the 1872 Expedition—Marsh standing in center

Williston tells us much about the early dinosaur collecting—how Professor Arthur Lakes discovered in March, 1877, near Morrison, Colorado, the dinosaur which was to be the type *Atlantosaurus immanis*, now preserved at Yale.

Arthur Lakes carried on explorations with William Reed and independently for some years, and a number of important specimens in the Peabody Museum collection bear his name. He also made sketches in water color of the various localities and the old-time methods of exhumation, several of which, bearing the date of 1879, are now hanging in the palæontological laboratory at Yale. The value of these is at once evident, for in the days before the omnipresent kodak, when the "wet plate" process of photography limited its use in the field, sketching was the only method of recording pictorially such events as these.

The year 1877 was highly productive of discovery, for Lakes was followed by O. W. Lucas, who found material near Garden City, Colorado, which he in turn reported to Cope. This was the *Camarasaurus supremus* type now in the American Museum of Natural History. While a veteran collector, David Baldwin, who had previously worked in New Mexico, found the unique and still somewhat problematical *Hallopus* specimen at Canyon City.

Como Bluff in central Wyoming, which became amazingly productive, was also discovered as a dinosaur locality in 1877. This time the collector was William, commonly known as "Bill," Reed, formerly a professional game hunter, who supplied certain of the construction camps of the Union Pacific Railroad with meat, as did the more renowned Buffalo Bill. Upon the announcement of this discovery, Williston was sent out and shortly opened Quarry No. 1 of a long series of excavations along the face of the eroded anticline which forms the bluffs. Among the most important of Reed's finds was the famous type of *Brontosaurus excelsus*, shortly to be mounted in the Great Hall of the new Peabody Museum, a specimen known the world over but, except for the pelvis and hind limbs, never articulated. After some fifty years it will come into its own!

Professor Mudge, of the University of Kansas, together with Messrs. Felch and Williston, opened the quarry which contained the type of *Diplodocus*. As Williston says, "it consisted of hind leg, pelvis, and much of the tail, lying in very orderly arrangement in the sandstone near the edge of the quarry," but the bones were broken into innumerable pieces and "most of them went into the dump." This is of course greatly to be deplored, but two circumstances conspired to produce the result. The technique of today had not been invented which makes the saving of much poorer material than this a matter of relative ease. The other factor was the apparent need of haste, as the collectors were urged to get their material to New Haven with the utmost dispatch, such was the rivalry of the already opposing palæontological camps.

These collectors, led largely by Reed, worked the year round, defying alike the summer heat and the winter cold, the thermometer once falling 38° below zero with high winds and snow. Every possible day saw them actually in the quarries or prospecting for more, while utterly impossible weather only shifted their activities to other work, such as the search of "pay dirt" for tiny mammal and other remains. Nor were the summer's days entirely uneventful, for once they were visited by swarms of siredons (salamanders) which, as Lakes says, "so insinuated themselves under every box and bed that although we threw out and killed dozens, it became useless to stop the horde . . . that waddled leisurely into the tents, as if they had a perfect right to them. . . . What with the noise of the creatures . . . and the baying of wild geese on the lake, the gnawing of mice at our furniture, and the roar of the thunder, the voices of the night were not conducive to slumber."

Another amazing locality, the famous Bone Cabin Quarry, lies at the head of a draw, tributary to the Little Medicine Bow River and not many miles west of Como Bluff. Here a Mexican sheep-herder had built the foundations of his hut of weathered-out dinosaur bones, the centra of vertebræ and pieces of vast limb bones. It was in 1898 that Walter Granger saw and realized the significance of this remarkable building and began, together with Doctor Wortman, the excavation of this world-famous quarry. Hither the following year came Doctor Matthew, and the author of this paper joined Mr. Granger's party in the work of excavation,—his initiation into the science of palæontology. The dinosaur layer at Bone Cabin is part of the same deposit as that at Como Bluff, the apparent discontinuity being the result of tremendous folding and subsequent erosion, two factors which bring to light material which otherwise would be buried far beneath the surface of the earth. At Como approximately complete skeletons may be had, while at Bone Cabin there are members rather than skeletons, tails, limbs, necks, the result of burial of disintegrating carcasses in some ancient backwater or river bar.

The Expedition of 1873 in the Bridger Beds

The product of a number of years of labor has been remarkable, representing at least seventy-three dinosaurs large and small. Osborn estimates the grand total, counting those eroded away, as at least a hundred. The principal reason for discontinuing the work was not that the quarry had ceased to yield, but that the bone-bearing strata were dipping too deep below the surface for economy of labor.

Sheep Creek, not very far from Bone Cabin, produced the splendid *Diplodocus* specimen of the Carnegie Museum, found by Doctor Wortman in 1899. Jacob Wortman, himself a research man of distinction, collected originally for Professor Cope and later for the American Museum and the Carnegie Museum of Pittsburgh. It is to him, I believe, that we owe the perfection of our modern methods of collection with the plaster and burlap bandages and splints, the application of a well-known surgical method by one who was himself a physician, and which not only makes possible the securing of relatively imperfect material, but adds greatly to the ease of subsequent restoration.

But not all of the old-time collecting was of dinosaurs, and the recognition of some of the Tertiary deposits, notably the Oligocene of the Big Bad Lands of South Dakota, is worth the telling. It was in 1874, when the threat of Indian uprising made it unwise to continue the student expeditions, that Professor Marsh went west alone, relying on the frontiersmen, his former guides, for aid. The story is that an Indian brought in a tooth in his tobacco pouch which he said was that of a "big horse struck by lightning." This Marsh recognized and named the *Brontotherium,* or thunder beast, a name apparently suggested by the Indian's remark.

Marsh was extremely anxious to penetrate into the new locality, but the Indians resented the coming of the white men into the Black Hills which were sacred to their forefathers. They could not appreciate a "bone hunt" and naturally imputed another motive, that of the search for gold, to the white men. General E. O. C. Ord, commanding the Department of the Platte, and Colonel T. H. Stanton, to whom Professor Marsh was first indebted for information concerning the newly-found fossil bed, promised every assistance toward its exploitation. The weather was already cold and the Indians feverishly sensitive about the approach of white men to the Black Hills, which had been given to them by treaty in 1868. Fortunately the fossil locality did not lie within the limits of any reservation, though it did lie north of the White River, where the Indians were less amenable to authority. There were camped in their tribal villages, within a radius of ten miles of the Agency, no fewer than 13,000 Indians. The Cheyennes were sulky because they had been ordered farther south; the Arapahoes were fresh from their fight and losses in the battle on Powder River with Lieutenant Bates; and in addition there were outlaws, renegade Indians, who made the vicinity of the Agency not only unquiet but actually dangerous.

The Indians finally consented to allow the expedition to proceed with an escort of young warriors under the leadership of the famous Sitting Bull, ostensibly to guard the party against the northern Indians, but really to keep watch upon the actions of the bone hunters. But snow fell, delaying the departure, and in the meanwhile the annuities were issued, so the Indians were no longer on their good behavior, and their sentiment toward the expedition again changed to one of distrust. When finally ready to start, so hostile a demonstration was made that their departure would probably have precipitated a general *mêlée,* and the only prudent thing to do was to withdraw.

Finally, exasperated by the numerous delays, Professor Marsh decided to evade the Indians, and that night, shortly after midnight, the expedition filed as silently as possible between the Indian villages to the only place where the White River could be forded. As they marched by, the Indians dogs barked furiously, but their owners slept. If the expedition had been attacked at this time, its case would have been indeed hopeless. Threats of attack by the northern Indians made the risk of remaining very great but, in spite of it, sufficient time had to be taken properly to pack the fossils, which would otherwise have been destroyed in transit. The party retreated, however, none too soon, as subsequent reports state that a large war party scoured the Bad Lands the following day in the vain search for the intrepid white "Bone Chief" and his band.

FIG. 1.—SOUTHERN GATEWAY TO THE ARBUCKLE MOUNTAINS, OKLAHOMA—THE WASHITA RIVER GORGE

The Arbuckle Mountains, Oklahoma

THE FOSSIL COLLECTOR'S HAPPY HUNTING GROUND

By CHESTER A. REEDS

Associate Curator of Invertebrate Palæontology, American Museum of Natural History

FOREWORD.—The writer's first experience as a collector in the Arbuckles was in 1903. Between that date and 1915, he traversed these mountains on five different occasions and made large collections of fossils for Oklahoma University, the United States Geological Survey, Yale University Museum, and the American Museum of Natural History.

INTRODUCTION

FEW are the places on the surface of the earth where, in walking a few miles, one can cross as many thousand feet of upturned and beveled-off strata as in the Arbuckle Mountains of Oklahoma. In addition to being wild and picturesque and full of Indian and cowboy lore, the region is a veritable paradise for the geological student. The stratigraphic succession of fossilferous beds ranges from the pre-Cambrian granite to the "Red Beds" of Permian age. Unlike the better-known section of Palæozoic rocks in New York State, the Arbuckle Mountain exposures, which belong to the same era of geologic time, are free of glacial drift and all other coverings.

The Arbuckle Mountain uplift is to be found in the south central part of Oklahoma in the counties of Murray, Carter, Pontotoc, and Johnston. Its area is roughly triangular in shape, having thirty-five miles on a side, with a handle-shaped portion, ten miles north-south by eighteen east-west, extending to the west across the Indian Meridian. The Washita River valley and gorge separate the two portions.

The term Arbuckle Mountains was derived from Fort Arbuckle, which was named for Brevet Brigadier General Matthew Arbuckle, who fought in the Mexican war of 1845. All lands in the former Chickasaw Nation, in fact all sections of what is now Oklahoma, except the panhandle strip north of Texas, were surveyed from a stone post, on the Indian Meridian, 97° 15′ W., which stood on the site of the fort. On the map, page 468, the "base line" of the Survey crosses the Indian Meridian at the stone post, and the township and range line readings on the map start from this bench mark. The fort was maintained by the Federal Government for many years, but has long since been abandoned. On the latest maps the name Arbuckle has been given to the post office, village, and rock-crusher in the Washita River gorge.

Prior to Oklahoma's being admitted to statehood in 1907, all the fine valley lands and considerable portions of the Arbuckle uplift had been allotted as homesteads by the Chickasaw and Choctaw Indians. Choice of 160 acres of first grade or larger amounts of second or third grade lands were allowed each member of an Indian family that possessed full or partial strains of Indian blood. Each former negro slave (freedman) of the Indians could select 40 acres. It is not surprising thus that much of the lowlands was cultivated while the remaining forested belts and rocky lands were devoted to grazing.

The grazed uplands, whether fenced or in open range, were a boon to the collector, for the cattle had cropped the grass close to the rocky surface, not only in places where the strata were gently inclined, but also in others where

Fig. 2—A typical view of the Arbuckle Mountain Plateau.—Looking southeast across the upturned Arbuckle limestone N.E. ¼, Sec. 21, T. 1 S., R. 1 E., five miles southwest of Davis, Oklahoma. The pre-Cambrian porphyry monadnock, of the East Timbered Hills, is in the background

Fig. 3.—A portion of the Simpson Formation.—Green Simpson shales of lower Ordovician age in the west bank of Dalton Creek, southern limb of the Arbuckle anticline, six miles northwest of Woodford, Oklahoma

they were steeply upturned. The shale or shaly limestone zones in many of the formations were weathered to such an extent that in places their surfaces were literally covered with fossils; weathered specimens oftentimes protruded from the harder limestone ledges.

GENERAL FEATURES

The Arbuckles are not mountains in the sense that they are high above sea-level—for the highest point is only 1350 feet above tide, and the lowest, 750 feet; at present they form a dissected upland exhibiting the basal structures of a mountainous area. From the heart of the plateau outward toward the margins of the uplift, the record of sedimentary deposition extending from upper Cambrian to Pennsylvanian time is well exposed. The impending events that followed this long era of sedimentation are suggested by the extensive Franks conglomerate of Pennsylvanian age on the northwestern and northeastern sides of the area, the Permian "Red Beds" conglomerate across the west end, and the Cretaceous deposits across the southeastern side of the uplift.

About the middle of the Carboniferous period, the older sediments, which had remained practically flat during successive periods of deposition, were uplifted, folded and faulted, forming high mountains. This development of the Arbuckle uplift is similar to that of the Appalachian Mountains in the eastern part of the United States. The earth forces that folded the rocks in one place buckled up the horizontal beds in the other area; in fact, they may be different parts of the same mountain system, as the former State Geologist of Arkansas, Professor J. C. Branner, and some more recent geologists contend. During and following the uplift and before the end of Permian time, the thousands of feet of rock that comprised the tops of these mountains were eroded away, and the upturned edges of the ancient strata, including the pre-Cambrian granite and porphyry in the heart of the mountains, were laid bare. Land conditions evidently prevailed during the following Triassic and Jurassic periods.

In Cretaceous time, when the waters of the Gulf of Mexico joined with those of the Arctic throughout the High Plains area, the entire Arbuckle Mountain uplift was covered by the sea, and a basal formation consisting of beach and nearshore deposits was laid down horizontally on a nearly smooth floor composed of granite and upturned beds of limestone, shale and sandstone, of varying degrees of hardness.

Following the retreat of the Cretaceous sea, caused by the uplift of the Rocky Mountains and the High Plains region, the streams, which took courses across the sandy formation that covered the Arbuckle uplift, began rapidly to erode the cover from the plateau. As these soft rocks were removed toward the south, the large streams were imposed upon the hard rocks of the Arbuckle plateau. The streams near the eastern end of the uplift, from which the Cretaceous deposits were last removed, still retain their wide shallow valleys. The Washita River, however, flows on a lower plain before reaching and after its passage through its deep and meandering gorge across the Arbuckle Mountains. The soft rocks in its course were worn down more rapidly than the hard limestones in the adjacent areas, and it was only at the two-mile gorge that it had to exert its power.

Along the northeast and southwest margins of the Arbuckle plateau there is a descent of from 100 to 400 feet to the level of the plain formed on the softer Carboniferous rocks. The erosion which produced this plain is probably of Tertiary age. Since the formation of this plain, the Arbuckle plateau and the surrounding region have been tilted slightly toward the southeast, for the large streams have descended in the softer rocks to approximately 200 feet below the level of the Tertiary plain and have cut for themselves wide, flat valleys. The smaller tributary streams have steeper grades, particularly near their sources.

The minor topographic features of the Arbuckle plateau are due chiefly to the varying resistance of the formations to erosion since the removal of the Cretaceous rocks. This differential erosion has emphasized the structural elements of the plateau, for the broad truncated anticlines and domes rise higher than the narrow faulted synclines and basins, and the softer formations outcrop in timbered annular valleys while the harder limestone beds form prominent ridges and cuestas.

Fig. 4.—General view along the strike of a Viola limestone ridge. The Viola limestone of middle and upper Ordovician age is on edge in the northeast limb of the Arbuckle anticline, four miles south of Davis, Oklahoma. Simpson formation in timbered belt on left margin, Arbuckle limestone in background; in forested area to the right, Sylvan shale, Hunton beds, Woodford chert, and valley of the Washita River

Fig. 5.—A minor fold in the structure of the Arbuckle Mountains. Elbow fold in Viola limestone, Dougherty anticline, Little Cañon of the Washita River, three miles south of Davis, Oklahoma

GEOLOGIC SECTIONS

From the beautiful Turner Falls on Honey Creek the Colbert porphyry of the East Timbered Hills rises to the triangulation station of the United States Geological Survey, the highest point in the Arbuckle uplift. A view from this station gives one a superb impression of the fossiliferous rocks of the region. Within a distance of five miles southward toward Springer, one may look across 12,150 feet of upturned strata which represent that long era of geologic time known as the Palæozoic. This remarkable section embraces the southern limb of the broad Arbuckle anticline west of the Washita River with all the beds clearly exposed and not disturbed by faulting.

Within a distance of four miles to the eastward of the triangulation station one may see the section repeated in the northeast limb of the Arbuckle anticline. The beds in this limb are more steeply upturned than in the southern one; in fact, most of them are vertically disposed, except at the northern end, where two minor folds have been impressed on the larger structure, as noted on the accompanying geologic map.

The entire section is also well exposed in the gently pitching limb of the Tishomingo anticline extending from the Tishomingo granite in the vicinity of Mill Creek westward toward Dougherty on the Washita River. Various sections of the formations above the thick Arbuckle limestone may be seen to advantage in the eastwardly pitching limb of the Hunton anticline, northward from Bromide; in the Lawrence anticline in the northeast corner of the uplift; and in the smaller Dougherty anticline and Vine dome north of Dougherty.

The extent and major subdivisions of the rocks of the Arbuckle Mountains are shown on the map on page 468, while the minor subdivisions, thickness, position in the geologic time scale and their characteristic fossils are summarized in the table on page 470. In this connection other publications[1] dealing with the Arbuckle Mountains may be examined with profit.

[1]Taff, J. A., 1902, U. S. Geol. Surv., Atoka Folio, No. 79. Taff, J. A., 1903, U. S. Geol. Surv., Tishomingo Folio, No. 98. Taff, J. A., 1904, Preliminary Report on the Geology of the Arbuckle and Wichita Mountains in Indian Territory and Oklohoma. U. S. Geol. Surv. Professional Paper, No. 31.
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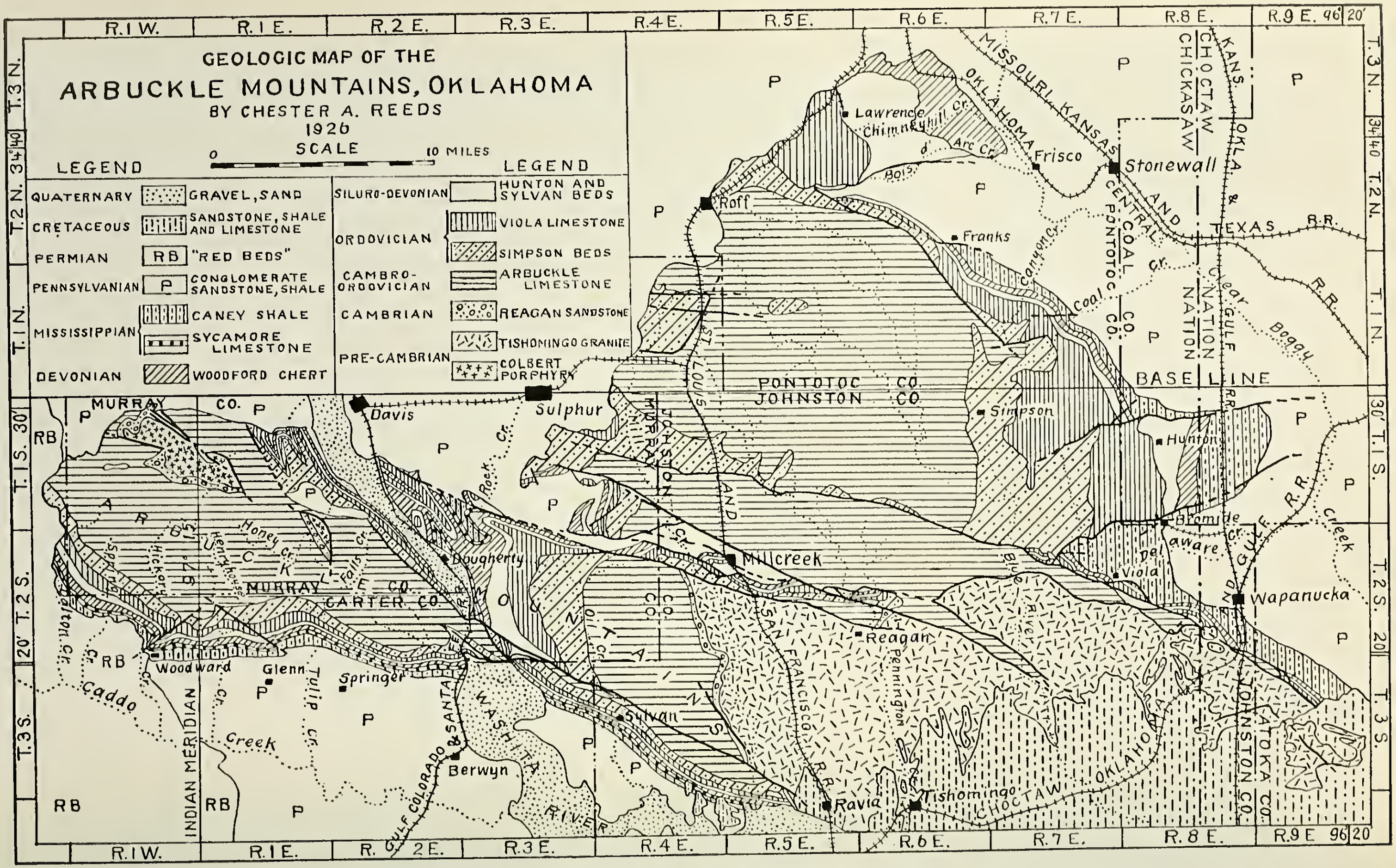
SOME PERSONAL EXPERIENCES

A collector's life in the Arbuckle Mountains is full of thrills. You may be nonplussed when you ride forth on the country physician's horse and inquire the way of a farmer. The farmer looks at the horse and then at you, several times, and finally replies: "You are riding 'Old Baldy' today." When you explain to him that the doctor is ill and that you have permission to ride the horse, he is surprised, and you press your claim. He answers but is not satisfied, for horses have been stolen, and if you are not a "horse thief," what are you? Even at night, when it is too dark to see the way home and you depend upon the horse to keep the road, some chance passer-by will recognize your mount. This sense of recognition of things native seems uncanny.

When you look at your field map and inquire the way to the "Washboard Springs" on Dalton Creek, some individuals will volunteer to show you the way and incidently try to ferret out your business; others will ask "How do you do it?" while still others will spy on you from cover, for they all have the idea that you are looking for the "hidden treasure" that was buried there by the Dalton gang of outlaws, and that you have the maps showing its location.

You may perhaps find several hundred specimens of that rare ball-shaped echinoderm, known as *Camarocrinus* in the Haragan shale, and as you attempt to haul them away a full-blood Indian will ride upon the scene and say "If there is money in these rocks me want it." You tell him that they have no money value, that you are collecting them for a school, an



GEOLOGIC MAP OF THE ARBUCKLE MOUNTAINS, OKLAHOMA

Fig. 6.—This map embraces a number of new features not shown in the preliminary map by J. A. Taff, 1904, in Professional Paper No. 31, United States Geological Survey

academy. He begins to understand but is not satisfied. Your driver tells him that you are from the Great White Father and that you are taking the specimens with you and will acknowledge John Seeley, Indian from Coal Creek as donor of the specimens. He is satisfied and permits you to depart with your treasure.

You may be innocently breaking fossils out of the Hunton beds on Honey Creek, when a 300-pound man with a shotgun in his hand sternly calls out to you from the bluff above:

"What are yer doing there? Do yer think yer have got yer a gold mine?"

When you reply that you are breaking *Orthostrophia strophomenoides* out of the rock, he asks.

"What did yer say?"

You repeat, but still he does not seem to understand for he begins to feel his way down the cliff with gun in hand. You note then that a ten-foot stream and a seven-strand barbed wire fence, with a "no trespass" sign on it, intervene. Fortunately you are on the outside of the fence and you sit tight. He balances himself well on the foot-log and even climbs through the fence, with difficulty, but not a word until he stands alongside. Between the hurried gasps for breath he repeats "What did yer say?" Then again you tell him that you are breaking *Orthostrophia strophomenoides* out of the rock. He appears a bit disturbed, but when you hand one of the small brachiopod shells to him he replies, "Oh, I didn't know they were there" and adds "I was really only looking for a chicken hawk."

You will tremble from head to foot for an instant when the rattlesnake, that gentlemanly denizen of the prairies and woods, suddenly gives you that shrill, hair-raising warning of an untimely death if you venture nearer. If you are beyond his striking distance and you hold your position, he will uncoil and crawl away, unless you annoy him. In the Arbuckle Mountains there are various species of these rattlers; the writer has observed that some specimens had as many as seventeen rattles besides the button, implying as many years.

You may be on foot in the open range when suddenly a near-by herd of cattle will follow the leader and charge you, for these animals are not accustomed to seeing a man except on horseback. On the other hand feral horses will come right up to you and beg you to pull the ticks off their breast. In the wild places your saddle-horse will not leave you even if you turn him loose, for seemingly he, too, is impressed with the strangeness of such places. Mutual comradeship is apparent; he is your sole companion and friend and favors are reciprocated.

THE STRATIGRAPHIC SUCCESSION

More than a thousand species of marine invertebrate fossils occur in the sedimentary rocks of the Arbuckle Mountains. The names of 150 of them have been arranged on the accompanying geologic table. All the formations contain fossils, but they are more abundant in the upper Reagan, Simpson, Viola, and Hunton beds than in the Arbuckle, Sylvan, Woodford, Sycamore, and Caney. The exposures visited will depend largely upon the position of the various camps and the time at one's disposal.

The Reagan sandstone representing the upper Cambrian horizon may be examined with profit along the southwestern margin of the East Timbered Hills near the old ranch house; also in the exposures along the western edge of the Tishomingo granite. The lower portion of this formation is conglomeratic and it is only in the

GEOLOGIC TABLE, ARBUCKLE MOUNTAINS, OKLA.

System	Group	— ROCKS —		— CHARACTERISTIC FOSSILS —
PENN.		FRANKS CONGLOMERATE		
MISS.		CANEY SHALE Black shales and slates with fossiliferous limestone lentils, 800-1600 ft.		*Lingula albapinensis, L. paracletus, Lingulidiscina newberryi caneyana, Chonetes planumbonus choctawensis, Productella hirsutiformis, Liorhynchus carboniferum, Caneyella nasuta, C. vaughani, Orthoceras caneyanum, Actinoceras.*
MISS.		SYCAMORE LIMESTONE Bluish to yellow rock 0-200 ft.		*Menophyllum, Ambocelia levicula, Productella, Chonetes geniculatus, Brachythyris peculiaris, Composita buckleyi, Proetus, Ostracoda.*
DEVONIAN		WOODFORD CHERT Limy chert and black shales 625 to 650 feet thick		*Dadoxylon newberryensis, Lingula cf. spatulata batesvillae, Leptaena rhomboidalis, Productella cf. concentrica hirsutiformis, Liorhynchus carboniferum, Spirifer moorefieldanus.*
DEVONIAN	HUNTON GROUP	FRISCO LIMESTONE Gray coquina stone 0-20 feet thick		*Leptostrophia magnifica, L. oriskania, Rensselaeria marylandica, Stropheodonta becki, Orthonychia cf. plicatum.*
DEVONIAN	HUNTON GROUP	BOIS D'ARC LIMESTONE Crystalline limestone-chert. 0-90 feet thick, average 60 ft.		*Cyrtina rostrata, Eatonia singularis, Meristella laevis, Spirifer concinna, Platyceras cf. tenuiliratum.*
DEVONIAN	HUNTON GROUP	HARAGAN SHALE Variegated marly shale and interbedded marly limestone. 0-166 feet thick, averaging 100 ft.		*Favosites conicus, Striatopora issa, Scyphocrinus (Camarocrinus) ulrichi, Callopora perelegans, Anoplia helderbergae, Atrypina imbricata, Camarotoechia bialveata, Cyrtina dalmani, Dalmanella subcarinata, Orthostrophia strophomenoides, Stropheodonta crebristriata, S. varistriata, Spirifer cyclopterus, Diaphorostoma ventricosa, Platyceras lamellosum, P. ungiforme, Tentaculites gyracanthus, Phacops logani, Dicranurus hamatus.*
SILURIAN	HUNTON GROUP	HENRYHOUSE SHALE Grayish to drab-colored shales and soft marly limestone. 0-223 feet thick. Lower 120 feet with few fossils.	Upper	*Astylospongia praemorsa, Aulopora repens, Eridophyllum rugosum, Favosites niagarensis, F. venustus, Plasmopora folis, Heliolites interstinctus, Pisocrinus milliganae, Strophonella tenuistriata, Rhynchospira globosa, Spirifer crispus, Cyrtoceras subrectum.*
SILURIAN	HUNTON GROUP		Lower	*Scenidium insigne, Strophonella prolongata, Ceraurus insignis.*
SILURIAN	HUNTON GROUP	CHIMNEYHILL LIMESTONE 3. Crinoidal member, 0-39 ft., averaging 15 ft.	Crin.	*Pisocrinus, Plectambonites tennessensis, Stropheodonta corrugata, Triplecia, Spirifer radiatus, Cyphaspis clintonensis, Dalmanites arkansas, Odontopleura arkansana, Sphaerexochus.*
SILURIAN	HUNTON GROUP	2. Glauconitic member 0-25 ft., averaging 15 ft.	Glauc.	*Callopora magnopora, Pachydicta bifurcata, Phenopora fimbriata, P. magna, Rhinopora verrucosa, Plectambonites transversalis, Cyclonema ventricosa, Illaenus ambiguas.*
SILURIAN	HUNTON GROUP	1. Oolitic member 0-12 ft., averaging 5 ft.	Ool.	*Atrypa, Schucertella, Rhipidomella, Cyclonema daytonensis.*
SILURIAN		SYLVAN SHALE 60-300 ft. averaging 150 ft.		*Diplograptus, Climacograptus cf. typicalis, Lingula, Leptobulus, Conularia, Conodonts.*
ORDOVICIAN		VIOLA LIMESTONE 3. Upper member, gray crystalline rock, averaging 300 ft.	Upper	*Pachydicta gigantea, Ptilotrypa obliquata, Rhynchotrema.*
ORDOVICIAN		2. Middle member, thin-bedded dark gray limestone, averaging 300 ft.	Middle	*Diplograptus pristis, Climacograptus typicalis, C. bicornis, Schizotreta minutula, Rafinesquina deltoidea, Conularia trentonensis, Trinucleus concentricus, Proetus parviusculus.*
ORDOVICIAN		1. Lower member, massive bedded, light-colored limestone 60-100 ft. thick	Lower	*Tetradium columnare, Phylloporina reticulata, Rhinidictya mutabilis, Escharopora subrecta, Rhynchotrema increbescens, Vanuxemia gibbosa, Cyrtolites retrorsus, Protowarthia pervoluta, Bumastus trentonensis.*
ORDOVICIAN		SIMPSON FORMATION Thick sandstone and thin limestones with interbedded greenish clay shales and marls, 1200-2000 ft. thick.	Upper	*Ischadites iowensis, Stomatopora proutana-pertenuis, Phylloporina sublaxa, Rhinidictya nicholsoni, Pholidops trentonensis, Plectambonites sericea, Strophomena filitexta, Orthis tricenaria, Herbetella bellarugosa.*
ORDOVICIAN			Lower	*Orthis costata, O. cf. holstoni, Leperditia bivia, Leperditia cf. fabulites, Pliomera (Amphion) nevdensis, Bathyurus*
ORDOVICIAN		ARBUCKLE LIMESTONE Massive and thin bedded limestones and dolomites, 5000-6000 ft. thick.	Upper	*Cryptozoon proliferum, Billingsella, Maclurea, Ophileta, Eccyliopterus, Euconia, Hormotoma, Trochonema, Orthoceras, Leperditia, Isochilina.*
CAMBRIAN			Lower	*Syntrophia, Dikellocephalus, Illaenurus*
CAMBRIAN		REAGAN SANDSTONE Coarse dark sandstone calcareous and shaly in upper part. 0-500 feet thick.	Upper	*Obolus tetonensis ninus, Acrotreta microscopia, Eorthis wichitaensis, E. remnichia, Ptychoparia romeri, P. affinis, Agraulos convexus.*
PRE-CAMBRIAN		TISHOMINGO GRANITE-COLBERT PORPHYRY Coarse red granite, pink porphyry, dikes		No fossils.

C.A.R. 1926

FIG. 7.—SUMMARY TABLE OF FORMATIONS AND CHARACTERISTIC FOSSILS, ARBUCKLE MOUNTAINS, OKLAHOMA

upper part that a stroke of the hammer reveals fossils.

The Arbuckle limestone is the thickest and most extensive formation exposed in the uplift. The lower 450 feet are also of upper Cambrian age and contain a number of unidentified species. The overlying extensive dolomite and magnesian limestone beds of Ordovician age, some 4000 feet thick, are not very fossiliferous, but in the uppermost 1000 feet of the Arbuckle, where the beds are more shaly and siliceous, fossils are not uncommon.

The Simpson formation of middle and lower Ordovician age contains abundant fossils in the wooded valleys on the south side of the Arbuckle anticline, north and west of Springer. The lower Simpson fauna is similar to the Chazy of New York and Canada, while the upper one is closely related to the upper Stones river group of Tennessee and Kentucky.

The gray Viola limestone of middle and upper Ordovician age appears massive on fresh exposures, and thin-bedded where weathered. It outcrops near the margin of the large truncated anticlines as high ridges and rounded knobs. In the small Vine dome and Dougherty anticline it occupies a central axial position. Lithologically and faunally it is divisible into three members. The lowest member is characterized by some twenty-five species which represent the latest Black River and earliest Trenton stages of New York and Minnesota. The species of the middle member are indicative of the upper Trenton stage of the Ordovician of New York. The abundantly fossiliferous beds of the upper member are characteristic of the widely spread Richmond stage of the upper Ordovician period.

The green Sylvan shale, yellowish where weathered, contains few fossils. The basal ledges exposed at the south end of Vine dome are fossiliferous; elsewhere, especially in the northeast corner of the uplift near Lawrence, tabular crystals of barite are common. The age of this formation is still problematical, but may be classed provisionally as lowest Silurian

The Hunton group of beds, which has been the subject of a special study by the writer, may be subdivided lithologically and faunally, from the bottom upward, as follows: (1) Chimneyhill limestone, with oölitic, glanconitic, and crinoidal members; (2) Henryhouse shale; (3) Haragan shale; (4) Bois d'Arc limestone; and (5) Frisco limestone. The beds, which are well exposed, vary in thickness from place to place, and no one section contains all of them. The first and second subdivisions are Silurian in age, the third, fourth and fifth are Devonian. Some 300 species have been collected from these rocks.

The fauna of the Chimneyhill limestone is the equivalent of the Ohio Clinton and Brassfield beds (lower Silurian) of Ohio, Kentucky, Tennessee, Indiana, Illinois, and Arkansas. The many fine specimens which occur in the oölitic, glanconitic, and crinoidal members are not easy to obtain for they have to be hammered from the hard and persistent ledges.

Although the Henryhouse shale has a great development on Henryhouse Creek, the finest exposures, longest section, and most fossiliferous zones are to be found in the northeast corner of the uplift on Chimneyhill Creek and to the northward. The lower 120 feet have relatively few species, while the upper portion contains many forms. The fauna of this formation is most closely related to the Bob and Lobelville beds (middle Silurian) of Tennessee.

The Haragan shale and marly lime-

Fig. 8.—Henryhouse Creek section, south side of Arbuckle Mountains. General view looking east along the strike of the Hunton beds (treeless ridge in center). The Sylvan shale appears in the characteristic timbered annular valley on the left margin; the Woodford chert underlies the timbered belt on the right side, while the barren Sycamore limestone covers the back slope of the Woodford chert

Fig. 9.—One of the numerous shale exposures abounding with fossils. "White Mound." an outlier of the Haragan shale, three miles southeast of Dougherty, Oklahoma. The surface of this mound is literally covered with invertberate fossils, many species being the same as those found in the New Scotland beds (lower Devonian) of New York State. A student party from the University of Oklahoma may be seen busily engaged collecting fossils

stone beds are best exposed on the east side of the Arbuckle uplift from Bromide to Franks and at "White Mound" and Haragan Creek three miles southeast of Dougherty. Many bushels of fossils have been gathered from the surface of "White Mound." The formation is replete with fossils of the New Scotland stage (lower Devonian) of New York.

The Bois d'Arc limestone, being hard, crystalline, and cherty, outcrops as conspicuous hogback ridges throughout its extensive exposures. Its rather abundant fauna is indicative of the Becraft stage (lower Devonian) of New York.

The term Frisco is herewith applied to the massive bedded coquina-like limestone some twenty feet thick which rests upon the Bois d'Arc formation two to three miles northwest of Frisco. The best exposures appear in the bed and bank of Bois d'Arc creek, also in the vicinity of Coal Creek seven miles south of Frisco. The fauna is the equivalent of the Oriskany stage, the highest member of the lower Devonian of New York.

The Woodford chert, in spite of its extensive exposures, contains but few fossils. A one-foot basal transition bed, noted at various places, contains fossils derived from the underlying formations. Fish scales in concretions and large tree trunks of *Dadoxylon newberryensis* were found in the basal layers in the northeast corner of the Arbuckles. The age of this formation is problematical; it may be in part Devonian and in part Mississippian.

The bluish to yellowish Sycamore limestone is confined to the southern and west-central part of the Arbuckle Mountains. The few fossils obtained suggest Mississippian age, but its equivalent in other states has not been determined.

The black Caney shale, being a soft rock, is well exposed in the bordering plain along the southern and eastern margins of the Arbuckle Mountain plateau. Limestone lentils in the lower part and sandy beds in the upper part contain fossils. The age of this formation is still problematical; the lower part is generally regarded as Mississippian, the upper portion as Pennsylvanian.

In the vicinity of Franks, Sulphur, Davis, and westward along the northern edge of the Arbuckle Mountains, the Franks conglomerate rests unconformably on the Caney shale and older formations. This deposit which increases in thickness to the westward represents an erosional and depositional stage following the uplift of the Arbuckle Mountains in Pennsylvanian time. To the south of the Arbuckle anticline the Franks conglomerate does not appear, but instead, a thick series of shales and sandstones, known as the Glenn formation, rests against the Caney shale. The Glenn beds are folded and upturned, and, although a rather extensive Pennsylvanian fauna

Fig. 10.—The highest formation of the Hunton Group. Massive bedded Frisco limestones of Oriskany age (lower Devonian) exposed in the banks of Bois d'Arc Creek three miles northwest of Frisco, Oklahoma

has been collected from them, the exact stage of the development of the high Arbuckle Mountains by folding and faulting has not been fully determined. Extensive deposits of Permian conglomerate, forming plains, appear across the western margin of the Arbuckle uplift.

The preceding description of the Arbuckle Mountains and the abbreviated list of the fossils found therein give but an inkling of the adventures and surprises in store for the fossil hunter who visits the region. The various formations are clearly exposed and the fossils are well preserved. Each little shell has a story to tell of the ages of long ago. From strata to strata the species either recur or show slight variations; in the succeeding beds they are apt to be somewhat different, with new forms appearing. The student becomes impressed with this record of the life of former ages, and notes that the theory of evolution as represented in these rocks and fossils is a reality and not a fancy. To the fossil collector the Arbuckle Mountains of Oklahoma are not only a happy hunting ground, but a great treasure-trove.

IN THE HEART OF THE ARBUCKLE MOUNTAINS

Fig 11.—Beautiful Turner Falls on Honey Creek, six miles southwest of Davis, Oklahoma. The blue-green colors in the deep pool below the falls are attributed to lime-secreting algæ. The rock comprising the falls is composed of travertine. These deposits contain impressions of living plants perhaps 4000 years old. Numerous falls and travertine deposits also appear on Falls Creek three miles to the southeast of this point

The Romance of Collecting Fossil Plants

By EDWARD W. BERRY
Professor of Palæontology, Johns Hopkins University

THE study of plant fossils possesses a many-sided fascination, not the least of which is the light which it sheds on the ancient history of the earth. Its story is not merely the history of the endless succession of plants which have inhabited the earth since life began, it aims to understand and interpret these in terms of evolution, geography, topography, rainfall, temperature, and distribution. Although I said the *study* of plant fossils, to my mind the student must also be the *collector* fully to interpret his material, for there is little that is romantic in sitting in a laboratory and sorting fossils that someone else has collected. One can never be sure whether better or more complete specimens could have been secured, or of the exact relations between specimens and sediments. Palæobotany divorced from the field of geology becomes sterile.

The true student must be a traveler—he must not only be a collector, but he must see all sorts of recent ecological groupings. The reason that so much nonsense has been written about geological climates is because the majority of palæontologists live in the North Temperate Zone. I know from experience that it is impossible to sense environment from herbarium specimens or books. The motto, then, of the successful student of fossil plants is the eighth verse of the twelfth chapter of Job: "Speak to the earth and it shall teach thee."

No more interesting chapter can be found than that recounting the mystical interpretations of the nature of fossils which are to be found in the writings of the ancients. It was Martin Luther who suggested that fossils were the physical evidence of Noah's flood, and we read in the Transactions of the Royal Society of London for 1757, that the flood occurred in the fall of the year—and this because the pyritized seeds in the London clays were fully matured.

In considering what I might tell the readers of NATURAL HISTORY about the romance of collecting fossil plants, I have thought of many romantic things that are now part of the history of palæobotany, such as the wonder aroused in scientific circles in the latter part of the last century when a prolific flora was brought back to Europe from Cretaceous and Tertiary rocks outcropping within a few degrees of the North Pole; or of the fossil plants found with Captain Scott's body in Antarctica; or of the marvelous Miocene flora found in the sediments of the tiny lake of Oeningen in Baden, described by Heer; or of the plants in the mouth and stomach of the frozen mammoth in Siberia; or the unique Triassic genus found in a stone in Strasbourg Cathedral; or of the wonderful petrified cycad trunk found on an Etruscan tomb in Italy; or the plants found on the lake-dwelling sites in Switzerland and Austria which record the beginnings of human agriculture; or the remarkable flora found with the ape man (*Pithecanthropus*) in Java; or the casts of plants found in the Palæocene travertines of

Sézanne on the western front in France, which can be injected with wax and the matrix then dissolved, giving us wax flowers and fruits showing the details of long vanished plants; or those preserved in amber—perhaps the most perfect of all; but I will pass these by and confine myself to a few personal experiences. One need not fall back upon history or the work of others, for there is ample romance in collecting plant fossils so that every individual may expect to experience his full share.

As a child I collected Palæozoic animal fossils from railroad ballast and along the stone fences of Schoharie County, New York, and in later years I collected vertebrate and invertebrate fossils from very many geological horizons, but I still have a vivid recollection of the thrill—now a generation old—when I found my first leaf impression in a clay bowlder of Upper Cretaceous age, at Cliffwood, New Jersey. That a thing so perishable should have been preserved for all those ages seemed marvelous. That a bone or a shell, a coral or a trilobite should thus survive the ravages of time seemed more understandable, but that a leaf or a flower—and I have since found many of the latter—should survive for millions of years to tell us something of the vegetation of the dawn of the Age of Flowering Plants, when mammals were just starting their careers and man was a far distant promise, has never ceased to impress me.

I have since collected animal and plant fossils in many climes and always that phrase from Ezekial, "Can these bones live," has run through my mind, and I know of no human delight more satisfying than that of trying to visualize the landscape of some remote stage of earth history, peopling it with its appropriate animals and plants.

It might seem that the record is scanty. Observing the seeming universal decay of all organisms, we should expect little to be preserved, but with our three score and ten years of existence, we forget the unending ages that the earth has been writing its autobiography in the rocks—which is Geology. I have calculated that a single clay lens in the Eocene of the Mississippi embayment took several thousand years to accumulate, so that a leaf a day saved would furnish very respectable collecting for the palæobotanist.

Part of the romance of all fossil collecting is that rarely does the geologist know just what he is going to uncover. I once took thirty-nine different species of Upper Cretaceous plants from a tiny clay lens high above the base of a bluff of sand on Cape Fear River, North Carolina, discovered by finding fragments in the talus at the base and tracing them to their source. At another time, when I was wading along a stream in the Coastal Plain of Georgia, looking for exposures in the low, vegetation-overhung banks, I discovered a small clay lens, not more than fifteen inches thick and a few feet long, in the marine sands of the Upper Cretaceous. This not only furnished nineteen different species, of which nearly half were new, but also two enormous and nearly perfect lobate leaves more than a foot in diameter and belonging to a new and extinct genus.

Almost always and everywhere when you have dug and split rock till your back aches and you are ready to quit, something new or startling will be uncovered that banishes weariness and

Fig. 1.—Recent nipa palms on a tidal flat in the Philippine Islands. Similar palms grew in the estuaries of the late lower Eocene Mississippi embayment

makes you work on till sundown.

> For whenever the way seems long
> Or your heart begins to fail,
> Nature sings a more wonderful song,
> Or tells a more marvelous tale.[1]

It may be ferruginized cones of a sequoia in the Dakota bad lands or the Potomac clays; or magnificent fossil ginkgo leaves in the Bridger forest reserve, where now only spruce and aspen are to be seen; or water chestnuts (*Trapa*) in the Pliocene clays of Alabama; or the twigs of the water cypress (*Glyptostrobus*), now represented by a single species in two regions in China, found fossil at almost every Fort Union plant locality of the West, and in the Tertiary of the Gulf Coastal Plain.

Who would expect to find nutmegs and date palm seeds in Texas, and yet they were there in Eocene times, and have been collected and described. One of the most interesting of modern palms, in that it grows on tidal flats,—and few higher plants have learned to tolerate salt water,—is the nipa palm. The single existing species is found from the Sunderbunds of the Ganges through the Malayan region to the Philippines, where it competes with the mangroves for a place in the sun and in the marine mud (Fig. 1). Its characteristic fruits have long been known from the earlier Tertiary of the Old World. Then, as now, the species was distributed by ocean currents. I found them while working in the lower Eocene of Mississippi, and have since found them in western Tennessee, so that once in the long ago they circumnavigated the globe, like Magellan. Historians, especially if they are given to sentiment, like to speak of the sun that shone in Galilee or at Runnymede or in the valley of the Nile, but the first dynasty in the valley of the Nile,

[1]With apologies to Longfellow.

Fig. 2.—Restorations of lower Eocene plants from the Mississippi embayment. (1) *Laguncularia*, a mangrove plant. (2) *Diospyros*, a persimmon. (3) *Pisonia*, a beach plant. (4) *Nyssa*, a sour gum

or Nineveh and Tyre, are but as yesterday compared with collectors' luck in palæontology. And one can visualize the *Archæopteryx* volplaning across the Jurassic Solenhofen lagoons, or the vegetation where the four-toed horse came down to drink, or the vernal and autumnal coloration of the Wilcox shores and bayous with their appropriate plants, with the crocodiles in the sluggish waters and the hum of insects over their surface, and live through millions and millons of years in a single lifetime.

A REMARKABLE PLANT LOCALITY IN WESTERN TENNESSEE

In Henry County in western Tennessee, a series of clay lenses, with their long axes parallel with the lower Eocene coast, stretch across the county. These are of all sizes and surrounded by sands, and commercial exploitation has resulted in many workings, so that the geological relations are rather plain. At the little town of Puryear I discovered fossil plants in the clay pit shown in Fig. 5 on page 481, and not

Fig. 3.—Restorations of lower Eocene plants from the Mississippi embayment.—(1) *Parkinsonia*, an Eocene horse bean. (2) *Inga*, a characteristic leguminous tree. (3) *Engelhardtia*, a winged walnut. (4) *Dondonaea*, a beach plant

more than an acre or two in area. This was nearly twenty years ago, and a few hours' collecting at that time resulted in over 200 pounds of beautiful plant fossils. I have revisited this locality a number of times and it has turned out to be the most prolific locality for lower Eocene plants in all of North America. The remarkable number of over 200 species have been discovered at Puryear, including leaves, flowers, and fruits—all wonderfully preserved,—and these are sufficient to give a very good idea of

Fig. 4.—A view from Florida which reproduces the appearance of Puryear in lower Eocene time. Photograph by Walter B. Jones

the appearance of the region in the early Tertiary.

The coast was low and the streams sluggish, emptying into lagoons behind wide barrier beaches, which were mostly forested. The accompanying photograph, taken in Florida by Walter B. Jones, will serve to give some idea of Puryear in the lower Eocene. (Fig. 4.)

I could not begin to enumerate even the more interesting of these finds, or the vista they give of the long ago in the earlier part of the Age of Flowering Plants. The beaches were covered with bowers of wild figs, fan palms, coral beans (*Sophora*), cocoa plums (*Chrysobalanus*), sea grapes (*Coccolobis*), beach almonds (*Terminalia*), soapberries (*Sapindus*), horse beans (*Parkinsonia*), paradise trees (*Simaruba*), iron wood (*Bumelia*), sword beans (*Canavalia*), and many other forms allied to those still living in Florida, Central America, and northern South America. On the muddy bottoms were black mangroves (*Avicennia*) and other plants of the mangrove type (*Laguncularia, Conocarpus, Combretum*). The bayou margins were densely forested with the bald cypress (*Taxodium*), custard apples (*Anona*), rosewood (*Dalbergia*), cinnamon or camphor trees (*Cinnamonium*) and many other members of the laurel family, including an Eocene representative of the avocado or alligator pear—in fact, only in northern South America do we find such a variety of Lauraceæ at the present time. Other interesting things were the rain tree (*Pithecolobuim*), dilly (*Mimusops*), mastic (*Sideroxylon*), tropical cedar (*Cedrela*), cycads like the existing Florida zamias, a citrus tree (*Citrophyllum*), representatives of the family to which the Asiatic tea plant belongs (*Ternstroemites*), persimmons (*Diospyros*) of several kinds, represented by both foliage and the characteristic concrescent cruciform calices that subtend the soft fruits.

Among the more exotic finds are the leaves and winged fruits of a tree belonging to the walnut family (*Engel-*

hardtia and *Oreomunnea*) with a single existing species in the uplands of Central America and several others across the Pacific in southeastern Asia. This is quite unlike our familiar walnuts and hickories in that the nut, instead of becoming large and bony and dependent on rodents for dispersal, remains small, and the bracts expand into large wings. We infer that this second method turned out to be less efficient in competition, for the walnuts and hickories are found over a much greater area at the present time. Where I had both leaves and flowers or leaves and fruits, I have prepared life-size restorations of many of these Eocene plants from Puryear, and a few of these very greatly reduced, are shown in Figs. 2 and 3.

Fig. 5.—The clay pit at Puryear, Tennessee, is the most prolific lower Eocene plant locality in America

A GLIMPSE AT A LOWER MIOCENE FLORA AT ALUM BLUFF

When the Chattahoochee River, which forms a part of the boundary between Georgia and Alabama, reaches Florida and joins the Flint River, it becomes the Apalachicola. About halfway across Florida to the Gulf, the east bank of the Apalachicola consists of a series of high bluffs which are in striking contrast to the low country west of the river. One of the longest of these is Alum Bluff—a classic locality of the so-called old Miocene and one that has been visited by a number of geologists.

I made my pilgrimage in the summer of 1910 and found the difficulties of the trip well repaid. In the wooded damp ravines along the bluff are to be found two of the rarest and most restricted gymnosperms—survivors from a long line of Mesozoic ancestors. These are *Taxus floridana* and *Tumion taxifolium.* They are much alike in appearance, but the latter has a very distinctive odor which has given rise to the popular name of stinking cedar, although it does not resemble a cedar, and the odor is not unpleasant, being much like that of the crushed foliage of a tomato plant. *Taxus* is found on all the continents except South America and Africa, but is widely scattered. The nearest species of *Tumion* is a somewhat restricted form in California and two others occur in eastern Asia. Obviously, such a range is indicative of great age and a distinguished ancestral line. More than a dozen of these ancestors have been discovered as fossils in different parts of the Northern Hemisphere, and although some are based on somewhat uncertain material, several are conclusive, and these show a Holarctic distribution in the Cretaceous. One Upper Cretaceous form found from North Carolina to Georgia is practically identical with the living Alum Bluff form and is probably its direct ancestor. Even as late as Pliocene times one of the living oriental species is common in Europe, and it would seem as if the continental glaciers of the Pleistocene are largely responsible for the present distribution of the genus.

Fig. 6.—A famous plant locality—Alum Bluff, on the Apalachicola River in Florida

The sediments exposed along Alum Bluff give an interesting, as well as instructive vista into the history of the earliest Miocene in this part of North America. At the base of the bluff one sees a few feet of marine sands packed with molluscan shells. This is the Chipola marl. The lower

Miocene sea was shrinking and, in the overlying ten feet, we can read the events of long ago quite as well as if they were recorded in cuneiform writing or Egyptian hieroglyphics. As the shallow sea with its prolific marine life withdrew, the sediments became more coarsely sandy with mud streaks, and these are filled with the vegetable débris of the wooded coast. Among these are packed masses of the detached and frayed rays of a fan palm like the modern palmetto. Here and there are the impressions of leaves on mud-films in the sand.

These are very fragile, and special means had to be devised for their preservation. My improvised method was to make hollows in the sand, lay a piece of burlap in this and then fill it with plaster of Paris. The specimens were sunk in this so that just the face showed, and after the plaster of Paris hardened, the whole was then removed and the loose margins of burlap tied over the face of the specimen. In this way, all the material collected effectually withstood the freight journey by river boat and train to Baltimore.

Lower Miocene plants are extremely rare in North America, and these at Alum Bluff give us a picture of the vegetation along the shore of the sea at this time, as this shore emerged to remain a land mass during all of the middle Miocene and to sink beneath the waves again in the upper Miocene, for the upper forty to sixty feet of the bluff consist of muddy sediments full of marine shells of that time, constituting the Choctawhatchee marls—more than a million years of history recorded in less than 100 feet of bluff.

Among the interesting lower Miocene plants found here were an abundance of fan palms, their leaves covered with spot fungi. Here grew elms (*Ulmus*), buckthorn (*Rhamnus*), camphor (*Cinnamonum*), satin wood (*Fagara*), iron wood (*Bumelia*), persimmons (*Diospyros*), and several less well known types. One of the oddities was the bread fruit (*Artocarpus*), a type now native only in the Orient, but common in North America from the late upper Cretaceous through the earlier Tertiary. This Alum Bluff form is its last native appearance in North America, although today it thrives in cultivation in the American tropics. Just why it should have become extinct and yet flourish when reintroduced is one of those palæontological mysteries equally exemplified by the camphor tree. This is present in North America from the upper Cretaceous and is, like the bread fruit, confined to the Orient in the existing flora, and yet the planted trees have been seeded widely over peninsular Florida by birds and effectually naturalized. A parallel example from the animal kingdom is furnished by the history of the horse, so common in the past in both Americas and yet entirely extinct when America was discovered by the white man, flourishing exceedingly and running wild when reintroduced.

The Alum Bluff section not only gives us a picture of shrinking and expanding seas with the passage of Miocene time, but the flora shows distinctly that the warm moist climate of Eocene and Oligocene times in this region was becoming cooler and that temperate forest types were gradually replacing the older more tropical types.

A TROPICAL FLORA ABOVE TREE LINE IN BOLIVIA

One of the main objects of the Williams Expedition of the Johns Hopkins University was to secure evidence of the time of uplift of the Andes. Because of the peculiar climatic conditions induced by the elevation of this great mountain mass across the paths of the trade winds and the roaring forties, fossil plants proved to be of prime importance in determining past conditions and changes of elevation. With the exception of the localities in southern Chile and that at famous old Potosí, which had been known for some years, it was a case of hit or miss search over a thousand miles of mountain trails. Having heard of the discovery of lignite near Cochabamba, I determined to try to visit the site. Our journey from Sucre —the attractive old capital of Bolivia —was made by automobile. Sucre itself lies in a fertile basin at an elevation of 9149 feet, and is in many ways the most cultured town in Bolivia—with what remains of the oldest University (Chuquisaca) in South America next to San Marcos at Lima. There is a flourishing Geographical Society, now more than fifty years old, a National Library especially rich in early works. The life-size oil portraits of bishops and archbishops in the Metropolitan go back to 1551.

An early start took us across the red sandstone divide between the Amazon and La Plata drainage systems. By ten o'clock we had gotten down to 6700 feet in the arid zone with the largest tree cacti I have ever seen and, where it is possible to irrigate, there are haciendas with oranges, bananas, and sugar cane. Going on down the Rio Chico valley, we picked fine alligator pears at 5200 feet. At 4500 feet, where we crossed the Rio Grande, which is the boundary between the provinces of Chuquisaca and Cochabamba, the temperature was very oppressive. From here onward the trail rose to 7200 feet at Aiquile—a local center for the manufacture of *chicha*—where the night was spent. The second day was one of gradual ascent toward the divide. At around 8500 feet there were many thickets of Dodonaea—commonly thought of as a strand plant, and groves of *Podocarpus*. Near the divide, which has an altitude of 12,000 feet, I caught my first glimpse of one of the strangest plants in existence, a gigantic terrestrial bromeliad (*Pourretia gigantea* Raimondi), erect in habit, and, when in bloom, more than twenty-five feet tall.

From the divide the journey was rapidly downward into the Cliza basin and the town of Arani, from which place to Cochabamba there is nothing startling along the trail.

Cochabamba impresses one as a most delightful place. Situated in a wide agricultural basin on the Rio Rocha—which on its way to the Atlantic becomes successively the Rio Grande, Mamore, Madeira, and Amazon—one does not use up all one's vitality just to exist, as one does at higher altitudes. Here life is easier, people are happier, the food is better —although I cannot say I learned to love the *pièce de resistance* at the Gran Hotel Union, namely, sheep's brains served in a neatly sawed half of the skull—on the half shell as it were.

However, fodder and animals are cheap. Next to the Yungas, I would choose Cochabamba as an ideal Bolivian climate. One sits comfortably in the flower-bedecked plaza under a mahogany or Jacaranda tree and sips lemon or limeade, cooled with ice brought from the glacier of Tunari in the Sierra, northwest of the city, and who is there "with soul so dead" that he would not prefer ice from an

Andean glacier to any from a sanitary ice machine, especially when there are none of the latter within a thousand miles?

The usual long-drawn-out routine of getting mules and *arriero* and getting started, which is almost a religious rite in the Andes, having been gone through with, a start was made bright and early one morning. The way lay northward over the immense detrital fans that skirt the Sierra north of the city. The trail was not an important one, and hence one of the worst I ever encountered, switchbacking up the Sierra. Its character may be gathered from the statement that it took five hours to make the four leagues to the divide. The divide was a bold mass of Bilobites sandstone (Ordovician), 14,625 feet in altitude, and the going was cold and windy. The trail led down a little valley beautifully glaciated to the Finca Palca at 11,700 feet, where we passed the night. The finca was the usual one-story windowless affair on two sides of the patio, with sheds forming the two other sides. The kitchen was at one corner, the dining room at the other. Across the patio a lariat was hung with the dismembered parts, both inside and out, of a recently butchered calf, to dry and catch the dust of the score or more of Indians that tramped in and out day and night, for we happened in when the national drink of *chicha* was being made. The firewood was of tropical species covered with dried orchids and other epiphytes and shreds of lianas from the mist-covered Yungas but a short day's mule ride beyond. We were lodged on an adobe ledge in the potato (chuña) storeroom, since there was no guest room, so that whenever our fitful slumbers with the potatoes were broken, we looked out on the bright fires where the Indians were cooking their 600 pounds of corn meal for the approaching *fiesta*.

The plant locality was three miles east of Palca. Here on the wind-swept pampa, at an altitude of 11,800 feet, is a series of lignite seams, beds of clay, and volcanic ash which must have come from a great distance, and in them leaves and fruits of tropical rain-forest plants, such as the fern genus goniopteris, heliconias, gleichenias, cherimoya leaves, rain trees, iriartia-like palms, laurels, and many others indicating a late Tertiary age (Pliocene) and a much lower altitude. Thus it was determined that this great mountain mass had been uplifted between 6500 and 9000 feet since this flora was entombed, so that its site was occupied by a glacier during the Pleistocene, the beautiful terminal moraine of which is to be seen a short distance down the valley.

I might go on indefinitely with similar extracts from the notebooks of a field geologist, but the last locality was about as near Heaven as the palæobotanist is privileged to collect, and may well afford a stopping place. I am quite sure that anyone who has once laid his hand on the altar in the temple of science will never be satisfied with any other career, and will pass happily through his allotted span.

SURFACE OF A MISSISSIPPIAN LIMESTONE LAYER COMPOSED LARGELY OF BROKEN BRYOZOAN COLONIES, MOST OF THEM BEING DELICATE, LACELIKE FORMS

Fossil Collecting in the Mississippian Formations of the Mississippi Valley

By STUART WELLER
Professor of Palæontologic Geology, University of Chicago

MANY years ago the writer was collecting fossils from a locality in northern Arkansas which had been visited frequently by geologists, when an old negro strolled along and seated himself upon a log at a little distance. After the usual salutation of "Howdy," he remained silent for some minutes, closely watching my movements. Finally he broke the silence.

"Say, Mister, I wish you'd tell me the reality uv all that."

I replied, "What do you mean?"

Said he, "Fellers hev been comin' to this here rock pile fur a good many years, breakin' rocks jes like you, and you-all don't spend your good money comin' here this-a-way without gettin' somthin' out uv it."

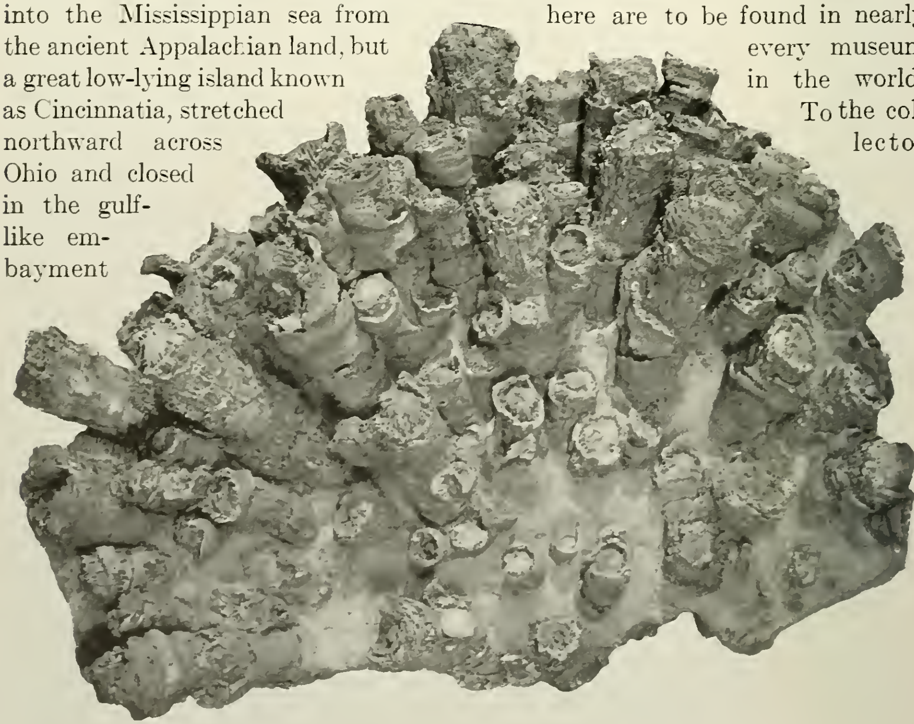
Of course it was hopeless to attempt to instruct the old negro in the problems of Palæontology, but finally, after being shown some of the fossil shells, which meant nothing to him, and after carrying on a general conversation for a half hour, he departed, probably with the idea that he had been talking with either a fool or a crazy man, perhaps both.

Many collectors of fossils have been actuated by the mere joy of collecting and possessing the strange objects which they could find in the rocks, who have never really come to appreciate the true purpose of the palæontologist. Ofttimes such collectors have brought together many rare and beautiful specimens which in time not infrequently have found a resting place at last in some one of our great museums. Other collectors, some of them starting as mere boys, have finally come to be counted among our leading palæontologists. Indeed, most of the outstanding men in this line of endeavor have begun their careers as fossil collectors, and no one has really attained eminence in palæontological work who is not also an ardent collector. Palæontologists and fossil collectors are born, not made, and no one who has discovered himself to be marked in this manner has ever been able completely to abandon the calling.

There is no field for the fossil collector in this country that is more fascinating than the great series of Mississippian rocks so well exposed in the Mississippi Valley region. The rocks which are included in the geologic period technically known as the Mississippian, have their great development in Iowa, Illinois, Missouri, Indiana, Kentucky, and Arkansas. Of course, they extend outside these states to the Rocky Mountains and beyond in the west, and to the Appalachians in the east, but their more typical exhibition is in the states mentioned. The fossil collector in these rocks does not find the wealth of trilobites which so delight the hearts of collectors in the older Palæozoic rocks, but oh, the joy of finding a beautifully preserved crinoid, or a whole colony of them, or of finding a new locality where any of the many forms of life in these rocks are more than usually well preserved. The fossil collector really may be engaged in some more prosaic sort of geological work, but if he lights upon a good fossil locality he usually camps there until the sun goes down.

The interior Mississippian seas of North America were of wide extent, the waters in them were not deep, perhaps nowhere more than one or two hundred feet, so that the sunlight could penetrate to the bottom. The surrounding lands to the north and west, at least in the earlier Mississippian time, were low-lying, so that comparatively little land-wash material was brought into the sea by rivers, and most of that which was brought in was in the form of fine mud which was not distributed far from shore. Under these conditions the waters were for the most part clear and pure, and were wonderfully suited as a place of abode for the beautiful sea lilies or crinoids. To the east much coarser sediments were brought down into the Mississippian sea from the ancient Appalachian land, but a great low-lying island known as Cincinnatia, stretched northward across Ohio and closed in the gulf-like embayment to the east, which was the recipient of these terrestrial sediments, and prevented the spread of the muddy waters into the great expanse of clear-water sea lying west of the island.

One of the most notable of the formations of this great clear-water sea was early known by the pioneer geologists as the "Encrinital limestone," because it was constituted almost wholly of the remains of crinoids. Later geologists have adopted the custom of applying geographic names to formations so that this formation is now known as the Burlington limestone, from the city of Burlington, Iowa. As early as the middle of the last century, Burlington became known as a famous crinoid locality; the exposures thereabout have furnished the original or type specimens of a great number of species of these graceful forms, and specimens from here are to be found in nearly every museum in the world. To the collector

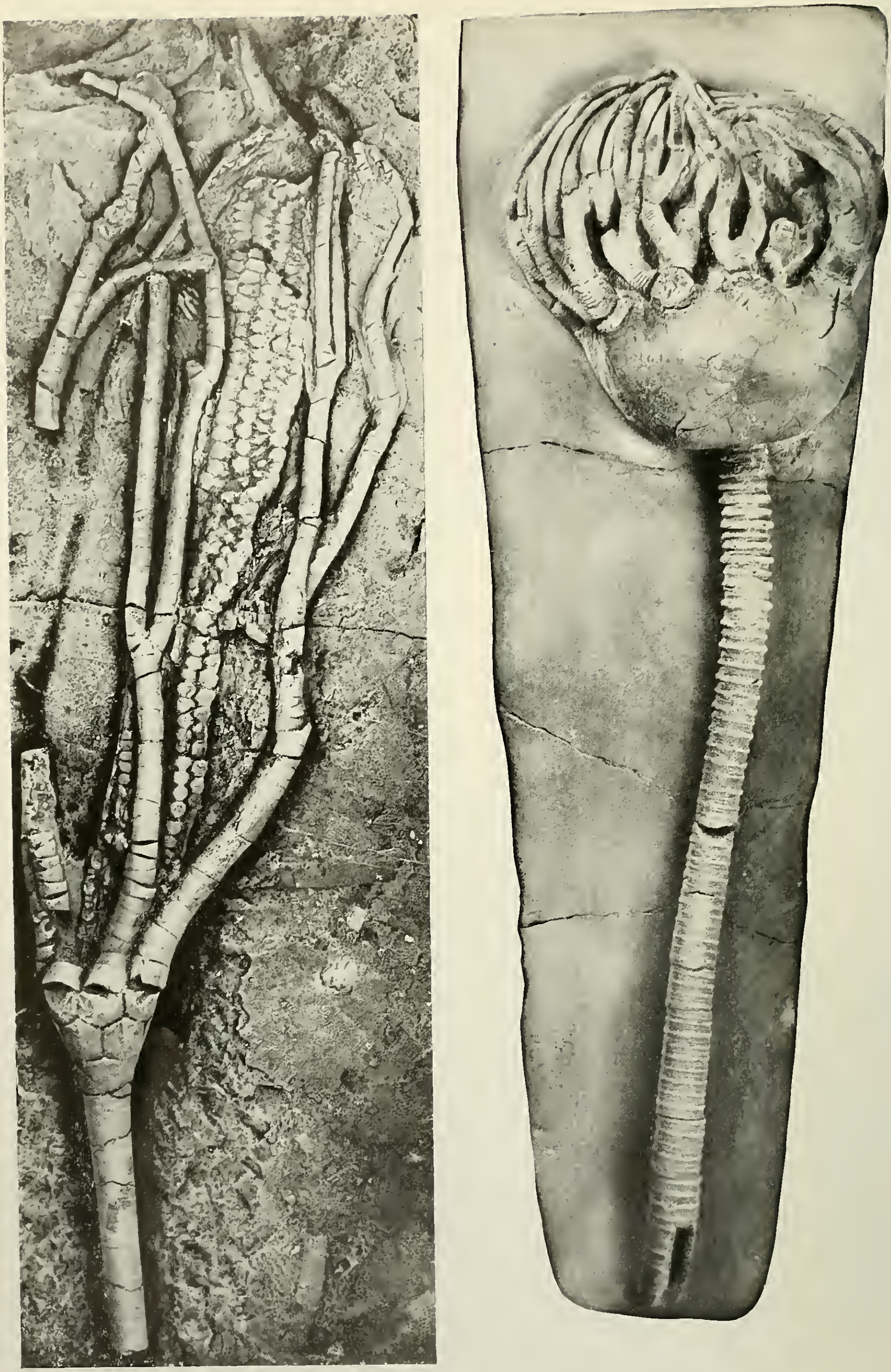


A large compound coral (*Lithostrotion proliferum*) from the St. Louis limestone today, however, the locality is disappointing. The early collectors gathered a crop of specimens that had been maturing through the processes of weathering for many thousands of years, but at this time, although an occasional specimen can be found, he is a lucky collector who finds a really fine specimen. Although perhaps 80 per cent of the rock itself is composed of crinoid fragments, mostly broken stems, the uninjured bodies of the creatures are rare.

Another locality where a host of beautifully preserved crinoids has been collected from rocks somewhat older than those at Burlington, is near Le Grand, Iowa. At this locality crinoids different from those at Burlington, but present in great numbers and variety, were collected from a large railroad quarry, now long abandoned, and perhaps not a single specimen has been found here in the last twenty-five years, although if quarrying operations were resumed more would likely be found. Another one of the world-famous Mississippian crinoid beds is near Crawfordsville, Indiana, but this locality, too, has been worked so extensively that the collector is no longer repaid by visiting it, and he could secure the beautiful fossils only through excavation so expensive as to be prohibitive. Keokuk, Iowa, Sedalia, and Boonville, Missouri, as well as Canton and Bono, Indiana, are collecting grounds for Mississippian crinoids, largely with a past.

A crinoid from Keokuk, Iowa, (*Lobocrinus nashvillae*), with the arms lacking, but exhibiting a part of the stem, the body, and a portion of the proboscis with a row of prominent spines

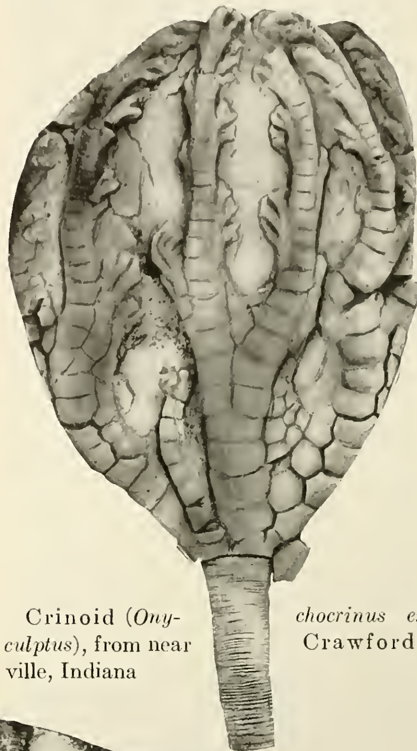
Notwithstanding the depletion of available specimens in many of the more famous Mississippian crinoid localities, the collector with a keen eye not infrequently comes upon choice examples of these forms at many localities throughout the region where the lower Mississippian rocks form the surface exposures.



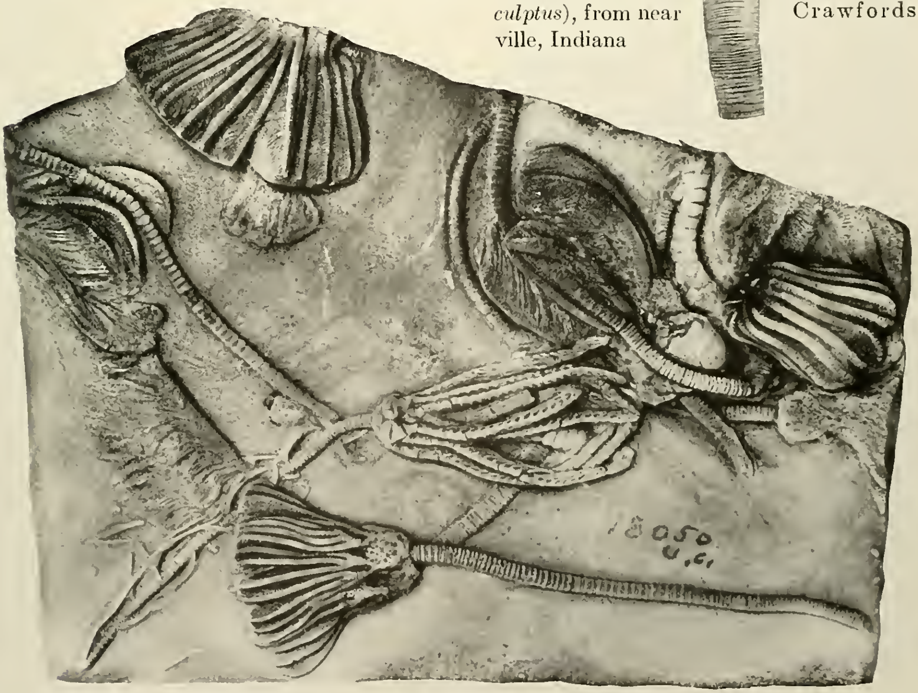
(Left) Crinoid (*Pachylocrinus missouriensis*), exhibiting a portion of the stem, the body, most of the arms, and the ventral sack between the arms; from Alton, Illinois.

(Right) Crinoid (*Megistocrinus nobilis*), showing the stem, body, and arms; from near Legrand, Iowa

The more modest blastoids, bud-shaped forms attached by a stem to the sea bottom during life (as were their cousins the crinoids, animals remotely related to living starfishes notwithstanding their plantlike habit of growth), lived with the crinoids in these clear seas, although they became far more numerous in later Mississippian time. A much different type of life in these rocks is the bivalve-shell-bearing brachiopod. Well-preserved fossil remains of these creatures occur much more widely distributed in the Mississippian rocks than do the crinoids or blastoids, and on a trip into the field the collector will in most cases carry home more specimens of brachiopods than anything else. Scarcely a quarry, large or small, or roadside ledge, or exposure along the streams, will fail to furnish some examples of brachiopods, although they are much better preserved and more interesting to the collector in some localities than in others. These shells



Crinoid (*Onychocrinus exculptus*), from near Crawfordsville, Indiana



A small slab exhibiting several different species of "sea lilies" or crinoids, from near Legrand, Iowa

A solid spiral axis of Archimedes (*Archimedes wortheni*) with the lacelike extension removed

exhibit a great variety in form and size and belong to many genera and species. The writer at one time collected a large number of complete and full-grown examples of a small species of brachiopod from one of the Mississippian formations, and on filling a cubic centimeter measure with the specimens, found it to contain more than 300 individuals. On the other hand some of the largest of our known brachiopods, four or five inches across, occur in these Mississippian formations.

A spirally growing bryozoan colony (*Archimedes invaginatus*), with the solid axis and the lacelike extension from the spiral axis

The moss animals or bryozoans are related to the brachiopods biologically, although the two are as different in appearance, when fossilized, as any two animals could well be. The bryozoans grow in colonies, as do many of the corals, and the individual animals are far more minute even than the small brachiopods that were just mentioned. Many of the Mississippian bryozoans grow in colonies which remind one of some delicate lace. In some localities, especially where the limestone beds are separated by thin clay or shale layers, these fossil bryozoans occur in innumerable examples. Besides the lacelike forms there are others which grow in dendroid or tree-like branching colonies, the branches varying in size from the diameter of a pin to that of a lead pencil or larger. A few forms are present also which grow in quite massive colonies. The collector who becomes interested in these forms will be rewarded by finding a great variety, more than fifty genera and probably 350 species being already named and described from the Mississippian rocks, while there are many others which are still new to science.

At certain horizons and in certain localities the fossil collector in the Lower Mississippian rocks can find a large number of the shells of snails and clams, most of them of comparatively small size, but mollusks of this sort are far less conspicuous in these faunas than in those of some of the other geologic periods. The chambered cephalopod shells are even less in evidence than the other mollusks, although in a few localities they are known to occur in considerable numbers.

Some corals lived in these seas, but most of them were simple, horn-shaped forms. A few colonial assemblages are present in some horizons, but nowhere do they seem to have had the reef-building habit which is so conspicuous among these creatures today, and which had also been established in some of the periods older than the Mississippian. In some other parts of the world during Mississippian time, coral reefs were in existance, but conditions were not favorable for them in the great interior sea of North America. The remains of an occasional sea-urchin and starfish are stumbled upon now and then by the collector in these rocks, but the starfish especially is exceedingly rare.

All the fossil forms which have been mentioned belong to the invertebrate phyla of the animal kingdom. The vertebrates were represented only by fishes, and all these fishes were related to our sharks. These creatures had no bony skeleton, their framework being wholly cartilaginous. The only hard parts capable of fossilization were the teeth and fin spines. These objects are likely to be met with almost anywhere by the collector of Mississippian fossils, and almost always they can be recognized by reason of their black or dark brown color, in sharp contrast with the lighter colored limestone in which they are commonly imbedded. A close examination always discloses a characteristic bony texture of these fossils. These Mississippian sharks were of two distinct types: first, the pavement-tooth forms in which both the upper and lower surfaces of the mouth were set with flat, crushing teeth, similar to blocks in a pavement, undoubtedly used for crushing the shells of brachiopods and other creatures upon which they lived, and second, the sharks with sharp-

A large Mississippian brachiopod (*Spirifer grimesi*), from Springfield, Missouri pointed teeth which more than likely preyed upon their pavement-toothed relatives.

In passing from the lower or Iowa Series of the Mississippian into the upper or Chester Series, a notable change took place in the outlines of the seas themselves, in the character of the sediments accumulated, and in the faunal associations which inhabited the seas. In the Mississippi valley the Chester sea occupied a somewhat restricted embayment lying between the Ozark land in Missouri, and the island Cincinnatia already mentioned. The head of this embayment was near the middle of the state of Illinois. To the south the sediments of this age cross Kentucky and Tennessee, and extend into northern Alabama and Georgia. In a southwesterly direction formations of similar age are known across Arkansas, Oklahoma, and as far away as southwestern Texas.

A nearly perfect trilobite (*Phillipsia portlocki*), from the Crawfordsville, Indiana, crinoid beds

The Chester Series was named from the city of Chester, Illinois, and the most extensive collections from these formations have been made in Illinois and Kentucky, although highly interesting fossil localities are known elsewhere.

The fossils to be found in these rocks are much different from those of the limestones of the Iowa Series. The Chester sea was not so dominantly a clear-water sea, and the difference in environment doubtless had its effect upon the animal life which inhabited it. The crinoids are still present, but they have completely changed from those of the older beds, and there are no such thick limestones made up almost exclusively of crinoid remains. Only rarely does the collector find a complete crinoid body, but among the oddities which he is likely to meet with almost anywhere in the Chester, are the so-called wing-plates of a peculiarly specialized "wing crinoid." A great variety of these plates may be found. The blastoids or bud-shaped echinoderms are much more abundant than the crinoids, and in some localities many beautifully preserved examples, belonging to numerous species, can be gathered. One locality in southern Illinois known to the writer, is visited on every possible occasion; every visit is sure to be rewarded with fifty or more beautifully preserved specimens, and occasionally a good crinoid is also found.

One of the most conspicuous types of fossils in the Chester faunas is the bryozoa. At this period of geologic history most of the species of these creatures were delicate and more or less fragile colonies, many of them lacelike in appearance. In some localities great numbers of Archimedes screws, the supporting axis of one form of bryozoan colony, can be gathered. These screws and the blastoids are perhaps the most characteristic of all the Chester fossils. Another of these bryozoan colonies is supported by a broad U-shaped calcareous base, examples of which are met with in many places.

The shells of brachiopods are exceedingly common in the Chester formations, and in some localities hundreds of specimens of a few species can be gathered easily, but the variety of species is much less than in the limestone of the Iowa Series. Locally many examples of the shells of clams and snails can be collected in some of the Chester formations, but most of them are small, and many of them are as yet undescribed species. The fishes which swam in the Chester seas were all sharks, related to those of the lower Mississippian formations, and their spines and teeth, either the pavement type or the pointed ones, are likely to be met with by the collector in any of the fossil-bearing beds of the series.

The most interesting localities for the collector of Chester fossils are certain calcareous shale beds which in places are exposed in glades, most commonly upon southern hill slopes, in southern Illinois and Kentucky. Where a favorable locality of this sort is found, there is little or no vegetation present, and the fossils occur weathered out clean. To gather the specimens the collector lies flat upon the ground with his face close to the surface, and picks and picks and picks the fossils, most of which are small. Probably the great majority of forms belong to a few species, but he is always expecting to find one of the rare ones next, perhaps a well-preserved crinoid body. In a really good locality of this sort, as many as sixty or seventy or even more species may be gathered.

There still remains a broad field in the interior of our country for the investigation of the collector of Mississippian fossils. Many new localities of great interest will certainly be discovered in the years to come. Within a few years a number of glacial bowlders with typical Mississippian fossils of Mississippi valley types, were found in a clay pit in Chicago, showing that somewhere to the north of this city, and now completely hidden by the glacial drift, there must be a Mississippian outlier that has never yet been seen by the eyes of man. Only this year a locality has been discovered in Mexico from which a characteristic lower Mississippian fauna has been secured, nearly 1000 miles from the occurrence of any similar fauna to the north. Other such discoveries will certainly be made, every one of which will help to interpret the geologic history of North America.

The pointed tooth of a shark (*Cladodus splendens*), from the Mississippian limestone near Legrand Iowa

Wm Clark

H. Herzer

Jay Terrell

PIONEER FOSSIL-FISH COLLECTORS IN OHIO

Dr. William Clark (1826–1908), discovered many fossil fishes in the vicinity of Rocky River and Big Creek, Ohio. His collections may be found in the British Museum and in the American Museum of Natural History

The Rev. Herman Herzer (1833–1912), in 1866 discovered fish bones in the large concretions which characterize the base of the black shale at Delaware, Ohio. The same year, Newberry identified the specimens as *Dinichthys herzeri*

Mr. Jay Terrell (1827–1904), while living near Lorain on Lake Erie, discovered, certainly before 1870, fossil bones which Newberry described in 1875 as *Dinichthys terrelli*. For twenty-five years he continued to be a successful collector

Collecting Fossil Fishes from the Cleveland Shale

By J. E. HYDE
Cleveland Museum of Natural History and Western Reserve University

Upon his back a bag o' stones
His pouches fu' o' fossil bones.
—Robert Dick.

THE instinct to "collect" is a very deeply rooted human character. Almost anything can be collected, if not too bulky. The sedimentary rocks of many lands have afforded rich opportunities for collecting small invertebrate fossils; amateur collectors, however, of the remains of vertebrates like dinosaurs and mammals are few because of the size, care required in handling the bones, and the organized support required. Fossil fishes, however, are not so bulky, and consequently are the only group of vertebrates to be extensively collected by amateurs.

One recalls at once Hugh Miller and Robert Dick, who collected fossil fishes from the Devonian Old Red Sandstone of Scotland. Each had experienced that supreme joy of discovery; of standing in the presence of apparently lifeless and meaningless rock, which under the stroke of a hammer yielded a fossil fish, and thereby took on meaning and significance. Both followed the vision.

Hugh Miller, the stonecutter of Cromarty, found his first fossil fish working as a quarryman in the Old Red Sandstone. Later becoming editor of his church paper, he wrote with such success of the keen pleasure of finding fossil remains, that his writings, gathered into book form and followed by other volumes, were widely read, and played their part in preparing the popular mind for the changes in intellectual viewpoint introduced by Darwin.

Robert Dick, the shy, retiring baker of Thurso, the northern-most, bleakest village in Scotland, never missed mixing a day's batch of bread, but so timed its setting that he could start, on foot, at midnight, on a fossil hunting expedition. He remained a poor, humble baker, but he was exalted by his glimpses of creation; and his love for his native ferns, holy grass, and fossil fishes endured to the end of his modest life.

Northern Ohio has maintained a like group of collectors of Devonian fossil fishes from 1870 to the present. Engaged the greater part of the time in their daily tasks and professions, these enthusiasts searched for fossil fishes in spare moments, stimulated each other in the brotherhood, and became worthy successors of Miller and Dick. Among them are names familiar to all those who know fossil fishes.

The Rev. Herman Herzer, gentle minister, superintendent of the Berea Orphan Home, and teacher in Baldwin-Wallace College, was the first discoverer of these fishes in Ohio, and his find, *Dinichthys herzeri* Newberry, bears his name.

Jay Terrell, fruit gardner and hotel keeper was the discoverer of *Dinichthys terrelli* Newberry.

Dr. Williams Clark, physician and man of strong personality, perhaps the best known of all because of his collections in the British Museum and the American Museum of Natural History, found many fishes which now bear his name, *clarkii*.

The Rev. William Kepler, ex-soldier, minister, professor of natural science in Baldwin University, Berea, and for one year its acting president, was a noted collector. His spare time, spent on the river banks, with his son as companion, yielded important finds during years of collecting. *Cladoselache kepleri* Newberry was the contribution which served to perpetuate his name in the world of fossil fishes.

C. C. Fyler, the deaf whetstone maker of Berea, was the discoverer of *Cladoselache fyleri* Newberry.

Dr. D. T. Gould, druggist of Berea, was inoculated with the urge for fish collecting, but found it necessary first to restrain his enthusiasm, and finally to abandon the art, for running a small-town drugstore was then an exacting business. But he did not stop until after he had discovered *Stenognathus gouldii* Newberry. He is still living in Berea, nearing eighty years of age, the last of the older generation of collectors.

A. A. Wright, professor of geology and natural history in Oberlin College, Ohio, and his successor, Professor E. B. Branson, were the only ones of the brotherhood of collectors to publish any of the results of their finds.

All of the men mentioned made splendid contributions to science through the mere act of recovering the fossils from the shaly rock. The descriptions and interpretations were mostly by others, Newberry, Dean, Claypole, Smith-Woodward, Jaekel, and Hussakof. Dean was a student under Newberry, and Hussakof under Dean, and their material is in the American Museum of Natural History. The present writer was a student under Dean.

In surveying the history of our knowledge of these Ohio fishes, it is interesting to note that it has been in the hands of two guilds; the guild of collectors, the members of which drew their stimulus or enmity one from another, and the guild of scientists which gave most of the professional treatment to the material. Indeed, one suspects that Wright and Branson, named with the collectors, are of the professional caste, whose interest is, at bottom, scientific, and who do not feel so strongly the periodic desire to go out to the stream banks and "collect," an urge which, in the true collector, is as real as the rise of sap in March. It does not originate in the inquisitive spirit of the scientist as much as in the venturesome spirit of the gambler, or fisherman, to try his skill and luck against chance and a worthy combatant.

Jay Terrell and William Clark were the outstanding leaders of the guild of collectors. Terrell discovered the fossil fishes independently of the Reverend Herzer and was a very enthusiastic collector until 1890. It was he who stimulated the Oberlin group of collectors and, later, Bungart at Lorain, who is now a collector for the Cleveland Museum of Natural History. Possibly Clark would have become a great collector without the development of the disease which brought Terrell into professional contact with him. Certainly to these two enthusiasts, and to their collections and stimulus of others, is to be attributed almost wholly the accumulation on which our knowledge of Cleveland shale fishes is based.

It is almost useless for a man, untrained in the ways of the black shale, to come into the region hoping to find much. The late Professor H. P. Cushing, Cleveland-born, professor of geology in Western Reserve University

Cedar Point on Rocky River. The bank, about sixty feet high, is Cleveland shale. Fossils occur throughout, but only the lower few feet can be prospected. For twenty years Doctor Clark visited this outcrop, twice yearly if possible, for specimens of fossil fish

from 1892 to 1921 and a local fossil collector of considerable keenness and assiduity, told the writer that he had never found the remains of a single fossil fish. The writer although resident eleven years, and devoting three of these to active work on the shales, has made only two finds worth carrying away.

The brotherhood of collectors of the fossil fishes of the Ohio black shale will forever be a restricted one, because few possess the love of nature, the desire to collect, the ability to find, and the patience to extract and to reassemble the bones broken in fragments.

These fishes in the black shale of northern Ohio are never common and are usually exasperatingly difficult to detect in the vertical shale banks where they are best sought. Yet a northern Ohio collector reads with a queer feeling of compassion Robert Dick's enthusiasm at finding a single fish bone, of his sometimes heart-breaking labor to extract it from the great ledges of Old Red Sandstone, and of his long, patient, often unrewarded search for the complete fish.

Cleveland shale fishes are sometimes astonishingly complete. Once discovered they may yield satisfactory return after no great expenditure of labor. Only a short time ago, the author with Peter Bungart, laid bare at a single hammer stroke, an entire three-foot shark, head to tail, with fins, and a large knot of ganoid scales "amidships," the last meal which it had snapped up; a curious little episode of a moment before the Appalachians were formed 400,000,000 years ago.

The Cleveland shale is the topmost member of a mass of black, carbonaceous shales, the Ohio shale, from 300 to

Typical occurence of Cleveland shale on Vermilion River. Several years progressive excavation at this point has revealed the crushed head and body of a *Dinichthys*. The 1926 season may reveal the missing fins

1000 feet thick in Ohio, and extending entirely across the state. Fish remains are found from bottom to top and from the Lake to the Ohio River, but knowledge of them is based almost entirely on material procured from the topmost member and from within forty miles west of Cleveland. No other portion of the state has ever developed amateur collectors for these remains, and no other portion of the state presents outcrops of the shales as good and as numerous as those of northern Ohio.

Varying from 20 to 65 feet in thickness, the Cleveland shale is cut by all streams flowing northward into Lake Erie from Grand River west to Huron River, a distance of ninety miles. It is thickest, and the outcrops are much better, from the Big Creek in the western edge of Cleveland west to, and including, Vermilion River.

The Cleveland shale fishes are the largest Devonian fishes found. Entire sharks up to 5 feet in length have been obtained, but jaw cartilages 2 feet long show that much larger ones existed, perhaps from 15 to 20 feet in length. The arthrodires were of similar size. These, more than any others the world over, have caused the attributes of hugeness and ferocity to be associated with our conception of fish-dominance in the Devonian Age of Fishes.

About forty different kinds of fishes are known from northern Ohio. These fall into two groups, the sharks and the arthrodires, with very rarely a ganoid. The sharks, though primitive, were already truly sharklike and had acquired much of their present features and mode. The shark jaws and dentition were established essentially as at present. The arthrodires, destined to extinction very shortly, were heavily armored about the head with great bony plates, but were a very plastic stock judging from the variation in character. The jaw parts show more unity of pattern and yet a greater range in character than has yet been described. They were not in the least a fixed line in the sense of lacking variation and adaptability. That they did not lack in ferocity and aggressiveness is shown by the great scars which sometimes mar the plates. Yet they did not solve the problems of living in a way necessary to meet the requirements of the great test—survival.

The arthrodires are found evenly distributed over the entire area of production and through the entire thickness of the Cleveland shale. The sharks are known from the entire area but their production is essentially confined to one stream, Big Creek. From the rest of northern Ohio, only teeth, an occasional fin, spine and jaw elements, unrelated to the rest of the creature, are known. On Big Creek have been found all of those exquisitely preserved Cladoselachians which are unique the world over among fossils. All the specimens listed in the literature as coming from Lindale (or erroneously from Linton), and Brooklyn, and most of those listed from Cleveland, were obtained on Big Creek and its tributaries.

The reason for this restriction to Big Creek is that they are there enclosed in concretions, flattened elliptical masses of siliceous and clayey iron and lime carbonate, two to five feet across. Nowhere else are such concretions found, and the flattened bodies of the sharks, though undoubtedly present elsewhere, cannot be detected in the Cleveland shale without these markers to reveal them.

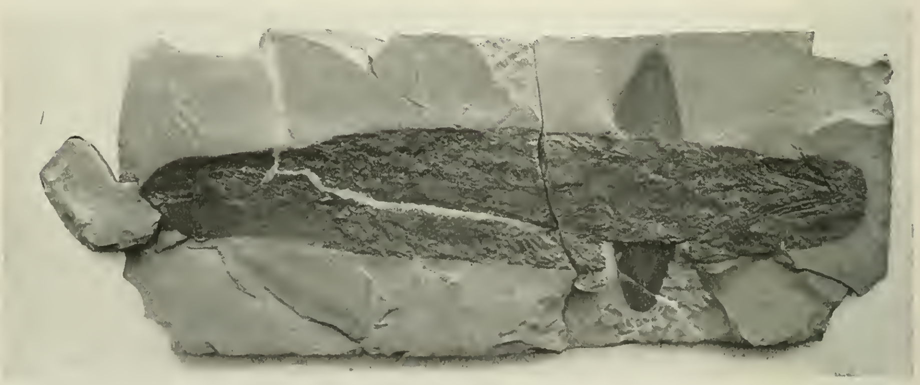
Cleveland shale exposure on Big Creek near Cleveland, Ohio. The flat concretion, at the point of the pick, contained a pressed cladoselachian shark about four feet in length

In some parts of the Big Creek system, every concretion contains an arthrodire bone or a shark. In other parts one out of four concretions is productive. The art of collecting in this creek consists in locating concretions, and by the break of the surrounding shale the experienced collector can locate a concretion that is yet beneath six inches or a foot of shale.

Two mysteries are not yet satisfactorily solved: Why are no arthrodires found with bodies preserved entire in the concretions, as are the sharks? A single one with head and backbone has been found, but without traces of body outline, musculature, or filling of alimentary canal. Why are ganoid fishes essentially absent from the shales and the concretions, except as masses of scales and bones in the alimentary tract of each shark or in coprolitic masses? These two questions present a glimpse of the problem of the ecology of the fishes. It is hoped to present, in time, a statement of the environment in which this fish fauna lived.

While a shark or the head bones of an arthrodire, once discovered, may be recovered easily, experience of the last three years has proved that our lack of knowledge of the body of the arthrodires has been due to the lack of sufficient care in collecting. For fifty years the impelling instinct to collect has been satisfied with finding the bodies of sharks and the bones of arthrodires that are easily won. We now know that with very great care in extracting and with days of patient work with the dental engine and tools, much more can be regained. The scouting for these fishes is now passing from the amateur to the professional collector and preparator.

Big Creek is on the edge of rapidly growing Cleveland. Six years ago one of the lesser collectors of the past generation, Thomas Piwonka, took the writer over a part of Big Creek which had been a favorite haunt of Clark's, whom he had known intimately. We rode by trolley a mile beyond the edge of the city through fields and occasional woodlands. That mile of country



Cladoselache, a primitive shark from the Cleveland shales. The body rested evenly on the ocean floor, belly down, and after burial by mud, was compressed without distortion to a thickness of a quarter of an inch. The tail was not flattened but remained standing at a high angle, so that it is foreshortened in the picture. The jaw elements and gill bars can be easily distinguished, but the spinal column and pelvic girdle are rarely preserved and are not here shown. The finer markings midway on the body are the muscles

The shallow valley of Big Creek in the outskirts of Cleveland, Ohio. During half a century this spot has produced many fine cladoselachian sharks. Twenty-six separate finds, part of them arthrodires, all in concretions, are known to have come from the bend in the foreground and a few rods to the left of the view. The city has encroached upon the limits of the area. The creek banks are of shale about one foot high. The flat valley bottom on either side is of shale covered with earth

The power shovel of the Cleveland Museum of Natural History fishing for concretions containing five-foot sharks in one-foot-deep Big Creek. On the sky-line is the encroaching city has now entirely disappeared. Three years ago when the Cleveland Museum of Natural History undertook the collection of these fishes, another prolific branch of Big Creek lay a good

The first concretion turned up by the power shovel of the Cleveland Museum of Natural History, operating in the shale beds exposed in the valley of Big Creek. Director Rea and collector Bungart of the Museum staff are at the left

quarter-mile south of the encroaching edge. That quarter-mile has now disappeared, and houses stand almost on the creek bank.

Everywhere in the Big Creek basin streets are being laid out, lots staked, pipes laid, and houses built, and very shortly several small stream heads will be confined strictly to allotted channels or will become closed sewers. Fish collecting on this stream will then be forever closed.

In the effort to save as much as possible from this unique locality, the Cleveland Museum has obtained the hearty coöperation of one of the land companies and through the generosity of friends who appreciate the situation, has placed a power shovel on one of the branches where there is a broad shale bottom under slight cover which has been productive in the past. This bottom will be turned over, as long as the support will keep the shovel going and the turnout of fishes is good.

Here, where Clark and Kepler wandered along low, shaly banks, each in hopeful anticipation of forestalling his rival in finding a concretion exposed by the past winter's weathering or the last spring's floods, the power shovel now turns out a concretion one or two or three times a day. But though the production is increased and choice things have been recovered which would otherwise have been lost forever, the keen pleasure of search is denied the collector assigned to the shovel.

However, whether we rise at one in the morning, to walk many miles with Robert Dick in the dark through a wet Scotch mist or a wetter Scotch rain, to a seacliff of Old Red Sandstone that is sure to produce a fossil fish, or whether we get down to the shovel at eight in the morning and quit with the whistle at half past four in the afternoon, the spirit is the same—and none will ever express it better than has Dick himself:

Hammers an' chisels an' a',
    Chisels an' fossils an' a';
Resurrection's our trade; by raising the dead
    We've grandeur an' honour an' a'.

It's good to be breaking a stone,
    The work now is lucky an' braw;
It's grand to be finding a bone—
    A fish-bone the grandest of a'.

Hunting Fossil Marine Faunas in New York State

By RUDOLF RUEDEMANN, Ph.D.
State Palæontologist, New York State Museum

ONE never knows what may turn up in fossil hunting; moreover one is buoyed up by the hope of an unexpected discovery. Prof. James Hall once called the collecting of marine fossils "dry dredging," and dwelt on the fascination of diving into the depths of ancient seas with hammer and chisel. His successor, Dr. John M. Clarke, often spoke of the pleasure of fossil collecting because of the "gambling" element in it.

The best specimens are usually found when least expected. It is this that makes fossil hunting so similar to hunting game. Rare fossils will appear suddenly like grouse flushed from cover, and often the collector, excited for the moment, spoils a good find—even as the hunter misses his quarry. For instance, on the Mohawk, near Rexford, I once saw in a block of stone a beautiful seaweed surrounded by a whorl of air-bladders. I picked it up quickly, and since it was traversed by countless cleavage cracks it crumbled instantly into a thousand pieces.

One summer morning, when I was walking toward the Dolgeville High School, I saw workmen leveling a near-by hill and dumping the shale along the road. Suddenly my attention was arrested by a large starlike graptolite. I picked up the specimen and saw it was a complete stock of Utica graptolite such as had never before been found. The shale was being covered with soil as fast as it was taken from the ledge, but I persuaded the engineer in charge to let the material remain uncovered every day until my school boys and I had searched it. To arouse enthusiasm in the boys, I told them to make their own collections, and we procured the finest set of complete colonies and their growth-stages known at present. All these specimens I borrowed for study and inherited in due time when the boys had lost interest.

The Deep Kill fauna was also discovered by accident as I walked through the ravine at sunset. The light fell upon a large block dumped below the dam (then under construction) in such a way as to bring out the barely visible thin films of *Phyllograptus typus* upon the adhering shale layer. This led to the finding of the very complete Deep Kill section in steeply dipping rocks that otherwise would not have betrayed their wealth.

Again, on a beautiful October morning, when I was on my way home from field work, my train was passing the gorge of the Hoosic River. I decided that it was too beautiful a day for me to go home so early, so I jumped off the train at Schaghticoke and went down into the gorge. Here I found the Schaghticoke shale fauna, the oldest graptolite fauna in America.

One of the most amazing finds was made by Doctor Clarke and me when we went to Jerusalem Hill to collect eurypterids for our memoir. There were no outcrops of the rock, but there was fair collecting in the stone fences. We searched these systematically. One morning we selected a long, straight, promising fence. Doctor Clarke took one side, I the other. We had hardly reached it, when we both exclaimed: "Look at all the crinoids!" The entire fence had a top layer of

The graptolite shale in the Hoosic Rivei at Schaghticoke, New York

large slabs of Coeymans limestone completely covered with *Homocrinus* (*Lasiocrinus*) and other crinoids, all beautifully weathered out. We could not understand at first why this treasure had been laid out ready for us to take home. There were no slabs of the kind in the fence itself. We learned afterward that many years before there lived near by a country physician, a Doctor Brown, who was a collector of fresh-water and land mollusks. To obtain material for exchange, he worked a layer of crinoids in a quarry on top of the hill, long abandoned when we arrived. The crinoid bed was covered by a thin layer of tightly adhering shale. To free the crinoids from the latter, the doctor used to expose the slabs to weathering for two years or more on that fence because it was not too near the road. He died after laying out the supply of material we discovered some twenty years later, leaving us a wonderful inheritance and testimonial of his love of nature and collecting spirit.

Eurypterids are rather elusive fossils. They refuse to turn up when you hunt for them, but delight in winking at you out of their bean-shaped eyes when you least expect them. In 1906, while the tunnel of the Erie Railroad was under construction at Otisville, Dr. H. B. Kummel, state geologist of New Jersey, telegraphed to Doctor Clarke that he had seen graptolites in the rock material brought out of the tunnel. Doctor Clarke was in Gaspé at the time, and I intended to leave within a few days for the International Geological Congress in Mexico. However, I made a hasty trip to the place, arriving in the evening and planning to leave the next noon. After I had collected what there was of graptolites, I walked along the track to the place where the Shawangunk grit rests

SCHAGHTICOKE GRAPTOLITES, INCLUDING GROWTH STAGES

ONE OF THE CRINOID SLABS LEFT BY DOCTER BROWN FOR OUR BENEFIT AT JERUSALEM HILL, LITCHFIELD, NEW YORK unconformably on Ordovician shale, an outcrop that has been figured repeatedly. I saw a large quarry beyond, and having still a little time to spare, I went in. It was not being worked at the time, but a splendid manifold repetition of grit beds and thin black shale seams, that do not show in weathered outcrops, was exposed. "Silurian graptolites, perhaps," I thought, and began to look for them. Instead I picked up a eurypterid head and some segments, and the remarkable Shawangunk grit eurypterid fauna was discovered. This and larger collections furnished the growth-stages of eurypterids described in the joint memoir by Clarke and myself.

Equally unexpected was the discovery of the Ordovician eurypterid faunas. While studying the graptolite shale of the Hudson and Mohawk river valleys, I visited a series of quarries just outside Schenectady where "bluestone" was broken. I secured a fair collection of graptolites, brachiopods, and trilobites in the thin shale intercalations, all new to that formation (Schenectady beds), hitherto supposed to be barren. By chance, one day as I was packing my material before leaving, the reflection from the evening sun illuminated a carbonaceous patch, half the size of a penny on a bit of shale. I picked it up and there was the finest piece of eurypterid skin with the characteristic scales that I have ever seen. The next day I went eurypterid hunting with a vengeance and I obtained the collection of eurypterids of the Schenectady beds described in the memoir, the first eurypterid fauna of Ordovician age known by more than a few fragments. It was the last opportunity, for the whole district was soon built over and is now buried under houses.

A few weeks later Professor Chadwick came through Albany with his students and I showed him my new discovery. The next day he notified me that he had found a like eurypterid fauna in the Normanskill shale at Catskill. That is the oldest Ordovician eurypterid fauna known. Thus one discovery often leads to another.

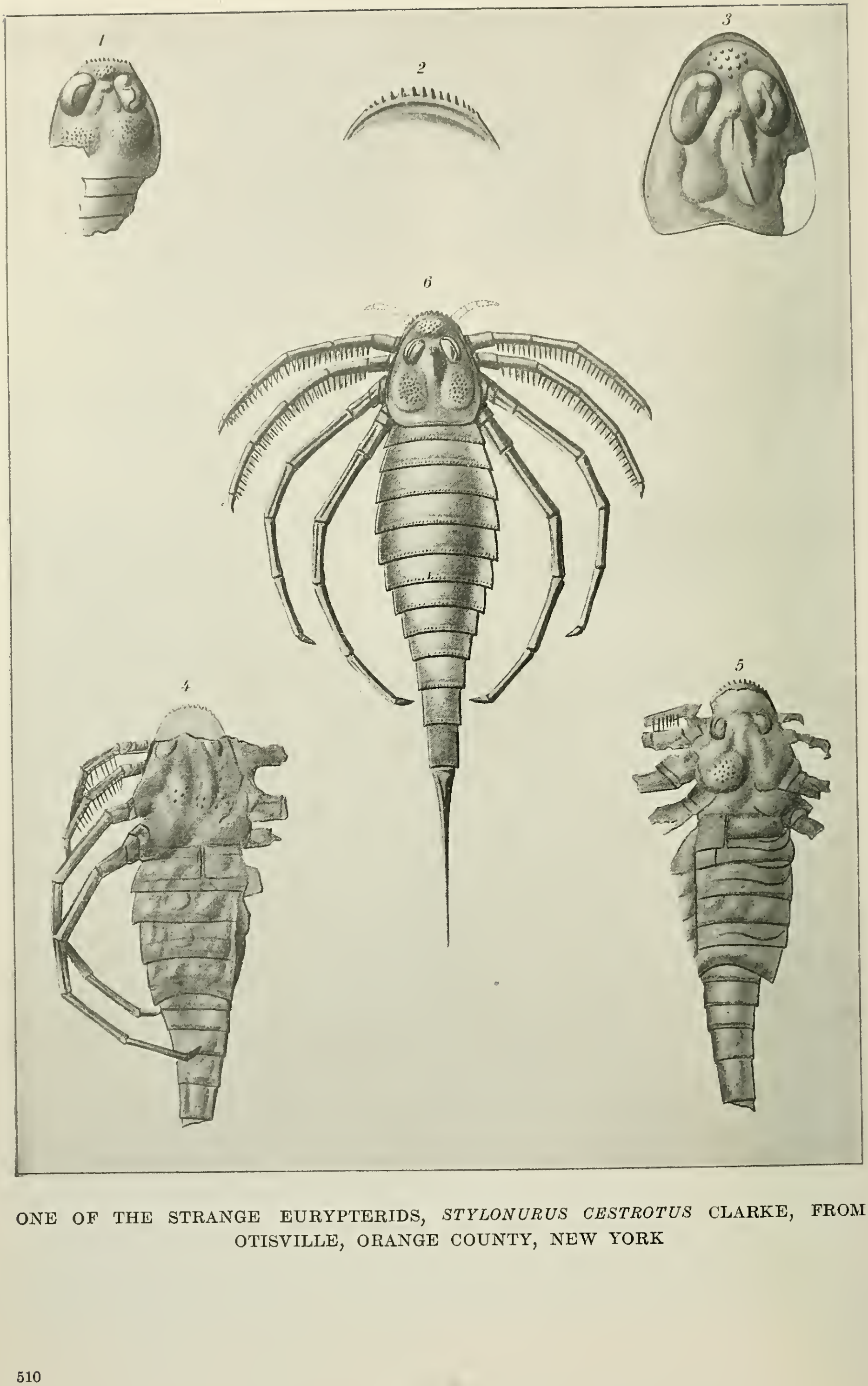
A third find of eurypterids was amusing. Two colleagues and I were at Gilboa to secure trunks of the Gilboa trees. One of them was trimming off the rock adhering to the base of a fossil tree trunk, when I remarked jokingly: "Let me have that hammer. You do not know how to handle it!"

"All right, show what you can do," he said, secure in the knowledge of his superior ability in that line.

Who can describe our amazement when my first blow brought out a beautiful head of a new eurypterid, nearly three inches wide (later described by me as *Pterygotus inexpectans*). It was the first of that formation. Miss Winifred Goldring of the State Museum staff later obtained three more specimens, two of which were very young growth-stages.

On that same trip, the seeds of the Gilboa trees were found, and that also is illustrative of the romance of collecting. Shortly before, I had seen figures of Carboniferous seed ferns with seeds described by David White, and had learned from Miss Goldring that Professor Johnson, of Dublin, had predicted Devonian seeds. So I thought I might look for them in the Devonian plant beds at Gilboa, but no promising black shale could be found.

One night, as we were trying our luck at fishing in the Schoharie Creek, both my companions went out on a big bowlder in the river while I



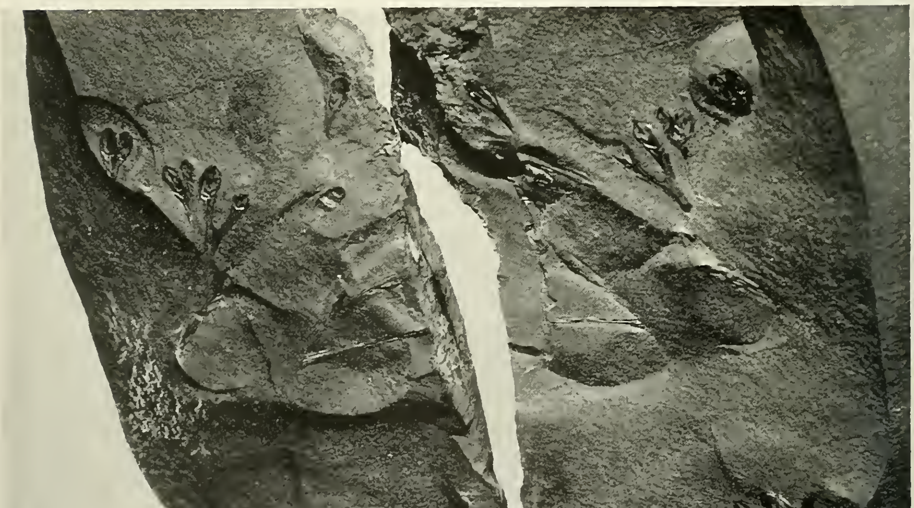
ONE OF THE STRANGE EURYPTERIDS, *STYLONURUS CESTROTUS* CLARKE, FROM OTISVILLE, ORANGE COUNTY, NEW YORK

The quarry at Otisville, where the eurypterids were found

remained on shore to enjoy the beautiful scenery of the Manorkill Falls just behind us. While I was sitting there, I noticed a large slab of black shale sticking out of the river sand. It was covered with beautiful clusters of fern seeds. I seized it, and yelled to the fishermen. We carried the precious slab home. When we arrived, my companions discovered they had left their pipes and tobacco on the bowlder and blamed me for having made too much "fuss" over my find. But it was worth it, for these are the oldest seeds known at present. There was no doubt that the bed from which the slab came was near by, and we found it the next morning not a hundred feet away at the foot of the cliff in the corner between the Manorkill and Schoharie creeks. From it we secured a fine collection of seeds. Miss Goldring went out later and obtained the spore-bearing organs, the foliage and rootlets. The locality will be lost to science when the reservoir is filled.

Sometimes fossils will turn up just as the collector is ready to "quit." Dana D. Luther and I were sent out to collect Guelph fossils and facts on the Guelph stratigraphy after Doctor Arey had obtained a fine collection of Guelph fossils, the first in New York State, in the sewer trenches of the city of Rochester. We had wandered for a week between Rochester and Lockport over a belt where the Guelph ought to be, without seeing a trace of outcrops or fossils, except a few specimens from loose blocks too poor to prove anything. One Saturday afternoon as we plodded back to Shelby, we decided to quit the hopeless job. We walked along a canal feeder and came north of the belt of supposed Guelph into a stretch of woods, where we were greeted by house-high piles of dolomite taken out of the canal feeder. The fresh Lockport dolomite is not a promising field, so we passed indifferently between the piles, but we stopped simultaneously with cries of amazement. All around us were the most beautiful *Monomerellas*, *Tremanotus*, and other Guelph fossils sticking out of the blocks. We could scarcely believe our eyes, but there was no doubt that here was a wonderful Guelph fauna, although it appeared at a horizon lower than that we had

The Manorkill Falls, Gilboa, New York. The seed locality is at the right



Two slabs with clusters of seeds from Gilboa, New York searched. It was the "Lower Shelby fauna" of Clarke and Ruedemann (Memoir 5). The next morning found both of us at those rock piles of tough dolomite; and many days thereafter we returned to the village inn, happy as crickets, with blistered hands and heavy loads, but feeling rich and filled with expectation of what the next day would bring. And so well was the locality hidden in the woods that a certain palæontologist, who wished to get ahead of us in publishing the Guelph fauna and to whom I had foolishly shown my material, rode back and forth on his bicycle between Rochester and Lockport several times without finding the place.

Certain groups of fossils have always been considered aristocrats. They do not mingle with the common horde of brachiopods, bryozoans, or mollusks, but prefer to remain by themselves in dignified reserve and grow in plantations. Such aristocrats are the eurypterids, crinoids, graptolites, and especially the sponges. That New York State has afforded the finest collections of Palæozoic sponges in the world, is made evident by the memoir of Hall and Clarke, and by the exhibit in the State Museum. It is no wonder, then, that sponge-hunting in the upper Devonian rocks of the middle central and southwestern counties early became a fine art among certain members of the staff and several local collectors. Stories of these sponge-hunting expeditions, when Hall's son "Jim" was the leader, were still current among the older men when I came to the New York Survey, and are still told by Jacob Van Deloo, son of Hall's veteran collector, C. A. Van Deloo. Many weird objects were sent to Albany by these collectors as sponges, but that was in the "good old prohibition days." The elder Van Deloo was an untiring collector, whom Hall considered the best he ever had. He would not stop until he had cleaned out a locality, and would lug the material for days if necessary, on his back. In 1869, with C. A. White, he cleaned out the Vincent crinoid plantation in western New York so completely that it is said no other specimens have since been found there.

Neither Hall nor Clarke had interest in the faunas of the eastern shale belt. Hall left that region severely alone after the acrimonious Taconic controversy, and Clarke was primarily interested in the Devonian faunas of western New York, where his friend Luther supplied him with ever new material. No wonder, then, that I could discover hitherto unknown faunas on Rysedorph Hill that for more than fifty years had been in full view of the office windows of Hall and Clarke.

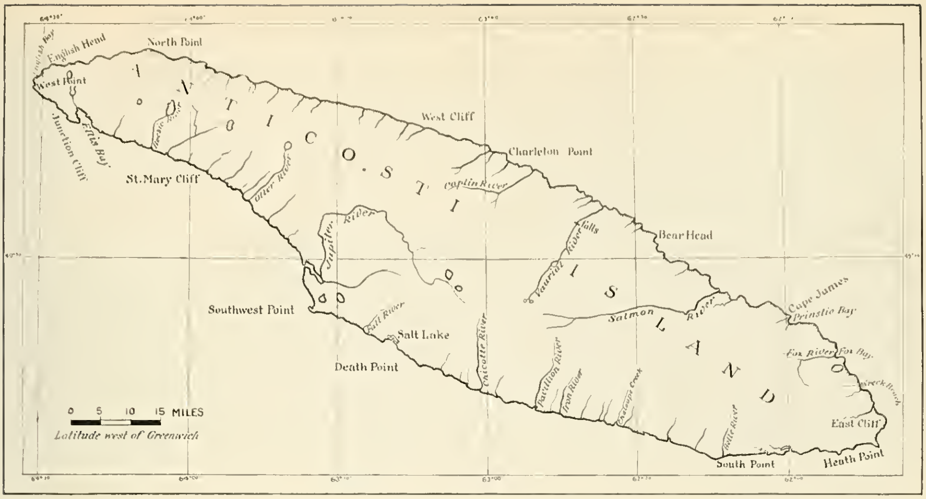
On the top of that hill a conglomerate outcrops, and the west side is strewn with pebbles. While climbing that side, I picked up a beautiful shell of the brachiopod *Christiania* which showed the interior structure perfectly. Because only one species (occurring in Tennessee) was known in America, Doctor Clarke was skeptical when I told him of this specimen, but one glance convinced him. The fauna of the conglomerate within view of Albany furnished more than eighty species, nearly one third of them new and containing seven new trilobites. Some of the latter belong to genera not before noted on this continent and indicating an Atlantic element in the fauna. This interesting conglomerate not only contains faunas ranging from lower Cambrian to the Black River and Trenton formations, but it has also yielded faunas that had not been observed before, and that belong to assemblages now hidden or obscured in the metamorphosed limestones of western Massachusetts but which were partially discovered later in the Chambersburg limestone of Pennsylvania and in Virginia and Alabama.

Sometimes fossils actually seem to press themselves upon one's notice. Miss Goldring lost her hold one day and slid down over a slanting cliff. Something stung her on that rapid journey, and when she looked for the offending party, it was a fossil starfish,—the only starfish known from the Gaspé beds. I have just described it and properly named it "Goldringæ."

On the other hand, when two collectors, each interested in a different subject, go to the field together, it often happens that the fossils are discovered by the disinterested individual. Thus when I was with Doctor Ulrich to collect in the Clinton formation at Clinton, he picked up a beautiful new *Dendrograptus* which I felt I should have, and I found a complete *Dalmanites* which was of interest to him. We exchanged our finds, but unfortunately Doctor Ulrich lost his share of the deal, and he still, with grave suspicions, asks me the whereabouts of that trilobite.

As a warning against over-enthusiastic collecting, I will close with a little experience of my lamented friend Gilbert Van Ingen. While still working with the New York Survey, "Van" walked one rainy day through the main street of Granville, New York. On the wet sidewalk he noticed many fine specimens of the Cambrian jellyfish *Dactyloidites bulbosus*, and, although he was to return that day to Albany, he set out enthusiastically to procure some slabs. He sought the manager of the quarry and asked him to take up some of the slabs and replace them with new ones. The manager kindly agreed and asked him to mark the desired slabs. So "Van" marked the slabs with a red cross and went home. Within a week or two a letter announced that a freight car loaded with the whole sidewalk of the main street was ready for shipment and that the bill was $600. Doctor Clarke had neither funds nor inclination to meet the expense and the wires were kept hot that day between the perspiring Gilbert Van Ingen and the kind manager. It happened that "Van" had put the paint and brush behind a near-by barn before leaving, and a little boy who had watched him had continued the job of marking the sidewalk.

The few experiences I have mentioned tend to show that even in the well-searched State of New York many surprises still await the enthusiastic collector, and that there is no lack of romance in the field work at home as well as abroad. It is true that the "kick" coming from the element of danger in foreign countries is lacking, only an ill-tempered bull, or dog, or farmer causing a little excitement at times, especially if one is out with a high-strung, independent companion. Then the unexpected may happen at any time. But what could replace the pure joy with which the collector sits down when he has made a good find, lights his pipe, and gloats over the new discovery! And in the fall, when fool game-hunters overrun the woods, there may even be an element of real danger, as for instance, when a reckless idiot mistakes the collector, who is in a stooping position, for a fox or something, and fires away. This once happened to me at the East Canada creek.



Sketch map of Anticosti Island

Hunting Fossils on Anticosti Island

By W. H. TWENHOFEL
Professor of Geology, University of Wisconsin

Foreword.—The recorded history of Anticosti extends back nearly four hundred years. It was discovered in 1534 by Jacques Cartier, who named it Isle de l'Assomption. At that time no people made the island their permanent home. It was visited each spring by the Montagnais Indians from the north mainland, who came there for hunting. They called the island "Natiskuan." Their last trip is said to have been made in May, 1882. Formerly, the Esquimos lived on the north mainland, but about 1600 the Indians defeated them in a great battle, and drove them to the east. It is possible that before their defeat, the Esquimos visited Anticosti. I camped one night on this old battlefield, a most ghostly place.

The island was granted to Louis Joliette in 1690. At that time it was known as "Anticosty"; the origin of the name is unknown. Until shortly after 1700, the descendants of Joliette lived on the island, but from that time until 1895, when it was purchased by Henri Menier, no Joliettes lived there. During this period of more than a century and a half the island was a rendezvous for smugglers, wreckers, and others of questionable occupation. Stories are still current among the fishermen of ships lured to the coast by means of lights suitably placed. One of the most famous smugglers was Louis Olivier Gamache, who came to Anticosti in 1810, and made his home at Gamache, now Ellis Bay. Many interesting tales are told of this man. It was supposed that he had Satan as an aid, and could make the winds and sea obey his will.

INTRODUCTION

EVERY ship that enters Canada by way of the great St. Lawrence passes by Anticosti Island. If passage be by the North Channel, the passengers will see the balsam- and spruce-crowned cliffs of the north coast; if by the South Channel, they will see the exquisite beauty of the moss-covered and lake-studded terraces of the south side of the island.

The island, for all its natural beauty, is not loved by the older sailors. They remember too many comrades who have lost their lives on its treacherous shores. In the old days of sailing ships, never a storm occurred which did not take its harvest of ships. The place is known among seamen as the

A view typical of the north side of the island. Cliffs of Tower Point and Bear Head each about 300 feet high

"cemetery of ships"; there is hardly a mile of shore which does not tell a tale of disaster and death in timbers and iron half buried in the sand and in the graves of unfortunate sailors.

CHARACTER OF THE SHORE AND SURFACE

The north coast of Anticosti is largely a succession of bold headlands of which many rise 200 to 300 feet directly from the sea. Between the headlands are small bays most of which are bordered by narrow strips of low land. On the south coast high headlands are not common, except on the extreme east end and from South to Southwest Point, where considerable stretches of the coast are cliffed. Few of the cliffs of the south coast exceed 25 feet in height and most of those which are higher than 25 feet are composed of unconsolidated sands and sandy clays. The bays of the south coast are generally bordered by considerable areas of low land. Nearly every bay on the island has a stream flowing into it and some have several. Near the coast the valleys may be several times wider than the streams, but inland they become narrow and terminate in cañons. Every stream is a succession of rapids and falls with an occasional deep pool, the latter abounding in trout and salmon. The largest fall is on Vaurial River. This is about eight miles from the sea and is about 130 feet high.

The island is terraced, with the widest terraces on the south side where some are several miles wide. On the north side several terraces may be seen on almost every headland. The highest land of the island is near the north coast, and does not much exceed 400 to 450 feet in height.

Lakes abound, and they occur at all observed elevations. Beavers are responsible for some; many are developed marginal to the sea through the building of littoral barriers. This is particularly the case on the south coast. Most of the barrier lakes contain fresh water; others rise and fall with the tide, and at low water some of the latter are very shallow. An amusing incident arose in connection with one of these. At one of the 1919 expedition camps, the two boys on cook duty for the day made some cornstarch pudding and set it in an adjacent small shallow lake to cool. At dinner-time, the tide was high, and one of the boys, on going after the pudding, found it under several feet of water.

CHARACTER OF THE ROCKS AND THE GEOLOGIC SECTION

The rocks of Anticosti consist of limestone, shale, and sandstone; important in the order named. The strata have southwesternly inclination of from 70 to 90 feet to the mile. As a consequence, the younger rock of Anticosti forms the south coast and the older the north. The thickness is about 2500 feet. These strata were deposited in an ancient embayment which was in existence in the Cambrian, Ordovician, Silurian, Devonian, and perhaps the Mississippian period. The oldest strata of the island are of Richmond, or late Ordovician age, and the youngest are early Niagaran, or middle Silurian age. The strata have been placed in seven formations which with their thicknesses are as follows:

Ordovician	
Richmondian series	
English Head formation	229 feet
Vaurial formation	600 to 700 feet
Gamachian series	
Ellis Bay formation	190 to 256 feet
Silurian	
Anticostian series	
Becsie formation	200 feet
Gun River formation	400 feet
Niagaran series	
Jupiter formation	620 feet
Chicotte formation	73 feet

A stratigraphic break occurs between the Ordovician and Silurian strata. This is not apparent in the structure, but is shown in the decided evidence of water shallowing, the presence of large rock fragments in the

Vaurial Falls. Because of the dryness the volume of water is scant. A small tributary is shown on the right

Portion of a slab covered with shells, fragments, and pebbles. It contains a small colony of a peculiar variation of Halysites. Natural size

basal Silurian, and the marked change in the fauna. It is not known that a land interval intervened in this region between the deposition of the Ordovician and the Silurian, but it is certain that the bottom of the sea was brought above the profile of equilibrium so that deposition was arrested, and the bottom probably underwent some erosion.

FOSSILS IN THE ANTICOSTI ROCKS

The rocks of Anticosti abound in fossils, the majority of which are splendidly preserved. The abundance of the shells of some species borders on the marvelous. A brachiopod known as *Parastrophia reversa*, found in the Ellis Bay formation, is almost unbelievably abundant, and the brachiopod *Atrypa reticularis*, in some Silurian horizons, is nearly as plentiful. Coral reef limestones exist in both the Ordovician and Silurian strata, the oldest reef being near the top of the Ordovician. This reef is less than ten feet thick, but it has great lateral extent, having been seen at points more than 75 miles apart. The youngest reef is in the Chicotte formation in which there are places where the coral reef limestones rise 15 to 20 feet into the overlying strata. The oddest coral found in the rocks of the island is known as *Beatricia.* This resembled unbranched trees and stood upright on the sea bottom, attaining heights of more than a dozen feet with diameters at the base up to a foot. The trunks now lie prostrate in the sediments and resemble logs embedded in cement. *Beatricia* is found in both the Vaurial and Ellis Bay formations and may be seen in great abundance in Ellis Bay, at Cape James, and at West Point.

Beatrica noduloso, distal end, one half natural size. Cape James, Ellis Bay formation. This coral stood vertical on the sea bottom and reached a maximum height of 12 or more feet

Top surface of *Chonophyllum canadense*, one of the rugose corals locally common in the Chicotte formation, Jumpers. Natural size.

Excellent places to obtain an abundance of fossils from the English Head formation may be found at English Head and Macasty and Charleton points; from the Vaurial formation at Vaurial, Oil and McDonald rivers, Battery Point and Observation Cliff; from the Ellis Bay formation at Ellis and Prinstie bays, Junction Cliff and head of Vaurial River; from the Becsie formation at Becsie River, Reef Point and Wreck Beach; from the Gun River formation at Gun River and near Cape Sand Top; from the Jupiter formation at East Cliff, Pavilion, Belle and Jupiter rivers and the Jumpers; and from the Chicotte formation at Death and South west points and Chicotte River.

EXPLORING ANTICOSTI ISLAND

I first visited Anticosti Island in the summer of 1909 and made the trip around the island, using a codfish schooner manned by two French Canadians, Mr. Selas Poirer and his son Edmond. The trip required nearly two months, and was unsatisfactory because the coast could be approached only where small harbors permitted the schooner to land and remain. There was also much rainfall that summer, and black flies and mosquitoes were so abundant at times that work in the open was hardly endurable. The result of this summer's work was a large collection of fossils which, however, represented only those parts of the sequence that had exposures adjacent to the places where landing was possible. A clear understanding of the stratigraphy was not attained. This expedition showed that a complete study of the stratigraphy required boats small enough to move in the shallow waters which margin most parts of the island.

A second expedition to explore Anticosti was made possible in 1919, and it was decided to attempt the study of its coasts by using the boats known as dories. These boats are clumsy and heavy, but are extremely seaworthy. Six students, Messrs. R. H. Bennett, W. H. Conine, W. J. Hamblin, Carl Hoppert, L. L. Pfrang, and Chester Rieck were members of the expedition. Three dories were obtained from Mr. George Martin-Zédé of the island's management.[1] These were rowed by the boys while I walked the beach all the way around. As the island is about 135 miles long and 35 miles wide, it is estimated that the boys rowed about 400 miles and that I walked between 600 and 700 miles. Ascent was made of Oil, McDonald, Vaurial, Salmon, Jupiter, and Gun rivers. Nearly every foot of the shore was seen; the exceptions being where high cliffs had deep water at their bases. The summer was dry, and black flies and mosquitoes were scarce, the weather was so fine at several of the camps that tents were not erected and we lived in the open both day and night.

The expedition started from Ellis Bay on the south side near the west end, preceded westward around West Point, thence eastward along the north coast to East Cliff, and westward to Ellis Bay. About two months were required for the trip. One half of the provisions was loaded in the dories at the start; the other half was shipped to Heath Point, a few miles from the east end. For fresh meat we depended on game and fish. Collections were left at each lighthouse as we passed.

The work of each day was full of interest and hardly a day passed that something did not occur to create excitement or amusement. On the morning of starting, Thursday, July 17, the waves were breaking on the edge of the reef, and it was very foggy. The boats started early in the morning while the tide was high. I walked along the beach studying the cliffs. From time to time I heard the oars as they worked in the crude oarlocks, but in about an hour I ceased to hear them and I assumed that the boats had gone ahead. At noon, Bennett and Pfrang came along and informed me that their boat was aground on the reef about a mile from the shore and about two miles back. I went back with them, gave them directions, and returned to find the other boys. I found them at Strawberry Cove, just west of the famous locality of Junction Cliff. Hoppert and Conine's boat came ashore first as they had become seasick and when they were found by Hamblin and Rieck both were sound asleep on the sands. Hoppert was in the navy during the war, and afterward, when the boys called him "The Old Salt," they invited an explosion.

A few days later English Bay was crossed, the start being made from West Point. For about a mile in the lee of West Point the rowing was in quiet water on the reef and on the west side of the bay. On the east side of the bay was a line of breakers; the waves breaking, recovering and then rushing across the reef at great speed toward

[1] Mr. George Martin-Zédé is a great personal friend of the owner of Anticosti, Mr. Gaston Menier, and he annually visits Anticosti. He afforded every possible facility to make the exploration of Anticosti possible.

English Head. Pfrang had never had a boat on the sea before this trip, and when he saw a big roller coming he would forget he had oars and follow the wave with his eyes to see what it would do. Had the boats been other than seaworthy dories, they might have been swamped at this place. As soon as English Head was passed, the water was smooth.

English Head is a famous locality for fossils of the English Head formation, and in a small brook on its west side may be seen an outcrop of the "Track Bed," a bed which has been traced for seventy-five miles on the north coast and which is thickly covered with markings consisting of double rows of cylindrical pits. These have been supposed to be tracks of crustaceans. No remains of an organism capable of making these impressions have been found in the Anticosti rocks.

The expedition moved along the north coast at a rate of from 4 to 5 miles each day. Camp was not moved every day and on some days 15 or more miles were made. The cliffs expose the geology in a wonderful way and reveal as in an open book the sequence of events which took place in the seas in which the Anticosti sediments were deposited. Nearly every exposure yielded a large collection of brachiopods, trilobites, corals, and other fossils, and it was not long before the transportation of the collections became a serious problem.

The scenery of this coast is wild and picturesque. Hundreds of gulls swarm about the high cliffs which tower above the beach. Following the bases of the cliffs was not always pleasant. Gulls and other birds dislodged rocks from the cliffs and these tumbled to the sands or water below. At high tide, water washed the bases of the cliffs and this made it difficult to get around them. This was not so bad in the daytime, but several times, as was the

A portion of the "Track Bed," English Bay

case at West Cliff, this had to be done at night. Wading in water above one's knees, with an occasional wave rolling in heavy enough nearly to swing one from his feet, and hearing the occasional rocks falling with a splash into the near-by water, gave one a strong wish to be elsewhere.

The expedition reached the mouth of Vaurial River on July 31, and on August 2 Rieck, Hamblin, and I began the study of the river section and the making of a plane table and alidade survey of the river's grade and course. Pfrang and Hoppert assisted on the first day of this work. We slept on the night of August 2 in Vaurial cañon and the following day the rest of the party came up to see the falls. By the evening of August 3 we had reached the falls, retraced our steps to get out of the cañon, climbed the cliffs, and ascended the river for a mile above the falls. The following day we ascended the river to where, at an elevation of over

350 feet, the beaver dams change it into a series of lakes. For a part of its course above the falls the water flows underground. We returned to camp on August 4, reaching it before midnight. Some splendid fossils were obtained from the Vaurial River section.

The expedition reached Salmon River on August 7. Here, the boys caught several big salmon and we obtained a large collection of fossils from Battery Point. The rocks of Battery Point are filled with prostrate trunks of *Beatricia* and as these ordinarily project from the cliff face a few inches and many are hollow, they resemble cannons projecting through the walls of a fort. This accounts for the name Battery Point.

Fox Bay was reached on August 12. The base of the Becsie formation is exposed on Fox Point on the west side of the bay and Reef Point on the east side is entirely composed of Becsie strata. Reef Points is the best locality known from which to obtain the beautiful fan-shaped bryozoan, *Phænopora superba*.

East Cliff was rounded on August 14 and the worst part of the journey was over, as there are three lighthouses, two telegraph stations, and many game warden camps on the low south coast. East Cliff is about one hundred feet high and faces the sea to the east with an extremely forbidding aspect. Its base is an ancient Silurian coral reef which extends seaward as a reef and submerged rocks.

East Cliff is a splendid locality from which to obtain basal Jupiter fossils. Corals of several species may be collected in unlimited quantity, while from the overlying shales slabs covered with an abundance of bryozoa and small brachiopods may be obtained. Free specimens of the trilobites *Calymene niagarensis* and *Phacopidella orestes* are common, and there is an abundance of the brachiopods *Atrypa reticularis*, *Eospirifer radiatus* and *Cœlospira hemispherica*. One can readily obtain from 30 to 40 species of fossils in the course of an hour's collecting.

Iron River was reached on August 25 and there we made what was probably the most attractive camp of the expedition. The tent was erected on top of the cliff, and cooking and eating were done beneath the overhanging cliff. The cliffs of Iron River and the adjacent coast are abundantly filled with fossils of the upper portion of the Jupiter formation.

We left Iron River on August 27. The weather did not promise a great deal, but I left on foot immediately after breakfast with directions for the boats to come when the wind changed. Pavillion River was to be the objective. I reached Pavillion River by two in the afternoon. I had not seen the boats all day. About four o'clock I started back and had retraced 6 miles of the journey, when the three boats came in sight about a half mile from shore. Just before I saw them I had shot a deer, so Rieck and Hamblin came ashore to take it into their dory. By the time this was done the other boats were out of sight and the water was beginning to get rough. Rieck and Hamblin shoved off. I walked along the beach at the mouth of Pavillion River. The other boats were not in sight and as it was dark I lighted a fire for a signal. Rieck and Hamblin finally appeared but were unable to reach shore because of the heavy sea and shallow water. However, they jumped into the water and I waded out to meet them. In this way we were able to bring the boat ashore. That night we slept on the sands and the

This slab from East Cliff, near the base of the Jupiter formation, shows abundance of bryozoans of the genus *Helopora*

The mouth of Iron River

next morning found that the other members of the party had passed the mouth of the river in the dark and had spent the night about a mile beyond.

The top of the Jupiter formation is exposed in the cliffs a short distance up Pavillion River and in another cliff three miles west of the mouth. It is doubtful if there are more fossiliferous strata in the Anticosti section than those of the upper twenty-five feet of the Jupiter formation. It is no trouble at all to collect a handful of beautifully preserved trilobites and a bushel of splendid brachiopods. Corals are also extremely abundant. The surfaces of the thin limestones are literally jammed with small shells and tests of brachiopods and ostracods, together with zoaria of bryozoa.

Ellis Bay was reached on September 11. The 1919 expedition was a success. The complete section was seen, not once, but several times, and the collections consisted of about two tons of excellent fossils, representing more than 400 species.

The Fossil Birds of North America

By ALEXANDER WETMORE
Assistant Secretary, Smithsonian Institution

THOUGH Emmons in 1857 described what is supposed to be a fossil bird from fragmentary bones from North Carolina, study of the bird life in the fossil deposits of North America may be said to begin properly in the year 1870, with the announcement by O. C. Marsh of five forms from the Cretaceous, and four from what were then called Tertiary formations. Others were recorded at once by Cope, while in 1872—from Marsh again—came notice of the first of the famous Odontornithes, the toothed birds of the Cretaceous beds of the west. The labors of the two eminent palæontologists mentioned continued to such good effect that in 1884 the list of described fossil birds had increased to 46 species. A number of others were added from various sources during the succeeding decade.

Exploration of Pleistocene beds, in what are known as the Fossil Lake deposits in Oregon, led to the discovery of large numbers of bones of birds, from which R. W. Shufeldt in 1891 and 1892 identified more than fifty species, including flamingoes, gulls, coots, grouse, eagles, a crow, and a blackbird among extinct species, and bones of the mallard, baldpate, hooded merganser, and many others among living forms.

Though rich in avian material the Fossil Lake beds have been eclipsed by discovery of the wonderful deposits in the asphalt lenses of Rancho-la-Brea near Los Angeles, California, which constitute one of the most important finds in this branch of palæontology on this continent, since they have yielded approximately 100,000 bones of birds. These have passed under the capable hands of L. H. Miller, who has found among them extinct and modern species of eagles and condors, a great heavy-beaked vulture (*Teratornis merriami*) a large gallinaceous bird, owls, storks, and many others. Knowledge of the Pleistocene avifauna of California has been supplemented by additional forms from asphalt deposits near McKittrick, and by bones taken from Shasta, Samwel and Hawver caves in northern California.

Between the birds of the Cretaceous and those of the Pleistocene that have just been mentioned intervene many interesting forms. Among those recorded from the Tertiary of North America, one of the strangest is the huge *Diatryma steini* named by Matthew and Granger in 1917 from a skeleton nearly complete, secured in the Eocene of the bad lands of Wyoming. This great creature, though not as tall as an ostrich, was heavier in body, with a massive head and neck and a compressed bill of tremendous size. Among the few other Eocene birds known, may be mentioned an owl-like form (*Minerva saurodosis*) and species resembling auks and avocets which have been described recently by Wetmore.

Forms of birds of the Miocene and Pliocene seem to have been similar in general appearance to those of today. From the diatomaceous beds of this age near Lompoc, California, Loye Miller has named shearwaters, boobies, auklets, and godwits closely allied to living forms. Explorations by parties of the American Museum in the deposits of Sioux County, Nebraska, supplemented by material secured by Mr. Harold Cook, and by Princeton University and the Carnegie Museum, have brought to light an interesting avifauna from the Miocene and Pliocene in which the present writer has identified hawks and eagles, a chachalaca, a limpkin, and a paroquet. In addition, from deposits in southern Arizona, recorded as of late Pliocene age, he has found a tiny goose, no larger than a duck, a tree-duck, some shorebirds, and fragments of an ocellated turkey, a bird that lives today in hot lowland jungles from Campeche south into Péten. With mention of J. A. Allen, F. A. Lucas, and C. R. Eastman, the list of those who have worked with our avian fossils is practically complete.

Continued investigations on the part of a number of institutions bring to light occasional bones of birds, usually of forms previously unknown, while there are still to be fully exploited Pleistocene and Recent cavern and fissure deposits. The present writer has identified a number of birds not previously known from midden and cave deposits in the Greater Antilles, among which a flightless land rail and a giant barn owl may be cited as perhaps the most interesting. That valuable data are to be obtained from careful study of such deposits is easily seen when we consider the results secured recently in Europe by Želízko in southern Bohemia, by Lambrecht in Hungary, and E. T. Newton in England and Crete, to mention only a few of those interested in such material.

At the present time the writer is engaged in revision of the fossil list from North America, for inclusion in a fourth edition of the official check-list of birds of the American Ornithologists' Union, from data that he has assembled for general work on this subject. The material at his command he believes to be more complete than that previously available to workers in the subject. The fossil list, exclusive of the West Indies, now contains approximately 150 species, while 100 additional forms of birds still found living have been secured from the Pleistocene.

In conclusion, attention is called to a further project dealing with avian fossils. Though students of this subject are often hampered by scanty material, they are fortunate in that their specimens are of such nature that reproductions may be made in plaster. Skilfully prepared, these are identical with the original and serve as well for study. Theodore S. Palmer, the energetic secretary of the American Ornithologists' Union, has been instrumental in organizing the project of having casts prepared of all types of fossil birds, so that they may be deposited in the principal museums of this country. When complete sets are finally available, there should result increasing interest in the subject of fossil birds.

Important Results of the Central Asiatic Expeditions

In far off Mongolia the Central Asiatic Expeditions of the American Museum of Natural History, under the leadership of Dr. Roy Chapman Andrews, are finding many a romance of former life hidden away in the Desert of Gobi. The region is a great interior basin surrounded by high mountains with all the drainage inland. Granite and greywacke rocks come to the surface and extend in every direction for great distances, but here and there the prevailingly level stretches are broken either by ravines, cliffs, escarpments, peaks, or basalt dikes. Small sediment basins also occur. These sediment basins are of vital interest in the present connection, for it is in the sedimentary and æolian deposits of former ages that the remarkable fossil finds are being made. The present abundant life that roams these great plains seeks the water holes, swamps, and intermittent lakes, as did the animals of the past.

In the following pages six members of the organization, Prof. Charles P. Berkey, and Frederick K. Morris, geologists, Major L. B. Roberts, topographer, Dr. R. W. Chaney, palæobotanist, and Dr. W. D. Matthew and Walter Granger, palæontologists, review briefly the most important finds in their respeetive fields.—Editor.

The Geological Background of Fossil Hunting in Mongolia

By CHARLES P. BERKEY AND FREDERICK K. MORRIS

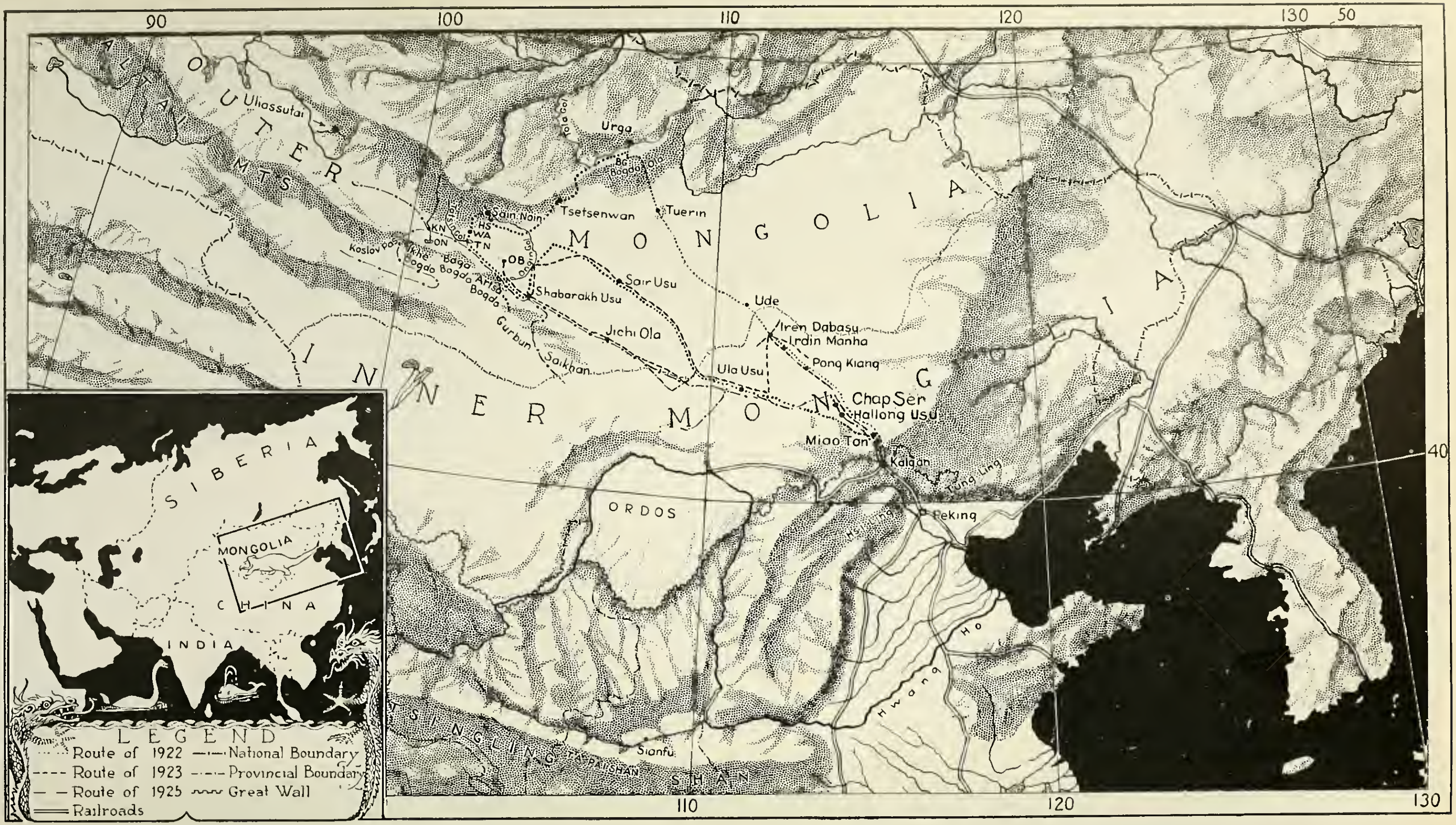
THE geologist's part in the romance of fossil hunting lies in reading contemporary history, piecing it together from the fragmentary evidence of the rocks that preserve both the fossils and the record. It is his task to find out what kind of a world it was in their time, and what has happened since, in the conviction that an interpretation of the physical conditions will be helpful both in leading to discoveries and in understanding them. All sorts of evidence are grist to his mill—rocks, fossils, structures, and surface features. Among his other activities, therefore, he is an inveterate fossil hunter. In this field the geologist works with the palæontologist to the same end.

Fossils could be found, of course, by any one who is willing to look for them. They could be collected by any one who would pick them up, and they could be classified by any one who would name and compare them. But all this might be done without greatly enriching our understanding. Collecting must be done in an orderly way, so that we know exactly from what stratum each bone came. Specimens so collected come to have a meaning in the succession of organisms and in the order of events, and take their place in science. Both geologist and palæontologist justly claim them.

The kinds of fossils found in the strata deposited in succession from earlier to later time differ in so orderly a manner over the whole earth that by means of them age may be determined. Thus, the organisms of a particular time whose remains lie buried in the rocks become distinguishing criteria in identification and age of strata.

When and how did Mongolia begin to accumulate fossil-bearing strata?

In the middle of the Age of Reptiles, Mongolia was uplifted into chains of rugged mountains. During the first few million years after the uplift, the mountains were worn down by the work of winds, frosts, and water, until the whole region became a nearly level surface.



MAP OF CENTRAL ASIA

Fig. 1—The mountains are shaded as though the light were falling from the upper left-hand corner, while the basins are left white. The mountain rim enclosing the Mongolian basin shuts out moisture so that the climate is dry and therefore almost none of the rivers reach the sea. During past ages such inland-flowing rivers have carried down to the center of the basin the sediments in which the fossils are found

Then the central portion of this low, nearly level country was lifted and warped into the form of a gigantic shallow basin, a million square miles older rocks (Fig. 2). It is only in this new series, belonging far up in the geologic column, that the great fossil fields of Mongolia have been found.

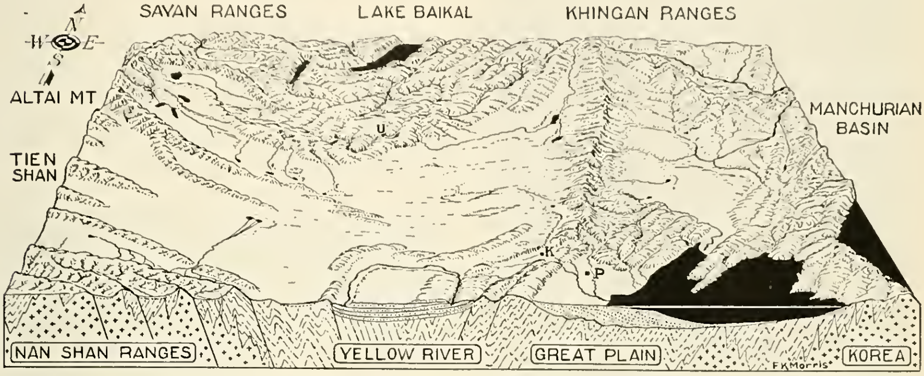


Fig. 2.—Perspective sketch of Mongolia and Manchuria. The drawing represents a block cut out of the earth's crust, showing the structure of the rock formations along the cut edge. Both countries are shallow basins surrounded by mountains. The basins are separated by the Great Khingan Range, whose steeper slope is toward the east. The sediments which have washed into the Mongolian basin in late geologic time contain the fossils of creatures which lived there while the sediments were being deposited. The letters P, K, U, stand for Peking, Kalgan, and Urga respectively

in area (Fig. 1.) The winds that swept across the continent dropped their moisture on the uplifted rim, and the rains that fell within the rim drained toward the interior. The inland-flowing rivers washed gravel, sand, and mud down from the highland margins and laid them out in thin sheets of sediment on the floor of the basin (Fig. 2.) These same rivers were the original gatherers of specimens, for we now find stems of plants and bones of animals enclosed in the muds which they deposited. It must have taken millions of years to assemble all this material from which were selected, in three short seasons, the collections brought back by the Expedition.

The contrast between these sediments and the rocks of the floor on which they lie is the most striking fact in Mongolian geology. The crumpled old rocks of the floor are remnants of the worn out mountains, and the overlying sediments are the beginning of a new series of strata, reposing on the upturned edges of the

All the largest mountain systems of Asia, even the Himalayas, have risen since the Mongolian basin was formed, and therefore are younger than some of these fossil remains. Growth of the continent to larger size and the building of new mountain systems have profoundly affected the rainfall, the temperature, soils and drainage, and thus have presented a changing environment in which plants and animals struggled for a chance to live.

The earliest sediments within the basin indicate a wetter climate than the present. Black muds were spread out in broad shallow lakes, forming layers as thin as paper, where fossil fishes, mosquitoes, May flies and caddis worms, are preserved as delicately as flowers pressed in a book (Figs. 3 and 4). They indicate an environment that exactly suited the huge, swamp-loving dinosaurs that belong to that time. But long ago, even during the Age of Reptiles, the climate began to change It must have become comparatively arid, for it is clear that the dinosaur

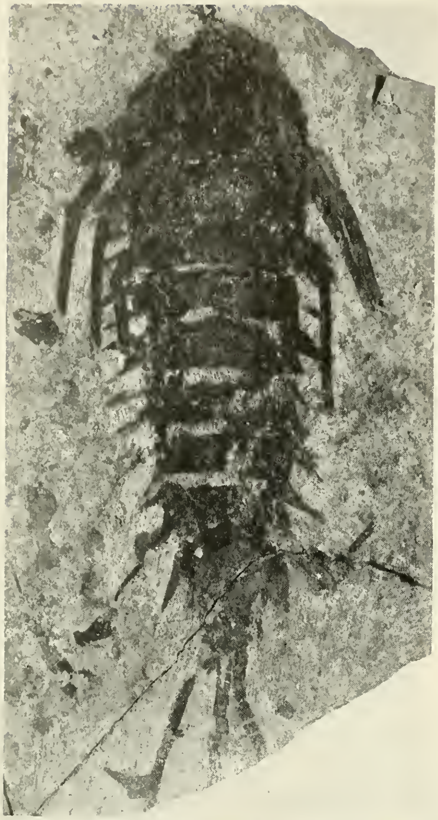


Fig. 3.—The larva of a giant May fly, almost natural size

eggs were laid in the sands of a semi-desert (Fig 4). All through the Age of Mammals, which followed, the rainfall was light and variable, but the withering rivers continued to deposit irregular strata of gravel, sand, and clay. Corresponding to this environment, we now know that there were many ranging types of animal life, like the titanothere and the giant *Baluchitherium*, together with small burrowing animals which lived much as prairie dogs do now in modern semi-deserts.

The last renewal of rainier conditions came in the great Ice Age, when there were cycles of wet, cold climate alternating with others that were warm and arid. In the wet cycles, lakes were enlarged, and rivers eroded the now abandoned valleys. In each arid cycle, which doubtless lasted for many thousands of years, their work of erosion was checked, and sediments clogged their courses. Thus it came about that this elevated interior basin, with its great stretches of steppe

Fig. 4.—Fossil "mosquitoes" from the Gobi Desert. They are not ancestral to our modern mosquitoes, but belong to a related family of *Chironomidæ*. They were contemporary with the largest dinosaurs yet found in Asia

country and its slowly changing climate, with all that such changes meant in abundance or scarcity of the necessities of life, constituted an environment that must have had a profound influence on the primitive human tribes, and may have been a major factor in compelling their migrations.

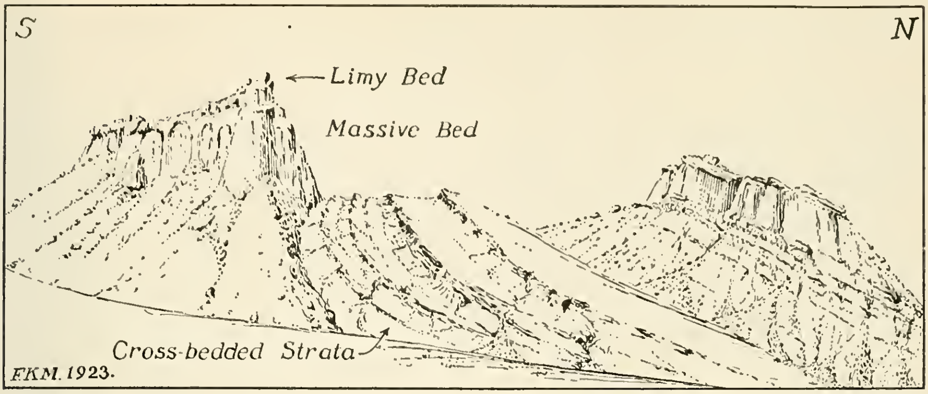


Fig. 5.—Field sketch of the dinosaur beds at Djadokhta. The sloping layers at the base of the picture are part of an ancient sand dune which was formed during the Age of Reptiles. The towering pillar at the left is a remnant of a bed of fine wind-blown sand. The rocks indicate a semi-arid climate at the time the dinosaurs lived

Topographic Surveys

By L. B. ROBERTS

THE general advance of exploratory knowledge depends on the manner in which records of progress are made available for others to use. This information is best understood when presented in map form, becoming, in reality, an intelligence document.

The topographic work accomplished as one of the many activities of the Central Asiatic Expedition to Mongolia during the field season of 1925 serves primarily as a base, on which information obtained by the various members of the party can be made a matter of record, through overprints, and can supplement their written reports.

Two classes of maps were produced; first, a topographic route map, to scale, of every mile traversed, constructed as a continuous line from Kalgan, the starting point of the 1925 Expedition, to the most western point reached on the traverse; second, a more detailed small scale topographic map of those localities of special interest where important scientific evidence was obtained.

The plane table method was used in all mapping work, orientation being obtained independently of magnetic compass bearings by means of the Baldwin Solar Chart. Distance was obtained, on the route traverses, by automobile speedometer, an adaptation of the perambulator method used with considerable success by British exploratory parties.

Differences of elevation were secured by vertical angles; and it is believed that elevations are reasonably correct. Because of disturbed local conditions, it was not possible to complete the route map as a closed circuit, and the line is not checked.

On such work as in this area, a topographer contends constantly with wind and wind-blown sand, with extremes of heat and cold, with distorted images and mirages; and he must be alert to adapt all known topographic methods to the conditions imposed by constantly changing circumstances.

Bearing of Palæobotany on Habitat Conditions in Mongolia

By R. W. Chaney

FOSSIL plants, like those now living, furnish the most reliable information as to habitat conditions. Unlike land animals, the plants of the land are held in place by their roots, and cannot escape to more favorable situations during seasons of drouth or temperature extremes. Their existence at a given point indicates an ability to withstand all the conditions there over a considerable period of years, which in the case of trees commonly reaches one or several centuries.

Most of the fossil plant material collected in Mongolia is in the form of petrified tree trunks. None of these has been finally identified but, from the small size and twisted stems of many specimens, it is clear that they are related to the trees now living in the semiarid parts of the world, where conditions are not favorable for tree growth. The more delicate plant structures, leaves and fruits, are for the most part absent from the Cretaceous and Tertiary sediments of Mongolia. As they fall from the trees today, these structures become dried and decayed, except in regions of standing water, where they mingle with the sediments and leave their impression in the resultant shales and sandstones. The scarcity of such impressions in the sediments of Mongolia suggests that its past climate was too arid for the presence of many permanent water bodies. At the two places where leaf impressions have been found, in the Cretaceous at Ondai Sair and in the Pliocene or Pleistocene beds at Hung Kureh, the plants represented are of aquatic types not greatly unlike some of those living on the borders of Orok Nor today.

The Most Significant Fossil Finds of the Mongolian Expeditions

By W. D. Matthew and Walter Granger

PERHAPS one may best sum up the importance of the fossil finds in Mongolia as the discovery of a new continent. New, that is, to palæontology. For while the present geography of Asia and its existing animals are fairly well known, the record of its past animal life was almost a blank page. We knew a good deal about the extinct animals of India, especially in the later Tertiary, and a marvelous series of faunas they were. But the animals of India are, and probably were in times past, very different from those of Asia north of the Himalayas. It is and was a distinct geological region. We knew a little about the Pliocene and Pleistocene animals of China, chiefly based upon fossil teeth and bones purchased in Chinese drugstores, where, under the name of dragon's teeth and dragon bones, they have long been sold for medicine. Of the earlier record of land animals in Asia nothing was known. It was a land area of great geological antiquity as well as of vast size; so much had been shown by geological exploration. Its past relations, geographic and faunal, to Europe and North America, to India and Africa, were a subject of fascinating speculation and of theories which, however strongly supported by inference and indirect evidence in the geology and faunas of these other continents, cried aloud for the crucial test of a few direct facts which would show whether or not they were sound.

Well, now we have the facts. Not all we should like to have or hope to get, but a very substantial body of them, sufficient to get a pretty good "line" on the characters of the successive faunas that inhabited Central Asia during the Cretaceous and Tertiary periods. One hundred and ten new species of fossil mammals and reptiles have already been described from the collections of the Central Asiatic Expeditions. Most of these belong to new genera, a few even to new families. They represent ten distinct successive faunal stages in the Cretaceous and older Tertiary, the largest and latest fauna being the Hsanda Gol *Baluchitherium* beds with more than thirty species.

To this evidence must be added the important results of the Chinese Geological Survey collections in the later Tertiary of North China, and those of the Russians in the Kirghiz and eastern Siberia. All in all we have now a pretty fair record of the extinct animals of Central Asia during the Cretaceous and Tertiary.

Probably the most important of these Mongolian discoveries, certainly the most interesting to the general public, is the Cretaceous desert fauna of Shabarakh Usu. This is the famous dinosaur egg locality, and it is the eggs, a familiar object in a very strange association, that appealed to everybody's imagination. They were really important scientifically, for it was the first positive proof that dinosaurs laid eggs, or at least that this kind of dinosaur did, for 'dinosaur' like 'pachyderm' includes a wide variety of animals, no more nearly related to one another than are a hippopotamus and an elephant. To the scientist the skeletons and skulls of the dinosaurs that laid them are of more importance than the eggs themselves, and a series of twelve skeletons and more than seventy skulls in all ages from newly-hatched young to adult makes this at present the best known type of dinosaur—even better than the famous *Iguanodon*. Four or five other kinds of dinosaurs and some smaller reptiles are also represented by skulls and skeletons. But of even greater interest to science are half a dozen tiny mammal skulls, the largest only an inch long, found in this same formation. Mammals of the reptilian era are excessively rare and, with one exception, nothing better than parts of jaws and teeth had ever been found. These skulls will increase greatly the scanty evidence as to the origin and earlier evolution of mammals.

Another large dinosaur fauna found at Iren Dabasu is of much scientific importance although of less popular interest. Preliminary studies indicate it as probably ancestral to the great Cretaceous dinosaur faunas of North America.

The earliest Tertiary fauna is the Gashato, of Palæocene age, and of curious and rather unexpected character. We had expected to find in this horizon the ancestors of the four-toed horses of North America and Europe. Instead we found the ancestors of certain South American ungulates whose origin had been equally obscure, but which we had expected to find in North America rather than in Central Asia. With these we find the ancestors of the giant uintatheres of North

America and a variety of other interesting small mammals.

Then there are three successive mammal faunas of the later Eocene. These include some large rhinoceroses and titanotheres so closely related to the American species that they have been placed under the same genera, and a considerable variety of smaller animals, also prevailingly American in relationships. Among them is the most gigantic of the Carnivora, *Andrewsarchus*, related to the American *Mesonyx*. In the latest of these Upper Eocene faunas appears the first of the ruminants, ancestral probably to those of the Oligocene of Europe and North America. But it is remarkable that we find no trace in the Eocene of Mongolia of the four-toed horses of the American, or of the palæotheres of the European Eocene. In their place occur various small, slender-limbed animals related partly to tapirs, partly to rhinoceroses, but not closely to either group.

Two Oligocene faunas follow; a third probably has been added by explorations of 1925, but the collections have not yet been studied and compared. The Lower Oligocene Ardyn Obo fauna contains the last of the titanotheres, nearly related to its American contemporaries, also various rhinoceroses, large and small, primitive Carnivora and a few rodents. The affinities of this fauna are rather more European than American.

The Middle Oligocene Hsanda Gol contains the giant rhinoceros *Baluchitherium*, a beast as large as an elephant, but in proportions a long-legged, long-necked rhinoceros, hornless and rather small-headed. The rest of the fauna consists of a few medium-sized and many small mammals, mostly Carnivora and rodents, some of them represented by many hundreds of jaws, others comparatively scarce. A few insectivores, intermediate between tree shrews and jumping shrews, are of unusual interest, as so little is known of the fossil history of these animals. Many of these carnivores and rodents are related to European Oligocene animals; some to American, and one or two find their nearest relatives in Africa. Rabbits are very abundant, but they are related rather to the Old World picas than to the New World true hares.[1] Here, too, we find the earliest true deer (*Eumeryx*), ancestral to the Miocene deer of Europe and North America.

Here then is a series of fossil faunas Cretaceous and Tertiary in age, from a region unknown to palæontology. They are represented not by a few fragments but by a great series of specimens, finely preserved skulls and skeletons, thousands of jaws, articulated limbs and feet, and so on. A few of them we have noted by name, but it is in fact the entire series of faunas, the light that they throw on the climate and conditions of Asia, the relationships and origin of various races of mammals and reptiles and upon numerous related problems; it is the whole of this large addition to scientific knowledge that is important, far more than any selected features. The dinosaur eggs, the giant *Baluchitherium*, or the huge carnivore *Andrewsarchus*, are of more popular interest but of no more scientific importance than the inch-long Cretaceous mammal skull or the equally tiny tree shrew skull with its possible bearing upon the origin of the Primate order.

[1]Old and New World respectively in origin, but each group has invaded the homeland of the other.

Scenes and Activities in Mongolia[1]

PHOTOGRAPHS TAKEN BY THE CENTRAL ASIATIC EXPEDITIONS
OF THE AMERICAN MUSEUM OF NATURAL HISTORY
DR. ROY CHAPMAN ANDREWS, LEADER

THE LEADER OF THE EXPEDITION INSPECTING A NEST OF DINOSAUR EGGS

The first dinosaur eggshell was found by Granger at Shabarakh Usu in 1922. The first nest was discovered by Olsen in 1923, and during the season several additional nests and many individual specimens were recovered. Olsen scored again in 1925, bringing in the first eggs of the season. Andrews is seen with this find, which was the first proof that the vigorous search of 1923 had not exhausted the supply

THE SUMMIT OF WAN CH'UAN PASS

Through a breach in the Great Wall between China and Mongolia a caravan trail enters the desert basins of Central Asia. The Expedition cars are seen in the gap, beside a ruined watch-tower of the wall, which follows the edge of a scarp of basalt forming a natural strategic boundary for many miles. The terraces, at the extreme left, are the approach to a small Buddhist temple. Here devout travelers are wont to tarry before venturing into the vast lonely stretches of the desolate interior

THE STAFF AT BREAKFAST

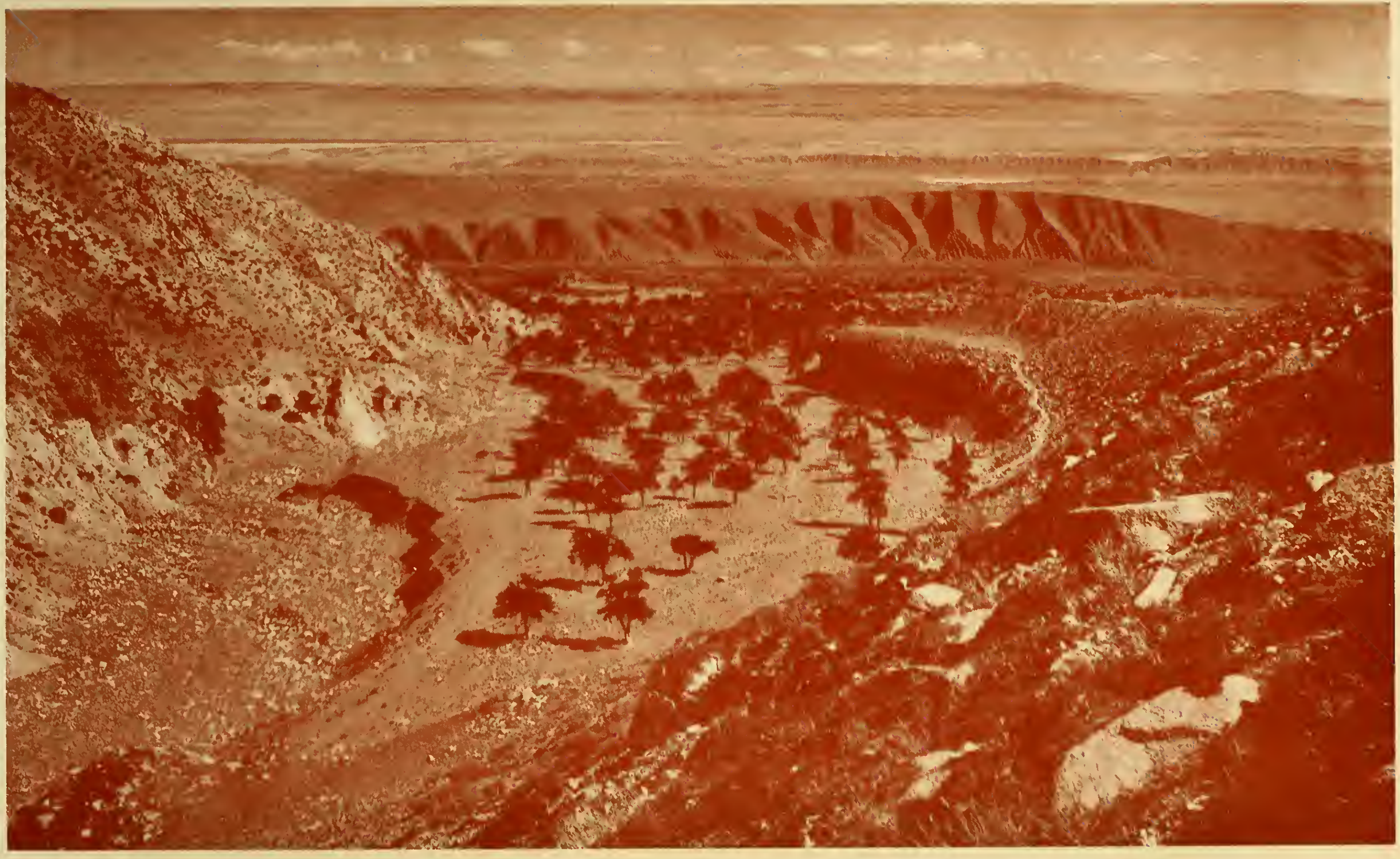
At breakfast and dinner the members of the staff were wont to assemble in the great tent and plan the day or recount adventures. Granger, Morris, Shackleford, Chaney, Butler, and Young face the camera; Robinson, Lovell, Nelson, Loucks, and Olsen face away. Andrews, Roberts, and Berkey are not in the view. The tent carries characteristic Chinese designs, the central one being the long life symbol, and this is surrounded by five conventionalized forms representing the bat, a symbol of happiness. The design along the ridge pole is a combination of swastikas, bats, and lotus flowers

THE TOPOGRAPHERS MAPPING THE VALLEY OF SHABARAKH USU

Chief topographer Roberts, at the right, records the observations made by Butler with the Gurley transit. At the left, Robinson, as rodman, uses a camel to speed up the taking of stadia-readings. In the background, beyond the native yurts, are eroded remnants of ancient sand dunes which rest upon still older deposits made by a sand-choked stream at the close of the Ice Age. Here were found thousands of stone artifacts, left by a vanished race of primitive man

GRANGER AT ULA USU, PREPARING A TITANOTHERIUM SKULL FOR SHIPMENT TO NEW YORK

These fossil bones of Eocene age often crumble when uncovered. To preserve such specimens, the bone is first soaked with gum arabic, which cements the particles together; then Japanese rice paper is stippled on with a brush. When this has dried, the specimen is bandaged with strips of burlap dipped in flour paste, which hardens and prevents breakage on the long trip to the American Museum of Natural History



THE SEDIMENT BASIN NORTH OF THE ALTAI RANGE

The photograph was taken from the mouth of Tiger Cañon which dissects the northern face of the Baga Bogdo mountain-block. The distant skyline is the Mount Uskuk block of ancient crystalline rocks. In the foreground are three terraces, marking three pauses in downward-cutting, corresponding to as many recurrent changes in the climate of the region. This is the Tsagan Nor basin, lying between Mount Uskuk and Baga Bogdo, one of the largest and most productive of scientific results found in Mongolia. In the distance, near Mount Uskuk, lie the collecting stations, Ondai Sair and Loh, where literally thousands of fossil specimens were gathered, ranging from lowest Cretaceous to Miocene age. The steep-sided, flat-topped hills at Hung Kureh, in the central distance, are composed of sediments washed from the uprising mountain range during the Pliocene and Pleistocene periods. Fossils of deer, ostrich, mastodon, and horse were found here, those of the horse being the oldest bones of its race thus far discovered in Asia

OLSEN DIGGING OUT THE LEG OF A TITANOTHERE

This is a typical Gobi Desert scene. The view is taken at Ula Usu in the Shara Murun district, about 300 miles northwest of Kalgan. Early Tertiary sediments underlie a great stretch of country and are eroded to bad-land form at many places, baring great areas of sediments to the search for fossils. From Ula Usu an especially fine lot of material of Eocene age was recovered. This spot was discovered in 1922, and extensive collections were made during the seasons of 1923 and 1925

PLANT COLLECTING IN THE GOBI

Chaney, the palæobotanist, finds a greater number of living plants than fossil forms. The traveler is always surprised at the variety to be found in so arid a region, which, to the casual observer, seems almost barren. There is, in places and at times, a wealth and beauty of vegetation that surpasses belief. About five hundred different species were collected during the 1925 season

Each fossil shell or bony fragment lures the imagination of the finder to picture the creature as it lived, its surroundings and associates, but as the writer stood within the ruins of the most celebrated school of the ancients and picked up this fragmentary elephant tooth there was an added stimulus, for it seemed to come from the invisible hand of the master Hippocrates, passed on as a problem unsolved by his philosophy. (Photograph is natural size)

Is This the Earliest Known Fossil Collected by Man?

By BARNUM BROWN

Associate Curator of Fossil Reptiles, American Museum

THIS small elephant tooth, identified as a milk molar of *Elephas antiquus*, is priceless because of its association, having been collected by the ancients more than 2000 years ago. Indeed it may have been handled and discussed by Hippocrates himself, for it was dug up where I found it among the pieces of statuary and figurines in the ruins of the famous Asklepieion, the medical school where he prosecuted his earlier studies.

Cos Island, in the Ægean Sea, lies close to the mainland of Asia Minor opposite Halicarnassus. Here are two small exposures where the Pliocene fossils *Hipparion*, *Bos*, and *Elephas* have been found—a thirty-acre area three miles southeast of the town of Cos, and another area of equal size one-half mile west of Cardamina on the south shore near the middle of the island, about ten miles westward.

Asklepieion, the ancient medical school, was located approximately midway between these points on the slope of Mount Prion, and it is evident that the fossil had been carried there in ancient days, for it was covered by débris in the ruins of one of the larger buildings.

Hippocrates has been called the father of medicine, for he was the first to introduce principles of inductive philosophy in the practice of medicine, which previous to his time had been a system of superstitious rites practiced wholly by the priests. He was born on Cos Island in 460 B.C. and his famous medical school flourished long after his death, but the Asklepieion was a ruin before the Christian era, so I believe this to be the first recorded instance of a fossil having been collected by man.

FELTONS HARBOR ON NORTH SHORE OF RIO GALLEGOS, ARGENTINA, SHOWING MUD BARS EXPOSED AT LOW TIDE

Fossil Hunting in Patagonia

By ELMER S. RIGGS
Associate Curator of Palæontology, Field Museum of Natural History, Chicago

PLANS for a palæontological expedition to Patagonia were first laid by the writer many years ago when a student-member of a field party under the late Professor Williston. Inspired by the enthusiasm of this great teacher, my intimate friend Barnum Brown and I had, out of the wide opportunity of college activities, chosen to follow the lure of palæontology. In the first flush of boyish zeal we canvassed the field of possibilities from Alaska to Patagonia. And so, lying awake in our bunks among the sagebrush of Wyoming to enjoy the coolness of a desert night, and looking up into the starry canopy above, we planned an undertaking which each of us was sooner or later to carry out under the constellation of the Southern Cross.

Toward the close of the year 1921, renewed activities of the Field Museum, backed by the generous support of Captain Marshall Field, made it possible to revive these plans. A series of expeditions to South America, covering a period of five years, resulted. The purpose of these expeditions was to make further studies of the geology of Argentina and of adjacent states, and to bring together collections of fossil mammals. These mammals belong to a unique system of animal life which had its earliest known dispersal in an ancient continent of which Patagonia is only a vestige.

A field party consisting of two collectors of wide experience in palæontological work, Mr. J. B. Abbott and Mr. G. F. Sternberg, under the leadership of the present writer, sailed for Buenos Aires in November, 1922. The party was courteously received by the director and the scientific staffs at the Museum of La Plata, and at the National Museum of Buenos Aires. Many favors were extended by scientists and by citizens throughout Argentina. American and British citizens at Rio Gallegos not only extended courtesies but lent substantial aid to the expedition in many ways. With the assistance of these new-found friends the work of the expedition was well and favorably begun.

Patagonia has long been a field of particular interest to naturalists. Early in the nineteenth century came Darwin as a young man on the famous *Voyage of the Beagle*. Later the Argentine pioneer naturalists, the Brothers Ameghino, and others from Europe and from North America followed. The task of the present expedition was therefore not one of exploration, so far as the Santa Cruz formation was concerned, but one of making a representative collection from a well-known region, and to accomplish this within a limited time.

The Santa Cruzean formation, as exposed in the cliffs along the eastern Patagonian coast, is about 300 feet in thickness. Fossils were found in these cliffs at almost all levels. However, the steepness of the cliffs often rendered them inaccessible to men working on foot. Landslips have from time to time carried down acres of the pampa and left the earth piled up in great windrows at the shore. The waters of the inrushing tide, rising to a maximum of fifty-eight feet, dissolve and carry

The Santa Cruz formation exposed on the north shore near Rio Gallegos, Argentina

away these clays. The sands are more slowly carried away and distributed over the sea bottom. The gravel and harder masses are left to accumulate on the beach, but are slowly worn away. Great blocks of stone are moved and ground together by the waves and are slowly disintegrated. In short the tide flat is a great natural sorting-pan; the waves as the moving agent, select and distribute the material according to mass and gravity.

Along these flats careful search reveals the fragments of fossil bones laid bare in this process of degradation. We find them as little brown fragments, broken and mingled with the gravel. We find them appearing like the broken ends of brown and hollow rootlets exposed at the surface of the fallen blocks of stone, accumulated at the shore. We find them exposed in the ledges of sandstone and in the layers of clays on the tide-flats where twice daily they are swept clean by the

Camp of first Captain Field Palæontological Expedition at Estancia La Costa, Santa Cruz, Argentina

advancing and retreating tides. We find them exposed in the steep faces of the cliffs where access is difficult and where the glare of sun on whitened surfaces sometimes drives one blinded and dizzy from the task. In this work there is no fixed rule and no guiding landmark. The collector must carefully, foot by foot and mile by mile, go over the more promising stretches. In so doing, success in every varying measure rewards his efforts.

The roadways along this Patagonian coast in many places run parallel to the shore but usually several miles inland, —beyond the obstructions offered by estuaries and the bluffs of stream-valleys. Through long stretches the height and the steepness of the sea-wall make approach to the shore impossible. Once in ten miles or more our party found valleys of small streams which offered passageway for men on foot and often for saddle-animals. Once reached, the hard sea-sand at low tide, offered a safe and convenient passageway up and down the shore for men and for saddle-horses. By this means, the shore exposures were worked eight or ten miles each way from camp bases.

The means of transporting specimens from the shore to the nearest point for loading upon vehicles, offered many problems. The specimens were usually brought together on shore by man-power and cached above the reach of tidewater on some bench of erosion or of landslip. From these points they were sometimes borne to camp on saddle-horses. On one occasion the curved fragment of a broken rowboat was made use of as a sledge and with specimens loaded upon it was drawn along the sand by a horse at the end of a saddle-rope. Boats on the open sea were not to be thought of, but on the estuary of the Rio Gallegos, a dory was made use of for this purpose.

Excavating a specimen in the Santa Cruz formation at Rio Coyle, Argentina

Members of the Captain Field Palæontological Expedition and their host and hostess at the Meteorological Station, Colonia Sarmiento, Argentina

At the south side of Rio Coyle, where the stream valley approached the beach without more obstruction than a wide stretch of loose gravel, a light motor car was brought to the beach by the aid of man-power. Once on the hard sea-sand this car was employed to speed rapidly along the tide-flat for a distance of ten miles and return with a load of four hundred pounds of specimens. Returning again, this operation was repeated five times between tides, and the accumulated cargo and machine safely removed from the beach before the next high tide.

On the north side of Rio Coyle conditions were less favorable for such operations. Specimens discovered some miles from the shore in a wide bush-covered basin, were to be conveyed to Estancia Coyle. A considerable embankment of sea gravel thrown up by the waves at high tide prevented approaching this basin from the shore. A continuous rim of cliffs some two hundred feet in height offered a similar barrier from the land side. The course of least hazard was decided upon. With rope and tackle the little car was let down the steep slope from above. A road was cleared across the basin and the specimens conveyed to the shore. There they were unloaded, the car again pushed across the gravel barrier by man-power, and the return along twenty miles of shore sand was begun.

In this last undertaking, rapid travel over hard, wave-marked, sand caused such a vibration in the car that a break in the front gear resulted. This occurred on the second trip of the morning, with a car loaded with specimens, and only an hour's margin of safety before the incoming tide would sweep over these sands to a depth of thirty feet. The needed "spare parts" were not at hand. Unless repairs could be made within the hour both car and specimens would be lost. The situation was met by driver and mechanic hurrying ashore, making a fire of driftwood, and doing a hurried piece of blacksmithing before the returning tide should overtake them.

The collectors of the party spent the first winter near Comodoro Rivadavia. As soon as the rains of late winter had somewhat abated they broke camp and set out to reach the Rio Chico. The locality which the Amherst Expedition in 1911 had found so productive in fossils of the *Pyrotherium* zone was the first objective. The way lay across a pampa two thousand feet above sea level which had recently been covered with heavy snow. After one unsuccessful attempt, and after spending two nights on the high pampa, the desired locality was reached.

A single tent protected by thorn-bush barricades as a shelter against wind and snow, constituted the camp. This was located in an open valley dotted by occasional buttes of the Patagonian formation. A single butte a half mile in length had preserved a section of an old channel deposit. In this butte fossils were found in limited quantities. The intensive work of the Amherst Expedition had left few specimens to be found.

The collectors were impatient to move on to new fields. A new supply of plaster of Paris now enabled them to take out a rare specimen of fossil bird and other specimens which had been discovered there. After spending another week in reconnoissance along the valley, a move westward to the region of lakes Coluhuapi and Musters was decided upon. A flooded stream and boggy roads made the valley of the

Rio Chico impassable. It was therefore necessary to return to Comodoro Rivadavia and to approach the lake region from the southward. Renewed rains again held the party inactive through the month of October. Valuable time was thus lost before supplies could be forwarded and the move toward Colonia Sarmiento begun.

One of the great dinosaur bones of the San Bernardo Hills, Chubut, Argentina

We camped at the source of the Rio Chico, where that stream issues from Lake Coluhuapi; gray shale bluffs were observed on either side of a narrow valley. After an hour or two of prospecting late in the evening of our arrival, Mr. Abbott returned to camp to report the occurrence of fossil dinosaurs in the gray shales. Somewhat dubiously he also announced finding evidence that another collector had been there before us. Together he and the leader of the party visited the locality of his discovery next morning, and found in a small cañon evidence of earlier work.

Bones of large dinosaurs had been dug out of the shale of the hillside and piled up in heaps on a level area at its base. Leg bones, pelvic bones, and vertebræ, all broken into many pieces, had been carried some distance and piled up, the pieces of a single bone constituting a pile. There they were found, without wrappings and without mark, to indicate ownership. Subsequent rains had washed mud from the hillside over them; sun, rain, and wind had weathered them so that they were now falling into decay. Three or four thousand pounds in all, this accumulation represented no small labor on the part of an earlier collector. Inquiry made of the oldest settlers failed to reveal who the collector was, or in what year his work had been done.

Some days later a deserted camp was encountered near the old fossil-cache. A ring of stones marked the outlines of a bush-shelter, or *tolda*, such as were earlier constructed by the Indians of this region, and which are still employed by the shepherds for temporary camps. A drift-pick, a shovel, and two hammers, all bearing the mark of a Sheffield tool-maker, together with a ring-bolt and the iron handles of a chest, offered the only clue. The shovel blade was rusted through from the waters of rains and of melting snows which had been caught in its concave surface. The ashen handle was old and weathered. The less durable hickory handles of pick and hammer had rotted away. Many years had certainly passed since this unknown devotee of science had done his work and had, perhaps, passed on in search of carts to remove his treasure to a seaport one hundred miles away. At any rate, no grave or other mark was found to indicate that serious mishap had befallen him.

The outcrops of the Deseado formation at Lake Coluhuapi offered some promise of fossils. Camp was established on the shore of the lake, in an adobe house, near the home of an Italian-Argentine fisherman. Saddle-horses were procured and search along the neighboring escarpment was pushed for several days. In the course of this work an old cart track leading from the shore toward the bad-land hills was discovered, and repaired in places where washouts had made it impassable. The motor truck was then brought into use to convey the members of the party to the scene of the day's collecting. By frequent use of pick and shovel this roadway was extended eight or nine miles into the bad lands from which point the work was continued on foot.

Collecting in the *Pyrotherium* beds, Rio Deseodo, Argentina

In this locality the Deseado formation has a thickness of perhaps six hundred feet. This consists of strata of clays, and of sandstone. In the upper strata were found the teeth, tusks, and various bones of the gigantic mammal, *Parastrapotherium*. Another large, and equally strange beast bears the name of *Pyrotherium*. Just enough fragments of these animals were found to add zest to the search. Molar teeth of the former, having a grinding surface more than three inches square, broken jaws, and tusks thirty inches in length, proclaimed the unusual size and character of this little-known form. Isolated jaws of the second great animal had been discovered by Ameghino forty years ago, but as yet no complete head has ever been found.

A more prolonged search resulted in the discovery of a fossil forest. The first indication of this was encountered in the form of a fossil pine cone brought out by the keeper of a roadhouse on the shore of Lake Coluhuapi. The informant said that this specimen had been found sixty leagues to the southward. Some time afterward a station keeper on the south shore of the Gulf of St. George displayed two similar specimens which were said to come from twenty leagues to the westward. Again at a crossing of the River Deseado we had seen others which were said to come from twelve leagues to the southward. Employing the owner of the last specimens as a guide, we traveled four days in a motor car to reach the goal, and this three months after the first specimens had been seen.

Having reached the locality in the vicinity of Sierra Madre y Higa, we found a considerable number of fossil trees, some with stumps standing, others lying prone with broken branches and cones scattered about them, revealing a forest of fossil *Arecaria* or Brazilian pines preserved on the site where it had grown. A large collection of these specimens was made.

A more surprising claim was set up by a gentleman of scholarly training who reported that he had examined the skull of a fossil man which had been found in the Santa Cruzean Formation at Passo Ibanyez on the Santa Cruz River. A further claim of a "buried city" on the shore of Lake Cardiel had led to another five-hundred-mile journey with less satisfying results. The skull of "fossil man" proved to be only a curious concretion; the "buried city" a natural lava dike which had been thrust up through clays of Cretaceous age, and had in turn been laid bare by erosion.

It may be said that the remote corners of the world are often favorable sources for extravagant stories. In our own country, Texas, California, and Alaska have in turn given out such emanations. It is not surprising that Patagonia should have held a similar position as a source of romance. The irony of circumstance has decreed that one of the most improbable of Patagonian stories should come true.

Rumor in the later nineties reported that a gigantic animal similar to the great Argentine sloth, *Mylodon*, had been seen in the "jungles" of southern Patagonia. Some time afterward a peon employed on a sheep farm visited a cavern near by and brought home and made a whiplash of a piece of dried hide which he had found there. As a result the scientific world was startled by a report that fresh bones, dried skin, and other evidence of a Mylodon-like animal had been discovered at the Cave of Ultima Esperanza. It was even asserted that quantities of cut-grass upon which the animal had fed were found in the cave. These reports were substantiated by a group of Argentine scientists. Their investigations added to the list of extinct animals the recognized name of *Grypotherium*, an animal which is probably more recently extinct than the Great Irish Deer of the fourteenth century.

NOTES

THE AMERICAN MUSEUM GREENLAND EXPEDITION

The Schooner "Morrissey," bearing the Greenland Expedition of the American Museum of Natural History, sailed from New York on June 20, 1926, and returned on October 2, 1926. During this time approximately eight thousand miles were covered. The party visited a number of places on the west coast of Greenland, from Holstenborg in the south to Inglefield Gulf in the north (about latitude 77° 30′ N.). This being an "open year," due to a comparatively mild winter and an early spring, no serious difficulties with ice were encountered. There was continuous daylight from the time Davis Strait was reached in the first days of July until the first of September when the homeward journey was begun.

The collection made for the Museum consisted of mammals, birds, fishes, and invertebrates. The most important specimens are the narwhals, of which several adults, one young and two foetal specimens, were secured. These afford extremely valuable material for exhibition, for the study of the soft anatomy, and for osteology.—H. C. R.

ASTRONOMY

Dr. Clyde Fisher spoke on "Popular Astronomical Education in Europe and America" at the annual meeting of the American Astronomical Society held early in September at the Maria Mitchell Observatory, Nantucket, Mass.

Plans for the Proposed Hall of Astronomy, to be a part of the American Museum of Natural History as outlined in the Astronomy (July–August) number of Natural History, are developing in an encouraging manner. In this work Doctor Fisher is aided by Miss M. Louise Rieker as secretary and by Mr. Charles J. Liebman, Jr., as assistant.

BIRDS

The Ruwenzori–Kivu Expedition.—Mr. Frank Mathews, a member of the Ruwenzori Expedition, who returned to New York City in September to enter a medical school, reports that Dr. J. P. Chapin and Mr. DeWitt L. Sage, the remaining members of the Expedition, are working with success and undiminished enthusiasm. Chapin writes of his ascent of Mt. Kenia as follows:

"The two parts of the mountain where birds appeared most numerous are the mountain forest (subtropical) from 5600 to 8500 ft., and the groves of large trees just above the upper level of the bamboos, near 10,000 feet. The bamboos are relatively poor in birds, and so of course is the more open country above the timber line, where, however, there is a splendid sunbird (*Nectarinia johnstoni*), a small thrush (*Pinarochroa sordida*), a starling (*Cinnamopterus tenuirostris*), a buzzard (*Buteo augur*), a swift (*Micropus mella africanus*, I think), and possibly a few other birds."

In a letter dated Nairobi, July 1, Doctor Chapin reports the collecting of complete material for a habitat group of the bird life of the great Rift Valley, which will include ostriches, bustards, jabirus, vultures, francolins, secretary birds, weaver birds, and other smaller species. This collection, together with color sketches, diagrams, and photographs has now reached the Museum.

CONSERVATION

National Parks in the East.—A movement is on foot to purchase from private interests 600 square miles of virgin territory on the boundary line between North Carolina and Tennessee known as the "Great Smoky Mountains" and to present the tract to the United States Government for development and preservation as a national park. In the Blue Ridge Mountains of Virginia about 400,000 acres are also sought for the same purpose. Since the creation of nineteen national parks in the West, out of the public land preserves, more than 2,000,000 people visit them annually. The establishment of national parks in the East will place within easy reach of the congested areas of population these great natural playgrounds.—C. A. R.

EXTINCT ANIMALS

The Childs Frick Expedition in the Mid-Miocene Deposits of Santa Fé, New Mexico.—The 1926 field party in charge of Mr. Joseph Rak, assisted as last year by two members of the Museum's preparation department—Mr. Charles Falkenbach and Mr. Charles Christman (who was associated with Mr. Rak in the work the past winter at Barstow)—has enjoyed a particularly successful season, having forwarded twenty-three cases of specimens to the Museum to date. Mr. Frick joined the party in September and spent a fortnight with Mr. Rak in a reconnaissance of contiguous areas and a checking of the stratigraphy.

HISTORY OF THE EARTH

Seismograph Record of Explosion at Lake Denmark, New Jersey.—The explosions at the United States Naval Ammunition Depot at Lake Denmark, New Jersey, on July 10, 1926, were recorded on the seismograph at the American Museum, some thirty-one miles distant. The wave undulations, when magnified a hundred times, are less than one millimeter in amplitude. Separate explosions were recorded at 4:28:00," 4:29:30" and from 4:31:00" to 4:34:00" p.m. Eastern Standard Time. Another explosion occurred at 5:06:30" p.m., The record of these local disturbances has been of service to representatives of the United States Bureau of Mines and the United States Geological Survey in their study of the disaster.—C. A. R.

MAMMALS OF THE WORLD

Blue-nose Sheep from the Central Asiatic Expeditions.—During the past summer a shipment of 391 mammals has been received from the Central Asiatic Expeditions. The most noteworthy specimens, in addition to 7 argali sheep, 7 ibex, and 6 wild asses, are a series of Bharal or blue sheep (*Pseudois nahura*), a male, a female, and one young. The Bharal is especially interesting scientifically and is new to the Museum's collections. This sheep is distinctive in that it is closely related to the goats in many respects. The face glands, which are found in all true sheep, are lacking in the Bharal, as in the goats. Another goatlike character is its greater length of tail. However, the Bharal has glands between the hoofs of the fore and hind feet, as in the sheep, whereas the goats have these glands in the fore feet only.

Morden-Clark Asiatic Expedition.—This expedition continues to meet with success in its collection of the large mammals of Turkestan. A sufficiently large series of *Ovis poli*, the spectacular wild sheep of the Pamirs, has been obtained, and now the expedition is concerned with working its way out of the country preliminary to the return home.

Because of political troubles in China, which prevented carrying out the original plan of the Morden-Clark Expedition to join forces with the Third Asiatic Expedition at the close of work in the Pamirs, Mr. Morden and Mr. Clark have made plans to cross eastern China and Mongolia, coming out at Urga about the end of December. During the return, the party will spend a month in the Tian-Shan collecting, where they will get ibex and other interesting specimens of the mammals frequenting this high country.

Akeley Expedition.—Letters from the field report very satisfactory progress. On July 19 the party had already secured all of the material and data for the Klipspringer Group, accessories, paintings, and animals. Splendid specimens of giraffe, oryx, Grant's zebra, and Grant's gazelle have been obtained for the water-hole group. For the background of this group Mr. Akeley has picked a superb scene near the Abyssinian border, one of the few remaining strongholds of African large game. Here the members of the expedition met with the Samburu, the native wandering herders so well portrayed in Martin Johnson's motion picture film.

Mr. Eastman and Mr. Pomeroy have been very successful in their hunting for specimens of African game. Mr. Eastman secured a calf buffalo for the Buffalo Group, which was well under way at the time of writing. Mr. Pomeroy planned to join Mr. Akeley in a kudu hunt in Tanganyika at the end of August, hoping at the same time to secure material for a Bongo Group, if the animals were not too scarce

MARINE LIFE

Bahama Islands Expedition.—Dr. Roy Waldo Miner has just returned from an expedition to the Bahama Islands where he ecured casts of fishes to be used in connection with the Coral-reef Group for the new Hall of Ocean Life in the American Museum, and also sketches for the backgrounds for the upper portions of the same group. Mr. John S. Phipps, of Westbury, Long Island, generously contributed the use of his yacht, "The Seminole," and several subsidiary boats. His son, John H. Phipps, efficiently managed the navigation of the boats, and through his skill as a fisherman many specimens were secured.

Doctor Miner was accompanied by Mr. Chris E. Olsen and Mr. F. L. Jaques, artist. Mr. Olsen was assisted in making the fish-casts by Doctor Miner's son, Roy W. Miner, Jr. About one hundred casts and color sketches of fishes were made and many studies of the reef surroundings.

Mrs. Miner also accompanied the expedition to secure photographs and moving pictures of the life and industries of the Bahaman natives both at Andros and Nassau. About 1500 pictures and 2500 feet of motion picture film were obtained.

During their stay the party experienced a narrow escape from a tropical hurricane.

A more detailed account of the expedition will appear in the next number of NATURAL HISTORY.

FISHES

BERING SEA.—During August Mr. J. T. Nichols made a short trip to Bering Sea to familiarize himself with the present physiographic, marine, and climatic conditions there, in so far as they may have influenced the distribution of fishes or other animals across this area in the past. His field observations suggest that the sculpins and salmons were of Pacific origin and reached the Atlantic across the Arctic Basin, that the cods gained the Pacific in the opposite direction, and that this would have been possible under conditions not very different from present ones. Fresh-water carps, on the other hand, probably crossed from Asia when the physiography and even climate were quite unlike the present. There is a considerable seasonal migration of salmon northward from the Pacific into Bering Sea, as evidenced by heavy catches in traps recently placed in the narrow pass between the Alaska Peninsula and Unimak Island.

THE ZANE GREY COLLECTION OF GAME FISHES.—Through the efforts of Mr. Van Campen Heilner, Mr. Zane Grey has presented to the Museum his large collection of mounted game fishes, one of the most complete collections of this kind in the world. The department is sending an expert to Lackawaxen, Pennsylvania, Mr. Grey's eastern home, to make arrangements for packing and shipping the collection to the Museum, for exhibition in the new Hall of Fishes.

THE NEW HALL OF FISHES.—Steady progress has been made in getting ready the new Hall of Fishes for the installation of exhibits. Most of the cases are completed. The series of seven scenes of deep-sea fishes by Mr. Dwight Franklin are about two thirds done. The color scheme for walls and cases has been worked out and a number of the wall-case exhibits have been arranged. Models for the Shark and Sailfish groups have been completed and work on these groups is in progress.

MINERALS

MURAL PAINTINGS FOR THE MORGAN HALL.—Mr. William S. Taylor, whose work on the walls of Alaskan Hall is familiar to all visitors to the Museum, is preparing a series of mural paintings for the Morgan Memorial Hall of Minerals. The excellent lighting and imposing setting of this hall will combine to furnish conditions for the most favorable display of Mr. Taylor's work, which will be done in a subdued key to harmonize well with its surroundings.

There will be a triple panel at either end of the hall, the middle panel of each group being over the entrance arch. There will also be two long rectangular panels on the south wall. The subjects of Mr. Taylor's paintings will be the Neolithic, Bronze, and Iron ages.

REPTILES

THE DOUGLAS BURDEN EXPEDITION TO THE ISLAND OF KOMODO.—Mr. William Douglas Burden, leader of the American Museum's Expedition to Komodo Island, Dutch East Indies, has reported singular success. The main object of the Expedition was to collect record specimens of the semi-mythical giant lizards of Komodo for a group in the new Reptile Hall in the Museum. The Expedition secured a large series of specimens of *Varanus komodoensis*, as the lizards are called, and has shipped two adult specimens to the Zoo alive. Their arrival in New York called forth considerable newspaper comment. They are not only the largest and most spectacular lizards in the world, but they should prove of great scientific interest in shedding light on the evolution of the large fossil Varanoids of Australia.

HONORS

THE JOHN PRICE WETHERILL MEDAL.—Carl Akeley, explorer and taxidermist of the American Museum of Natural History, has been nominated for the John Price Wetherill Medal of the Franklin Institute, for his invention of a moving picture camera designed for photographing wild animals.

APPEAL FOR BACK NUMBERS OF "NATURAL HISTORY"

THE LIBRARY of the American Museum receives frequent requests for complete files of Natural History, which it is no longer able to furnish. Should any subscribers care to donate copies of earlier issues, the gift will be very much appreciated, and postage will be refunded to the donor. Address the Librarian, American Museum of Natural History.

NEW MEMBERS

Since the last issue of Natural History, the following persons have been elected members of the American Museum, making the total membership 9050.

Life Member

Mr. W. H. Carpenter.

Sustaining Member

Mrs. Ethel Bergstresser Stewart.

Annual Members

Mesdames: James A. Finn, Minot Simons, A. Solomon.

Miss: Lena F. Vanner.

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THE MUSEUM EXPLORING

NOVEMBER-DECEMBER

Pliny E. Goddard, Editor

Dr. Roy W. Miner visited the Bahamas during the summer to secure specimens, color studies, and notes for the completion of the Coral Group. A hurricane visited the same locality. An illustrated article will give a vivid account of this trip.

Assistant Director Murphy cruised in the Mediterranean where there are birds above, fish below, and mammals on the surface of the sea. There are pictures and interesting text.

Associate Curator Nelson and Mrs. Nelson have been in Asia with the Central Asiatic Expedition two summers and a winter. The winter they spent in the upper Yangtze valley hunting for early man. Mr. Nelson writes interestingly and scientifically of the evidences of Stone Age man. Mrs. Nelson tells of her experiences with the living inhabitants.

Mr. H. E. Anthony, curator of mammals, presents some observations on the Indians of Ecuador. The country these people live in is better adapted for scenery than agriculture, but nevertheless supports a considerable population.

Mr. Erich Schmidt, a graduate student at Columbia University, undertook a research problem in archæology which he worked out in the laboratory of the Southwest. The field trip was financed by Mrs. William Boyce Thompson who personally assisted in the work of excavation.

Douglas Burden, a trustee of the Museum, went to the Grand Cañon and saw things in Arizona which tourists miss. Besides the deep cañon and sculptured mesas he saw where erosion has taken away enormous deposits in other geological periods.

How did the fishes of the North Atlantic get to the North Pacific without passing through tropical waters? Associate Curator Nichols discusses this from some observations made on a recent trip to Bering Sea.

THE AMERICAN MUSEUM OF NATURAL HISTORY

FOUNDED IN 1869

MEMBERSHIP MORE THAN NINE THOUSAND

For the enrichment of its collections, for the support of its explorations and scientific research, and for the maintenance of its publications, the American Museum of Natural History is dependent wholly upon membership fees and the generosity of friends. More than 9000 members are now enrolled who are thus supporting the work of the Museum. The various classes of membership are:

Associate Member (nonresident)*	annually	$3
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Sustaining Member	annually	$25
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Natural History, published bimonthly by the Museum, is sent to all classes of members as one of their privileges. Through Natural History they are kept in touch with the activities of the Museum and with the marvels of nature as they are revealed by study and exploration in various regions of the globe.

AUTUMN AND SPRING COURSES OF POPULAR LECTURES

Series of illustrated lectures, held in the Auditorium of the Museum on alternate Thursday evenings in the fall and spring of the year, are open only to members and to those holding tickets given them by members.

Illustrated stories for the children of members are presented on alternate Saturday mornings in the fall and in the spring.

MEMBERS' CLUB ROOM AND GUIDE SERVICE

A room on the third floor of the Museum, equipped with every convenience for rest, reading, and correspondence, is set apart during Museum hours for the exclusive use of members. When visiting the Museum, members are also privileged to avail themselves of the services of an instructor for guidance.

THE AMERICAN MUSEUM OF NATURAL HISTORY has a record of fifty-six year of public service during which its activities have grown and broadened, until today it occupies a position of recognized importance not only in the community it immediately serves but in the educational life of the nation and in the progress of civilization throughout the world.

Every year brings evidence—in the growth of the Museum membership, in the ever-larger number of individuals visiting its exhibits for study and recreation, in the rapidly expanding activities of its school service, in the wealth of scientific information gathered by its world-wide expeditions and disseminated through its publications—of the increasing influence exercised by the institution. In 1925 no fewer than 1,775,890 individuals visited the Museum as compared with 1,633,843 in 1924 and 1,440,726 in 1923. All of these people had access to the exhibition halls without the payment of any admission fee whatsoever.

The **EXPEDITIONS** of the Museum have yielded during the past year results of distinct value. The collections being made by Mr. Arthur S. Vernay in Angola, Africa; the studies of Andean avifauna pursued by H. Watkins in Peru; the three fossil expeditions in the western United States, in New Mexico, and Nebraska and Montana; the extensive survey of Polynesian bird life conducted by the Whitney South Sea Expedition; the work pursued in selected faunal areas of Venezuela by Mr. G. H. H. Tate; the field observations and collections made in Panama by R. R. Benson; the studies of microscopic pond life of Mt. Desert Island by Dr. Roy W. Miner and Mr. Frank J. Myers; the archeological excavations at two important sites in Arizona; and the continuation of the brilliant work of the Third Asiatic Expedition during the past season—these (and the list might be extended) are among the notable achievements of the past twelve months.

The **SCHOOL SERVICE** of the Museum reaches annually about 6,000,000 boys and girls through the opportunities it affords classes of students to visit the Museum; through lectures on natural history especially designed for pupils and delivered both in the Museum and in many school centers; through its loan collections, or "traveling museums," which during the past year circulated among 410 schools, and were studied by 977,384 pupils. During the same period 672,479 lantern slides were loaned by the Museum for use in the schools, the total number of children reached being 3,941,494. 1,076 reels of motion pictures were loaned to 48 public schools and other educational institutions in Greater New York, reaching 333,097 children.

The **LECTURE COURSES**, some exclusively for members and their children, others for the schools, colleges, and the general public, are delivered both in the Museum and at outside educational institutions.

The **LIBRARY**, comprising 100,000 volumes, is at the service of scientific workers and others interested in natural history, and an attractive reading room is provided for their accommodation.

The **POPULAR PUBLICATIONS** of the Museum, in addition to NATURAL HISTORY, include *Handbooks*, which deal with the subjects illustrated by the collections, and *Guide Leaflets*, which describe some exhibit or series of exhibits of special interest or importance, or the contents of some hall or some branch of Museum activity.

The **SCIENTIFIC PUBLICATIONS** of the Museum, based upon its explorations and the study of its collections, comprise the *Memoirs*, of quarto size, devoted to monographs requiring large or fine illustrations and exhaustive treatment; the *Bulletin*, issued since 1881, in octavo form, dealing with the scientific activities of the departments, aside from anthropology; the *Anthropological Papers*, recording the work of the staff of the department of anthropology; and *Novitates*, devoted to the publication of preliminary scientific announcements, descriptions of new forms, and similar matters.

For a detailed list of popular and scientific publications with prices apply to:
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NATURAL HISTORY

JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

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NATURAL HISTORY

THE JOURNAL OF THE AMERICAN MUSEUM

DEVOTED TO NATURAL HISTORY, EXPLORATION, AND THE DEVELOPMENT OF PUBLIC EDUCATION THROUGH THE MUSEUM

THE MUSEUM EXPLORING

PLINY E. GODDARD, EDITOR

NOVEMBER-DECEMBER, 1926

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EXPLORING

IN order to provide habitat groups and other exhibits illustrating the natural history of the entire world, expeditions must be constantly in the field. These exploring parties travel over land to remote regions often difficult of access and lacking means for easy and rapid transportation. Other investigations require ships for the study of the life of the seas, islands, and shores more accessible by water than by land. There is also a vast and varied under-water world of both vegetable and animal life that must be explored and recorded by dredging and diving.

This issue of NATURAL HISTORY presents the experiences of several Museum expeditions during the current year. These include voyages in the Pacific, Atlantic, and Mediterranean, and up the great river of China, the Yangtze. While such trips often present the lure of the unknown and reward the participants with striking scenery and many pleasurable experiences, dangers are ever present. The Mediterranean is not always safe and comfortable for a small boat; and the Yangtze gorges, normally infested by bandits, were in the Chinese war zone. A hurricane devasted the very region in which Doctor Miner and his party were exploring. It is precisely this element of the unexpected and unknown, with the attendant dangers, that makes the explorer's life alluring.

THE OCEANOGRAPHIC MUSEUM AT MONACO

The only complete and most beautiful institution of its kind, this Museum was founded by the late ruler of the Principality, His Serene Highness Prince Albert I. It was dedicated in 1910. In addition to sumptuous exhibits illustrating oceanographic technique, fisheries and other marine resources, the physical and chemical properties of the earth's water, and the life of the sea in all parts and at all depths, the Museum also includes laboratories for oceanic research and an aquarium in which Mediterranean animals may be studied under conditions which simulate their natural habitats

NATURAL HISTORY
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A Cruise to Majorca

EXPERIENCES OF A SUMMER YACHTING TRIP, 1926

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THE windless sunset of July 13 lived up to Iberian traditions, making us forget for the time that such weather was getting us nowhere. The sea lay pale green, with purplish flashing hollows. No swell rocked our schooner; no air shook the sails. Over the red west the new moon carried a luminous sphere within her horns. The leaden east, toward Corsica, had a peculiarly impenetrable appearance until stars broke through, after which those of high magnitude cast unbroken beams across the water. At eleven o'clock our host, standing the evening watch, called me to the quarter-deck to see the whole bright reflection of the Milky Way in the depths of a refulgent mirror. Nothing of the sort came to memory from my previous life at sea and, moreover, for the first time I could discern stars down to the level of the eye, almost at the boundary of sky and water.

At dawn of the previous day we had left Monaco with a cool and lively wind which had been blowing for a week off the Maritime Alps. The Oceanographic Museum and the green promontory had gleamed in the first rays of the sun as we left them astern. All day we had slanted away from the Riviera on our westerly course, through increasing choppy swells from the north. Those on board who were not incapacitated by the sudden break from life ashore were on the lookout for sea birds, but it took an experienced eye to make out the fluttering specks which were stormy petrels, and which passed us bow and stern as they beat their way up wind toward the coast of France.

The "Wawaloam," the craft of our adventuring into old fields, had been placed at the disposal of the American Museum by her owner, Mr. Jesse Metcalf. She was a seemly three-masted schooner of comfortable Dutch build, equipped with every necessity and much more, including a laboratory under the forward deck. Best of all, she had for the time but one purpose, one objective—to be steered by the plan or the whim of a naturalist.

The favoring breeze of our first day at sea had carried us nearly half way from Monaco to Minorca, but the land wind vanished as the continent dropped below the horizon, and after noon of July 13 we were doomed to six days of calms and shifting cats-paws. It interested us to see how quickly and thoroughly the face of the Mediterranean accommodated itself to the breath of the native wind gods. From tumbling waves to flat calm, or *vice versa*, were transformations of but a few hours, and the aftermath of even a tempest brought nothing of the prolonged heaving of the open ocean.

With the flattening out of a rippled surface, the visibility of the tiny black petrels increased so that they could no longer be overlooked. Provided with a bucket of thin grease to make the necessary trail of bait, our host and I often lowered the dinghy with the object of observing and collecting these ocean rangers. The birds turned out to be the true stormy petrel (*Hydrobates pelagicus*), the first described form of the whole cosmopolitan group of "Mother Carey's chickens," and which, since it belongs to waters on the Old World side of the Atlantic, has always been scantily represented in American natural history collections. Odd it seemed to find this bird not far from some unknown nesting ground in the sunny Mediterranean when we knew that its fellows of the same species were at the very time laying eggs at the far-away Faroes.

The "Wawaloam" at anchor in Alcudia Bay, Majorca

Such seeming anomalies, however, were largely resolved when we had gained a more intimate acquaintance with the waters in which we were cruising. Thermometers lowered into the sea at frequent intervals during both day and night showed surface temperatures of from 67° to 68° F., considerably lower figures than one might have guessed for midsummer. The associations of history and of human seasonal movements combine to make us link up mental images of the Riviera and Florida, the Mediterranean and the Gulf of Mexico, north Africa and the trans-Caribbean coasts. But the analogies are mainly false, for the Mediterranean is not a tropical sea. A huge continental lagoon of shallow or moderate depth, shut off from the Atlantic by a submerged sill between the close Pillars of Hercules, it has acquired certain of the biological characteristics of equatorial waters, but its generally temperate relationships are indicated by the nature of most of the life which inhabits it.

Nevertheless, the low temperatures encountered during the early days of our journey are not to be taken as typical of the whole expanse. Alpine winds which had been whipping up the northern border for days on end had driven the littoral surface water southward, and its place had been taken by cooler water from below. The rising movement incidentally brought a more plentiful supply of the petrels' food within their reach, a circumstance which may help to account for the almost universal tendency of such birds to fly to windward.

This train of thought unfolded gradually while we watched the nimble *Hydrobates* from day to day, and added a number of them to the ornithological treasury of the American Museum. It prepared us to identify without surprise, and subsequently to collect, a still more boreal and somewhat larger species of Mother Carey's chicken, the one known as Leach's petrel, which nests on both sides of the Atlantic as far north as Greenland. A specimen which showed by its internal condition that it was close to the height of its breeding season, fell into our hands on July 16, fifty-three nautical miles west-northwest of Minorca.

The reprehensible sport of shooting innocent little sea swallows was not without its thrills, despite the luxuriousness of our voyaging. One afternoon, for example, we set off on a bouncing sea during a lull in a fresh southeast wind. Pulling away in the squat dinghy, we laid our "slick" of evil-smelling bacon fat for a mile or more, and its prompt effect in spreading a smoother area about us was quite astonishing. Petrels, and a few of the bigger Mediterranean shearwaters, soon appeared from nowhere and began to work up from the leeward, respectively pattering and swooping back and forth across the oily streak, and clustering about the larger scraps of bait. But, in the meanwhile, the breeze had begun to blow with augmented force. The "Wawaloam," with her motor machinery spread all over its housing while the engineers tinkered with some defect, bore rapidly away two, three, four miles, before Commander Blair could bring her about. We felt that we were out of sight of the yacht, but were confident that the skipper had kept our bearing.

The wind was by this time a whole-sail breeze which quickly lashed up short and uncomfortable waves. A yacht's tender is at best a wharf-to-mooring, inside-the-breakwater craft, and no sea boat. Glad enough we were to hug the leeward margin of our own shimmering grease-patch, and glad that we had not yet used all our supply of galley fat to lure petrels to destruction. One of us at the oars held the bow of our diminutive tub to the wind, while the other spattered oil with utmost parsimony upon troubled waters. The Mother Carey's chickens whisked up lightly from astern, passed us sometimes at arm's length from the gunwale, and disappeared magically among the whitecaps ahead. They were immune from harm, and not only because we were thoroughly occupied; speaking for myself alone, I confess to a disingenuous, even though vague, propitiatory superstition. The birds' beady eyes carried no reproach, and perhaps, if we waved them cheerily by, the storm-controlling sprites would never suspect that several of their brothers' bodies lay rolled in cotton on the thwart.

The "Wawaloam" now bore toward us, with an ironical "come aboard" signal flying. We timed our strokes to back across her bow when she luffed, and were soon on deck, all dripping.

Now, when after a comparatively fair day's run, the schooner arrived one quiet morning fifty miles northwest of the nearest point in the Balearic Isles, we had an opportunity to observe something of the little understood vagaries of the sea and of the creatures which seek their own demarcated realms within it. During the night the surface temperature had risen from 68° to 75° F., a seemingly slight difference to the landsman who thinks in terms of atmosphere, but strikingly apparent when we plunged over for our daily calm-weather swim, and still more so when we observed what was going on about us. Perhaps we had entered a warm local current; perhaps we had merely passed beyond the zone of upwelling. At any rate, small flying fish, which had certainly not been in evidence in the cool water along the European coast, began to scud from our stem. Bonitos, leaping a man's height into the air, were in hot pursuit, and lines were quickly paid out to

Commander David Blair, captain of the "Wawaloam," and leader of the "St. George" Expedition to the tropical Pacific in 1924

tempt them. Dolphins or dorados, too, loafed below in the ultramarine shadow of the hull, their fins shining as sidelights of purple fire. Unlike the bonitos, they declined to be interested in either bait or spoon, and I recalled that the only time I had ever hooked and landed one of these wondrously opalescent fish was when running before half a gale in the South Atlantic. Sea insects — true oceanic bugs — jerked along the surface and, finally, the first shark, which may or may not have had any relation to the increase in temperature, swished past us with fins exposed.

The proximity of the Balearics was intimated, when we were still a day's sail from the land, by a sprinkling on the sea of small uniform particles which proved to be the seeds of the Aleppo pine. When the bare, wind-swept plateau of Minorca loomed on the horizon, butterflies, dragonflies, and smaller insects became common. Commander Blair declares that he saw a bonito catch a butterfly which was a foot or more above the sea. A whale or two spouted in the coastal waters, and lines of jumping porpoises, seen first at a distance, came to play under our bow when we were favored with wind enough to give us headway. In the afternoon, as we sailed past the low violet cliffs of Minorca, hundreds of the inimitable shearwaters were scaling and interweaving in a stiffening breeze off the land. We had no need at this season to seek the perfectly sheltered haven of Mahón, the Minorcan capital, for, as the Spanish sailors say,

Junio, Julio, Agosto, y Puerto Mahón
Los mejores puertos de Mediterráneo son.

Next morning the rugged headlands which flank Alcudia Bay, Majorca, lay on either beam. The folds of the escarpments made a jumble of desert brightness and heavy shadows, while

Recording the delicate and evanescent colors of the feet and webs of a Mediterranean shearwater

Pine-covered coastal hills of Majorca, at Alcudia Bay. The abundant Aleppo pine is responsible for the existence at the island of such northern types of birds as crossbills and kinglets

on the slopes below, copses of small trees seemed to be spread out with almost geometrical precision. Signs of human habitation were few as we scanned the vast landward horizon; the illusory spell which most islands cast over new-comers pervaded the still air of daybreak and the thin mist which clung to the face of the bay. It seemed as though we were entering a wilderness instead of a venerable and self-sufficient community with a population twice as dense as that of Spain.

As the engine of the "Wawaloam" was still dismembered, the launch was lowered to tow us toward our anchorage, and we skimmed forward through films of pine seeds. A legion of huge pink and lavender jellyfish, trailing appendages which resembled clusters of translucent grapes, passed us on the outgoing tide, their mantles pulsating slowly. Thus we skirted a clearly discerned shelf under the margin of the bay, the swinging lead rhythmically plumping to the bottom, seven fathoms below, while we headed toward a tower of yellow masonry which appeared to mark the entrance to the hidden port of Alcudia. When we neared this lonely structure, which stood in a waste of shrubbery and stunted pines, a boat suddenly rounded the point beyond, and a pilot who might have stepped forth from a Zuloaga *genre* painting clambered aboard the "Wawaloam."

From our anchorage the moresque walls of Alcudia lay in full view, the boxlike church rising above all other buildings. The verdure of swamp land and of luxuriant thickets of pine and juniper at the head of the bay gave place first to the warmer hues of scrub-covered hills at the left of the town, and then in turn to paling stretches of scattered conifers and arid ridges toward the sea. When the first evening's sunset had faded to an afterglow, the piled up masses became steeped in the spectrum of Mediterranean magnificance, each successive crest endowed by varying distance with its own subtle and distinctive shade. But above the church of Alcudia, a hole through the farthest range made a window to the crimson sky.



GLIMPSES OF ALCUDIA

At the left is the embattled watch tower of the port from which sentries of old cried the dreaded alarm "The Moors are coming!" In the center is one of the arched entrances to the town, with clusters of vegetation thriving in crannies of the crumbling stone. At the right are two tiers of massive walls and the double turrets of the Roman gateway which bridges the main thoroughfare leading through Alcudia toward Palma and other parts of Majorca

Left.—Señor Juan Jofre, pilot of Alcudia, who, between the rare calls of vessels, does a substantial business by shipping spiny lobsters to Barcelona. Upper right.—Fishermen of Alcudia Bay lunching in the shadow of their sail, with the "Wawaloam" in the background. Lower right.—A giant jellyfish passing the yacht's anchorage, the pebbly bottom, five fathoms below, showing indistinctly

Majorcan women filing out of the church at Inca after a funeral

At this hour, too, the fishermen set forth from port before the breath of the nightly land breeze. One by one their feluccas, with large and small lateen sails rigged yawl-fashion, glided silently past us wing-a-wing.

I am one of the contrary-minded travelers who prefer to read about a new region after, rather than before, visiting it. The stored facts of history and Baedeker doubtless prepare one to seize with most economy upon features which previous visitors have found entrancing; but, after all, the world is so full of charm that experience can hardly exhaust even the first choices. The appeal of the unknown, however simple; the joy of fresh impressions upon a blank page; the satisfaction of personal discovery—these more than compensate for an overlooked cathedral or saint's tomb. Majorca, queen of the ancient Aphrodisiades, lay before us. It mattered not, at the time, that some say Hannibal was born here in the days of the renowned Balearic slingers, or that the ports of the isle were once the center of a medieval world bounded by the rich limits of Africa, Italy, France, and Spain. We gave no thought to the snug kingdom of Don Jaime, the Conqueror, to the great school of chart-makers which was here cradled in the fourteenth century, nor to the native mystic of the same period, Ramón Lull, whose strange philosophy is still studied by Majorcan youth if by nobody else on earth. For myself, I was yet ignorant that among the sublime hills, somewhere to westward of that beckoning hole-in-the-crest, lay the piny glade of Valldemosa where, in an abandoned Carthusian monastery, George Sand and Chopin lived in lonely contentment during the winter of 1838–39. But during the all too few days of our visit we were to find between Alcudia and the islet of Dragonera traces enough of the long past, with its succession of prehistoric, Carthaginian, Roman, Vandal, Saracen, and Catalan islanders.

With the "Wawaloam" at a comfortable mooring, we lost no time in setting about our field work. Our official host, the courteous captain of the port, explained that the issuance of credentials was here, as elsewhere, a time-consuming matter. He suggested that pending the arrival of documents from Palma we carry on our collecting under his personal ægis, confining our operations as far as possible to the coast. If, however, we wished to shoot in the interests of science among the hills, or in the marshes of Albufera, he offered to make the necessary arrangements with the owners.

So we began work in the launch, cruising along the base of precipices which extend from Alcudia Bay to the Bay of Pollensa. Here the twisted strata of limy shales have been cut back by the sea in steep or even overhanging cliffs, speckled in places with caves and niches from which rock doves streamed like bees from a hive as we chugged along below. Two or three hundred feet overhead, green pines leaned out from precarious footholds, and at that level an osprey and occasional Eleonora's falcons soared above the water. The latter species is a glorious little Mediterranean freebooter, related to our American pigeon hawk but with longer, sharper wings, shaped almost like those of a swift. A week later, at Dragonera, we saw as many as a score of them together, and became better acquainted with their marvelous aërial displays. On the updraft of the sea breeze, the falcons would glide along the brink of the Gibraltar-like cliff, and, suddenly half-folding their wings, they would hurtle toward the sea. Three, five, six, or seven hundred feet—a quick eye was needed to follow that breathless plunge down the vertical fault scarp. Sometimes it seemed as though the living darts would be swallowed among ripples which were in reality great billows breaking at the foot of the wall. But at the critical moment, the falcons would scale forward, to float again toward the heights and perhaps to repeat the dive. Clearly this performance was carried out with no other object than the joy of it. There was no food for the birds on the sea face of the islet. The full stomach of a specimen collected contained only remains of orthopterous insects, probably the grasshoppers which were abundant among the asphodel and warped bushes on the landward slope of Dragonera. Eleonora's falcons, however, have the reputation of being bird-eaters, and their gift for dashing speed supports this. At this late season they were just beginning to nest upon the sea cliffs of the Balearics, which is possibly shrewd Nature's scheme for assuring a plentiful larder of northern songbirds, in autumn migration across the Mediterranean, at the very period when nestling falcons are most insatiable.

The rocky coast near Alcudia Bay was broken here and there by pleasant coves, unmarred by anything man-made, in which we could usually find flocks of shags and groups of Mediterranean yellow-legged gulls which closely resemble the herring gulls of the north. In the roofs of lofty, sea-level caverns small swifts[1] were evidently nesting, for the birds darted in and out with incredible rapidity more than gun-shot above the heaving water. Many lesser caverns were dark and deep; into some of them we could pole the launch until the light of day was nearly cut off behind. Such as these were, of course, the result of wave action, but higher up the sheer precipices were geologically ancient limestone caves of the type for which Majorca is famous. Upon one of the latter we stumbled when our eyes followed up an unaccountable flight of steps, hewn in the straight front of the cliff, to a half-concealed doorway sixty or seventy feet above. Inquiries among the fishermen brought out the universal Majorcan reference to the *tiempo antiguo*, and a hint about the never idle *contrabandistas* or smugglers. More than this we could not learn, but next morning we returned with blue flares from the "Wawaloam" and explored our find.

Landing at the foot of the steps was a ticklish matter, even in quiet weather. Once inside the half natural, half hewn gateway of the cave, we found our way blocked by a wrought iron door suspended between stalactitic columns. This, however, was not locked, and we went on to a devious passage which wound into the earth, sometimes opening into bristling chambers and again mounting or descending through tunnels by way of neatly chiseled stairs. It was clear that the original users of this sinister retreat had been actuated by no spirit of mere diversion, for an enormous amount of labor had been expended in quarrying, not to mention the forging and hanging of the prison-like gate. After perhaps four hundred feet of gingerly progress, we entered a vault as large as an ordinary church, which sparkled in the light of the torches as though it were lined with a million icicles. At the near end stood an overflowing basin of spring water, formed by a natural rim of limestone which had been built higher with masonry. At the far end, and along the dim sides of the chamber, were dark slides or *oubliettes* descending from the floor to nobody knows where.

Lack of flashlight apparatus was now a source of deep regret for the torches made sorry substitutes when we attempted photographs of the gleaming stalagmites and complete columns. We remained, however, until smoke

[1]In addition to *Hydrobates pelagicus* the following birds are referred to in the text. All were observed between July 16 and 30, 1926.

Leach's petrel (*Oceanodroma leucorhoa*), locality and date recorded; Mediterrean shearwater (*Puffinus kuhlii kuhlii*), off Minorca, Majorca, and Dragonera; rock dove (*Columba livia*), Majorca and Dragonera; osprey (*Pandion haliaëtus*), Majorca; Eleonora's falcon (*Falco eleonorae*), particularly abundant at Dragonera and observed also at Majorca and the Columbretes Islets; shag (*Phalacrocorax aristotelis desmarestii*), Majorca and Dragonera; yellow-legged gull (*Larus cachinnans*), Majorca, Dragonera, and the Columbretes; swifts in the sea caves of Majorca (probably *Micropus murinus illyricus*, but not collected). Other species worthy of note include Moroccoan shearwater (*Puffinus puffinus mauretanicus*), two off Dragonera, July 26; common sandpiper (*Actitis hypoleucos*), Columbretes Islets, July 29; red-legged partridge (*Alectoris rufa*), common on Dragonera.

The breeding birds of the Balearics are almost entirely European, rather than African, in character, but there are about twenty endemic races among the land birds. The resident avifauna numbers 102 forms, in addition to which nearly 150 migrant and visiting species have been recorded. (Cf. von Jordans, 1925, *Journal für Ornithologie*, LXXIII. pp. 194–207).

The needle of Dragonera, viewed from near the northeastern end of the bold islet. The lighthouse, which can be faintly discerned on the peak, has been abandoned because it was prevailingly hidden by clouds

Smugglers' cave in the sea cliff of Majorca, between Alcudia and Pollensa bays

One of the chambers of the cave, photographed with the aid of the yacht's signal flares rendered the air intolerable. A final, and at the time inexplicable, phenomenon just before our exit provided a weird climax. Where the ash from our calcium lights had been falling through the murk to the warty surface of the limestone, it produced instantaneous jets of flame, which were accompanied by a crackling sound and followed by tiny but explosive puffs of smoke. The effect seemed to be cumulative, for presently an area about the bole of one huge pillar began to sputter like a battery of spark plugs. It is odd, in the cool light of retrospect, to think how such a normal and interesting chemical reaction could serve to precipitate our departure.

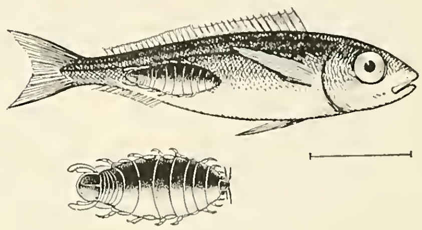
Our attention was not given entirely to the birds and caves. Majorca proved to be a moderately good fishing ground, especially important because the Mediterranean fishes, which have always been scarce in American collections, are the type forms upon which many of the early naturalists based their descriptions of wide-ranging species. We haunted beaches to which the fishermen, who carry on their trade week days and Sundays with the single exception of the Feast of All Saints, brought their catches. We informed our friend, the pilot, that we would purchase fishes of all sizes, large or small, without reference to their edibility. The fishermen, brigands only in appearance, were glad to humor our queer wishes; they asked no more than the market price and the privilege of watching us pickle the specimens in formalin. One crew even invited me to share their lunch, which they cooked in the felucca. I declined in a manner which seemed to content them by saying that I should prefer to record their meal with the motion picture camera. The most original incident was the passing round of the *paróm*, a green glass bottle with a side spout like that of a watering pot, which was held six inches above the mouth while the wine streamed into thirsty gullets in a fashion altogether sanitary.

Sometimes we used an electric detonator to explode charges of dynamite under the water of gulches or caverns at the foot of beetling cliffs. The catches of fish were always extraordinarily small when compared with those obtained by the same method along the teeming west coast of South America or about remote oceanic islands. Although the Mediterranean has a wide variety of fishes and other marine organisms, it is a relatively depauperated sea as regards numbers of individuals. Our specimens included an assortment of sea basses (Serranidæ) and their relatives, porgies (Sparidæ), wrasses (Labridæ), and a scattering of others such as the sole, a scorpion-fish, a viper-fish (Trachinidæ), and the remarkable stargazer (Uranoscopidæ) which I had previously met in a porringer of *bouillabaisse* at Marseilles. The commonest single species everywhere on rocky bottom was the small black, blue, and gilded swallow-tail (*Chromis chromis*), a representative of a reef-living family known as the Pomocentridæ. The last, as well as the scorpion-fish and certain others, are tropical in their affinities, but the Mediterranean assemblage as a whole is distinctly temperate, though doubtless originally derived chiefly from warmer waters. It is a fish fauna comparable with that of the California coast, but quite unlike that of eastern North America where the boreal fishes come practically into contact with undifferentiated tropical forms.

One morning when a discharge of dynamite in five fathoms had brought slowly to the surface a handful of fishes of four or five kinds, we observed that every individual of a small porgy (*Box boops*) had attached to its flank a proportionately large parasitic crustacean. This has since proved to be an isopod, identified by the name *Anilocra mediterranea*. The isopods live in the gills or upon the skin of fishes all over the world, but the extraordinary point about those which clung to the Majorcan porgies was that they were countershaded in an asymmetrical manner. The side of each crustacean which was toward the back of the fish was dark in color, while the other side matched the silvery belly of its host. Such a remarkable protective adjustment (if, indeed protection has anything to do with it) seemed a new biological variant. It was expressed so aptly that those isopods which continued to hold persistently to the right side of the dead fishes had their left halves darkened, while those on the left side of other fishes were oppositely shaded. Thus the usual type of countershading, which combines a dark back with a light ventral surface, and which favors the concealment of living creatures throughout many branches of the animal kingdom, was here altered to a right and left hand distribution of pigment, correlated with the peculiar position of the parasite on the body of its victim.

But we confined our travels by no means to trips along the wave-beaten coasts. In antique French motor cars, which could be hired at Alcudia, we crossed the great plain of the island and visited villages perched on hilltops. Fantastic place names dot the map of Majorca and draw one like a magnet. Where else, outside the vicinage of Cabell's "Poictesme," could one find such towns or localities as Aumelluitx, Estallenchs, Marroig, Lluch, or Andraitx? Perhaps the Saracen influence is to be sought in such unpronounceable words, for one of the last of the Moorish chiefs rejoiced in the name of Xuayp.

The agricultural country has all the picturesque charm of a semi-tropical terrane which has been tilled since the beginning of time. Protected by the sierra of the northwesterly coast, which attains an elevation of more



The parasite and its host. The lower figure show the actual size of the asymmetrically shaded isopod. The upper figure is drawn to scale, the line representing one inch

than five thousand feet, from the raw winds which sweep across the neighboring island of Minorca, the arable land begins first upon terraces which support wheat, flax, and the vine, and then descends by pleasant stages to the zone of palms and figs. True figs are the "figs of the Christian," while the lowly fruit of the cactus, introduced from America and now cultivated behind goat-proof *chevaux de frise* of prickly twigs, is known as the "figs of the Moor." Oranges thrive best in some of the deep valleys of the northern shore. Vast orchards of almonds give the plain in springtime the appearance of a garden in the Hesperides. In the bare, harrowed soil beneath the almonds, droves of native lop-eared pigs root and grow fat, while sheep graze upon grass allowed to flourish under the gnarled olives, all of which, if one were to believe the Majorcans, are "a thousand years old." Whatever their age, some of them are the most

MAJORCAN PASTORALS

(Left)—A heart-shaped hoe or mattock is used to spread the irrigation water which flows from a horse-turned wheel. (Right)—An orchard of ancient olives, and a typical small farmstead

THE COLUMBRETES ISLETS

(Left)—View of one end of Columbrete Grande from a gorge through the red and black volcanic ash of La Horadada. (Right)—Mr.Metcalf inspecting a sea cave of La Horadada. On the horizon is the volcanic stack known as El Bergantín outlandish trees in the world, as almost every visitor has testified. They lured me into impressionistic flourishes in my notebook, but I have since found that the French artist, Gaston Vuillier, had already yielded to the same temptation, as follows:

> These trees . . . , said to have been planted by the Moors, rear most fantastic figures. Enormous trunks end abruptly in plumes of branchlets. Others are twisted like gigantic cork-screws, or simulate dragons fighting coil to coil. Still others appear forbidding monsters with huge hands and the grimacing faces of trolls, hideous with wens and nameless excrescences. Some give the impression of running away in terror, their roots writhing with pain. . . . By moonlight I shivered, in spite of myself, before their gaunt forms vaguely discerned in the cool radiance. . . . The night breeze, rustling the leaves, sounded like spectral whispering, while preturnatural eyes glimmered from the trembling shadows.

Irrigation is used everywhere, and the Marjorcans of today are the heirs of an elaborate system of reservoirs, built by the Moors, in which the rainfall of winter is stored against the dry season. Aside from this supply the lowland is dotted with ceaseless water wheels turned by mules, asses, or even cows. All day long the blindfolded beasts walk weary circles, pausing in the palpable shade of an overhanging tree only when the voices of their equally toiling taskmasters are made faint by distance among the adjacent plantations. In some parts of the island the labor of animate creatures is replaced by that of windmills, often standing side by side in long rows, and doubtless of the same appearance as those which once goaded the Knight of la Mancha into disastrous combat.

The "Wawaloam" could not have put into a port of Majorca at a more opportune time of year, for the Feast of St. James, Patron of Spain, was celebrated during our stay. Throughout the week after our arrival, the streets of Alcudia were decorated with festoons and with green boughs carried down from the hills. Strings of electric bulbs lighted the plazas during the evening. The massive walls and gateways of the town which date, as the inhabitants with cheerful lack of agreement tell you, from the *tiempo Romano*, the *tiempo Moresco*, or simply *tiempo antiguo*, and which in any event had been quarried ages since from the great square pits outside the battlements, were likewise embellished with branches of the Aleppo pine.

On the happy day itself, Sunday July 25, we attended high mass at noon. The service had begun just before our coming, and we disposed ourselves without regard to the conventional segregation of men and women. However, the worshippers were uncritical of their guests, and the incomparable Majorcan courtesy went so far that the sacristan who took up contributions attempted to avoid us when he saw that we were strangers! A majority of the women were covered with mantillas, but a few modernistic young ladies wore hats. The choir was made up of boys more vociferous than musical, but the harmony of the organ left nothing to be desired. Of the sermon, preached in Majorcan, I understood not a word. It was a pleasure, nevertheless, to sit in the twilight of the ancient temple and to examine at leisure its attractive interior, which in taste of ornamentation and lack of tawdriness made a welcome contrast with many churches in more sophisticated Latin lands. The central chandelier, suspended from a hemp hawser which had evidently been spliced by sailors, was a

The bull ring of Alcudia.—The date of this picturesque structure was not learned, but it has the appearance of a Roman arena

splendid piece of wrought iron. Additional maritime touches could be seen among the votive offerings on either side of a subsidiary altar.

Me tabula sacer
votiva paries indicat uvida
suspendisse potenti
vestimenta maris deo.
—Horace, I, v.

One of these was a pair of exquisite, brilliantly colored half-models of fleets of ships on a storm-tossed ocean, from the terrors of which some rare and perhaps unappreciated artisan of past centuries had been miraculously delivered. With my eyes wandering from such nobly fulfilled pledges to the simplicity of worm-eaten benches banked against the nave, my unreligious thoughts can be expressed in words by Edmund Gosse, who under somewhat similar circumstances confessed, "My instinct . . . , I am ashamed to say, is habitually confined to hankering after loot. I always discuss with myself what, in case of extremity, I should 'take away.'"

On the afternoon of this same Sunday, the festivities in honor of the sainted patron of Spain culminated in a bull fight. We came prepared to support the charitable ends which were to be served, but when we landed at the pier a written invitation from the physician of Alcudia claimed us all as his guests. As there were eight in our party, I slipped ahead to the bull ring with the object of purchasing tickets surreptitiously. But the doctor had circumvented any such move, and my good Spanish money was not acceptable. When our host overtook us, however, he very graciously relieved our minds by touching the surgical kit in his pocket and giving us to understand that, as the appointed sewer-up of any toreadors who might be gored, he had the privilege of inviting as many guests as he chose!

An Alcudian bull fight is a somewhat rustic affair which perpetuates a national custom, maintains a hospital, and produces a supply of cheap beef. No horses are involved in the affray. So far as the bulls are concerned, it is not much worse than other modes of slaughter, and if it has any unfavorable effect upon the Majorcan populace I can only say that this does not show in other aspects of the gentle island temperaments.

The ring scene on the feast day was

At the right, is part of the defensive wall of the town, and at the extreme left of the opposite half, the box of the *alcalde* or mayor

wonderfully exotic. The old stone amphitheater was crowded with enthusiastic men, women, and children. Carabineros, wearing *opera bouffe* leather hats, were standing with rifles at rest on either flank of the mayor's box. On one side, as we looked outward from the top tier, lay the blue bays of Alcudia and Pollensa, separated by a barren ridge, and on the other the tiled roofs of the compact little city, with Arcadian country-side and the soft azure mountains of the sierra beyond. The crowd had thrown off all its Hispanic reserve. Whenever a matador waved a charging bull beneath his caped arm, he was cheered to the echo, while derisive laughter greeted callow beginners scuttling to safety behind the barricades.

After the spectacle had ended we gathered at the physician's residence where champagne, anisette, and a table of pastry awaited us. The feast of the patron saint was also the doctor's name day; his intimates called him Don Jaime, and most of the cakes and bottles bore the cards of his friends. The band which had played at intervals during the bull fight now came before the house to serenade him, followed by a mob of other well-wishers. So all together we filled both the pátio and the street as we listened to music which had apparently been transcribed for the occasion, for small boys were holding manuscript sheets before the eyes of full-cheeked blowers of horns and clarionets. It was a living bas-relief from the Renaissance. The players were not professional musicians, but tradesmen, farmers, fishermen, shoemakers, and other guildsmen of Alcudia, who trained and puffed for the love of it, and who accepted no remuneration other than the approval of their townsfolk and the cakes and cordials of which the doctor now invited them to partake.

This was our last day at Alcudia, and sad enough we were to depart. After dark the "Wawaloam" nosed out of the bay into a heavy swell, and we set off toward our next stations which were to be Dragonera and then the Columbretes. At half past three in the morning I came on deck when Cape Formentor lay close abeam. The spectacular black promontory, looming six hundred feet above rumbling breakers, was topped by a tall lighthouse, and directly above beamed the round moon.

Prehistoric Man of Central China

By N. C. NELSON
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INTRODUCTION

THE caves and rockshelters of the Yangtze River Gorges were the special object of archæological investigation during the past winter season on the part of the Central Asiatic Expedition. With unexplored territory of continental dimensions before us, this particular choice of locality was nevertheless almost inevitable. Mr. Walter Granger, the Expedition palæontologist, had previously sojourned for two seasons in the country above the Gorges, collecting Pleistocene fossils; and in passing through the great chasms he had repeatedly observed and reported the presence of numerous natural shelters, obviously more or less suitable for human habitation. He also had caused minor trial excavations to be made in a few of the caves, and while nothing was actually found at these places, he did bring out two artifacts alleged by native workmen to have come from his own fossil pits. Little more in the way of encouragement could be asked for. There seemed to be held out to us here the half promise of—well, why not?—another Castillo cavern containing perhaps the whole story of the Old Man of Asia.

The Yangtze Gorges, it may be explained at the start, are one of the show places of China. Yet, like many other choice sights of the strange old Flowery Kingdom, this one, too, is hidden behind an unattractive exterior. A majestic waterway leads to it, it is true; for the Yangtze is the father of all Asiatic waters; but you have to traverse literally more than a thousand miles of low, flat, and generally unpicturesque country before you reach the impressive natural wonder. Once there, however, your interest is bound to awaken and, if reports are ever to be believed, it will not flag until you have passed on westward over the "roof of the world" to the very summits of the Himalayas. In other words, the famous Gorges are situated about 1200 miles up the Yangtze River, in the border region of the Hupeh and Szechuan provinces, approximately at the geographic center of China. The final point of departure for the scene is ordinarily the treaty port of Hankow, nearly 700 miles inland from the Pacific shore, and this starting point may be reached equally well by steamer from Shanghai and by train from Peking.

The Expedition, under escort of Mr. Granger, left Peking during the first week of November and by the fifteenth had reached the treaty port of Ichang, at the lower end of the Gorges. Some local reconnoitering took place here, sufficient at least to obtain actual traces (fragments of bone and pottery) of Neolithic man in a rockshelter directly across the river from the city. Preparatory to serious reconnaissance work, the Gorges were also traversed by one of the small steamers which ply the somewhat dangerous waters of the Upper Yangtze, with the result that considerable information of practical value was obtained, and a rough topographic chart was made giving the approximate number and location of the principal caverns. Documentary permits were secured from various civil

Going up the Yangtze.—Trackers pull the vessel up the rapids. At this one the line broke and the boat whirled around in the foaming eddies

and military officials under circumstances, I cannot refrain from emphasizing, at once strange and delightful, as well as surprisingly expeditious! Before the end of November, through the helpful assistance of the Rev. J. Herbert Squire of the China Inland Mission, a native vessel had been chartered and by December 3d we were off on our cruise.

Partly with the purpose of trying out our strange equipment, we at once dropped down the river some fifteen miles, to the lower limits of cliffs and visible caverns. At the small town of Kulowpei, therefore, we really began our slow, uninterrupted two and a half months' exploration tour up through the succession of great Gorges and beyond. It ended ultimately at Pai-shui-ch'i, a few miles above the port of Wan Hsien. Here the resumption of military activities practically compelled us to give up the river survey and we therefore retired inland to Mr. Granger's camp at Yen-ching-kou, about ten miles up a southern tributary valley. From these new headquarters, when weather permitted, joint excursions were made on foot in various directions, chiefly south and east, covering in particular the Hupeh-Szechuan border region. At the end of five weeks, or on March 24, we broke camp and all set out once more for Peking.

EQUIPMENT

Archæological exploration conducted from a boat was a new experience. Dictated by necessity and acceded to with some misgivings, we soon discovered its manifold advantages, particularly as regards mobility, comparative independence, and, we fancy, even personal security.

Our vessel—a *ma-yang*, in native parlance—was of 24-tons burden, 68 feet long and 11 feet broad, with a single mast of 55 feet. It had a low, toboggan-like prow, round bottom, bulging sides like our whaleback vessels on the Great Lakes, arched roof aft and amidship, and a curiously high protruding stern, so constructed to accommodate the excessively broad and shallow rudder with its long tiller. Further to insure a straight course amid the dangerous swirls and eddies to be navigated, an extra-long, stout, oarlike rudder was also attached to the prow, from which it extended directly forward. In addition, two large sculling oars were fastened one on either side, and these, together with the 20 by 40 foot sail, completed the essentially permanent features of the really handsome craft.

Navigating the Upper Yangtze being at all times a tricky undertaking, it goes without saying that the mature professional sailor performs his tasks, especially at critical junctures, with admirable skill and precision. The vessels themselves—junks, sampans, etc.,—are no doubt the result also of age-long adaptation. They are built largely of whitewood, preserved with a coating of wood oil, and are therefore extremely light both in weight and in draught; and this unquestionably facilitates their easy handling. Propulsion in our case was effected in a variety of ways: by wind and sail when possible, by the sculling oars, and very often by mere poles and hooks. As a rule, however, in going upstream, the boat was simply towed at the end of a long bamboo rope by some six to ten members of the crew running along the river bank. The number of these trackers had to be increased to a hundred or more when we came to ascend the more difficult rapids. At the minor rapids, however, we helped ourselves, generally by the use of the capstan.

Such, in brief, were our unique and singularly adequate transportation facilities. With these went a perma-

Snow on the hills made the boys pull the mats over the boat early in order to keep warm

A Chinese stronghold.—This structure clings to a narrow ledge accessible only by a dangerously narrow trail

nent staff and crew of twenty-one people, all housed in more or less segregated quarters above deck. There was Mrs. Nelson, in the double capacity of purser and quartermaster, a native interpreter, a personal assistant for the reconnaissance work, a head boy, a cook, and, of course, the captain and his crew. Below deck was ample room for large quantities of fuel and provisions, as well as for tools, collected specimens, etc. The opium den, while not officially sanctioned, was there also. From the point of view of mere comfort and convenience we have never before enjoyed like field accommodations. The native members of our party very soon became adjusted to the limited quarters and the slightly new type of routine. In short, as a result of the adventure, it is safe to say that automobiling in Mongolia lost some of its former attractions for several of us and I for my part wished I could have sailed on westward straight to Constantinople.

INVESTIGATION

The work itself was in the main very simple. On its way through the Gorges, the Yangtze cuts across a great succession of more or less folded and repeated geological formations, including conglomerate, sandstone, limestone, shale, and granite. The most conspicuous of these is the limestone, which rises to heights of four and five thousand feet and constitutes the partially sheer walls of all the five or six distinguishable Gorges and their several tributaries. As would be expected, the limestone also provides

A good example of the type of cave occurring in the sandstones. The barren branches in the foreground belong to the renowned wood-oil tree

A cave in the Wushan Gorge.—Fine example of the caverns typical of the limestone sections of the Gorges

Avenue of grottoes.—Part of a long series of small caves such as are typical of the conglomerate formations near Ichang

Modern cave dwelling.—Partial view of a crescent-shaped cave near Wan Hsien, occupied by a Chinese farmer and his family, including goats, pigs, etc.

Neglected cave home.—View looking out of a large limestone cave at Yen-ching-kou village, Mr. Granger's headquarters during three seasons of fossil hunting

most of the real caves, which pit its surfaces from below the high water level almost to the summits of visible relief; but the sandstones, the conglomerates, and even the shales furnish a considerable number of generally modest shelters. Only the granites are entirely devoid of anything approaching the essentials of a natural habitation. Our chief task consisted in trying to see the entire environmental setting from the point of view of an imaginary primitive man; to guess which of the caves and shelters he would most likely have occupied since we couldn't visit all; to climb to those selected; and, finally, to test their floor deposits for chance inclusions of cultural or skeletal remains, as well as to examine the walls for possible pictorial inscriptions.

Hunting caves in this way was an exhilarating and even a fascinating form of activity, but it very soon grew a trifle discouraging. From the start nothing worth the name *prehistoric* turned up and before long it became tolerably clear that nothing much was to be expected. Nevertheless, the investigation went on as before, with reasonable thoroughness, in order to make the negative conclusions as certain as possible. In the end, after scanning more than two hundred miles of the Yangtze trough proper and traversing in more hasty fashiona similar distance in the back country to the south of the river, we were in possession of only the faintest suggestions that prehistoric man had ever been near the caves! This will seem all the more astonishing when it is stated, first, that a Late Stone Age man had left a fair sprinkling of his works both in the cultivated fields and on the river banks and, second, that a large proportion of the caves and shelters investigated proved to be, or recently to have been, occupied by the Chinese.

This fact of modern occupation was at first regarded as a serious obstacle to the completeness of our survey. It turned out the opposite, for very often the occupied caves and shelters had been subjected to more or less excavating, done for a variety of purposes. Sometimes the clay floor deposit had been removed for use as soil to cover the small agricultural terraces built up of rocks on the adjacent slope; at other places it had been dug up and leached for its nitrous properties; and elsewhere it had obviously been cleared away for no other reason than to make room. The result was that whenever the earthen contents of a given cave were not all spread on the artificial terraces below, where it revealed its sterility at a glance, we commonly found within the cave a prepared section of the floor débris anywhere from one to twenty feet in thickness, awaiting our inspection. This meant a vast amount of time and labor saved for the Expedition, which in consequence was able to proceed with greater speed and yet with full assurance that no likely chance had been overlooked. In short, the Expedition is beholden in a variety of ways to the kindly and industrious cave dwellers of Szechuan.

DISCOVERIES

The extent of our exploration may be summed up briefly as follows: we navigated the Yangtze for a distance of a little more than 230 statute miles and made excursions on foot up various of the tributary valleys and into the back country totaling at least an equal distance. This, it will be understood, was in addition to the ordinary daily task of climbing about from cave to cave facing directly on the river. Of major landings, that is, such stops as involved actual examination of shore features, there were recorded, in all, 122; and the greater number of these were confined to the fifty-mile stretch comprising the Gorges proper. By way of accomplishment, we examined 367 caves and shelters, of which 139, or 38%, were, or had lately been, inhabited. Notice was taken also of the presence and position of 316 additional caves and shelters, many of which likewise gave proof of modern occupation. The results, so far as evidence of Palæolithic man was concerned, proved, contrary to lingering expectation, absolutely negative; and of Neolithic man we obtained in the caves only doubtful traces.

The investigation was not, however, confined entirely to the caves. At the very start of our cruise we discovered on the left bank, at the village of Kulowpei, what had been either a workshop or a settlement of Neolithic date. Most probably it was a village and quite likely the direct ancestor of Kulowpei itself. Coming upon the place at the low water season, we found, at the base of a thirty-foot bluff, a gently sloping foreshore, nearly 100 yards wide and 600 yards long, literally strewn with worked stone implements such as hammers, grinders, axes, chisels, hoes, and scrapers, and broken pottery. The prehistoric relics, unfortunately, were largely mixed with brickbats and débris of all kinds from the present settlement on the bluff above; so that while we were able easily to gather about 150 genuine old axes, we could not distinguish in all cases the ancient and the modern pottery.

This discovery became a clue as to what sort of archæological remains might reasonably be expected all the

Ancient Yangtze River village.—The Kulowpei roadstead, in the flatlands twenty miles below the Gorges. It was here on the bank directly beyond the boats that we found abundant traces of a Stone Age settlement

way up the river; and while it was pursued under protest and as a last resort, we at no time neglected it. The result was that we observed and collected remains of this culture at numerous points from the beginning to the end of our river cruise. Most of our finds, as already stated, were made on the surface, either along the river banks or above in the adjacent fields; but we did discover two undisturbed deposits of culture-bearing débris which gave us a partially correct idea of what traits belonged to the true Neolithic inventory. One of these accumulations filled a small rock cavity (too small for habitation), which we excavated and which proved stone tools and wheel-made pottery to have been, in part, contemporary. The other site was an open-air deposit exposed by a gully and revealing a thickness of nearly eighteen feet. Composed mainly of clay wash from the hills above, this section was nevertheless noticeably stratified, showing throughout streaks and lenses heavily charged with ashes and charcoal, fish and animal bones, traces of human bone, as well as considerable amounts of worked stone and broken pottery. Though the great mass of refuse seemingly implied a consider-

Collection of broken and unfinished axes, scrapers and hammerstones gathered within the space of a few square yards at the village of Kulowpei able time duration, unfortunately, there were no appreciable changes from bottom to top in the character of the artifact materials such as might have been expected. This view is, however, subject to modification because, with a farm house standing on top of the site, we had to be satisfied with a merely superficial investigation.

CONCLUSIONS

These archæological finds, it must be emphasized, were all made on or very near the Yangtze River. Search in the back country to the south produced nothing decisive. It is true that we have the two artifacts brought out by Mr. Granger; likewise that in three places I picked up on the surface single fragments of foreign rock material bearing evidence apparently of human workmanship. But over against these doubtful and alleged discoveries may be cited the fruitless examination, first, of miles upon miles of cultivated fields and minor stream banks; second, of a respectable number of caves and rock-shelters; and, third, of the débris hoisted out of more than one hundred of the Pleistocene fossil pits. The indications all favor the view that Neolithic man, who certainly inhabited the Yangtze valley proper, was such a late comer that he did not have time to penetrate, at any rate, certain parts of the hinterland before he was overtaken by his metal-using successor, presumably the Chinese of early historic times. In other words, it would appear that the forest-clearing process begun with stone axes in late prehistoric times, perhaps three to four thousand years ago, is the process still being carried forward by the present agricultural population.

It would take too long here to explain adequately the scarcity of prehistoric remains in the Yangtze Gorge country. There are, however, plausible reasons enough, such as the comparative ruggedness and impenetrability of the country, the scarcity of game, and above all the nearly complete absence of flint and other rock substances especially suitable for the production of tools and weapons. Caverns, as such, were no special attraction to primitive hunters at any time or place except during extremes of cold,—and Szechuan is semi-tropical. Even Neolithic man in these parts preferred shelters of his own construction, and it is only in recent centuries, perhaps owing to the increasing scarcity of timber, that the Chinese farmers and fisherfolk have taken to the caves.

The results of this Central Asiatic Expedition survey of the Yangtze River Gorges, while in one sense disappointing, are nevertheless both interesting and illuminating. Being first reports on the locality, they are naturally of prime importance for archæological science. They show that prehistoric man played a very inconspicuous rôle in this territory, that he was not a cave dweller, not a hunter, but a woodsman and agriculturist, and that he arrived upon the scene, probably by boat, at a time not long prior to the introduction of the potter's wheel. They suggest, moreover, than Palæolithic man, the true hunter, either never reached the heart of China, or else that the forbidding character of the environment kept him out of this particular region. Of these two alternatives the second is of course the only safe one to embrace for the present; for not until the reconnaissance has been carried farther west, well up into the Tibetan highlands, can we safely exclude Palæolithic man from this corner of Central Asia.

A Houseboat on the Yangtze

By ETHELYN G. NELSON

WHERE but a few years ago ten thousand junks sailed the Yangtze, carrying freight and passengers over more than 1500 miles of waterway, today many steamers, large and small, are performing these offices, and the more picturesque native boats are rapidly disappearing from the river. So it was with some difficulty, and only after a search of two weeks, that we were able to secure one for a trip such as had been planned for the archæologist of the Central Asiatic Expedition during the winter of 1925–26. At last, just as we were beginning to despair, we came suddenly upon the very boat for our purpose and, after the inevitable amount of bargaining, found ourselves in possession of a floating home. It was not really a houseboat, merely a freight boat which had recently discharged a cargo from up river and whose captain was looking around for another to take back.

Our vessel was not large and the personnel, including the captain and crew and the five members of our personal staff, numbered twenty-two. Nevertheless, when we were all settled down in our respective billets we were scarcely more crowded than in a small New York apartment, and we had a lot more fun. True, we had to learn not to bump our heads on the ceiling beams of our special compartment, but a few hard knocks taught us to be cautious. Mr. Nelson and I occupied the center of the boat, with our servants and the captain at the stern and the crew out in front; and although there was no outside passage we were not troubled by any use of our quarters. When it was necessary to pass from one end of the junk to the other the boys simply ran over our roof. Their own sections had no permanent roof, being covered with large mats which were only drawn over at night or when the weather was bad.

On the Yangtze the men who tow such boats as ours are called "trackers." The path they follow is sometimes down near the water's edge, at other times so high up on the face of a cliff as to appear from below like a mere pencil mark. Often among the bowlders it is so indistinct as to be almost invisible and again it is a real highway paved with stone. Our trackers were mostly mere boys or very young men. They were dressed in the scantiest of cotton clothing in spite of the winter season, and in some cases this was so covered with patches that the original garment had well-nigh been lost sight of. Some wore straw sandals, others were barefoot. Such insignificant details, however, had little power to quell the abundant good spirits of these boys. When the boat tied up they usually began skylarking on the beach, regardless of the fact that they had been running for miles, often plunging into the icy water stark naked to free the rope from troublesome rocks. They were equally prompt to retrieve a duck which had been shot on the water or to dive for a lost article. We grew very fond of them, as well as of our genial captain, whose soft persuasive voice would have coaxed renewed efforts out of the most stubborn of boatmen—or extra dollars from the pocket of the reluctant foreigner. Only once did we see him lose his temper, when he applied terrific epithets, which fortunately we did not understand, to the first mate, during a

The "Fairy Bridge," scene of our first anchorage

serious struggle to pull the boat over a difficult rapid. The mate himself jumped up and down in his wrath and displayed all the symptoms of an apoplectic fit. However, neither seemed to cherish any grudge after the incident was over.

But my special pet on this expedition was Hsi-tze, the cabin boy—a chubby, rosy-faced youngster of about nine years, who was certainly the most important member of the crew next to the captain. From morning until night his name was being called from one end of the boat to the other and was always responded to with a cheery "Hi!" as he scrambled over the roof, mop in hand, or rushed to get the captain's pipe and fill it, taking a few puffs to see that it was well lighted before handing it over. At times he even went on shore and took a turn at pulling on the rope, while at hoisting the sail or handling an oar, he was as lusty as any, joining in the vigorous chantey and stamping his feet with the best of them.

Our cruise started where the flat country which borders the Yangtze

River all the way from Shanghai rises into hills a few miles below the city of Ichang and the really picturesque region begins. The first night's anchorage was most appropriately at the Fairy Bridge—a natural arch spanning, as it were, the gap between the monotony of the plains and the splendor of the Gorges. Of course we did not proceed at night, even the steamers do not do that in this part of the river, and the charm of our mode of travel resided largely in the fact that we stopped wherever fancy or business demanded. A wave of the hand to the captain and in less than five minutes we were running over the gang-plank and beginning a scramble up the hillside toward a cave or a temple, while the crew scattered along the river bank and sought for any of those curious rocks of which they soon learned that the archæologist was particularly fond.

They learned this, I may say, almost at the outset of our trip. We had stopped to buy some supplies at a village. Mr. Nelson never missed an opportunity to look the ground over, so even though the prospect did not look very favorable, we strolled along the shore to examine the bowlders with which it was strewn. Soon we were excitedly picking up the fragments of stone axes scattered every where, later to discard these and replace them with the better specimens which a longer search revealed. Children of the village joined in the hunt, bringing to us at first any sort of rock, but shortly learning to discriminate, and in the end so surrounding us that we had no chance to do anything and were obliged to take refuge in the boat. We never found another place so rich in specimens as that, but it served as an excellent object lesson for our boys, who seemed to enjoy hunting thereafter and were greatly delighted when a piece of their finding was pronounced *ding hao* (very good) by the master.

Christmas Day found us at Ichang, a thousand miles from the mouth of the river and only a few miles below the entrance to the famous Yangtze Gorges. We were so fortunate as to receive an invitation from Mr. and Mrs. Squire of the China Inland Mission to join them at an excellent Christmas dinner, just another of their many kindnesses which did much to make our river trip comfortable and happy. And I should like to remark right here that if it were not for the missionaries in China the way of the foreigner would be very much rougher than it is at present. They extended many courtesies to us at various points on our journey.

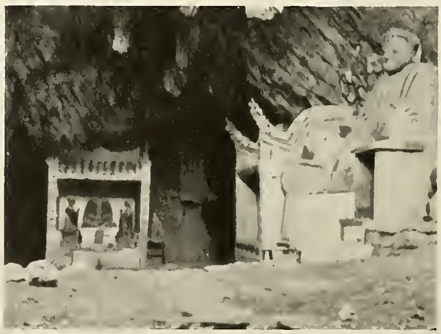
Ichang, viewed from a distant hill or from the river, presents a very attractive appearance. Its white houses with gray tiled roofs follow the curving line of the beach and face a series of pyramidal peaks on the opposite shore. But to walk its narrow, dirty streets, besieged by awful-looking beggars, possibly passing the body of some poor person who has given up the struggle and is callously left lying where he fell—these things make one want to run far away to some cleaner country where people have sensibilities and hearts. The river was very low at that time, and the foreshore was covered with the temporary mat houses which the natives occupy until the rising of the water in the springtime compels them to retreat cityward again. Many sampans lay along the water's edge to carry passengers out to the steamers at anchor in deeper channels, and the harsh cries of their owners soliciting trade made the night hideous. So we were glad when we were able to move on up river.

Snow lay on the hills for a day or two and we had to light our brazier in the evening to keep our feet warm. Usually we found our little cabin very comfortable with only the heat of the lantern by which we read. Our boys kept the sheet-iron kitchen stove stuffed full of wood from morning until night and as this was very near it served to warm us also. These boys we had brought from Peking—they were in fact a part of the regular Expedition staff of servants for Mongolia so they knew our requirements and looked after our needs punctiliously. Sha cooked our meals well and Wang served them with as great care as if we were in our own home, deploring the ragged tablecloth, a relic of Mongolia, but insisting on giving us finger bowls. We took along a sufficient stock of canned goods and in addition it was possible to buy chickens, eggs, and vegetables at almost every village. Little meat except pork could be obtained, this being the principal form of flesh eaten by the Chinaman when he is able to vary his chiefly vegetable diet. Oranges and pumalos were also plentiful along the river.

There had been much talk of bandits before we started, and of soldiers who would not hesitate to take a shot at us if they felt in the mood. On several occasions we were warned by the captain to have our guns ready, some of the villagers having reported bad men in the vicinity. Mr. Nelson thereupon laid his pistol within reach when we went to bed, but I do not think that either of us was sufficiently impressed by the danger to occasion loss of sleep, except that caused by the excited conversation of the boatmen, who apparently sat up most of the night looking for trouble. We were never at any time molested, though we were necessarily obliged to carry with us a considerable sum of money to keep our outfit running. It is only fair to say that we were under the protection of what we called our "river god," an inscribed tablet which stood on a shelf in front of the captain's small

This beautiful colored temple lies opposite the town of Yun-yang-hsien

Every farm has its shrine before which incense is burned to insure success for the crops



Caves, with their mysterious nooks and crannies suitable for installing images of the gods, are favorite places for Buddhist temples

We spent more than a week in the twenty-four mile Wushan Gorge, the longest and finest of the Yangtze Gorges

Sunset on the Yangtze transforms the river from a yellow turgid stream into a glistening bronze mirror

cabin behind our kitchen and before which incense was burned on occasion —presumably when we were in danger of a bandit raid or about to cross a difficult rapid.

Travelers in junks do not look with great favor upon the steamers which are continually passing, and we were no exception to the rule. They raise enormous waves as they plough along and toss the small boats around unmercifully. Sometimes as many as six passed us in half a day. If our little vessel was lying by the bank, the boatmen had to exert every effort to keep it from being smashed against the rocks. So when we saw a steamer struggling to make a difficult rapid we did not feel toward her the brotherly sympathy which the situation seemed to demand. On the contrary we chuckled as she snorted fire from her smokestack and made awful noises with her engines. Once we had the satisfaction of being able to lend some of our own trackers to assist a steamer over a bad place. We did not, however, let our vindictiveness carry us to the point of being glad when one of these larger vessels was actually wrecked, as occurred several times during our short sojourn on the river, once just the day before we reached the scene.

Proceeding through the Gorges slowly as we did, we lost none of their grandeur or beauty. Long vistas opened up before us which we could enjoy to the full before we had compassed their length. Anchored at the base of some towering cliff, our small boat shrank into insignificance, and we could only restore self-confidence by climbing high up the steep walls to increase our perspective. The season was too late for the semi-tropical foliage to be at its best, but there was still the delicate loveliness of the bamboo groves, while clusters of graceful palms shaded the small wayside shrines or marked an ancient tomb. Occasional bushes of brilliant red enlivened the dull gray or brown of the rocks, and wherever the farmer could get a foothold on the slopes, or find a bit of soil in which to drop seed, patches of vivid green testified to his industry. Sometimes a cave high upon the hillside had a stream of water flowing from it which cascaded over mossy stones to join the river. Black and white limestone ridges rose in fantastic peaks and spires and afar off on some pinnacle the gleaming walls of a temple standing against the sky seemed to tempt the first high wind to blow it from its perch.

Everyday was washday along the river, but at Wan Hsien the women were particularly active

This steamer came to grief in trying to avoid running down a junk the day before we reached the spot

These temples, which occur at frequent intervals along the river, serve other purposes than merely to ornament the landscape. Their chief end is to keep the river dragons from wrecking the boats, and if you pay tribute in passing, your safety is assured. One day we climbed a very long and steep stairway of many, many stone steps to reach a small cave in the vicinity of a temple. Contrary to the usual experience, no one seemed to be around collecting coppers to placate the gods, and we got back to the boat with our funds intact. Some time in the middle of the night we were roused by shouts from the bank, followed by a few sharp words in the voice of our interpreter. In the morning we learned that the "priests" had heard of our visit and had come down to exact a fee for enlisting the aid of the gods on our behalf, but as our boys refused to disturb us they withdrew, muttering ominously, "Well, we have warned you." That we suffered no inconvenience from this can only be attributed to the fact that our own gods were more powerful than theirs.

Other guardians of the temples were more vigilant. One man had a unique device for collecting money, consisting of something like a butterfly net attached to the end of a long bamboo pole. He stood on the rocks by the side of the river and as soon as a boat came within reach he thrust this receptacle over the side for a contribution. Later we climbed up to his temple, quite an imposing one situated in a large cave and furnished with many Buddhas, and he regaled us with tea and sweetmeats. Adjoining the main body of this temple, a large image of the Buddha carved from the living rock has a lamp continually burning before it and is quite black from the oil which has been poured over its head by many generations of worshippers.

On our long walks over the hills and through the side valleys we encountered a good many of the country people, who looked upon us as curiosities though they were always good-natured and ready to exchange ideas on the slightest encouragement. Our means of communication was chiefly the sign language, but it is astonishing how much one can put over in this way when he has to. If they sometimes got the idea that Mr. Nelson's stone implements which he tried so hard to explain to them were merely his special brand of "medicine," no harm was done and we parted friends. The women were especially interested in the things I wore, almost undressing me in their eagerness to see how my costume was built up, and taking off my hat to look at my hair. It is possible, that on account of my feet they may have doubted my being a woman, since they themselves were hobbling about on little stumps, even those who were carrying heavy burdens or working in the fields. At times we were invited into their homes. On one occasion we were treated to hot popcorn and our pockets filled with sweet potatoes. At another time it was the home of a fisherman and his wife, who lived in a cave. This man said that his family had occupied that same cave for more than a hundred years. The furnishings were of the simplest type imaginable. On a raised portion of the rock floor at the back, mats were spread for a bed. The front part of the cave contained a table, a couple of benches, and a stove built of clay on which was a large shallow iron bowl for cooking the rice and vegetables which constitute their chief diet. Some chinaware bowls and the indispensable teapot completed the equipment, which doubtless had been the same for the entire time of occupation.

We did not care so much for the people of the villages. They were more sophisticated and the small boys insisted on following us in droves and hampering our work of examining the river banks for specimens. They had fierce dogs, too, which had a disconcerting way of rushing out at us as if they would tear us to pieces, and sometimes they seemed to mean it. There was little difference in the character of these small villages and a visit to one or two was enough to satisfy our curiosity. Narrow, and to our senses at least, very dirty streets, were bordered by tiny dark shops where meats, vegetables, live ducks and chickens, articles of clothing, and numerous other things were mostly displayed on a front counter or sometimes actually out on the sidewalk for the pedestrian to make his way around as best he might. Mangy and hungry dogs and pigs wandered about seeking stray bits of food. Repulsive beggars blocked the way holding out bowls for coppers and whining dolefully. Open cesspools offended both sight and nostrils. Apparently the natives enjoy these conditions, as they huddle together even where there seems plenty of room for expansion of their quarters. So we did not linger in the villages any longer than was necessary, but hurried away to breathe the flower-scented air of the fields.

The Feng Hsiang Hsia, or Wind Box Gorge, is the last to be traversed on the trip up river. While the shortest, it is perhaps one of the most impressive, the cliffs being very high and of many picturesque shapes. Things of interest pointed out to every traveler are some coffins lodged in a cleft of the rock in what is now an inaccessible spot; the iron rods where a chain was once drawn across the river by a general in charge of of Kuei-fu to prevent his enemy from ascending and attacking that city; and the holes in the cliff which the wily enemy had made to hold the pegs on which his men climbed around and thus reached the city after all. At Kuei-fu itself are the salt springs which are worked feverishly all winter when the river is low. In summer they are buried under the yellow waters of the Yangtze. The white steam rising from the evaporating pans gives the appearance of an active volcano from a distance, while a visit to the scene shows naked workmen silhouetted against a background of glowing furnaces as they stream in and out of the brine pit carrying water to the pans.

While lacking the grandeur of the Gorge region, the country between Kuei-fu and the village of Pai-shui-ch'i, a few miles beyond Wan Hsien, where we dismissed our boat and became landlubbers again, was by no means without interest. We found a good many caves and visited various temples. The farms presented a more prosperous aspect as we neared Wan Hsien, with beautiful green fields and glistening rice paddies. Water seemed flowing everywhere. Even the air was full of vapor so that the landscape appeared as if seen through a veil of gauze. Sugar cane was being harvested and once we passed a mill where three water buffaloes were employed in crushing the stalks with a big roller. The harvesters offered us pieces of the cane, which we chewed and found quite refreshing.

The captain had been very proud to sail his boat under the American flag. When we gave it into his hands at Ichang he immediately had it hoisted about halfway up the mast. We objected to this as giving our craft the appearance of mourning, so he hung it on a pole at the stern. We would have taken it in at times to save it from being whipped to pieces by the wind, but we hadn't the heart to insist on this in the face of his evident reluctance to take it down. In the end it would appear that his attitude was justified. No sooner had we said goodby to the outfit, which we did with considerable regret after all these weeks of happy roving, taking our flag with us, than soldiers descended upon the boat and took away most of the crew to serve as baggage coolies, besides robbing the captain of twenty dollars and several bags of rice. We were sorry, but we were helpless. Our voyage was finished.

Pagodas are placed on promontories for the protection of the river craft

The water front at Nassau. Photograph by F. L. Jaques

The Bahamas in Sunshine and Storm

By ROY WALDO MINER
Curator of Lower Invertebrates

NOTE.—The work of the expedition described in this article was carried on in two localities in the Bahamas, and had two main objects. In connection with the first, at Nassau, capital of the Bahamas, Doctor Miner and his wife, Eunice Thomas Miner, secured photographs and motion pictures illustrating the life and industries of that picturesque city. This portion of the expedition was financed by the general funds of the Museum. The second, at Andros Island, was made possible through the generosity of Mr. John S. Phipps and his son Mr. John H. Phipps, the latter of whom shared the leadership of this part of the expedition with Doctor Miner. In this case the expedition continued Doctor Miner's study of the Andros coral reef, in connection with the new coral group for the Hall of Ocean Life. During their stay here the party experienced a hurricane. On their way back to New York, Doctor and Mrs. Miner made a second trip to Nassau and obtained photographs of the destruction left in its wake. The story of the trip naturally falls into three parts.

TROPICAL NASSAU

IT was a beautiful morning in the latter part of June. The good ship "Munamar" was gently swaying at anchor in the roadstead outside the harbor entrance, where for the last three years a huge steam dredge had been steadily at work deepening the channel. In the course of time, as it is counted in Nassau, the liners from New York will enter like vessels of lighter draft and dock at the city wharf. Just now, however, we had to curb our impatience until the puffing steam tug came blustering out with two huge lighters lashed to her flanks, to take passengers and cargo ashore.

Our three days' voyage from New York had been delightful, with the charm that always attends slipping from the dull green waters of the North to the brilliant deep blue of the tropical sea and sky. Though it was the month of June and, as we reckon it, summer, the heat of the tropical sun was not so oppressive as in New York at this season, and as we lay off the portal of this island of perpetual June, with the trade winds, laden with the spicy fragrance of tropical blooms, blowing over its gently sloping hills, the thought was borne in upon us, that here summer resides as in its natural home, and is not the fitful series of scorching blasts which, in northern cities, drive us restlessly to shore and mountains in search of comfort.

Baggage and passengers were now transferred to the tug, and from the upper deck of this self-important craft we watched the panorama of beautiful Nassau unfold itself as we swept in past the lighthouse guarding the harbor entrance. The rose-pink walls of the great Colonial Hotel showed conspicuously amid groves of waving palms. Away to the eastward, like a kaleidoscopic ribbon, stretched the low hills, dotted with picturesque houses of yellow, and pink, and blue. These peeped forth amid luxuriant groves of coconuts, royal palms, and casuarinas, their garden walls brilliant with flowering vines.

The landing place was almost hidden by the masts and sails of the sponging fleet, idle at this time of the year. Finally our craft nosed her way to an unoccupied berth, and soon we found ourselves ashore and attending to our baggage beneath the lattice-covered customs shed. The friend whose hospitality we were to enjoy, though an American, believed that motor cars and Nassau were not consistent. There were plenty of these dashing about. In fact, a native proudly told us there were "seven hundred cabs in Nassau, yaas suh." But the narrow streets of this quaint and ancient city, with high garden walls masking the corners, certainly are not adapted to the chariots of modern civilization, for one never knows what sort of an accident awaits him around the next corner. Previous visits had taught this, so it was with a feeling of distinct relief that we heard our host state that, during his frequent stays in Nassau, it was his custom to engage the entire services of Nathaniel Cambridge and his "sea-going hack." These traditional vehicles are two-seated, canopy-topped affairs, often in a state of semi-decrepitude, and drawn by a diminutive and equally frail "hoss." Mr. Cambridge, however, is a gentleman of enterprise as intense as his complexion, for his equipage was neat and shining, while sturdy little Lion, tossed the spirited tawny mane which gave him his name, and showed himself to be as well conditioned and ambitious a horse as one could wish.

Seated in this conveyance, we jogged out through Rawson Square and down Bay Street, the business center of Nassau. Before a cluster of public buildings of graceful colonial type, a marble Queen Victoria is seated on her

Panorama of Nassau from the hill-top. The Colonial Hotel rises in the middle distance, with the harbor beyond, separated from the open ocean by low-lying Hog Island. Photographed by Sands

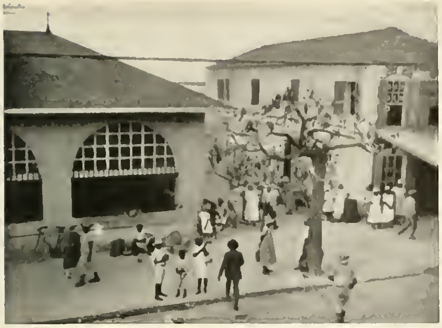
Nathaniel Cambridge and his sea-going hack ready to start on a photographic expedition

Entrance gate of old Fort Montagu, captured by the Americans during the Revolution

throne. To the left an enormous silk-cotton tree, ancient in years, raises its shaggy head. The picturesque shops of a past generation are interspersed with more modern structures, bespeaking a recent prosperity not wholly disconnected with the prohibition movement in the United States. So does national reform contribute to the well-being of communities not within our borders! In the shade of a spreading tree, rustling with the dried pods of "old women's tongues," a well-appointed and modern granite bank building welcomed our American travelers' checks and transmuted them into English pounds. The genial manager, the Hon. G. H. Gamblin, who is also the presiding officer of the governor's council, at once fell in with our desire to photograph, so far as possible, the life and industries of Nassau for the American Museum, during the two weeks at our disposal. Through the efforts of this official, these plans were greatly expedited. We continued on our way, turning up picturesque George Street and around the grounds of Government House, whence we passed westward between garden walls overhung with cascading tropical vines aflame with the magenta blooms of *Bougainvillea*, or golden with the drooping blossoms of the yellow bell-flower. Halfway down the hill a *Poinciana* spread its huge clusters of scarlet almost across the entire street, while the slender, silver shaft of a royal palm, rising from its midst, pierced the brilliant blue of the tropic sky with its plumed crown of foliage.

A sponge yard. Native women filling baskets for the clippers

The picturesque antiquity of Bay Street is invaded by the modern motor car



Outside the market on Bay Street. The tree was stripped by a recent hurricane

The outer market on the wharf, with fruits and vegetables in great variety

Finally we turned up a street on the crest of the hill, drove through a gate, and along a driveway to the front door of a mansion, where our host stood ready to greet us. Here we were made comfortably at home in a part of the house from which we could look south and east over the rolling hills of New Providence, with their waving coconut palms and casuarinas, and north over the vivid blue of the Atlantic, where the ship which we had just left lay at anchor. Not far to the west the tall skeleton masts of the wireless towers dominated the sky-line; while at our very feet, the houses and walled gardens of the city rose tier on tier from under the wings of the hotel.

During the next two weeks Nathaniel Cambridge and Lion were our constant companions. The "sea-going hack" bore us with our cameras and moving-picture machine through the highways and lanes of Nassau and the surrounding country-side. We photographed the natives with their picturesque huts, their outdoor ovens, their little plantations of bananas, coconuts, and papaws, their churches of coral limestone, their babies, and their sunny smiles. We could not photograph their soft spoken accents and their polite endeavors to please, but these remained in our memory as part and parcel of the languorous atmosphere of that land of mellow sunshine. We visited the wharves crowded with native sponging boats and other craft loaded with sisal and the tropical fruits of the outer islands. We lingered often in the

Mutton guaranteed absolutely fresh is sold on the hoof in this part of the market

Fleets of native boats bring sponges, sisal, fruits and vegetables from other islands

The gardens of Nassau are filled with many-colored tropical blooms so luxuriant that they overflow the garden walls and droop into the streets

market place, where the colored population of every shade mingled with the whites as they bartered for mangoes, limes, pineapples, melons, and vegetables, freshly unloaded from the boats tied to the neighboring wharf. The public market is a masonry building, with walls pierced by a succession of arches guarded by iron gratings. Inside we passed through aisles between fruit and vegetable stands, and made our purchases, sheltered from the heat of the tropical sun. The semi-obscurity of the interior was in vivid contrast with the succession of brilliant outdoor pictures framed by the arched openings. On one side, we glimpsed the blue harbor with its white-sailed boats. Yonder, a confusion of schooner prows loomed close at hand; decks heaped high with island products; gangplanks busy with the traffic of unloading, and the passing figures of dark-skinned stevedores. Through the wrought iron grill of the street entrance we could see natives, clad in vivid colors, passing back and forth in interweaving processions, straight-backed, ebony-faced figures, balancing baskets on their heads. In the background, across the sun-flooded street, lined with shops, the vista formed by a narrower side street was visible, overhung by balconies, and a cathedral tower outlined against the sky.

The inhabitants, both white and colored, were greatly interested in our operations. All the British officials, from the Governor and his Council down, gave every facility that we could desire. The delightfully hospitable English families that form the backbone of Nassau received us into their homes, while the dusky-skinned natives aided us with beaming smiles. As the result of their courtesy in the two short weeks of our stay we were able to go far toward picturing the real life of Nassau, and to obtain many photographs bearing on the sponge and sisal industries, those important factors in its prosperity.

We explored the ancient forts still standing on the heights of the island.

Fort Fincastle, on the summit of Bennett Hill, was built in 1794 by Lord Dunmore, who, after having been royal governor successively of New York and Virginia, in the years immediately preceding the American Revolution, was later appointed governor of the Bahamas. The thick-walled bastions of the old fort are still surrounded by a moat, now dry. We entered through a narrow, arched doorway, and, ascending a flight of stone steps, found ourselves standing within the fort enclosure among ancient dismounted cannon. Scaling the ramparts by the aid of the rusting gun carriages, we obtained a magnificent view of Nassau, spread out before us in the tropic sunshine. The fort is now used as a signal station, and pennants are displayed from a tall flagpole to announce the approach of vessels.

Fort Charlotte, on the heights to the west of the city, was also built by Governor Dunmore. Beneath it are passages and chambers cut from the solid rock, which, tradition says, were once used as dungeons. Another tradition states that a secret passage leads half a mile to the eastward, to Governor Dunmore's mansion. This still stands, and is used as a Roman Catholic rectory.

On the shore overlooking the eastern entrance of the harbor, about two miles from the town, is old Fort Montagu, built in 1746. This was captured by the Americans during the Revolution, and held for a short time. Later it was taken by Spaniards from Cuba, who held it until 1783, when it again fell to the English.

The island of New Providence has always been closely associated with troublesome times in our own country. In the early part of the eighteenth century it was the headquarters of pirates, especially of the notorious Edward Teach, the "Blackbeard" of pirate lore. His ships preyed upon the commerce of the American colonies until he was killed in action with two American ships in 1718. During the Revolution, the Bahamas were the refuge of tories, and, at the time of the Civil War, Nassau attained sudden and great prosperity as the center of blockade-running activity. In more recent years another wave of wealth overflowed this tropical city when rum-running was at its height. Its entire history seems to have been a succession of stirring and romantic events alternating with periods of tropic languor and somnolence. Many of its inhabitants suddenly rose to considerable wealth and temporary prosperity, later to pass through straitened circumstances.

To the sojourner in its midst, Nassau is redolent of romance and adventure, with evidences on every hand of a historic past. While it draws a moderate sustenance from its plantations and the ocean round about, it is ever ready to rouse itself to take advantage of the turn of events, especially when adventure is in the air. Perhaps the traditions of buccaneering days still linger among its inhabitants. Nevertheless, its hospitality to the traveler is unbounded, and weaves a

The strong fiber obtained from the sisal plant rivals hemp for the manufacture of cordage

The expeditionary fleet receiving its gasoline supply. The largest vessel, the "Seminole" carries 3000 gallons and the "Iolanthe" 2000

spell of charm and beauty which draws him irresistibly to return again and again.

THE TRIP TO ANDROS

On the eleventh of July the yachts "Seminole" and "Iolanthe," with the Phipps party and our Museum colleagues aboard, arrived in the harbor, and the next day, after taking on gasoline and additional provisions, we got under way for the coral lagoons of Andros. Our destination was Mangrove Cay, about sixty-five miles away, where two years previously our Museum expedition, with the aid of Mr. J. E. Williamson and his wonderful submarine tube, descended to the bottom of the sea outside the famous Andros barrier reef, and made studies and photographs of the living corals. At that time we succeeded in transporting about forty tons of coral growth to the American Museum, and since then our skilled artists have been engaged in preparing and coloring it for the great artificial coral reef in process of construction in the Hall of Ocean Life. Our purpose, on this occasion, was to secure studies of the reef fishes themselves, as well as sketches for the great panoramic background to be erected about this exhibit. Through the liberality of the Messrs. Phipps, father and son, the houseboat yacht "Seminole" and several subsidiary launches were provided for this purpose, while Mr. Phipps, Jr., who is a born sailor and fisherman, was to act as commander of the

The "Iolanthe," lying at anchor in the lee of Little Golding Cay, on the Andros reef. The photographs on this page are by Roy Miner, Jr.

fleet and of the actual fishing operations. Mr. Phipps, Sr., with his family and several guests, accompanied the expedition as visitors, on board the sea-going yacht "Iolanthe," and engaged in game fishing during the first week of our stay at Andros. The "Seminole" is a gasoline-driven, twin screw vessel, 115 feet long at the water-line, and with a draft of about four and one-half feet. It is well equipped with staterooms and baths, dining room and social room, as deck structures, and with adequate kitchen facilities, including ice machines. We fitted up a workshop on deck, forward of the social room, which in turn was used as a general meeting place and for laboratory purposes. The after deck was set aside as an artists' studio. The vessel had a crew of eight men under the command of Captain Nelson.

The Museum party, besides the writer, included Mrs. Miner; Mr. Chris E. Olsen, modeler; Mr. F. L. Jaques, artist; and Mr. Roy W. Miner, Jr., as assistant to Mr. Olsen.

The "Iolanthe" proceeded to Andros ahead of the "Seminole," which, owing to various delays and its slower speed, put into Clifton Harbor, at the west end of New Providence for the night. Here, after darkness closed in, the water became brilliantly luminescent with light-producing jelly-fish, ctenophores, and other marine organisms. Large squid were swimming about apparently prey-

Mr. John H. Phipps with two of the hound fish shot by him from the deck of the "Seminole"

Above at the left,—a nurse shark captured by the expedition being hauled aboard the "Seminole." (Photograph by C. E. Olsen.) Upper right,—raising fish pots containing tropical fishes caught on the outer reef. Just below,—fishing for green morays with a three-pronged grange. Lower left,—a catch of spiny crayfish; center,—Roy Miner, Jr., casting a rock hind; right,—finished molds of fishes cast for the Museum's new coral reef group

ing upon them. We swung a powerful gasoline lantern just clear of the water and succeeded in spearing a number of the squid that were attracted by the light. They were light colored, mottled with bright orange patches.

The next morning we were under way before daybreak, and reached South

Bight entrance of Andros Island early in the afternoon, where we found the "Iolanthe" awaiting us. This anchorage was not roomy enough for our vessels, so while Mrs. Miner and I went ashore in a launch to pay our respects to Commissioner Forsyth at Mangrove Cay, the two yachts sailed outside the reef and proceeded to Middle Bight entrance, seven miles farther north, and anchored in Hog Cay Channel. As this was not close enough to the reefs, we soon transferred our location to the lee of Little Golding Cay, our anchorage of two years before.

Our first task was to set the fish traps in the neighborhood of the outer reef. Five of these were placed with the aid of the launches, and, by the next day, were beginning to yield catches of brightly colored reef fishes. These were placed in aquaria as soon as they were brought aboard, so that color sketches might be made by Mr. Jaques. A captive fish in an aquarium soon begins to fade. It is necessary, therefore, to make color records immediately, if our fish models are to be accurate. Again, many species of fish undergo more or less rapid changes of color, apparently at will, or in response to varied stimuli, even in their natural environment. It is desirable to record so far as possible the range of these changes.

As soon as each fish was colored, it was brought to Mr. Olsen to be cast. A plaster mold was made, in two pieces, one for each side of the specimen, in such a way that when the mold was finished, and the two halves placed together, melted beeswax could be poured in through an opening, and thus produce a wax cast of the entire fish. During three weeks' work on the reef, more than sixty of the most representative species of reef fishes were cast and sketched in color. Specimens were also preserved in fluid, for reference. This will make possible the construction of lifelike reproductions of the typical fish fauna of a coral reef, with all its natural coloration.

The younger Mr. Phipps, aided by his friends, Messrs. Lee Bradley and Winston Guest, and his younger brothers, Messrs. Michael and Hubert Phipps, succeeded in spearing a number of the larger parrot fishes. Yellowtails, trunk fishes and slippery dicks were taken with hook and line. Mrs. Miner caught in this way a four-foot barracuda. The gill net was used for "passing jacks." Mr. Phipps obtained hound fishes with a shot gun. The best success, however, attended the use of the fish traps. These secured for us parrot fishes, squirrel fishes, blue, black, and black and yellow angels, butterfly fishes, groupers, spotted hinds, nigger fishes, beau gregorys, blue heads, striped grunts, red snappers, margate fishes, and many other species. The molds and sketches of all these have been brought back safely to the Museum, and will be entirely adequate for our purpose.

Mr. Jaques also secured a full series of sketches of the reef surroundings, including notes on the vegetation and sky and water effects, to be used in painting the group background. Those who have seen the remarkable sky dome which he painted in the bird hall of the Museum as a setting for the flying bird exhibit, anticipate another notable achievement by him in this new undertaking.

About one thousand still photographs were taken in the course of the Nassau and Andros expeditions. More than half were secured by Mrs. Miner and myself, while fine series were taken by Messrs. Olsen, Jaques, Phipps, and

THE "BLUE HOLE" ON GIBSON CAY

Above.—Spearing parrot fish at the "blue hole," a landlocked pool, connected with the open sea by a subterranean passage. (Photograph by C. E. Olsen.) Below, left,—The rain- and wave-eroded rock of the disintegrating Gibson Cay; center,—a weird corner of the pool; right,—Mrs. Miner holding aloft a fragment of the porous rock

Roy Miner, Jr. These will be of value not only as assets to the educational lecture resources of the Museum, but also as authentic records to assist us in preparing the new group.

The cays in the neighborhood of the reef presented features of great interest. On Gibson Cay, at the entrance of Middle Bight, are two landlocked and nearly circular salt-water pools, known among the natives as "blue holes" from the color of the water. The larger is about two hundred yards in diameter, and the smaller is about half that dimension. Both are of great depth and have a subterranean connection with the lagoon outside, where similar circular submarine "blue holes" form their outlets. When the tide rises, the water is sucked in through the external openings, in each case forming a whirlpool, and the tide rises in the pools within the cay. When the tide ebbs, the opposite phenomenon occurs. Within the landlocked pools are many marine fishes, often of large size, which have found their way in through the subterranean passages. As the water is very quiet and transparent, it is possible to see them as clearly as in an aquarium. A number of our largest parrot fishes were speared here.

The outlet of the larger hole is on the north side of the cay, situated in the midst of a coral bar in shallow water. At low tide it is possible to walk out through water about three inches deep, to the edge of this submarine chasm. The shallow sea bottom here is completely carpeted with small living corals. These are of various beautiful shades of color and produce a remarkable effect as seen through the thin layer of transparent water. At the edge of the hole we peered down to unknown depths. As far as we could see, its sides were lined with magnificent living corals overhanging the pit with their rich foliate expansions, the successive growths gradually melting into the blue as the eye failed to penetrate the watery shadows. The rock of the entire island is of porous æolian limestone, and is much disintegrated by rain and wave erosion. As we walked over it, we could peer down through a network of cavities, where rain- or sea-water pools were visible. In the more elevated portion of the island the pits are small, shallow, and on the surface. Nearer to the shore they become deeper, and end in spherical cavities. At a still lower level, these cavities are seen to be connected with each other, to form larger, but still miniature caverns, or continuous chambers, the former partitions of which have dwindled to pillar-like supports. When the region of wave erosion at the water's edge is reached, the roofs of these caverns have collapsed and washed away, leaving the irregular and grotesquely shaped pillars tapering upward to terminate in sharp pinnacles. It is evident that the limestone is eroded by acid rain water which pits the rock and, as time goes on, deepens the cavities, enlarging them till they unite with each other to form continuous caverns, to be finally unroofed by the assaults of the dashing surf. The cays were doubtless once much higher, but are now in the last stages of disintergration. Apparently the same process has taken place on the mainland of Andros with modifications, and in combination with wholesale subsidence of the land mass, as shown by its maze of intersecting waterways.

During these days life on the reef was very pleasant. Except for occasional rain squalls, the weather was delightful. The trade winds continually blowing from the east counteracted the effect of the burning July sun, and it was hard to realize that in New York, so many degrees farther north, the streets were sizzling in heat. The tropical sea was almost unbelievably blue, and the shallows in the lagoon here and there showed broad bands of brilliant emerald, of a hue impossible to find in any artist's color box. The trade wind clouds heaped themselves into huge billowy towers, at times reaching almost to the zenith, dazzling white against the blue dome of the heavens. Every evening the sun sank in a blaze of gold and scarlet, flecked with burnished cloudlets. Sometimes the cloud towers were silhouetted against the sun in dark finger-like masses, edged with silver. These divided the sunlight into great rays that shot their fan-like radiance up into the zenith, beyond which they converged once more in the extreme east, producing a huge banded arch across the entire sky. Mr. Jaques succeeded in recording some of the most remarkable cloud effects by means of a camera equipped with a ray filter. For two weeks our work was carried on in a tropical paradise.

CLOUD FORMATIONS IN THE BAHAMAS

The towering cumulo-stratus clouds are characteristic of this region of trade winds. They are often piled in snowy white masses reaching nearly to the zenith, their bases flattened out into stratus formations where they rest on denser layers of air near the sea. At sunset they are illuminated in colors of almost unbelievable splendor. (Photographs by F. L. Jaques.)

THE HURRICANE

On Saturday, July 24, our glass began to go down. A swell was working its way in from the Tongue of the Ocean. The wind was swinging north of east. That night the moon was at its full and seemed very large in the heavens, across which light-flecked clouds were scudding. The tide was unusually high and, completely burying the reefs, covered the entire beach on the lee side of Little Golding Cay. The thirty-foot launch "Barbara" was tugging at her anchor not far from the beach. The next morning, Sunday, was clear, but a strong wind was blowing from the northeast. Nevertheless Olsen went ashore on Andros in one of the launches to do some collecting. The launch was to pick him up later in the day at Mangrove Cay, not far from Commissioner Forsyth's residency. As the glass continued to fall and the wind became stronger, Captain Nelson decided we were in for a northeast gale and determined to ride it out. We already had two anchors with heavy chain cables out forward. We had begun to strain at these, so he lowered a third anchor attached to an inch-and-a-quarter rope hawser. This hooked deeply into the sandy bottom, and the Captain confidently asserted our ability to ride out any storm that night.

About three in the afternoon the launch arrived with Commissioner Forsyth aboard. He at once hurried to the captain's cabin and, after a short conference, the latter appeared and informed us that a West Indian hurricane was sweeping toward us and was due to arrive at any moment. Mr. Forsyth had received the information from a native fishing boat, which had been sent over from Nassau for that purpose, as we had no telegraphic or wireless communication. Since our anchorage was practically in the storm's path, it would be impossible for us to hold on where we were. The Commissioner advised us to get up our anchors at once, and he would endeavor to pilot us to a place where we would be reasonably safe if the storm did not strike too far in shore. We immediately set about this and at the same time sent a launch over to Little Golding Cay, to get the younger Mr. Phipps and several others of the party who had landed there earlier in the afternoon. Mr. Phipps, Sr., with his family and guests, had returned to Miami in the "Iolanthe" the week before, so that we had to depend entirely on the "Seminole" and her subsidiary boats. About this time Olsen was seen approaching from the mainland of Andros, tossing about in a native sailboat. Our launch picked him up. He had heard on shore about the approaching storm and had decided to come out and warn us without waiting for us to send for him. Meanwhile we had started our donkey engine to raise our anchors, but, to our chagrin, found that their chain cables were twisted about each other and were badly fouled. We had to lower a couple of sailors over the bow in rope-slings to disentangle them. This was a difficult task as the sea was now running very high and waves were continually washing over the men as they desperately struggled with the refractory chain loops. It took two hours to get the chains free, and then the engine was started once more to haul them in, only to break down. So all hands had to get to work and raise the heavy anchors by man-power. By this time the angry sea was high above the outer reef, which thus offered no protection, and huge waves were rushing upon us in swift succession. The wind was blowing a gale, and the vessel was tugging and straining at the single rope hawser which was now left. Meanwhile we found she had been dragging in a direct line toward the rocks of Goat Cay, a half mile to leeward. With our powerful gasoline motors going full speed, we managed to head about before the wind, and then cut our cable with a couple of axe-blows. We were none too soon, for we just missed the rocky shallows of Goat Cay, as we headed in toward Middle Bight entrance.

These so-called bights are really straits that run entirely through Andros Island to the west shore, and divide it into four parts. We succeeded in penetrating the strait for ten miles and anchored behind a projecting point in comparative safety. The storm continued to increase all night and was at its worst about four in the morning. At daybreak we looked back toward our old anchorage and saw continuous processions of black cloud masses flecked with white, marching swiftly up the Tongue of the Ocean in the direction of Nassau. All about us the tossing water of the Bight was as white as milk, due to the soft, calcareous mud which had drifted through from the sponge banks on the western shore of Andros. During the night the wind had shifted counter-clockwise from the northeast and was now blowing from the south and southeast. We were forced to remain in our sheltered position for three days, when the storm had abated sufficiently to permit us to make our way out to the Bight entrance, near Gibson Cay.

That morning an American coastguard cutter came down the Tongue of the Ocean looking for us. She had been sent from Miami at the request of Mr. John S. Phipps, who had been greatly concerned about us. She had Captain Lind of the "Iolanthe" aboard as guide and pilot. We now learned that the wireless towers of Nassau were down, leaving her with no communication with the world, and that considerable damage had been done at Palm Beach. This was the first of the series of hurricanes that have so devastated the West Indian region during the past few months, and was totally unexpected, as they are seldom known to occur before August or September. We sent telegrams back by the cutter to inform the Museum and our families of our safety, and she started back to Miami. She had not been gone long when we heard a familiar humming in the air, and, looking up, discovered that a hydroplane was approaching from the northwest. When it was immediately over us it planed down, and, alighting on the water, taxied up to us.

"Is this the house-boat "Seminole"?

"It is."

"Is everybody safe"?

"We are."

"Well, Mr. Phipps is worried about you."

Apparently the hurricane at Palm Beach had been so severe that Mr. Phipps felt it necessary to take every means to learn of our safety at the earliest possible moment. As a matter of fact, we had come through with no casualties except that our largest launch, the "Barbara," had been driven ashore, her keel torn off and her propeller bent. During the next few days, however, she was overhauled by the captain and crew, and put into as good repair as possible.

Now that the hurricane was over, we returned to our work on the reefs. We had already accomplished practically all that we had set out to do. Our series of sketches and molds was nearly complete, and we had taken many photographs. We had not, however, accom-

The hurricane of July 25 wrought great damage in Nassau. Trees were uprooted, houses blown down, and fields laid waste. Two later hurricanes completed the destruction

plished the diving that we had planned and for which we had come equipped with diving hoods. We now found that the white mud or marl, from the west shore of Andros had been driven completely through the Bight to the lagoon at the eastern entrance, and had so clouded the water that diving was out of the question, and even the fish would not bite. After a day or two the mud had settled and we resumed our fishing, obtaining a number of species that we were still anxious to get. The sea was still somewhat rough and it was not until toward the end of our stay that conditions were favorable for submarine work. Nevertheless, Mr. Phipps, Jr., Mr. Olsen, and Mr. Lee Bradley, as well as myself, managed to do some diving during the last three days. In the meantime Mr. Phipps, Sr., had returned with the "Iolanthe," and on the morning of August fourth, that boat was detailed to take Mrs. Miner, my son and myself back to Nassau, that we might obtain pictures for the Museum showing the damage wrought by the hurricane. The swift "Iolanthe" made the passage of sixty-five miles in five hours, and we were in Nassau by breakfast time. After landing us, the vessel immediately put back to Middle Bight and escorted the "Seminole" to Miami, stopping at Bimini on the way.

When our section of the party reached New Providence, we were amazed at the change that had been wrought by the hurricane. The whole island appeared to have been swept by a blight. Nearly every tree had been either stripped bare of foliage or the leaves were dry and withered, due to the suction of the terrific winds. Scores of trees were uprooted, or stood grotesquely maimed, with torn stumps where leafy branches had been. In Nassau, masonry churches were completely demolished or unroofed, many of the frame dwellings reduced to kindling wood, steel telephone poles bent double as if made of tin, and every tree on the Parade laid prostrate. Many of them were centuries old, and had withstood countless storms. The water front was strewn with wrecked vessels, while at least forty others, including many of the sponge fleet from the outer islands, were blown out to sea through the harbor entrance and were never heard from again. Fortunately there was no loss of life on land, but many crews of the vessels must have been drowned. Four bodies drifted ashore within the harbor. The wharves and buildings along the waterfront suffered severely. One large storehouse for liquors, built of concrete blocks and elaborately ornamented with columns of masonry, was completely demolished by the force of the wind, scarcely one block being left standing on another. Many houses escaped miraculously, while others immediately adjoining were destroyed or at least unroofed. The damage had been largely confined to the path of the storm and the more substantial buildings everywhere remained comparatively unscathed. The beautiful flowering vines and shrubs and blooming gardens that so attracted our attention a few weeks previously, were masses of tangled wreckage, while royal palms had lost their graceful tops and now stood with one or two bedraggled plumes, like roosters after a cockfight.

The people of Nassau, however, were calm and cheerful and went about the business of repair with undaunted spirit. They were as cordial and hospitable as ever and related their experiences and narrow escapes with evident thankfulness that the event was no worse, though it was everywhere agreed that it was the most terrific hurricane since that which laid waste the island in 1866.

We spent ten days photographing scenes of damage, and on August 15 sailed for New York with all the objects of our trip accomplished and our minds filled with memories of storm and sunshine in tropic seas that we shall not soon forget.

The houseboat yacht, "Seminole," the floating headquarters of the expedition

Scenes in the Isles of June

PHOTOGRAPHS BY EUNICE THOMAS MINER

and other members of the American Museum Expedition to the Bahamas, 1926

A HUMBLE HOME IN THE TROPICS

Many of the natives live in small houses of coral limestone, thatched with palmetto and embowered in tropical vegetation. They are often surrounded by small plantations of bananas, coconuts, and alligator pears. Where the soil is not too stony, it yields a variety of vegetables. Photograph by Sands, Nassau

TYPICAL BAHAMAN CHARACTERS

Left,—"Old Flowers," a native of Andros, living in Nassau. He carries his purchases in a primitive basket made of two palmetto leaves. The two stems form the handle. Middle,—the watermelon is balanced on this boy's head as the proper way of carrying it, not as a juggling act. Right,—two sisters in Andros. The mother has died leaving a family of eleven children. They live in a primitive thatched hut of two rooms

Returning from market one sunny morning this picturesque native lad attracted our camera but refused to have his picture taken until he learned that we were admiring his fish

The market. Bringing home the milk. The animated milk bottle at the left will afford a continuous family supply. Goats replace cows as milk producers because of the scarcity of pasture land

Diving on the Andros reef. Upper left,—Captain Nelson placing a diving helmet on Mr. Olsen's shoulders. Upper right,—the diver descending. Photographed by John H. Phipps. Below,—the sea bottom with growths of living coral. This picture was taken through the Williamson tube during the expedition of 1924

Mr. Jaques sketching in color a recently caught butterfly fish (*Chætodon striatus*). These little fishes, fluttering among the corals, readily suggest their terrestrial namesakes

Mr. Jaques making sketches for the background of the new coral reef group for the Museum's Hall of Ocean Life. Goat Cay on the Andros Reef

Mr. John H. Phipps mending a gill net after a catch of passing jacks (*Caranx chrysos*). These fishes formed a welcome addition to the expeditionary larder

Street scene in Nassau.—Halfway down the hill a *Poinciana* spread clusters of scarlet, while, rising from its midst, a royal palm pierced the tropic sky

A quaint side street dominated by the tower of the cathedral

SCENES IN NASSAU AFTER THE HURRICANE

Above,—steel telephone poles bent like paper. Center, left,—St. Ann's church with spire and roof blown away. Center right,—a native church completely demolished and even the altar broken. Below,—a study in topsy-turvydom

Photograph by F. L. Jaques

The "Iolanthe," floating in the evening light. A Bahaman sunset baffles description

In Jane Gale's Cavern. This remarkable cave has been eroded by the sea in the cliffs at the West End of Nassau, cutting through successive petrified beaches with shells of sea animals imbedded in the rock formation

The S. S. "Victoria"—Akutan Island. Photograph by M. L. Thompson

Impressions of Alaska,—Where East and West Approximate

By J. T. NICHOLS
Associate Curator of Recent Fishes

ALASKA, or more particularly the Bering Sea area, is a region in contact with notable seasonal migrations of fishes and whales by sea and of birds by air. It is an area which has been significant in dispersal migrations of the past, lying as it does between the faunæ of two great continents, Asia and America, and also, in a way, between those of two great oceans, North Pacific and North Atlantic across the Arctic basin. It was with this in mind during the past summer that the writer spent a month or two of relaxation from Museum laboratory and library work in a general reconnaissance of northwestern waters and shores.

North and west of the state of Washington there are two routes of travel: one may either strike out to sea or follow the deep sounds and channels of theBritish Columbia coast. This latter is very reminiscent of the rugged rocky shore of Maine, only on a larger scale. There are no valleys to speak of, save the one intricate many-armed valley now occupied by the sea. The land consists of hilltops, for the most part clothed with an evergreen forest. Except under the actual shadow of the trees almost everywhere naked rock is in view. This is not in weathered outcrops but in solid masses, seemingly planed smooth and into straight or rounded outlines by some gigantic glaciers of the past. Beyond superimposing the forest upon this terrain, the heavy precipitation of the present day has altered it but little. The scenery almost everywhere is fine, often of striking grandeur. When at sundown, the breeze is hushed, and the nearer and more distant hills of various shades of turquoise blue are reflected in the mirrored surface of the water, here and there broken by a streak of silver in the wake of some swimming guillemot, the scene is one of surpassing beauty. It is so still that one can hear the patter of the birds' feet on the water as they rise.

An Aleutian Island shore, where the dull grayish song sparrow is almost as large as a towhee; and one of the ordinarily alpine rosy finches feeds on the sea beach. Photograph by M. L. Thompson

Thus one comes to the southeastern boundary of Alaska, that American territory of land and sea which stretches away to the northwest until it all but touches the old world of Asia. At once one seems to notice a change in the character of the land. The Rocky Mountain system which, in higher latitudes, has been edging west, seems now to be actually looking out across the great ocean. There are mountains and groups of mountains, close to the shore line or rising faintly against the sky above their foothills inland. There are naked rocky summits broken by frost and scoured by avalanche, long slopes and valleys, little glaciers which cling high on a mountain-side, and great glaciers which sweep down to the sea to form a wall of ice across the heads of one or several narrow fjord-like bays. But there are small mountains and large mountains, those that seem rugged and new beside others seemingly softened by the touch of time and erosion. In fact the variety is such that out of simple, even conventional units is built up a confusion impossible for a casual observer to reduce to any system. Still farther northward, and stretching away to the west in the Alaskan Peninsula to the Aleutian Islands, mountains of a volcanic nature are the rule in a land whose scenic beauty could scarcely be excelled.

Northward of the line of the Aleutian Islands, the Bering Sea shore of Alaska takes on an entirely different character. It is mostly low tundra, with the weathered hills well in the background. The shore front in places is cut by the sea, into a bank of soil of some height varying according to exposure. Both shores of Bristol Bay are low and treeless, no less so than the south shore of Seward Peninsula, where there is an occasional headland of some elevation but little indentation of the shore line between such headlands. The streams about Nome also fit into the landscape as though it were made for them without apparent interference from recent glacial conditions. Which are the older, these hills or Bering Sea? If the hills, would not there be some evidence of aggrading, which there is not? Were the two perhaps coincident? How did this area escape recent glaciation? By insufficient precipitation? Its precipitation is much less than that of the coast farther south, more to leeward of the ocean.

At present Alaska's principal economic distinction is her fisheries, as in the past it has been her gold, and in the future may be air lines of communication which curve northward towards the pole between the four corners of the earth. This possiblity, in line with the distribution route of animals in geologic time, has now, however, the appearance of being improbable,—lack of communication with the outside and between its parts being the one handicap everywhere apparent to the progress and development of the territory.

Northbound along the "Inside Passage" in July, the first interesting cetacean (whale or porpoise) to be noticed was a black and white porpoise, *Phocoenoides dalli*, reminiscent of a similarly boldly marked but unrelated species (*Lagenorhynchus cruciger*) of Cape Horn seas.[1] *Phocoenoides* is related to the common harbor porpoise, or "puffing pig," (*Phocaena phocoena*), but nothing could be more unlike than the actions and appearance of the two. The latter rolls its back and fin out and under again with scarcely a ripple; the former breaks along the surface, splashing an amount of white water disproportionate to its size and the part of its body that comes into view. This species was first seen in British Columbia waters at the north end of Vancouver Island, and though not common, was noted at various points all the way northwest on the east side of the Gulf of Alaska. It seems to travel in small groups of from two to a half dozen individuals, and can be recognized at some distance by its manner of breaking. This is so characteristic that distant schools of porpoises off shore midway between the islands and Seattle (53° 36′ N. 145° 37′ W. to 52° 19′ N. 137° 42′ W.) were referred to it with confidence. It seems so different in life, that one cannot but be pleased that Doctor Andrews has separated *Phocoenoides dalli* generically from *Phocaena*.[1]

A station for the capture of the larger whales by steam whalers, situated on Akutan Island close to Unimak Pass between the Pacific and Bering Sea, is taking these leviathans of the deep (whale oil is good for making soap) at a rate which may be expected to deplete their numbers for that immediate vicinity in a very few years. The greater number are finbacks and humpbacks, with a few blue, right, and sperm whales. It is surprising to see what different looking animals are the trim, slender finback and the long-armed humpback, if one is given the unusual opportunity to see the two hawled out of water. They can also be differentiated at sea, to be sure. Not

[1] *Bulletin of the American Museum of Natural History*, 1908, XXIV, p. 219, fig. 3.

[1] *Bulletin of the American Museum of Natural History*, 1911, XXX, p. 34.

The whaling station on Akutan Island.—Notice the sharp V-shaped groove cut by each little rivulet which courses the gentle grassy slopes of the hill. Photograph by Al. S. Oliger

Finback whale hauled out at the Akutan Whaling Station. The birds in the background are glaucous-winged gulls. A few ravens are also present about the station. Photograph by Al. S. Oliger

Pacific right whale. The once valuable whalebone from this species is now of comparatively little worth, since whip handles and corset stays have gone out of fashion. Photograph by Al. S. Oliger

In summer the seas about the Aleutians are so little Arctic in character that an occasional warm-water sperm whale is taken at Akutan. Photograph by Al. S. Oliger only is the finback's fin higher and better defined, but its spout is less scattering, going up straight and tall like a fountain, when there is not much breeze. The humpback commonly lifts its flukes above the water as it disappears.

Aside from the whaling station, the landscape about the harbor on Akutan Island is not only very beautiful but exceedingly interesting. The gentle, graceful curves of the sloping hills are clothed in delicate green grass, without a tree to hide a single detail of their outline. From the point of view of erosion they show every appearance of maturity, but with this maturity as a background, the imprint of a recent uplift is shown also, for each little brook that descends their slopes has cut a sharp V-shaped gorgelet down which it tumbles to its present baseline at the sea. There is also evidence of sea-carving on the cliffs high above the present level of the ocean, where just such a cave as is cut by the wash of the waves may be seen. One may contrast this condition with the flat valleys opening to salt water between hills at the east end of Unimak Island (only a short distance farther east); hills which are almost identical with those at Akutan.

The fur seal in the water, off shore in Bering Sea, is a slender, graceful, dark-colored, active animal, very different from the true seals or the ponderous northern sea lion. Not having seen the Pribilofs, one may mention it only, and pass to the salmon fishery.

The various species of Pacific salmons, particularly the smallest with bright red meat, called locally "redfish," are here taken in almost incredible quantity. The redfish, which is the same species as the blue-back salmon of the Columbia or the sockeye of Puget Sound, enters fresh water to spawn in streams tributary to cold lakes which serve as nurseries for the young before these descend to the sea. There are various and extensive lakes of this sort about Bristol Bay, a broad funnel-shaped arm of Bering Sea which cuts deeply into the outline of the mainland just north of the Alaska Peninsula. In seasons of a good run such as the present one (1926) waters outside the rivers which empty into the head of the bay are glutted with this particular salmon. The fish are caught in drifting gill nets from staunch double-ended boats, each with a sail, two pairs of oars, two men, and no power. The method is almost identical with that employed at the mouth of the Columbia. It calls for daring and resourceful seamen, for whereas Bering Sea summer weather is, as a rule, one of light breezes and smooth water, there is always the possibility of a sudden gale from the north or northwest in which a salmon-laden boat will prove quite unseaworthy. The funnel-like configuration of its shores gives the head of the bay tides of considerable magnitude, and the tidal current racing out or in and the coldness of the water add to the danger. This year seven fishermen were lost here in one blow.

One of the most remarkable faculties possessed by the Pacific salmons is the ability, when they meet in the sea the taint of fresh water from the particular type of drainage favorable to their spawning, to recognize it and follow it to its sources. Thus the redfish crowd into Bristol Bay which is fed by lakes, and but a few stray king salmon are taken among them. According to one of the fishermen he took only about twenty-five of them among the thousands of salmon which fell to his net this year. The large king salmon by preference enters major rivers, such as the Columbia and the Yukon.

Conservation of Alaska's salmon supply is a problem of very great importance to the country, and one to which much thought is being given. The interesting life history of Pacific salmons has been the subject of careful study and in a general way is now fairly well understood. Data on their age and growth have been obtained from microscopic examination of the scales of large series of individuals. Methods for taking salmon eggs and hatching them artificially have been perfected. The catch of fish in Alaska is so vast, however, that it cannot be materially effected by hatchery work on any scale practicable at present. More imperative are restrictive laws and closed seasons in relation to conditions as they arise in different localities.

As regards hatchery work, so far, it has proved impossible to obtain any reliable information as to the return of artificially hatched fish, when adult, after they have obtained their growth in the sea. No method of marking has been devised that will last over this period of growth and give reliable data. Due primarily to this fact, one finds a certain scepticism as to the value of hatchery work, which is, however, not at all justified. In nature there is a great wastage of salmon eggs and fry between the time the former are deposited and the latter are scattered through the little pools and shallows bordering the parent stream, each, by that time, a small fish able to care for itself in the narrow confines of such an environment. Spawn artificially taken and hatched may, on the other hand, be returned to the stream as small fishes with negligible loss. There is no question that the process can be carried out so as to pay for itself and be a powerful conservation agency, if each step is taken in the right way. The important one of scattering the planted fry in shallows natural for them must not be overlooked.

That salmon in large numbers run north into Bering Sea from the Pacific, prior to spawning, is thoroughly well established by the heavy catches made in the pass between the Alaska Peninsula and Unimak Island. Data seem to be lacking as to the extent to which they move north and south seasonally during their years of growth in salt water. Here is another point: various unrelated bits of data tend to show that the present season (1926) was one where warm water conditions extended unusually far to the north along the coast. It was also one of a heavy take of salmon at False Pass (entrance to Bering Sea) and in the Bristol Bay area of Alaska. Is it possible that the run of salmon, as a whole, shifts more to the north during such warm seasons? This would be a contradiction to the hypothesis that each individual fish seeks its parent stream. It may be, however, a mere coincidence. But let no one suppose, from the amount of knowledge that we do already possess concerning Pacific salmons, that their life history and migrations are thoroughly known.

Alaskan fisheries are fortunate in having a center for investigation into all things pertaining to them, close at hand, in the College of Fisheries of the University of Washington, Seattle. Here information is obtainable not only regarding the various marine animals which form the bases of the fisheries, and the practices relating to their capture and utilization, but experiments are going forward, in the mechanics of fisheries and in chemistry, to determine the best method of treatment for the fisheries' products. This college of fisheries, the only one existing in America, has a certain peculiar interest in that it is a center of special learning and at the same time articulates with and in many ways is directly helpful to a vital industry. At present its facilities are thrown open to an international investigation of the Pacific halibut fishery, members of the staff of which the writer found at work in one of the college buildings. They are obtaining data of considerable natural history interest, which should also prove of economic importance, but it would be premature to speak of the results so far obtained.

The Pacific halibut seems to be the same as that found in the Atlantic, and it is possible that the fish has a continuous range in deep water across the Arctic basin. It will be a triumph for modern scientific conservation if the considerable Pacific halibut fishery can be maintained without depleting the supply as it has been depleted in the Atlantic.

A thorough oceanographic investigation of waters from Puget Sound to Bering Strait with special regard to various fishing would be worth while from many points of view. The local and off-shore currents, even the potential fishing banks of this area, are imperfectly known. In July and August the writer found comparatively warm-water conditions prevailing farther north than he had anticipated. Coming in southeast, west of the Queen Charlotte Islands, when about the 52d parallel of latitude was reached, there was a band of water several miles wide, thickly strewn with *Velella*. The glistening sails of this little animal dotted the smooth blue surface of the sea as the falling petals of apple blossoms do the grass under apple trees. South of this line phosphorescent ctenophores flashed their sparks of blue light in the ship's wake at night. Again, farther southeast, a fragile pelagic stalked barnacle was numerous. Several of these barnacles float attached to a central globular mass seemingly of the same structure as that of their stalks. At about 50° north, the steamer passed close to a sea sunfish three or four feet across, swimming in a vertical position, its upper fin projecting somewhat above the surface of the water.

A codfish which is almost identical with the Atlantic cod occurs in very large numbers about the Aleutian Islands. Such differences as one would notice in a boatload of fish are only of the degree that one would expect from the somewhat different character of the fishing grounds in Atlantic and Pacific. The Bering Sea cod is the basis of a fishery doubtless capable of some development. Taken by dories from three-masted schooners, salted at sea, and landed in Seattle, it meets the Atlantic species in the salt-fish market. There is no reason to suppose that at present cod occur in the Arctic basin either to the east or to the west, connecting these Pacific cod with their Atlantic relatives. On the other hand, within comparatively recent times, there must have been such a crossover.

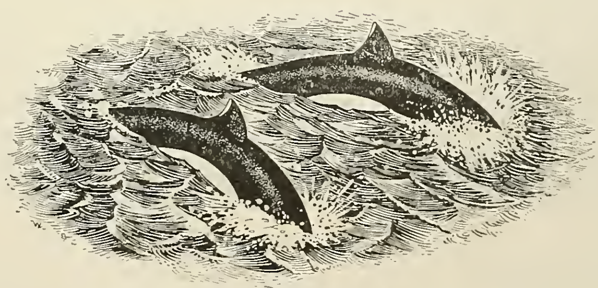
It would be out of place here to try to fit the writer's diverse field observations into the hypotheses of migration and dispersal (dependent or independent of physiographic and climatic changes) on which they have a bearing. But it may be mentioned in passing that it is only reasonable to suppose that the cod family is of Atlantic origin, since it is so much better represented in the Atlantic than the Pacific. The seasonal changes in

Bering Sea, to which Pacific fishes are unaccustomed, probably have enabled it to find room there unoccupied by Pacific forms.

In contrast with the cod, which is scarcely distinguishable from our Atlantic fish, the Alaska pollack, food of the fur seal, is quite different, being specialized away from anything occurring in the Atlantic and classified in a separate genus, *Theragra*. The writer was interested in watching a school of them, fish about eighteen inches in length, swimming lazily not far below the surface under the shadow of the steamer's side as she lay at the wharf at Akutan. Sluggish, slender fish, they are probably capable of supporting life on comparatively slight rations. Perhaps the weight of numbers of the salmon in Bering Sea has, by competition, forced some heavier more salmon-like pollack to specialize in this direction. When, in winter, the salmon cease to come north, *Theragra* doubtless takes advantage of having the sea comparatively to itself, and one can fancy it sucking into its capacious mouth many a young salmon making a first voyage in yet unfamiliar water.

If Pacific cods have come from the Atlantic it does not in any way follow that the crossover between the two oceans has been in the same direction, from east to west, for other groups of marine fishes. For similar reasons it seems more likely that the sculpins, for instance, crossed from Pacific to Atlantic. The Arctic has a specialized fish fauna of its own, but there is no indication of passage from one of the larger oceans to the other through intermediate Arctic forms, though the Arctic fauna seems entirely derivative from one direction or the other.

Such crossover of marine fishes as there has been between Atlantic and Pacific appears to be comparatively recent, and to have been possible under conditions not very different from those existing at present. Whether it is taking place under present-day conditions can only be determined by further investigation of the Arctic basin, and such investigation would therefore have considerable theoretical interest.



Black-and-white porpoise of the Northwest

AN ANDEAN SPINNER

The native women are seldom seen idle and when their hands are not otherwise engaged they spin. A loose tuft of the wool is twisted on the end of a stick and then fed out gradually as a coarse strand which is twirled into thread or yarn and wound on to a spindle. Long practice makes the fingers adept, and the yarn is even and free from lumps. The woman's dark skirt is made from homespun woollens

A Collector's Impressions of the Quichua Indian

By H. E. ANTHONY
Curator, Mammals of the World, American Museum

THE intensive studies of the mammal and bird life of Ecuador carried on by expeditions from the American Museum annually since 1920 have been the means of bringing the field parties into intimate contact with the native peoples. Some of these natives are still savage, such as the Jivaros, an account of whom was given in NATURAL HISTORY in 1921 (Vol. XXI, No. 2, pp. 146–159). Others, while primitive when judged by certain modern standards, have developed extensive cultures dating far back, which are today only thinly veneered by the aftermath of the Spanish invasion. To this group belong the Quichuas who live in Ecuador and northern Peru. While the Museum expeditions did not undertake to make ethnological studies of the Quichuas, nor was the personnel of the party qualified by experience for such studies, many interesting impressions were obtained from even the casual contacts with the life and customs of these descendants of the Incas.

The historian Prescott tells us of the conditions prevailing in western South America when Pizarro led his conquistadores against the empire of the Incas. This empire had its northern capital at Quito in what is now Ecuador, and a vast dominion stretched southward for hundreds of miles, more or less confined to the Andean region. The most important of the northern tribes which gave allegiance to the empire were the Quichuas. They tilled the soil, tended flocks of llamas, maintained the extensive systems of mountain trails and irrigating ditches, and carried on an industrious livelihood at elevations of 8000 to 13,000 feet above sea level. The Incan form of government imposed strict obediance to authority and tended to develop a docile and uncomplaining proletariat. This state of affairs made the task of subjugation far easier for the Spaniards than it would otherwise have been, and it is one of the present-day attributes of the Quichua that he accepts his lot as he finds it and is patient and hard working in the face of discouraging difficulties.

The simplicity and trustfulness of the rural Quichua, unsophisticated by contact with cities, was impressed upon me by incidents which took place in the Punin region, where we searched for fossil mammals. When our small pack-train filed over the eroded ash beds from Punin and headed up into a wild ravine, the Quebrada Chalan, there was scarcely any sign of human habitation. Here and there in the distance one might see evidence of cultivation, but the general impression was one of barren lifelessness. With the halt of the pack-train and the unloading of the mules at our selected camp site, the community began to stir. The unexpected arrival of strangers and the erection of a green tent on the open hillside was too much for the curious Quichuas. Moving figures cropped up on the sky-line ridges and our camp was the focus of converging attention. Indians gathered along overlooking crests and a few bolder spirits came directly down to where we were. When nothing happened to these individuals, others lost their shyness

From towering Chimborazo and near-by peaks a heavy mantle of volcanic ash has been laid down over the Riobamba region. These ash-beds are fertile and many Quichua Indians have farms in this district, so barren at first glance. Note the terraced fields in the foreground

and very soon we had quite an assemblage of very much interested spectators.

The Quebrada Chalan is open and practically devoid of any vegetation, so we were forced to scheme out some means of erecting our large tent-fly with whatever ridgepole the locality afforded. This meant cutting down a small wild cherry tree which grew at the bottom of the quebrada and which seemed to be ownerless so far as we could see. But I felt some of the George Washington complex after the deed was done, and the raw stump and litter of twigs were damning evidence at our very tent door.

It was not long before one of the older Quichuas came up to the bank directly above the tent and noted that a tree had been cut down. He promptly demanded payment for the tree, representing that it belonged to him, but it was evident from the snickering in the crowd that he was simply trying to make the best of the situation. When he realized that he must prove ownership before he was paid, he lost his interest in the episode and we never heard from him again.

Apparently the Quichua believed that our unusual activities indicated that we were skilled in all of the higher branches and could discharge the office of priest or of doctor as well. A young man came up to me where I was excavating fossils and knelt before me, removing his hat as he did so.

"What do you want," I asked, rather impatiently I suspect.

"Your blessing," was the humble answer that made me ashamed of my impatience.

I was halted on the trail one day by a man and his wife and asked if it were not true that I could heal sickness, if I were not truly a "medico." When I replied that I was truly not a "medico" but would be glad to give whatever assistance the occasion and my limited medical kit indicated, I learned the symptoms. The man had a bad heart, so he thought, but since his troubles apparently could also be due to colitis which I could treat, I chose that diagnosis rather than heart trouble for which I could do nothing.

When I announced that I had a "remedio" for the patient, the man spoke quickly in an aside to the woman and she produced, seemingly from nowhere, two eggs which the "doctor" gravely accepted as his fee. In the Quebrada Chalan the gift of an egg is a favorite expression of esteem.

Near Molleturo, in southern Ecuador, Mr. Tate, in charge of an expedition, was approached by a Quichua who asked how long it would take him to make a pilgrimage to the Holy Land. His simple and devout mind had grasped something of the desirability of such a journey, but nothing of the physical barriers in the path of a pedestrian. A similar naïve view of the external world was expressed by a native who asked me whether a certain foreign people we were discussing spoke English, and when I replied in the negative, he said,

"Oh, then they speak Chinese."

The only foreign tongues he had ever heard were English and Chinese, hence all foreigners must speak one or the other.

These childlike concepts do not always take a harmless outward manifestation, and on two different occasions Mr. Tate has been the target for shots fired by normally well-behaved, but temporarily illusioned, Indians. Some of the Quichuas have a belief that leprosy may be cured by bathing in human blood. When Mr. Tate was collecting near Cuenca, the Indians became alarmed at the strange behavior of a man who did so many things unaccountable to them. They concluded that he was an escaped leper, from the leper colony situated between Cuenca and Cinincay, and that he was lurking about to capture a cure for his malady. Fortunately their apprehensions disturbed their aim and no serious results took place.

On another occasion, we camped on the basal slopes of Cotopaxi on an ancient lava flow. One night when Mr.

From the uppermost slopes of Pichincha one views distant Cotopaxi hidden in the clouds, and scores of cultivated fields scattered over a broad valley

Tate went hunting with a headlight, several rifle shots were fired at him. The native who did the shooting evidently thought that the spot of light, moving about where no normal-minded native would be at night, was an evil spirit and he acted accordingly. We showed no more lights about camp that night, and thereafter took particular pains to advertise in advance any night hunting we attempted.

Although I received very little tradition or legend directly from the Quichuas, I have little doubt that the material is there for the observer who seeks it. Several stories that had gained current belief dealt respectively with an enchanted lake, a man who appeared in the guise of a mountain lion, and a vast treasure buried by the Incas when Atahualpa was killed by the Spaniards and all hope of ransoming the monarch had fled.

I had pointed out to me the site of the enchanted lake, at the top of a nearly inaccessible peak. The lake was surely enchanted because it always disappeared when any one climbed up to the spot. An unusually destructive lion could not be killed because he was not an ordinary puma, but in reality a clever man disguised as a lion. Belief in the existence of the treasure has led to the formation of an unsuccessful syndicate and to the devotion of years of search on the part of individuals. There is nothing supernatural in the legend of the treasure, and while all such tales are apt to arouse skepticism, it must be confessed that the account

While most of these fields today are owned by Ecuadoreans of Spanish descent, this region was formerly a stronghold of the Inca empire and farmed by Quichuas

of the lost ransom of Atahualpa as it was told to me was a fascinating and plausible story.

The Quichuas are a musical people and have their own instruments for the production of their native airs. One of the commonest instruments is a series of graduated tubes of bamboo, like the pipes of Pan, played by blowing across the open ends and producing a flutelike tone. This piping requires a great amount of air, and I wondered how the boy who visited us in camp on Pichincha, 13,000 feet above sea level, could find the breath to lilt his tune as he trudged along the trail. We had no breath to spare at this elevation and when we walked we kept our mouths shut.

There is a peculiar minor quality to the Quichua music. Just what Quichua airs may be indigenous or to what extent they may have been modified by European influences, I am not competent to judge, but the strains sounded original and, furthermore, seemed to have latent possibilities for adoption into modern scores. I was told by Señor Jijon of Quito, who has made an exhaustive study of his country's prehistory, that the Quichuas have had an extensive musical experience.

At a festival in Loja I saw a Quichua orchestra of one musician who played a flute with his right hand and beat a drum with his left, providing dance music for four young Indians who danced and gestured to the rhythm. During the same fiesta I saw another Indian flute player, who was also a devotee of Bacchus, stop a passer-by and carry on what might be described as a musical monologue. He addressed his flute to his audience of one and with great earnestness and gravity proceeded to search the depths

The clear, flutelike notes of the Quichua pipes carry far on the mountain air, a melodious interlude in the hush of early morn

of his repertoire. The incident served to demonstrate to me that love of music was a fundamental instinct with this Quichua who had reached the stage in his celebrations where his very equilibrium was threatened.

The Quichua still does many things in the way of his forefathers. His farming methods are crude in the extreme, from the plowing with a wooden plow to the threshing and winnowing by slow hand processes. While one sees many cultivated fields, it is seldom that a large and bountiful harvest is seen and the yield is inadequate to the long hours of labor that the Indians spend over the crop.

These farmers are adept at side-hill cultivation, and in a fertile section the fields of grain, peas, alfalfa, etc., are perched on the sides of the mountain slopes with a fine disregard of gravity. In many places one can still see today the traces of the old ditches, built by the Incas to irrigate these high Andean fields, at elevations of 12,000 and 13,000 feet.

The landscape in one of the agricultural sections is most interesting and unusual, presenting as it does the aspect of a gigantic patchwork quilt made up of broad, geometrical outlines of brown, green, and yellow, depending upon whether the field is plowed, is growing grain, or is ready for harvest. Add to this the ever-present fence of green cabuya, related to the century plant, and the simile is completed by stitching around the margins of each patch.

When soil is to be prepared for sowing, the Quichua yokes his oxen, mules, burros, or horses, or any combination of these animals, and they drag a rough wooden plow, sometimes scarcely more than a sharpened stick, over the field, scratching up shallow furrows. In some of the best agricultural sections where great, level expanses exist, modern plows may be seen, but most of the cultivation done by the Quichua is by the old-time method and, perhaps, on certain of the steep slopes, it is about the only practical method.

When the crop appears above ground, apparently it is left much to itself, as we saw little to show that nature was being assisted. Some pulling of weeds

It is little wonder that the Quichuas love their mountains and remain an upland people. The sight of Cotopaxi, rearing white across the green of mountain meadows, is alone worth a trip to Ecuador

About Punin one sees a network of the cabuya hedges marking off the cultivated fields. While the hills beyond look desolate, they are the home of many Quichuas

Perched among the hills about Punin are many Quichua homes where cultivated fields are on edge and the Indians travel far for water

An ancient stone corral on the flanks of Antisana, facing Cotopaxi, was the nightly bedding ground for a mixed flock of black and white sheep

Grain is staked in neat symmetrical piles which look almost as if they were the work of a landscape gardener who trimmed them with shears

The Quichua yokes his oxen to a crude wooden plow and turns a slow, laborious furrow but, patient as his team, seems well content

The Quichua wife is often seen wearing a large silver pin, the "topa," which she will not sell because it is a token of her marriage

All rope used by the Quichua is made from the fiber of the cabuya plant. Great piles of this cordage are brought to the market at Riobamba

Loads of heavy red pottery are brought to market, the various pieces tied together with the cabuya rope, and borne on the backs of the Indians

Matting woven from palm leaves or other similiar material is used for beds or placed upon the ground to give a clean, flat surface may take place. After the grain is cut down, the threshing is done by driving horses, mules, or cattle over the stalks which are scattered over a hard, earth threshing-floor. Finally, the resulting mixture of chaff and grain is winnowed by pouring it from bowls on a day when the wind is strong enough to divert the light chaff,—the plump, heavy grain falling at the feet of the harvester.

Everything the typical Quichua wears is homemade. This boy has on a heavy wool hat and his poncho is made of wool, spun, dyed, and woven by his family

The Quichua women are inveterate spinners and one seldom sees a woman without her spindle, which is simply a slender reed or splinter weighted by a small potato or other handy object. The yarn is spun from wool grown on their own sheep. The ponchos and all of the woolen fabrics used by the Quichua are hand woven. Cheap cotton fabrics, woven by power mills, are marketed in the towns, but the Quichua of the high Andes places more reliance upon the warm cloth of domestic manufacture.

Other native industries are the making of pottery and the twisting of rope and cordage. Clay suitable for the structure of jars, pots, tiles, etc., is of fairly common occurrence, for all through Ecuador one sees the ever-present, red-tiled roof and the dark-red water jars, cooking pots, and pottery vessels. The Incas were noted for their achievements in this field, and seemingly the Indian of today utilizes the same processes, although by no means with the same degree of artistic skill. In the native markets one sees quantities of the hand-made pottery for sale.

The native rope is made from the cabuya, one of the Agaves, which has a long, strong fiber well suited for cordage. This plant grows everywhere throughout the Andean plateaus, and because of the thick, spiny leaves makes an effective hedge. Most of the fences are simply rows of cabuya plants.

One seldom sees llamas in any number in Ecuador. These "sheep" of the Incas, so-called in the early Spanish chronicles, may have been common as far north as Quito in Pizarro's time, as Prescott would lead us to believe, but today they are to be found in comparatively small numbers and more or less restricted to the region about Chimborazo and Riobamba. In their place the Quichuas raise the true, domestic sheep, and rather an unusual feature of these flocks is the high percentage of black animals. The Andean meadows furnish almost exhaustless pastures for live stock, for they are always green and well watered.

Like so many native peoples, the Quichuas love to bargain, and a transaction is spoiled for them unless it passes through a lengthy preliminary. Market day is a big event in their lives and if any one offers to buy the entire load of produce that an Indian is carrying along a trail, at a figure above the market price, it will not be surprising if the Indian refuses to sell, because then he is deprived of the joy of bargaining at the market.

The market at Riobamba is especially interesting because it draws a large attendance of Quichua Indians. While the Indians are rather given to wearing black, when one finds them about their own terrain, many of them wear brighter colored ponchos when they come to market, and in the crowded plaza bright reds, yellows, and browns relieve the somber black homespun. The women have babies slung in cloths over the back, between the shoulders, and if the hands are free they spin as they walk. Women and men alike have huge bundles on their backs if they have produce to bring to the market. One quarter of the plaza may be given over to the display of native-made rope which lies about in great piles; another section displays various sizes and shapes of pottery vessels; a native at a sewing machine gathers a crowd about him as he stitches the brims of hats to make them stiffer; here and there, dotted on the ground where space allows, are the open-air cafés, a pot of charcoal and four or five earthen vessels with stews and unknown concoctions for the hungry passer-by.

The Quichua has a legacy of unsurpassed landscapes and grand mountain scenery. After one has watched the dawn from Pichincha, Antisana, or from any vantage point on the vast Andean upland, or felt the beneficent effects of the sun's rays after passing through an Andean rain or fog, one finds it not difficult to understand why the Incas were sun worshippers.

One of the rewards of an early start on an Andean trail is the splendor of the sunrise over lofty mountain ramparts and the rout of darkness from the Stygian cañons

THE EDWIN NATURAL BRIDGE IN WHITE CAÑON. NOTE FIGURE IN FOREGROUND

Niznaz Boko—The Great Hole in the Ground

By DOUGLAS BURDEN
Trustee of the American Museum

Foreword.—The following article is the result of a recent pack trip through southern Utah and northern Arizona during which the author studied the geology of the High Plateaus.

The work is based on C. E. Dutton's great monograph, "The Tertiary History of the Grand Cañon," and on W. M. Davis' *An Excursion to the Grand Cañon of the Colorado.*

To the helpful advice and criticism of Prof. Douglas Johnson of Columbia University, especial acknowledgements are due.—Editor.

LONG before the arrival of the white man in western America the Navajo Indians had supplied themselves with a satisfactory explanation as to the origin of Niznaz Boko—the Great Hole in the Ground. When the Colorado River on its initial journey to the sea, so they asserted, found itself confronted by great mountainous plateaus thousands of feet high, the River gods burst these high plateaus asunder, thereby forming the Grand Cañon and allowing the river access to the sea.

To the Navajos the explanation was simple yet sufficient. Not long ago white men were asking themselves the same question and it is their answer and the reasons for that answer that will be presented in the following paragraphs.

We are dealing with one of the most amazing stretches of country in the world, namely the High Plateaus of Utah, Arizona, and New Mexico. This country is the last stronghold of the wilderness in the United States—a wilderness renowned as much for its great forests as for its waterless wastes. There are deserts that stretch away in an ever shifting sea of moving sand dunes till land meets sky, their graceful crest lines seeming to undulate as our pack train winds through them. Wind ripples scour their surface in a vain attempt to destroy a pattern of most elaborate and delicate design—a woven network of tiny tracks—the imprints of the fauna of this wild land. There are painted deserts of rock whose delicate coloring, lavender, vermilion, magenta, and mauve, lure the traveler on to new discoveries. There are deserts of Palæozoic age formed of solidified sand dunes which have been covered up and obliterated for millions of years only to be reborn again—thus bridging the gap of time. There are nameless gorges on whose seemingly inaccessible cliffs innumerable dwellings have been cunningly built by a race of Indians which has long since passed on to its happy hunting grounds. There are countless cañons in this land of the purple sage; amphitheaters, recesses, caves, and stupendous natural bridges hewn from the living rock whose masterful masonry and noble carving defy description. The attention of the traveler is forever absorbed in the great works of nature, be it in the weird contours and exquisite coloring of the slick rocks, in the great outpourings of igneous material which once devastated the land with a deluge of molten lava, or in the formidable red and white cliffs that present a well-nigh impassable barrier to the wanderer beyond the clay hills. It is a land of chasms within chasms and plateaus superimposed upon plateaus —a veritable rainbow land in which earth and sky reflect each other's glory.

It is here, in this wilderness of mountain and plain, that nature has surpassed herself. Evolution is one of her illimitable laws by which she avoids monotony and manifests herself in never ending change. This great law is applicable as well to the physical evolution of the earth's crust as to its flora and fauna. In the region of the High Plateaus the history of its physical evolution may be traced with a remarkable degree of accuracy. The method by which this evolution has taken place is that of erosion following uplift of the land. The scale of the Tertiary Erosion of these great plateaus is almost beyond the power of the finite mind to grasp.

The vertical range of this erosion in the Grand Cañon district is 16,000 feet and its horizontal range extends for a distance of more than 140 miles. An average of no less than 10,000 feet of strata has been stripped from an area ranging between 13,000 and 15,000 square miles.[1] This means that approximately 28,000 cubic miles of rock have been removed by the Colorado River from the region of the Grand Cañon.

In the slick rock country of Southern Utah

Camp in White Cãnon

In dealing with so great a subject which, when studied in detail becomes infinitely complicated, it will be necessary here for the sake of brevity to limit the discussion to the major and most striking features of the great denudation.

In the first place it should be understood that the vast measures of sedimentary strata in the High Plateaus represent the accumulation of material derived by the erosion of pre-existing land surfaces in Palæozoic, Mesozoic, and even in Cenozoic times. In the Palæozoic era the region of the High Plateaus was a great geosynclinal trough below the level of the sea. The Palæo-Cordilleran Mountains to the west and the Palæo-Rocky Mountains

[1]Dutton, C. E. *Tertiary History of the Grand Cañon District*, page 61.

Many of the undercut cliffs shelter ruins of masonry houses occupied by Indians in pre-Spanish times

to the east were the origin or source of the great thicknesses of strata that were piled up on the floor of this Palæozoic sea. These formations are now exposed in the great gorge of the Grand Cañon and the unconformities that exist there are evidence that the deposition was not continuous. More than once the sea retreated and long periods of erosion set in.

During the Mesozoic era another epicontinental sea spread northwestward from the Gulf of Mexico covering New Mexico, Arizona, and Utah, and lapping up against the Meso-Cordilleran Mountains which occupied the region of the present great basin. This must be regarded as a shallow sea, the floor of which was subsiding simultaneously with the accumulation of sediment upon it. In this era no less than 10,000 feet of strata were deposited. During the Eocene a gradual change was taking place from marine to lacustrine conditions and, finally, with the close of the Eocene uplift it brought about the emergence of a new land. From now on our story deals with the Tertiary erosion of this land.

It will be well, before entering upon our discussion, to examine the meaning of the two words erosion and denudation. When more accurately defined, erosion signifies the sum total of all processes by means of which rock particles are cut away from the mass to which they are attached, whereas the word denudation is applied to the lowering of a land mass by the combined action of weathering, erosion, and transportation.

In any country such as the High Plateaus where the formations are approximately horizontal, the drainage channels will at first dissect the land, thus creating cañons. The in-

Cliff of the Upper Colorado. Denudation takes place here primarily through the recession of cliffs

ward-facing cliffs formed by these cañons are then exposed to all the forces of destruction so that they will gradually retreat.

Erosion is not very effective when attacking the surface of plateaus for, when the strata are horizontal or nearly so, the plateaus or uplands are covered by a protecting mantle of waste. Under such conditions, denudation resulting from erosion plus transportation takes place primarily through the recession of cliffs, and the speed of retreat of any given cliff is dependent on its height and on its resistance to the agencies of weathering. If, however, the talus at the base of a cliff accumulates until the whole face of the cliff has been covered, erosion will progress but slowly until the protecting waste has been removed. Softer formations will break down to form a more gently rolling topography. The erosion of the cliffs forming the boundaries of the High Plateaus must, therefore, have been differential. Due to differences in height and durability they have receded at different rates.

Now let us turn back to the new land that by the end of the Eocene had emerged from the sea. First of all, a drainage system was established. The course of the rivers forming this system was consequent upon the initial slope of the land surface. Their work consisted at first of the cutting of deep channels by the process of downward corrasion and then, when a profile of equilibrium had been reached,—the carrying power of the water being just equal to its load,—of the opening up of these narrow gorges into great open valleys. The picture now is of a new land raised above the sea, dissected by rivers and then denuded by a stripping off of the strata until a large part of the area had been worn down nearly to sea level. Thus was formed the great Tertiary Peneplain. Subsequent to this period of extensive base leveling came the period of general uplift which resulted in the incision of the cañons that still exist today. Thus in the history of the Grand Cañon district we have two distinct cycles of erosion.[1]

[1]Davis—*An Excursion to the Grand Cañon of the Colorado.*

Part of a cut-off entrenched meander of the Colorado River

The Colorado River in a second cycle of erosion. Note the receding cliffs on either side

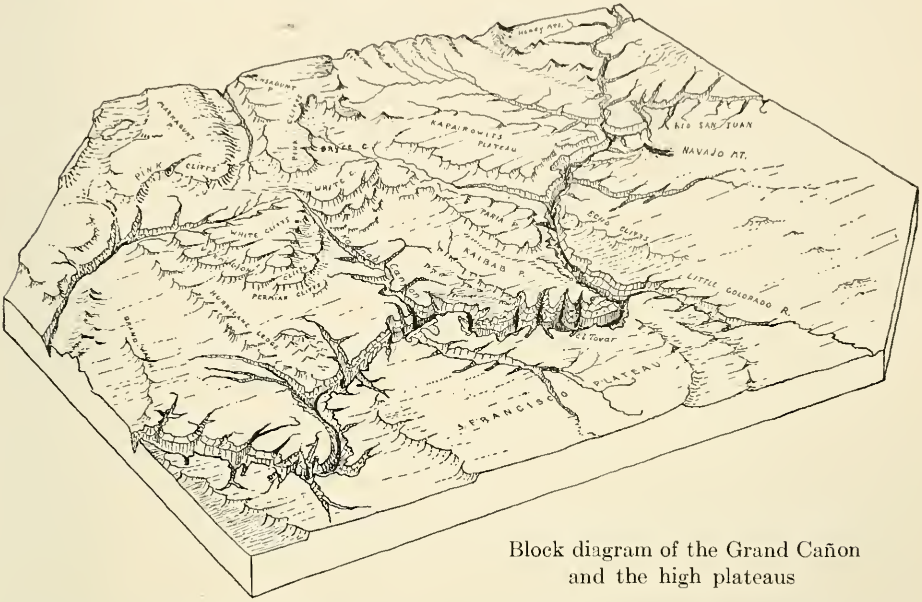
Both cycles were consequent upon orogenic disturbances. The first disturbance may have been intermittent, in which case there would be alternate periods of uplift and quiescence, each successive period of activity resulting in the rejuvenation of rivers. The evidence in support of intermittent uplift is, however, insufficient. The movements of land, although not accompanied by much folding, were differential in that different sections underwent different degrees of uplift. Due to these differential movements in the initial uplift, a series of north-south faults and monoclinal folds were established which greatly complicate the structural geology of the country. A

Bryce Cañon.—Erosional features of the Pink Cliffs

long period of erosion, however, beveled the area, reducing it to one of faint relief across which the Colorado River lazily meandered. Following this came the general upheaval which inaugurated a new cycle of erosion and which resulted in the entrenched meanders of the upper Colorado and the incised cañons that we see today.

Needless to say, the uppermost formations have been subjected to erosion for the longest period of time and are therefore the ones which have been more completely denuded. Between New Mexico and Bryce Cañon, a distance of 140 miles, the Eocene has been entirely stripped off. Northwest of the Grand Cañon the remains of the Eocene may be seen in the Pink Cliffs. The detail and delicacy of their erosional features have no equal. South and east of the Colorado, no Eocene is found until we cross the border into New Mexico. Over the entire intervening region it has been completely removed.

From the base of the Eocene escarpment of Pink Cliffs the traveler journeying southward to the Grand Cañon must first cross the typical rolling hill topography of the Cretaceous. Due to the fact that the Cretaceous hills are usually covered with pine and spruce, this formation is not difficult to recognize even from a distance. Below these hills he will ride for some distance over a level platform which suddenly breaks away to form the unmistakable cross-bedded massive white cliffs of the Jurassic. From the edge of this great escarpment he will step down several hundred feet upon the Triassic platform which in its turn drops away to form the famous Vermilion Cliffs. Not far from the base of the Vermilion Cliffs are the badly eroded remains of the Permian or Shinarump Cliffs, which form the lowest and smallest step in nature's great stairway. A glance at the diagram reveals plateaus superimposed upon plateaus, the terminal southward-facing walls forming a great stairway so that one may literally step down upon successively older and older formations. There are islands of Mesozoic sediments superimposed one upon the other, with an island of Eocene beds capping them all. From the summit of the Eocene to the base of the Permian the traveler has descended, due to the northward dip of the beds, only 5400 feet in altitude, and yet he has traversed more than 10,000 feet of strata.[1]



Block diagram of the Grand Cañon and the high plateaus

And now I am going to ask my reader to reconstruct the series of formations just mentioned and to project them in his mind's eye as they would have been had there been no great denudation previous to the last general uplift which caused the incision of the Grand Cañon. In such a case the rim of the Cañon would be formed by the Pink Cliffs, the altitude of which in the Buckskin Mountain region would not be 8000 feet (the present altitude of the rim of the carboniferous platform) but 18,000 feet.

It would be useless to conjecture about the Cañon that might have been.

[1]Dutton C. E.—*Tertiary History of the Grand Cañon District,* page 47.

It appalls us and yet I can think of no better way of getting some grasp of the meaning of the great denudation. The Grand Cañon now is undoubtedly the most sublime, awe-inspiring spectacle in the world of nature. It is difficult, however, to realize as one stands on its rim that the excavation of Niznaz Boko does not represent one-tenth, nay, not even one-hundredth part of the total work performed by the Colorado within the region of the High Plateaus alone. Furthermore, as we gaze into those stupendous depths, if we contemplate the appalling slowness with which the work of erosion is carried on even in an arid climate where the formations are but slightly protected by vegetation, we begin to get some idea of the æons and æons of time that have been necessary for the High Plateaus to reach their present incomplete state of denudation.

And yet this erosion is only supplementary to very much longer periods of deposition. In the Palæozoic Age of invertebrate, fish, and amphibian life, there were vast periods of deposition interrupted by periods of erosion perhaps as long as the present one. In the Mesozoic Era—the Age of Reptiles—with a time duration recently estimated at not less than 150,000,000 years, deposition was continuous. Only comparatively recently, when the Age of Mammals had well begun, did the great denudation begin,—yet man did not appear on earth until it was nearly as far advanced as it is today. Thus we begin to get a faint concept of time and of the duration of the world that the human mind is unable fully to compass. Small wonder it is that geologic time, at best, is only relative and that the age of the world in number of years can, even under the most carefully made computation, be only a hazardous guess.

Cool nights on the desert

The Mrs. William Boyce Thompson Expedition

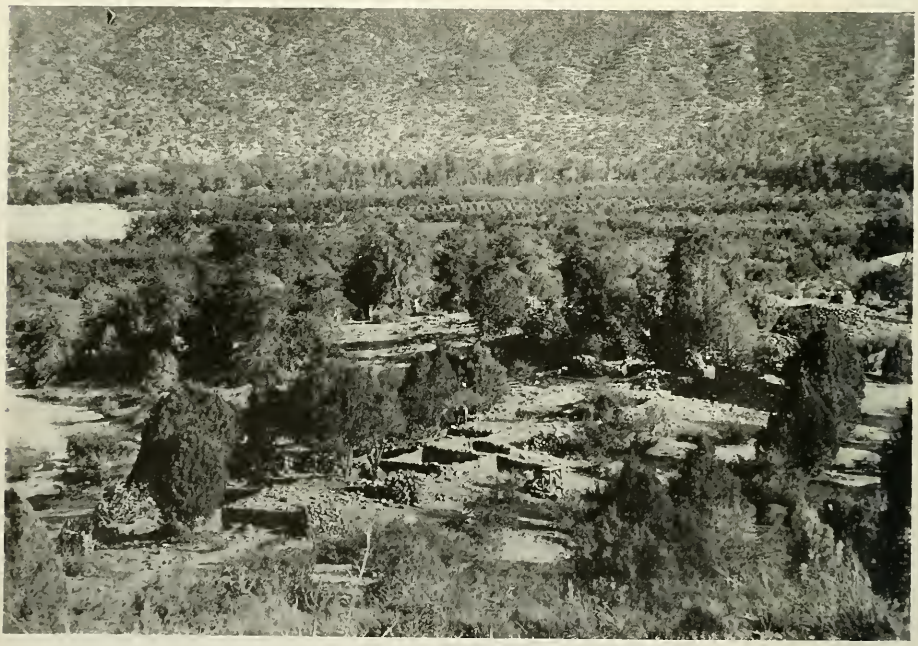
By ERICH F. SCHMIDT

THE southwestern area, which includes Arizona, New Mexico, the southern parts of Colorado, Utah, and Nevada, is a fertile field for the student of human prehistory. Buried in the sands of the Saguaro Desert, and the soil of the mountainous regions, hidden in caves and beneath the overhanging rocks of cañon walls, are the remains of sedentary peoples, Indians who lived here before the existence of this continent was known to white men.

The term pueblo has been applied to this area because of the peculiar type of dwellings, honeycomb-like communal houses. During the last two decades it has been determined that the period during which these pueblo buildings were built represents only the latest stage of prehistoric development in the Southwest, and that the life of these prehistoric pueblo dwellers did not differ materially from that of the historic Indians still living at Zuñi, on the Hopi mesas and along the Rio Grande.

Three other prehistoric culture periods preceding that of pueblo building have been established by archæologists. They are named Pre-Pueblo, Post-Basket Maker, and Basket Maker. The Basket Makers are the earliest settlers in the southwest of whom we have any knowledge. They are named from the excellently made baskets found with the dead, which were buried in cists or pits dug in the floor of caves. They seem not to have made fired pottery and their houses were simple shelters which have left no permanent remains for our study. These Basket Makers were followed by the Post-Basket Makers who learned to mold clay vessels which they dried in the sun and even developed a crude kind of burned pottery. The Pre-Pueblo people who succeeded them made crudely decorated pottery. Their houses were one-family in size and stones were employed only in the building of the foundations. Soon after the pueblo building era the entire region mentioned above was occupied, but by the time the Spaniards arrived in 1540, the area inhabited had shrunk considerably. Our present interest is in this early period of the Pueblo era, since the architectural remains, the implements, works of art, and the remains of human beings here discussed are attributed to that time.

In the beginning of 1925 the American Museum of Natural History undertook explorations in Arizona under the patronage of Mrs. William Boyce Thompson, who had previously supported archæological expeditions in Crete and Egypt. The purpose of the expedition was the investigation of the Lower Gila region, an archæological subarea which extends over the greater part of southern Arizona, including the Giant Cactus Desert in the west and a mountainous country in the east. One of the most famous ancient structures north of Mexico belongs to this region, Casa Grande, near Florence. Its existence was first recorded in 1694 by Father Kino, a Spanish priest. Since very little was known about the archæological remains in the region between the Gila and Salt rivers, it was considered best first to excavate thoroughly a respresentative site in a central position and later to acquire



Upper picture—General view of Ruin Togetzoge before excavation.
Lower picture—Same view after partial excavation

comparative material by extensive reconnaissances. As a starting point a ruin was chosen which had previously attracted the attention of Mrs. Thompson. It is situated in a very fertile natural basin about half-way between

Excavated room at Ruin Togetzoge; the snow-covered earth piles are fireplaces, indicating floor levels of different depth

Metates, manos, hammerstones, and pebbles from rooms in Ruin Togetzoge. In the background is an excavated room

Superior and Miami at an altitude of 5,000 feet. The surrounding flat has been cultivated for many years by Mr. Craig, who remembers the time when the Apaches had their summer camps here. They called this basin Togetzoge, the name we gave to the ruin also. The latter is a typical communal house, containing about 120 rooms arranged in tiers and surrounded by an enclosing wall.

For the work of excavating, four San Carlos Apaches were employed. They appeared with their women and children and built their typical dome-shaped huts of branches and brush covered with rags of canvas. The ruin had first to be cleared of a dense growth of thorny bushes and cactus, many a spine finding its way into our skin. There were no walls standing above ground. The only indications of the contours of rooms were partly visible regular rows of stones. The upper part of the walls, which were built of unworked bowlders, had crumpled down in each case, often filling the rooms with hundreds of wall stones. The excavations were carried on carefully from one end of the building to the other by following one tier for a series of rooms, then working in zig-zag fashion and again cross-cutting, so as to gain all possible information in regard to the various tiers of the structure. Each room was sectioned vertically in order to determine successive inhabitations. Soon the evidences and products of the industry and workmanship of the ancient inhabitants appeared. Metates and manos once used for grinding the corn which was cultivated in the surrounding valley, stone hoes for tilling the soil, beautifully polished axes and arrow straighteners, saws, knives, arrow heads and spear points, beads, and pendants made of turquois, a pathetically crude fetish, and many other objects of stone were found. Besides these there were awls and needles made of bone, and beads, finger rings, and bracelets of shell brought here from the Gulf of California. The only metallic object discovered was a small copper bell, probably a trade piece from Mexico.

The pottery at Togetzoge, as in all the other Pueblo ruins, was of major importance: first for its artistic value, since the shapes of the vessels and particularly their decorations represent the foremost art products of the prehistoric Southwest—fabrics having disintegrated in most cases—and second for its classificatory value. In this connection it has been determined that, as a rule, within a given territory during

Gila polychrome, bowls and small olla from floor burial of the Ruin Togetzoge

Apaches with ollas mended by them. From Ruin Togetzoge

Black-on-white pottery from the burial ground at the courtyard ruin, Armer's Gulch

a definite period, one principal painted type was made, uniform in technique and style of decoration. The painted pottery made by the builders of Togetzoge was Gila polychrome, a pleasing three-color ware with black designs on a white and red background. In addition to painted bowls and jars, many undecorated vessels were found, ranging in size from miniature pots one inch high to huge ollas with a circumference exceeding six feet. To be sure, most vessels were crushed by the weight of stones and lumps of adobe which had fallen from the crumbling walls and roofs, but many pots could be restored. The Apaches, after having been trained for a short time, became quite expert in pot mending.

There were well-protected places—the graves—which yielded precious unbroken specimens without crack or scratch. The people of Togetzoge used to bury their dead in one of two ways: either underneath the floors of rooms, or in a common burial ground. The excavation of a room did not stop when the first floor level was reached at a depth of from three to five feet. There were often several floors, one above the other, indicated by hard tramped soil and also by the difference in the level of fireplaces, which were round holes sometimes plastered with clay and containing ashes and charcoal. When the lowest floor level had been reached, and the holes in which had stood the posts which supported the roof were found, the floor was examined for places with soft soil. Almost invariably, burials were discovered at such spots. The skeletons were often found lying in an artificially widened groove of the bed rock.

Mrs. W. B. Thompson, who took active part in the excavations and restoration of specimens, herself uncovered the richest of these room burials, the grave of a woman. The skeleton was extended at full length facing north, with four Gila polychrome vessels placed near the head and left arm. Nearly 500 black, red and white beads, made of stone and shell, were gathered from the soil near the skull. Many of the beads were clinging to the jaw bone and to the upper vertebræ, indicating that as a highly prized possession they were once arranged in three strings decorating the neck of their owner. Two shell rings were on the fingers of the left hand, and a bone awl was found in one of the bowls. Three feet away was a grave containing the skeleton of a child, accompanied by two unpainted bowls, one on the bone of the right hip the other near the right foot. Both woman and child were buried underneath the wall, with their feet extending into the adjoining room an indication that they were probably interred before this wall was built.

The most exciting incident of the work at Togetzoge occurred when, at last, after a long and systematic search the test trenches struck the common burial ground. There were no surface indications at all suggesting the presence of burials underneath. The number and character of surface sherds were the same as everywhere else. There was no elevation indicating a "burial mound," no fragments of bone were found brought to the surface by rodents, as noted at other localities. When we first started work in this grave-yard, the Apaches felt somewhat uneasy, and Nat, who was a kind of a Medicine Man, said he would much prefer to work in the rooms where there were not so many dead people. One day, while he was cutting off the surface soil, kneeling near an exposed skeleton, he suddenly jumped up and ran away. When asked what the matter was, he said:

"Hair going up, betsintsin (skull) hollering like chicken, I no more working."

It took quite a bit of friendly scolding, combined with practical demonstrations of the absolute dumbness of the skull—by brushing and petting it—to make Nat continue his work. Otherwise he was the best worker of the crew.

In addition to the important osteological specimens, a large number of beautiful pottery vessels were recovered, as well as beads, bracelets, pendants of shell and turquois, and little clay effigies representing quadrupeds. The most interesting specimen was a pot, modeled in the shape of a duck with a human face, with ears and nose perforated. Apparently the ancient inhabitants of Togetzoge observed the following customs when disposing of their dead: Initiated persons were buried in the common burial ground, their bodies extended full length in a north-south direction, never east-west. Small children, presumably those who died prior to the initiation, and also a few women, were buried under the floors of rooms.

The work of the Expedition extended over two seasons. Toward the end of the first but principally during the second season, the circle of the explorations was widened and reconnaissances were carried on within a radius of about fifty miles toward the east and the north and somewhat farther toward the west. The faithful and indispensable expedition Ford carried the reconnoitering parties to the ruins in the vicinity of Globe, Cutter, Rice, and Wheatfield in the valleys of Alizo and Pinal Creeks, and San Carlos River. All the settlements found at these localities resemble Togetzoge closely in architecture as well as in artifacts, the pottery, Gila polychrome, being the same. There was a greater abundance of specimens in the rooms of these ruins than in those of the mountain Pueblo Togetzoge. This is espe-

The temple mound of the Casa Grande in Armer's Gulch, Roosevelt Lake

Plazas of courtyard ruin in Armer's Gulch, Roosevelt Lake

cially true of the ruin near the Indian schoolhouse at Rice, situated within the San Carlos Apache Reservation. Here the Apaches, living near by, had been digging, probably in order to find turquois beads, highly valued by all the Southwestern aborigines.

"Murphy Mesa," a Pueblo near Wheatfield, was built on top of a conical hill in an excellent strategic position, overlooking the valley of Pinal Creek for a distance of many miles. Several enclosures encircling the Pueblo nucleus like terraces made a formidable fortress out of this settlement. In one of its rooms another burial was discovered. The skeleton was disintegrated, but on both sides of the skull two perfect little urns were found, one of which represented a drift piece of an exceedingly rare type. It was determined

View from Ruin Murphy Mesa, near Wheatfield

later that this had originated in the territory around Phoenix.

So far we have considered only the settlements to the east of Togetzoge, which were built by the close cultural relatives of the inhabitants of the former pueblo. The situation changed when we turned north. We were informed that the water level of Roosevelt Lake had receded, thereby exposing a number of ruins. It was a sad event for the farmers in the Salt River valley, dependent on the water supply of the lake, but a lucky accident for the archæologist; and Mrs. Thompson agreed that the lake ruins should be investigated in order to save as much as possible before they were again submerged. The patroness of the Expedition went on the trip herself and helped to excavate a site which yielded very interesting results. There was a series of ruins near the northeast shore of the lake, all of them below the high-water line. Here once more a burial ground was discovered, situated close to a "courtyard" ruin, which consisted of rectangular plazas enclosed by long rows of stones with a few rooms in the center and at the sides. About 1000 feet southeast of this place was another extensive ruin, composed really of two structures, one a communal house, the other of Casa Grande type. This resembled the courtyard ruins except for an additional "temple building" originally perhaps three stories high. Among the water-worn bowlders and pebbles on the slope of the bank on which the courtyard ruin was situated, numbers of potsherds were found, but they were scarce on top of the bank. This fact led to the discovery of the burial ground, for, when the edge of the bank was cut off, disintegrated remains of skeletons appeared, fossilized through the absorbtion of lime. Parts of those nearest to the edge had been carried away by the water. This explained the large number of sherds on the slope. They were fragments of mortuary gifts. Some of the skeletons were accompanied by an abundance of beads, arrow points, and pottery. The painted pots were of a type, known as "black-on-white," a fine white ware with black designs, commonly associated with the first phase of the Pueblo period. During the course of these explorations it was determined that all the settlements, situated on the shores of Roosevelt Lake and associated with this ware were built and probably deserted before Togetzoge or any of the other "polychrome pueblos" existed. Another "black-on-white ruin" on the southern shore of the lake was closely examined. It was a two-story pueblo situated about three miles north of Spring Creek store. Here two more burial sites were uncovered, their localities indicated by low mounds covered with thousands of potsherds. These tumuli were originally refuse heaps, used secondarily as burying places. Each mound contained about ten skeletons, accompanied as usual by mortuary pottery.

By this time the Apaches were used to "dead people" and what is most surprising, they even liked them,—because they received a small bonus for every complete pot they uncovered, and complete specimens were most frequent in graves!

In addition to divergencies in certain architectural features and in ceramics between the series of ruins represented by Togetzoge and the ruins near Roosevelt Lake, there was a difference in the burying customs. At Togetzoge, as noted above, all the bodies were extended in a north-south direction, while those uncovered at Spring Creek as well as at the courtyard ruin were lying in an east-west direction. A number of criteria like these combined, show the archæologist the limits of cultural subareas, possibly coinciding with tribal territories.

An interesting reconnaissance trip was made to cliff-dwellings situated in Roger's Cañon, an arm of the well-known Fish Creek Cañon southwest of Roosevelt Lake. Joe, an old-time cowboy, was our guide, and furnished horses and packmules. After a ride of about six hours we arrived at our destination. The cañon was narrow and its walls, rising steeply from the bottom, were overgrown with trees and bushes. In one of the cañon walls were natural caves, sheltering several cliff-houses. One of the buildings was in perfect condition. It seemingly represented the main structure and had an annex in the form of an ante-court. The cave containing this building was about fifty feet above the cañon bottom and was accessible only by a narrow ledge leading up to it. In addition, the entrance was well protected by a parapet, making an attack almost impossible. There were remains of some other houses and also storage bins in the same cave and in the adjoining ones. The walls were carefully

General view of caves containing cliff houses, Roger's Cañon

Main cliff house with antecourt, in Roger's Cañon built of alternating flat stone slabs and adobe, the adobe plaster applied on both sides still bearing the impressions of hands. When Nat, the Medicine Man, saw the houses, he said, "Fifty years, no older," and he could not be convinced that they were built long before his ancestors knew gun or horseback riding.

The final part of the exploratory work was concentrated on ruins in the vicinity of Phoenix, the beautiful oasis in the Saguaro Desert. The City Manager of Phoenix as well as the City Archæologist, Dr. O. A. Turney, had previously applied to the Museum of Natural History for an investigation of the prehistoric structures, the largest of which was city property. Their wish coincided with the plans of the expedition since the territory around Phoenix on the lower Salt River was part of the archæological area to be explored. There is no doubt that this "Lower Salt Region" is one of the most interesting and at the same time archæologically least known sections of the Southwest. The area now occupied by the city of Phoenix—the present day political and cultural center of Arizona—and its immediate neighborhood was also in prehistoric times the center of a homogeneous culture which extended from the mountains bordering the desert in the east and north, to the Mexican frontier in the south and probably beyond. Toward the west it may have extended as far as the Colorado River. Huge mounds marking the sites of structures once two or three stories high, and the remains of hundreds of smaller buildings are found along the lower course of the Salt River. Remains of irrigation canals, the most imposing products of the industry of the ancient population, are preserved in the "Park of Full Waters" east of Phoenix. Structures outside of national or communal reservations are disappearing rapidly on account of the progressing cultivation of land.

The larger buildings are accompanied by refuse deposits in the form of mounds. The depth of these rubbish heaps in addition to many other criteria indicates that the Lower Salt culture lasted for a considerable time. To the archæologist these refuse mounds are of inestimable help in determining the chronological sequence of pottery types and consequently of all the cultural features associated with the particular ceramics. By sectioning the refuse deposits, he will find the old types at the bottom and the more recent types near the apex of the mound. During our stay in Phoenix, we were principally engaged in this kind of work. By investigations of the refuse deposits of the ruins of "Pueblo Grande" seven miles east of Phoenix, and of "La Ciudad" within the city limits near St. Luke's Hospital, it was determined that the Lower Salt settlements were built by the makers of the so-called "red-on-yellow" pottery, a ware with yellowish base and red designs. At the same localities one of the most important problems of the expedition was solved: the time relations of "Gila polychrome" and "Lower Salt red-on-yellow." The fact was established that the settlements associated with red-on-yellow pottery are of much greater antiquity than the structures built by the makers of Gila polychrome, for instance Togetzoge.

In addition to the stratigraphic investigation of the refuse deposits, two rooms of the ruin "La Ciudad" were excavated. In one of them a frail but well-preserved skeleton was found buried underneath several suc-

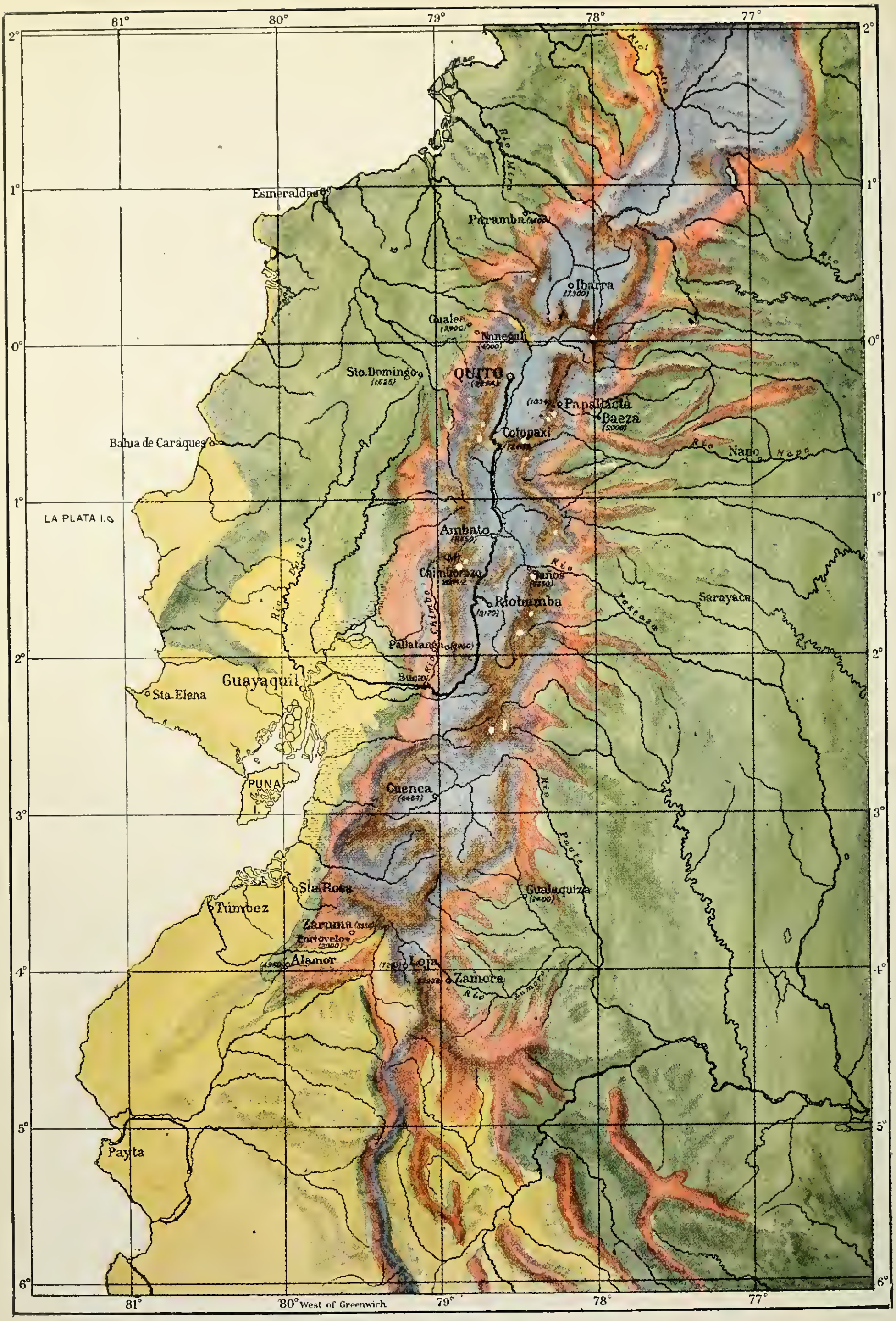
Mound of Pueblo Grande near Phoenix

Stratigraphic investigation of the refuse deposit of Pueblo Grande

Sectioning the rubbish heap of "La Cuidad." Mound of ruin in the background

cessive floors. Due to the character of the work, only a limited number of specimens was recovered. Of particular interest were beautifully carved animal effigies of shell. Private collections in Phoenix show an abundance of pottery vessels, effigies made of stone, shell, and clay, and other artifacts. Works of sculpture, most characteristic for the Lower Salt Area, are stone cups usually bearing representations of rattlesnakes in relief. Artifacts of this type are found nowhere else in the southwest, but similar specimens recovered in Mexico, point toward southern affinity of the Lower Salt culture, emphasizing the importance of this area.

The work in the Lower Salt region concluded the explorations of the Mrs. W. B. Thompson Expedition. Altogether, several thousand specimens were recovered and much information was gathered concerning the culture and, as far as possible, the physical type of the ancient settlers. Large areas are still unexplored and many problems which arose during the investigations must at present remain unsolved, but a beginning has been made in deciphering another chapter of the fascinating prehistory of the southwest.



DIAGRAMMATIC REPRESENTATION OF THE LIFE ZONES OF ECUADOR AND NEIGHBORING AREAS

GREEN = Humid Tropical Zone. YELLOW = Arid Tropical Zone.
RED = Subtropical Zone. BLUE = Temperate Zone.
BROWN = Paramo Zone

"The Distribution of Bird-life in Ecuador"[1]

By WITMER STONE
Editor of *The Auk;* Director of the Museum, Academy of Natural Sciences, Philadelphia

NINE years ago Dr. Frank M. Chapman published his notable work on "The Distribution of Bird-life in Colombia," constituting the most important contribution to our knowledge of Andean birds that had appeared up to that time. Even before the completion of this work, he had planned an extension of his investigations southward into Ecuador. Some of the American Museum collectors had already begun securing the necessary material, while Doctor Chapman in May, 1916, had made a brief visit to several Ecuadorean localities. He again visited the country from July to September, 1922, to obtain first-hand information on the distribution of the characteristic birds of the several life zones, while the Museum collectors, W. B. Richardson, George K. Cherrie, Harry Watkins, Geoffrey Gill, and G. O'Connell made five expeditions into Ecuador, and the native collectors Olalla and Sons, who had been personally trained in the preparation of specimens by Doctor Chapman and his assistants, made very large collections. The result of this field work has been the acquisition by the Museum of some 13,500 specimens of Ecuadorean birds upon which Doctor Chapman has based his second report on Andean ornithology, entitled "The Distribution of Bird-life in Ecuador," which has just appeared from the press and which in every way might be termed "Volume II" of his studies of South American birds. Much that was said in our review of the former volume[2] applies with equal pertinence to the work now before us, as it follows almost exactly the same plan; and the data and conclusions are presented in the same clear and logical manner.

The great bulk of the volume (Part II.—pp. 134–702) is taken up with the distributional list of the birds of Ecuador in which are enumerated 1357 species and 151 additional subspecies, all of which, with the exception of 33, are represented in the Museum's collections. The plan of including all forms recorded from Ecuador is a distinct improvement on the Colombian report which covered only those obtained by the American Museum's expeditions.

That the bird fauna of this comparatively small country is enormously rich may readily be gathered from the above figures, but we are still further impressed when we learn that Ecuador includes within its boundaries "one fourth of the birds of all South America and one-twelfth those of the entire world"! No less than 148 species of humming-birds inhabit the country, 114 ant-birds and 160 tyrant fly-catchers, 120 tanagers, 106 woodhewers, 78 manikins, 19 toucans, 39 parrots and so on down the line of bird families! No wonder that we find here an unequalled field for the study of distribution and the origin of zonal life which forms the underlying motif of Doctor Chapman's researches.

[2] "Chapman's Distribution of Bird-life in Colombia," *The Auk*. 1918, pp. 242–46.

[1] Frank M. Chapman, "The Distribution of Bird-life in Ecuador," *Bull. Amer. Mus. Nat. Hist.* Vol. LV, 1926

The "distributional list," however, is far more than a list, as references are given to the original place of publication of each species, and to previous records of its occurrence in Ecuador, while all Ecuadorean specimens in the American Museum of Natural History are listed with their localities, as well as many of those in the Rhoads collection in the Academy of Natural Sciences of Philadelphia, to which Doctor Chapman was afforded free access. There is also a brief statement of the range of each species, and of both species and subspecies in the case of geographic races.

Following this is a discussion of the relationship of each form, and its general distribution as well as its distribution in Ecuador. A well annotated list of collecting stations in Ecuador and a bibliography of the more important papers on Ecuadorean birds complete this portion of the report, which furnishes the systematist with a wealth of information, bringing together under one cover practically all of the scattered data on the birds of this astonishing country, together with the new information derived from the American Museum expeditions. In addition to its importance to the systematist this array of data has a still greater value in that it contains the facts upon which Doctor Chapman has based his discussions of the distribution of Ecuadorean bird-life and the origin of the Andean life zones which are contained in Part I of the volume.

In this part one finds, first, an extremely interesting "review" of the history of Ecuadorean ornithology, beginning with Lesson's description of four new species of birds obtained from Guayaquil in 1844 and tracing the successive explorations of William Jameson, Jules Bourcier, Louis Fraser, Rosenberg, Festa, Goodfellow and Rhoads, and the influence of Ludovic Söderstrom, long-time Swedish Consul at Quito, who for more than forty years did so much to instruct and encourage native bird collectors.

After this comes an account of the American Museum's expeditions of 1913–1925 and a detailed list of localities visited and the number of specimens obtained.

The general physiography of Ecuador is next considered. Here is pictured the great mass of the Andes rising on either side a tropical forest with an eastern and western snow-capped ridge or series of peaks from 15,000 to 20,000 feet in height, and at emperate table land between them where lies the city of Quito. The enormous differences in climate in different parts of this rugged country due to altitude and the influence that this has had in diversifying the animal and plant life are emphasized. Forest distribution is also discussed, and in this, as well as in the consideration of climate and physiography, the author adds to his original data by quoting from the works of Wolf and other writers on the physical features of Ecuador. Numerous illustrations from original photographs give one a graphic idea of the various collecting localities and the characteristic features of the several zones and habitats. Five colored plates from paintings by Fuertes picture a few of the 83 new birds described by Doctor Chapman from the Ecuador collections, while numerous maps add to the understanding of the text.

Finally, we have the "Life Zones of Ecuador and Their Bird Life" and the author's "General Summary and Conclusions," and it is to these pages, in which Doctor Chapman sums up his conclusions, that one turns with the greatest avidity.

For many years it was exclusively the systematic side of bird study that concerned ornithologists, and problems of zoögeography and of the origin of species were looked upon as somewhat outside their field of activity. Fortunately in recent years this attitude has entirely changed, and few authors are now content to publish an "annotated list" without drawing some general conclusions from the data presented. While, moreover, a "systematic list" may easily be prepared from the study of a collection in the laboratory, an author must have some personal acquaintance with the region before he is competent to attack the more general problems involved. This personal contact with Andean bird-life Doctor Chapman obtained abundantly in his explorations in Colombia, and with this foundation, his two trips to Ecuador put him in a position to grasp the problems of distribution as there presented and properly to interpret the collections and data brought to the Museum by his field assistants.

The explanation of the origin of Andean bird-life offered in his Colombian report he finds fully substantiated by his researches in Ecuador, and he is more than ever convinced of the correctness of his theory. He finds clearly defined today a Tropical Zone extending from sea level to 2000–5000 feet, a Subtropical Zone from the upper limit of the Tropical to 9000–9500, a Temperate Zone reaching up to 11,000–13,000 feet, and, finally, a Paramo Zone terminating at the snow line.

Briefly it would seem that the upheaval of the great Andean chain from the widespread tropical forest region was a gradual process or better, a succession of uplifts, which produced conditions favorable to the development of new life zones one above another. The more active species of the tropics pushed into the new areas and, as the new environment developed they developed with it into new species and new genera. So, as his tabulated data seem to prove, the bird fauna of the Subtropical (rain forest) Zone was derived from that of the tropical forest and that of the forested part of the Temperate Zone in turn from the subtropical.

When, however, the elevation became greater and the accompanying conditions of climate, etc., produced the unforested, or arid regions, of the Temperate and Paramo zones, these areas, being in direct touch on the south with sea-level regions of exactly the same physiographic character, were at once populated by south temperate species which spread, more or less rapidly, northward.

So we have these two sources of Andean bird-life, one, the spreading of an existing south temperate fauna northward through similar contiguous areas and, the other, the development of an entirely new fauna from one lying directly below it. The fact that the tropical and subtropical faunas are so distinct today and that the subtropical forms have left no "intergrades"—no clear traces of their development from their tropical ancestors—is probably due to the gradual nature of the evolution of both environment and species for, as Doctor Chapman says, "zone and fauna were developed together." The Subtropical Zone did not exist prior to the Andean upheaval and, when it occupied the tops of the mountains, there was no contiguous area of similar character with a fauna ready to spread into it, as in the case of the arid Temperate and Paramo zones, and it had to develop a fauna step by step with its own development from the tropical forest below.

Probably all students of zoögeography had their attention turned to this subject by the classic volumes of Wallace, and, like the writer, have never forgotten the fascination of tracing the history of the earth's changes from the present distribution of life. And so the problems discussed by Doctor Chapman hold our attention and arouse our enthusiasm, as step by step we seem to see the development of the wonderful avifaunæ that populate the successive altitudinal zones of the great Andean Chain, which he so graphically describes.

While it is impossible, in the short space at our disposal, to consider all the interesting zoögeographic problems that he presents, or to quote the array of tables and distributional maps with which he fortifies his theories, we may, however, mention one of them involving the origin and extent of the west Ecuadorean tropical fauna, which is now so completely separated from the great Amazonian tropics by the whole chain of the Andes, although the identity of many of the birds in the two areas shows that they were once contiguous.

An abundance of data from various sources shows conclusively that the condition of aridity or of forest growth along a seacoast is dependent upon the relative temperature of land and water. Where the water is warmer than the land, and the air over it is blown to the shore, its temperature is lowered and precipitation follows with resultant heavy rains and luxuriant forest growth; but when the conditions are reversed the opposite is the case and we have a minimum of rainfall and a desert environment.

The former is the normal condition and prevails along the Pacific coast of South America from Colombia to northwest Ecuador, and on the coast of southern Chile; from the latter region to northwest Peru, however, the cold Humboldt Current washes the shores, and we have in consequence a continuous arid coastal region. From Cape Blanco the main Humboldt Current sweeps westward to the Galapagos, which are consequently desert, but a narrow arm continues north, producing a semi-arid fauna on the Ecuador seacoast, populated by birds of Peruvian desert origin, while inside of this at the base of the mountains is a strip of the humid tropical forest of western Colombia and northwestern Ecuador. It seems probable, moreover, that western Ecuador was more extensively desert before the Andean upheaval and from the fact that there are many more Amazonian tropical birds in northwest Ecuador than farther to the south, it looks as if this west Ecuadorean tropical fauna had been populated from the east, probably though passes in the Colombian Andes which were open to passage of tropical species long after the greater upheaval in Ecuador had effectually separated the two regions.

The point to be borne in mind in these interesting discussions is that the theories are all based upon definite figures and facts deducted from the study of the bird-life of this rugged country.

Fascinating as are his zoögeographic discussions, to our mind the most important feature of Doctor Chapman's work is the mass of evidence that he presents to show that "first as well as last, evolution is largely the product of environment, particularly of change of environment, with more or less direct

A NEW HUMMINGBIRD FROM ECUADOR

The Aethereal Sylph (*Cyanolesbia cœlestis æthereus* Chapman)

NEW BIRDS FROM ECUADOR

1.—Zaruma Ant-Bird (*Grallaricula costaricensis zarumæ* Chapman)
2.—White-faced Ant-Bird (*Aptocryptornis lineifrons* Chapman)
3.—Watkins' Ant-Bird (*Grallaria watkinsi* Chapman)

NEW BIRDS FROM COLOMBIA AND ECUADOR

1.—Red-tail Pacific Paroquet (*Pyrrhura melanura pacifica* Chapman)
2.—White-breasted Paroquet (*Pyrrhura albipectus* Chapman)

action on the organism and its rejection or retention of the resulting characters." It seems most significant that when ornithologists with their wide field experience and knowledge of environment and their extensive series of specimens come to consider the origin of a species or subspecies, they never for a moment question the dominant part that environment plays in the matter, and always agree with Doctor Chapman that "physiological agencies which give rise to variations are enormously stimulated by the action of environmental forces, and that nothing is more effective in promoting evolution than to subject an organism to a new set of environmental influences."

This all seems so clear that with Doctor Chapman we are amazed at the claims of the geneticists "that chance mutation is quite sufficient to account for all organic evolution!" Such claims, unfortunately, are usually made by those who have never studied species and subspecies in nature, where to our mind they must be studied, and are not trained to interpret the evidence presented by adequate series of specimens combined with data on the environment in which they were obtained, but the present attitude of a few geneticists, such as Dr. F. B. Sumner, is most encouraging and must result, we think, in a more general modification of views.

Ornithologists have been too reticent in the matter of taking part in these broader inquiries, and we feel that the forcible emphasis that Doctor Chapman has given to his views on the problem of the origin of species through environmental influence really constitutes the most important feature of his work. He has, in fact, given us three things in one: a masterly systematic treatment of the bird fauna of Ecuador; a fascinating discussion of the origin of the Andean life zones and the present faunal areas of South America; and a forceful plea for the proper recognition of environment in the evolution of species.

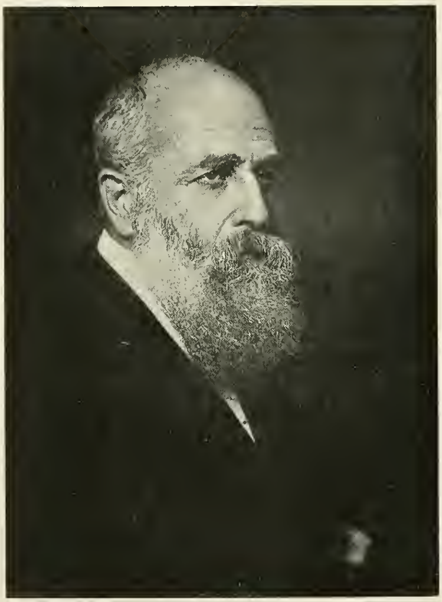
When results such as Doctor Chapman has produced can be obtained, the time devoted to the field work is time well employed, the acquisition of the large collections is well worth while, and the money spent in this kind of research is money well spent. The American Museum is to be congratulated upon an important piece of research well done, and the author upon another notable contribution to ornithology in its broadest sense.

Felix von Luschan and His Collections

By CLARK WISSLER
Curator in Chief, Division of Anthropology, American Museum

SOME time ago the American Museum acquired the famous anatomical collection and the library of Prof. Felix von Luschan. Since death has now brought Professor von Luschan's work to an end and as this collection represents in many respects his greatest contribution to anthropology, it is fitting that something be written about the man and the personality expressing itself in this collection.

It is generally true that a great museum collection is the life work of some one individual, who expresses in the collection his zeal, his spirit of inquiry, and who impresses them also upon all who meet him. It is also believed that the biological sciences as they stand today owe a great deal to the natural history cabinet of a century ago and to the enthusiastic collector. In any event, the collection of scientific materials in the past dignified the sport of exploration, so that now a person who goes out to roam in the unfrequented parts of the earth cannot claim the title of explorer, or escape contempt, unless he gives intelligent attention to scientific materials or makes scientific observations.


Professor Felix von Luschan
1854–1924

But while the passion to explore and to collect is probably inherent, it is but rarely that we meet with a genius. Such was Professor Von Luschan. We know little of his early life except that he was the son of a court barrister and was born August 2, 1854, in Oberhollabrunn, a village near Vienna. We are told that he attended the high school in Vienna and about his seventeenth year took up the study of medicine in the University of Vienna. Here he labored for seven years, graduating with honors, and receiving the degree of doctor of medicine in 1878. Throughout all this period of routine education, we learn that the collecting spirit was strong. Even before entering high school, he was collecting natural-history specimens and, following the usual human interest, became an antiquarian. No one seems to know just why all of us are so moved by what is old and by what belonged to the ancients, and why we stand ready to turn archæologist on the least provocation, but that is one of the hidden springs within us. It is not strange, then, that young Von Luschan, with his scientific bent, should feel the call of the antiquarian, and that we should find him at eighteen years of age carrying on archæological excavations in Austria.

However, his medical studies were destined to turn his collecting interests to human anatomy and, after receiving his medical degree, he seems to have made a concession to his antiquarian interests, a kind of compromise between medical anatomy and anthropology, since he went to Paris for a time to study with Paul Broca, one of the founders of racial anthropology. If he had not previously committed himself to collecting the racial types of the world, he did now, for we learn that he spent all his savings and what he could spare by cutting his living expenses to the bone, in order that he might purchase skulls brought back to Paris by travelers and traders. The studies of Broca and his predecessors had stimulated a market for such specimens and the genius of Broca impressed upon the young Von Luschan the value and scientific importance of such material.

After a brief stay in Paris, Von Luschan returned to Austria and served in the army for a year as a medical officer. He was stationed in Bosnia, at that time in the military control of Austria, now a part of Jugoslavia and previously under the control of Turkey. This sojourn in interesting archæological territory greatly stimulated him and added to his passion for collecting scientific material.

Following his brief military experience, Von Luschan spent two years in hospital work in Vienna. During all this time by great sacrifice, he continued his collection of skulls and other racial material, and indulged in every possible way his passion for archæological research. Thus we learn that in 1880, he made a collecting trip to Dalmatia and Montenegro, for the Royal Museum of Natural History in Vienna, and in 1881 and again in 1882, made similar trips to Asia Minor. As a logical result, therefore, he was admitted in 1882, to the medical faculty of the University in Vienna, to teach anatomy and anthropology.

After this Professor Von Luschan spent a part of almost every year in field collecting, chiefly in the Near East, making systematic excavations in northern Syria from 1889–1902. Here he acquired the famous archæological collections now in the Museum at Berlin and incidentally added greatly to his growing anatomical collection now in our Museum. In 1888 he joined the staff of the Ethnographical Museum in Berlin, and it was under the auspices of this institution that his subsequent expeditions were made. Later, he was professor of anthropology in the University of Berlin, where his anthropological laboratory became famous and where a number of American students received their training. Over and above all, Professor Von Luschan was a teacher, and the one great drive back of his collecting was to accumulate materials for use in imparting knowledge and enthusiasm to his students. Yet it is apparent that he was also an explorer and a museum enthusiast, thus combining all the essential high qualities necessary to a real naturalist.

J. L. Wortman—A Biographical Sketch

By HENRY FAIRFIELD OSBORN

Honorary Curator

THOSE who have never been in a fossil-hunting camp with J. L. Wortman and witnessed his boundless energy and enthusiasm can hardly realize the great part he played in the history of vertebrate palæontology in America. It was indeed a rare bit of one's education as a palæontologist to see him return to camp on a cold night after a hard day's fossil-hunt, roll a cigarette, huddle as close to the fire as possible, and tell glowingly of the day's discovery or lament bitterly the fatigue and exhaustion of fruitless search. After a large draught of hot coffee and perhaps a good supper, the casualties of the day were forgotten and the Doctor would begin to philosophize or discuss some favorite hobby of his in comparative anatomy or to expound some new theory of mammalian descent, stimulated perhaps by some outstanding "find" of the season. Such personal contacts were frequently enjoyed by the writer of this tribute during the brief but brilliant period of eight years when Doctor Wortman laid the first field foundations of mammalian and reptilian palæontology in the American Museum of Natural History.

J. L. Wortman, first field collector of the department of vertebrate palæontology, American Museum

The writer's first choice of a field leader fell in the autumn of 1890 upon John Bell Hatcher, who was at that time in the Peabody Museum of Yale University under Professor O. C. Marsh. Hatcher had, indeed, made the first advances to the American Museum of Natural History, but after arranging for a definite call he was induced to retain his old post under Marsh, wherein he had done signal service in the collection of the titanotheres of South Dakota and the giant horned ceratopsians of Converse County, Wyoming. Upon Hatcher's final declination, Wortman received the call from the American Museum. He was already highly experienced—in fact, a peer of Hatcher's, for he had served for an equally long period under Marsh's great rival, Cope, especially in the Lower Eocene formations of the Wind River and Wasatch of Wyoming.

Accordingly, when the summer of 1891 was well advanced, Wortman, as assistant curator of the department of mammalian palæontology, went into the Wasatch beds of Wyoming and, despite his previous explorations there, brought back a small but very important collection of *Coryphodon*, *Eohippus*, *Systemodon*, *Heptodon*—in other words, coryphodonts, four-toed horses, tapirs, and lophiodonts. In a very small laboratory in the very roof of the Museum, at the top of an old elevator shaft, Wortman and the writer worked these fossils out of the rock together, and extracted from them much new and significant light upon the life and times known as 'Wasatch' and the 'Wind River.' The outstanding discovery was the beautiful skull of *Palæonictis*, a very ancient carnivore, hitherto known only in the Soissonais of France. Many of the new points of great interest were described in the first joint bulletin of Doctor Wortman and the writer, which was published in 1892 under the title of "Fossil Mammals of the Wasatch and Wind River Beds."

With this very promising opening of the year 1891, Doctor Wortman continued as leader of all the American Museum expeditions to the Rocky Mountain region between the years 1891 and 1898, and it was with great regret in the year 1899 that the Museum accepted his resignation as assistant curator to become curator in charge of vertebrate palæontology in the Carnegie Museum of Pittsburgh.

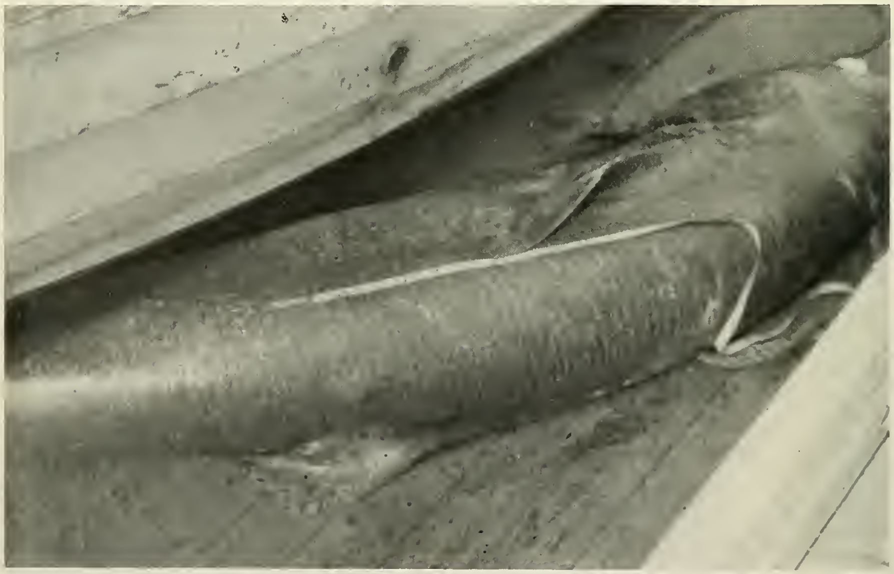
Meanwhile, he had not only very thoroughly explored the Wasatch, Wind River, and White River horizons of Dakota with new and brilliant results in each field of work, but had begun, in the final season of 1899, to explore the dinosaur beds of Wyoming in the region of Medicine Bow, the locality famous in literature as the starting point of *The Virginian* of Owen Wister. Not the least of his great services to palæontology and to the American Museum during this period was the splendid field training which he gave to Walter Granger, Albert Thomson, and O. A. Peterson, each of whom has since become distinguished in the branch of work in which he served as apprentice under Wortman.

His chief contribution to science previous to this period was a book on the anatomy of the teeth. While serving under Professor Cope, Wortman had no opportunity to describe any of the remarkable fossils which he discovered. As soon as he came under the writer's direction, he was given a generous share of the fossils of his own finding and in several instances the best finds of the season were placed in his hands, notably the very ancient animals he called *Ganodonta*, which are otherwise related to the sloth tribe but are distinguished by the persistence of enamel on the teeth, a dental feature which is wanting in all the true Edentata. His contributions to the *American Museum Bulletin* between the years 1892 and 1899 include fourteen papers numbering 394 pages.

After his many years of service in the American, the Carnegie, and the Yale museums, Doctor Wortman retired to Brownsville, Texas, where he lived until his decease, on June 25, 1926.

Photograph by George Palmer Putnam

A Greenland shark (*Somniosus microcephalus*) caught by natives at Upernivik, North Greenland, and being hauled aboard the launch by Carl Dunrad and Will Bartlett. These sharks which appear so firm and whiplike under water are really quite soft, and partly flabby, when taken out of their element. In years past these great carrion eaters accompanied the whalers about Greenland and even off the northeastern coast of the United States, appearing in numbers when there was flesh to be had



Photograph by H. C. Raven

A search of the literature dealing with fishes of the north Atlantic has failed to reveal a record of the color pattern of the Greenland shark, which consists of numerous dark bands on the back and sides of its body. Part of the animal's dark grayish-brown color is due to dirt and slime adhering to the rough skin, but the color pattern remains after this has been washed off

The Greenland Shark

By H. C. RAVEN
Associate Curator, Comparative and Human Anatomy

ONE of the most important specimens secured by the American Museum's Greenland Expedition under the leadership of Mr. George Palmer Putnam was the Greenland shark, which will be prepared for exhibition in the new Hall of Fishes. This animal inhabits principally the seas about Iceland and Greenland, and rarely comes far enough south to be taken on the northeastern coast of the United States. In consequence of its boreal habitat, few naturalists have had the opportunity of observing this interesting animal in life.

The body of the Greenland shark is slender and nearly circular in section, gradually tapering backward from the region of the pectoral fin, where it is thickest. This shark is characterized by small fins, the dorsals, about equal in size, being exceptionally small and spineless, though as in members of the Squalidæ to which it is related there is no anal fin. The tail resembles the homocercal type in outline, though less so than in the mackerel sharks. All the fins are comparatively thin and more flexible than in most sharks, which gives an impression of weakness.

The skin is decidedly rough and abrasive, as it is covered with erect shagreen denticles. The color of the animal as a whole is dark grayish-brown. Part of this coloration is due to slime and dirt adhering to the skin, even in life. When this has been scraped off, the skin is seen to be more of a bluish-gray, without any brown. The back and sides of the body are crossed by numerous narrow dark bands which, as a rule, are not very distinct.

By examination of five specimens, the food of these fishes was shown to be practically any kind of flesh they were able to obtain. Most often there would be remains of small fishes, the two commonest species being the Greenland rock cod (*Gadus ogac*) and the Greenland sculpin (*Myoxocephalus scorpius*). One shark contained the remains of a small lump-fish only five or six inches in length. In another was the greater part of a small seal (probably *Phoca vitulina*) which had been bitten to pieces, each piece being from seven to ten inches long. There were feathers of some sea bird and numerous invertebrates and other material that was unidentifiable.

The Greenlanders catch these sluggish sharks on ordinary hook and line and use the dried flesh for food for dogs during the winter. The most valuable part of the shark, however, is the liver, from which a quantity of oil is procured by boiling. This oil is placed in kegs and shipped to Denmark The liver is large,—that of a ten-foot shark measured six feet.

The largest shark we saw was slightly more than ten feet long. The average length is about nine feet and the maximum of which I have heard was approximately fifteen feet.

NOTES

CENTRAL ASIATIC EXPEDITIONS

WINTER PLANS.—Mr. Walter Granger, chief palæontologist of the Museum's Central Asiatic Expeditions, in a letter addressed to President Osborn dated October 15, 1926, from Yunnanfu, outlines plans for the winter. With Mr. Granger is Mr. N. C. Nelson, archæologist, who is searching for remains of prehistoric man. As far as Yunnanfu the two explorers were accompanied by their wives. The party arrived there on September 17 after having had experiences with typhoons on the China coast and delays at Tongking due to the flooding of the country, which interfered with railroad travel. By good fortune the trip to Yunnanfu, a three days' ride, was made without delay between long periods of interrupted railroad traffic.

Nearly a month was required at Yunnanfu to secure a caravan of thirteen horses and attend to formal and official matters. On the day of writing the caravan had gone forward to a temple on the opposite side of the lake, where camp would be made for the night. Mr. Granger and Mr. Nelson were to make this part of the trip by boat. Mrs. Granger and Mrs. Nelson were to remain at Yunnanfu, where they were to keep house in the American

Consulate during the interval following the leaving of Mr. Myers, the consul, and the arrival of his successor.

The plan of operations is first to make a six or seven days' trip to Yuan-Kiang on the Red River, almost directly south of Yunnanfu, dropping from an altitude of 6500 feet to one of 1500 feet. It is hoped that Mr. Nelson may find archæological remains in the Red River valley and that Mr. Granger may make a zoölogical collection. Later a trip westward from Yunnanfu to Talifu is planned, to be followed by trips to the northwest and east. Besides these definite trips. Mr. Granger hopes to visit certain localities from which fossils have been obtained. Conditions, however, are bad as regards bandits, and travel, even by missionaries, is now restricted in Yunnan.

FISHES

Angola Fresh-water Fishes.—The department of fishes is studying a fresh-water collection obtained in Angola by the Vernay Expedition. This area lies just outside the remarkable highly developed fish fauna of the Congo Basin, and this collection comprises mostly minnows (*Barbus*) and perchlike Cichlids, with only an occasional Mormyrid and Characin. A review of Angola fishes correlated with Mr. Boulton's (one of the collectors) more or less first hand knowledge of the physiography of the country, should give an interesting side light on the distribution of old-world fresh-water fishes. The genus *Barbus* seems to have entered Africa in the northeast, spread rapidly through east and multiplied in south Africa, without gaining any dominant position in the Congo fauna.

MAMMALS

Mediterranean Seals for the Museum.—Through the field work of Mr. Jesse Metcalf, of New York City, the American Museum has just acquired skins and entire skeletons of three Mediterranean seals, comprising an old male 8 feet 6 inches long, an adult female, and a very young cub. The specimens are accompanied by measurements, as well as by photographs and notes relating to the animals and to their haunts among the sea caves of the Desertas Islands, off Madeira.

This rare seal which was formerly widely distributed in the Mediterranean region, is one of the subtropical genus known as *Monachus*, the "monk seals." Seals of related species were formerly abundant in the Caribbean Sea and on the shores of certain mid-Pacific islands, but they have long been greatly reduced in numbers, if not quite exterminated. It is believed that the three examples of the Mediterranean species which Mr. Metcalf has presented, are the first in any American collection.

The search for this seal was one of the objects of the cruise described in the leading article of this issue of Natural History. It was not encountered within the Mediterranean Sea, however, although Mr. W. K. Vanderbilt reports that he recently observed one or more of the animals off the coast of Tunis.

After Doctor Murphy's departure from the "Wawaloam," Mr. Metcalf continued his voyage, taking with him Mr. Ogilvie Gordon, of London, as natural history collector. The yacht first visited the Spanish island of Alboran and then proceeded through the Strait of Gibraltar and southward to Madeira, the Desertas and the Salvages groups. Landings were made and collections obtained upon seven or more islets, the most interesting experiences being the penetration of the seal caves on Deserta Grande and the subsequent capture, with the aid of several skilled Portuguese cragsmen, of a family of the desired sea mammals. Throughout the work at the islands, the expedition received generous privileges and personal assistance from Col A. R. B. Cossart, of Funchal, owner of the Desertas.

Other natural history material obtained by Mr. Metcalf in this part of the world includes insects, marine fishes, and invertebrates, lizards, and both land and sea birds. Among the birds are several kinds new to the collections of the Museum. Most interesting of all is a petrel (*Pterodroma mollis feæ*) locally called by the Portuguese word meaning "nun." It is known to nest in only a few inaccessable localities on the islands between Madeira and the Cape Verde group. Specimens of adults and young make an important addition to the Museum's collection of petrels and their allies, which is now more nearly complete than any other in the world.

One downy chick of the "nun petrel," obtained on the Island of Bugio on September 23d, has been fed on raw fish by Mr. and Mrs. Metcalf, and on the date of this note (December 31) is still flourishing in New York. There is perhaps no other instance of a bird of this group thriving so long in captivity.

Taylor Sudan Expedition.—Mr. Irving K. Taylor, a Life Member of the American Museum of Natural History, one of the Board of Directors of the New York Zoological Society, and a director of the Explorers Club, left New York City early in December on an expedition to the Egyptian Sudan. Mr. Taylor has made three expeditions into this region as a sportsman and has generously decided to make his fourth trip to the Sudan an American Museum expedition. He is taking with him as the Museum representative Mr. H. E. Anthony, curator of mammals of the world in the American Museum.

This expedition is known as the Taylor Sudan Expedition and all of the resources and energies of the party will be devoted to the collection of material for the Museum. The primary purpose is the formation of large study collections of mammals, birds, fishes, and reptiles, together with photographs, both moving and still, and notes on observations, etc. If any fine exhibition material is secured, plans will be made to include it in the proposed Hall of Mammals of the World.

Mr. Taylor's long experience in the region insures an advantageous arrangement of transportation. Part of the time the expedition will work from a small steamer, chartered specially for the trip, ascending the White Nile and stopping to collect wherever specimens are encountered. There will also be one or more trips made by camel away from the Nile to collect the desert fauna and the animal life of the foothills along the Abyssinian frontier.

The region about the White Nile and the Blue Nile is today one of the finest hunting grounds in Africa. Not only are most of the commoner species of African mammals encountered here, but also species of antelope, such as the white-eared kob and Mrs. Gray's kob, which are found nowhere else. The American Museum has practically no material from the Sudan in its collections, and Mr. Taylor's generous gift of all of the specimens to be collected on his expedition will fill a very real need.

The Taylor Sudan Expedition will be gone about six months and will operate out of Khartoum as a base.

MINERALS

A Novel Idea in Locality Collections.—During the recent visit to this country of Queen Marie of Roumania, the department of minerals in the American Museum featured a temporary exhibit of the minerals of Roumania, involving several ideas that are believed to be new in museum installation.

The 250 specimens representing Roumanian localities contained in the general series were not removed to a separate case, but remained in their places distributed throughout the collection, and were designated by a narrow strip of colored paper in the Roumanian colors (red, orange, and blue) attached to the mount. Paper shields 1½ inches by 1¼ inches in the same colors were attached to the glass of the cases as markers in such a manner as not to interfere in any way with the view. A group label of conspicuous size and position called the attention of the visitor to the specimens thus singled out, by directing him to look for the Roumanian colors.

This method of installation for temporary locality series has an educational advantage over the older and more universal method of segregated specimens, because it admits of the specimens being compared with those from other localities, and also in the ease with which it shows what proportion of a certain species or group comes from the selected locality.

SCIENCE OF MAN

Dr. J. R. Walker, for many years a physician in the United States Indian Service, died at his home in Denver, December 13, 1926. He was a careful student of Indian life, specializing on the Sioux Indians of Dakota. Part of the Dakota collection in our Plains Indian Exhibit was received from him and a detailed study of the religious beliefs of these Indians, entitled, "The Sun Dance and Other Ceremonies of the Oglala Division of the Teton Dakota," was published by the Museum. He carried on investigations of a physiological and medical nature among the Indians in his charge, the results of which were published elsewhere. He was an enthusiastic supporter of the Museum, and was endowed with a lovable personality which endeared him to all.

The Season's Archæological Exploration in Arizona under the Ogden Mills Survey has just been completed. Following up the work of last year in Cañon del Muerto. this season operations were extended into the adjoining cañon, de Chelly, where rich deposits of Cliff Dweller refuse were excavated. These deposits were near the famous White

House cliff ruin, shown in the background of the great Navajo group in our hall for the Southwestern Indians. The part of the cañon adjoining this ruin is of special interest since the ruin itself occupies a grotto some fifty feet above the valley floor, with a second ruin at the foot of the cliff directly beneath the grotto. The two together constitute the most spectacular aboriginal monument in the entire de Chelly cañon system, of which Cañon del Muerto is a part. The only possible rival to the White House and its setting is Mummy Cave in Cañon del Muerto in which extensive excavations were carried on last season. Mr. Earl H. Morris was in charge of the work, assisted by Mr. Erich F. Schmidt of the Museum staff. No excavations in the upper ruin were undertaken, attention being given wholly to the lower one and to the large heap of refuse on the valley floor and containing, for the most part, pottery and other objects thrown down from the dwelling above. The rooms of the lower ruin were cleared. Sections of this refuse deposit were excavated, revealing successively from the bottom upward, the following culture periods in the prehistory of the Southwest: Post Basket Maker, Pre-Pueblo, and Pueblo. Several small burial plots were found yielding an unusual store of pottery vessels, one grave containing nineteen vessels in all. The collections resulting from these excavations are rich in woven objects, particularly sandals. In addition there are many examples of cotton cloth, cord, matting, etc. It so happened that the refuse deposit was protected by the overhang of the cañon wall and thus kept dry, preserving all objects of fiber, wood, and other perishable materials. Consequently, this collection gives a much better picture of prehistoric life in the Southwest than do ordinary archæological collections.

Ancient Salt Mine in Arizona.—In August of this year Mr. Warren S. Smith, representing the Western Chemical Company informed the Museum that an ancient salt mine had been discovered at Camp Verde, Arizona. This information was forwarded to Mr. Earl H. Morris, then on his way to Cañon del Muerto. Mr. Morris made a brief visit to Camp Verde, where every courtesy was extended him by the local officials of the Western Chemical Company. His observations revealed that in prehistoric times the Indians of that vicinity had mined for salt in the deposits at that place, running tunnels underground many feet. In some of these tunnels were evidences of prehistoric mining operations, consisting of bark torches, worn-out sandals, mats, and carrying devices, together with mining tools of stone. In order to date these salt mine operations archæologically, Mr. Morris explored several near-by cavelike dwellings, from which he secured a collection of cotton cloth, matting, sandals, and implements similar to those found in the tunnels. From these materials it may be possible to fix the time of these mining operations. One unique find was an infant burial, the body rolled in many pieces of cotton cloth, one of which bore an elaborate embroidered design of unusual excellence.

APPEAL FOR BACK NUMBERS OF "NATURAL HISTORY"

The Library of the American Museum receives frequent requests for complete files of Natural History which it is no longer able to furnish. Should any subscribers care to donate copies of earlier issues, the gift will be very much appreciated, and postage will be refunded to the donor. Address the Librarian, American Museum of Natural History.

NEW MEMBERS

Since the last issue of Natural History, the following persons have been elected members of the American Museum, making the total membership 9159.

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Mesdames: James H. Ottley, William I. Walter.

Messrs: Harvey S. Ladew, John H. Phipps, John S. Phipps, James F. Porter, William I. Walter.

Fellows

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Mr: Frank Johnson.

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Mesdames: Harriet Buck Cook, W. B. Dickerman, Eva H. Eastman.

Doctor: Charles A. Dewey.

Messrs: George G. Barber, Otis Barton, Russell S. Codman, F. Bayard Rives.

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Messrs: Gustav N. Ballin, Maurice E. Bandler, Al Heller, Robert G. Hooke, Philip LeBoutillier, Jos. Nemerov, H. T. Sands.

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Doctors: Francis J. Edelstein, Geo. W. Jacoby, Maurice Lenz, Edward Wallace Lee, Chas. G. McGaffin, Floyd Orten Reed.

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Master: Lewis Schiele.

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Prof: Wallace W. Atwood, Charles D. Bean, Emil O. Deere, George F. Kay, Frederic B. Loomis, Alfred S. Romer.

Doctors: Theodor G. Ahrens, Walter C. Alvarez, Samuel Amberg, Daniel A. Atkinson, H. E. Auringer, Rufus Mather Bagg, Frank C. Baker, Michael V. Ball, Max Ballin, R. V. Bangham, Walter E. Bartlett, Thos. R. Boggs, Lloyd T. Brown, Martha Bunting, Charles W. Burr, C. O. Carlson, C. F. De Garis, James John Monahan, Herbert V. Neal, Wm. A. Riley, William P. Rothwell, H. I. Stehlin, L. H. Trufant, L. C. Wooster

Messrs: E. L. Adams, Fred D. Aldrich, Charles Laurence Baker, Harry Barkby, H. W. Barker, Fred Asa Barnes, Stanhope Bayne-Jones, R. H. Beamer, F. Z. Bennett, G. B. Bodman, M. F. Bohart, Claud I. Boles, George M. Bond, Wymond H. Bradbury, F. Fulton Bramble, Jacob Bunn, Morris Carter, Kenneth M. Chadwick, Wilbert A. Clemens, F. G. Collins, Lewis F. Crawford, Bert Cunningham, R. N. Davis, Sinclair Dodge, G. D.

Edwards, Edward C. Eliot, John T. Faig, Arthur H. Fisher, Geo. R. Fox, Edward J. Foyles, Clifford C. Gregg, Roland B. Hall, A. L. Hart, Jerome J. Herdina, Clement C. Hyde, Frank L. Jobson, James C. Kinard, Boyden Kinsey, C. A. Kinsey, Willis Leriche, J. C. Maginnis, R. Newton Mayall, Parker J. McHale, Levi W. Mengel, C. J. Millar, E. C. Palmer, Austin M. Reed, Philip L. Riley, Adolph R. Ringoen, Edmund L. Sanderson, John H. Scheide, Louis Schellbach, 3d., Edward Wm. Schmidt, J. C. Shaw, Samuel Barton Sklar, C. Y. Stanier, J. Lauer Stauft, C. S. Stephano, Stanley Stolba, Charles M. Throop, Thos. A. Warthin, John H. Wagner, Jr., Edmund H. Wuerpel, Ernest G. Yocom.

THE MUSEUM IN FIELD AND STUDY

JANUARY-FEBRUARY

The first number of Natural History for 1927 brings up to date many of the activities of the American Museum both in the field and in the study.

The quest for the semi-mythical dragon lizards of Komodo led the Burden East Indian Expedition halfway around the globe to the Dutch East Indies. Mr. Burden tells how he found and captured these giant lizards,—living remnants of the monster saurians which lived in Australia during the Pleistocene Age.

As the ice of the last glaciation melted and disappeared from eastern North America, it left behind annual records of its retreat in the stratified clay sediments deposited by the rivers that flowed out from under the ice mass. Dr. Chester A. Reeds tells how, in assembling the American Museum's series of sections of these clays from near New York City, he is unfolding a new chapter in the palæogeography of the region.

While most of us picture Greenland as eternally buried under snow and ice, in reality part of the coast is free during the summer months. Mr. H. C. Raven, of the American Museum Greenland Expedition, saw flowering plants, birds, polar bears, walrus, and seals, and describes the fine series of narwhal (fabled unicorn of the ancients) secured by the Expedition, from which models will be made for the Hall of Ocean Life.

Samos, ancient scene of the journeys of St. Paul and St. John, was visited by Barnum Brown in his recent fossil-hunting expedition. The romantic background of the region, together with the geological relationship of the fossils, found only on a single narrow strip on the island, form the theme of Mr. Brown's story for the next number of Natural History.

Dr. G. Kingsley Noble discusses the rôle of environment and heredity in an animal's inheritance, with special reference to experiments which he has been carrying on in the Museum's laboratories.

That many species of fishes exercise parental guardianship over their egg nests up to the time the young are hatched, is an interesting phenomenon of fish life. Dr. E. W. Gudger describes the only known gunnel "nest" on exhibition in any museum, which is presently to be installed in the new Hall of Fishes.

Prof. T. D. A. Cockerell's article on his recent trip to South America for fossil insects relates the incidents of "a journey packed with varied experiences, worth while equally for scientific results, knowledge of the physical conditions, and the delightful contact with interesting people."

The museums of France, Spain, and Italy were visited by Mr. H. P. Whitlock during last summer, with special reference to studying arrangement and presentation of exhibits. He gives his impressions in "A Museum Pilgrimage."

THE AMERICAN MUSEUM OF NATURAL HISTORY

FOUNDED IN 1869

MEMBERSHIP MORE THAN NINE THOUSAND

For the enrichment of its collections, for the support of its explorations and scientific research, and for the maintenance of its publications, the American Museum of Natural History is dependent wholly upon membership fees and the generosity of friends. More than 9000 members are now enrolled who are thus supporting the work of the Museum. The various classes of membership are:

Associate Member (nonresident)*	annually	$3
Annual Member	annually	$10
Sustaining Member	annually	$25
Life Member		$200
Fellow		$500
Patron		$1,000
Associate Benefactor		$10,000
Associate Founder		$25,000
Benefactor		$50,000
Endowment Member		$100,000

*Persons residing fifty miles or more from New York City

Subscriptions by check and inquiries regarding membership should be addressed: George F. Baker, Jr., Treasurer, American Museum of Natural History, New York City.

FREE TO MEMBERS

NATURAL HISTORY: JOURNAL OF THE AMERICAN MUSEUM

NATURAL HISTORY, published bimonthly by the Museum, is sent to all classes of members as one of their privileges. Through NATURAL HISTORY they are kept in touch with the activities of the Museum and with the marvels of nature as they are revealed by study and exploration in various regions of the globe.

AUTUMN AND SPRING COURSES OF POPULAR LECTURES

Series of illustrated lectures, held in the Auditorium of the Museum on alternate Thursday evenings in the fall and spring of the year, are open only to members and to those holding tickets given them by members.

Illustrated stories for the children of members are presented on alternate Saturday mornings in the fall and in the spring.

MEMBERS' CLUB ROOM AND GUIDE SERVICE

A room on the third floor of the Museum, equipped with every convenience for rest, reading, and correspondence, is set apart during Museum hours for the exclusive use of members. When visiting the Museum, members are also privileged to avail themselves of the services of an instructor for guidance.

THE AMERICAN MUSEUM OF NATURAL HISTORY has a record of fifty-six years of public service during which its activities have grown and broadened, until today it occupies a position of recognized importance not only in the community it immediately serves but in the educational life of the nation and in the progress of civilization throughout the world.

Every year brings evidence—in the growth of the Museum membership, in the ever-larger number of individuals visiting its exhibits for study and recreation, in the rapidly expanding activities of its school service, in the wealth of scientific information gathered by its world-wide expeditions and disseminated through its publications—of the increasing influence exercised by the institution. In 1925 no fewer than 1,775,890 individuals visited the Museum as compared with 1,633,843 in 1924 and 1,440,726 in 1923. All of these people had access to the exhibition halls without the payment of any admission fee whatsoever.

The **EXPEDITIONS** of the Museum have yielded during the past year results of distinct value. The collections being made by Mr. Arthur S. Vernay in Angola, Africa; the studies of Andean avifauna pursued by H. Watkins in Peru; the three fossil expeditions in the western United States, in New Mexico, and Nebraska and Montana; the extensive survey of Polynesian bird life conducted by the Whitney South Sea Expedition; the work pursued in selected faunal areas of Venezuela by Mr. G. H. H. Tate; the field observations and collections made in Panama by R. R. Benson; the studies of microscopic pond life of Mt. Desert Island by Dr. Roy W. Miner and Mr. Frank J. Myers; the archeological excavations at two important sites in Arizona; and the continuation of the brilliant work of the Third Asiatic Expedition during the past season—these (and the list might be extended) are among the notable achievements of the past twelve months.

The **SCHOOL SERVICE** of the Museum reaches annually about 6,000,000 boys and girls through the opportunities it affords classes of students to visit the Museum; through lectures on natural history especially designed for pupils and delivered both in the Museum and in many school centers; through its loan collections, or "traveling museums," which during the past year circulated among 410 schools, and were studied by 977,384 pupils. During the same period 672,479 lantern slides were loaned by the Museum for use in the schools, the total number of children reached being 3,941,494. 1,076 reels of motion pictures were loaned to 48 public schools and other educational institutions in Greater New York, reaching 333,097 children.

The **LECTURE COURSES,** some exclusively for members and their children, others for the schools, colleges, and the general public, are delivered both in the Museum and at outside educational institutions.

The **LIBRARY,** comprising 100,000 volumes, is at the service of scientific workers and others interested in natural history, and an attractive reading room is provided for their accommodation.

The **POPULAR PUBLICATIONS** of the Museum, in addition to NATURAL HISTORY, include *Handbooks*, which deal with the subjects illustrated by the collections, and *Guide Leaflets*, which describe some exhibit or series of exhibits of special interest or importance, or the contents of some hall or some branch of Museum activity.

The **SCIENTIFIC PUBLICATIONS** of the Museum, based upon its explorations and the study of its collections, comprise the *Memoirs*, of quarto size, devoted to monographs requiring large or fine illustrations and exhaustive treatment; the *Bulletin*, issued since 1881, in octavo form, dealing with the scientific activities of the departments, aside from anthropology; the *Anthropological Papers*, recording the work of the staff of the department of anthropology; and *Novitates*, devoted to the publication of preliminary scientific announcements, descriptions of new forms, and similar matters.

For a detailed list of popular and scientific publications with prices apply to:
THE LIBRARIAN, AMERICAN MUSEUM OF NATURAL HISTORY
NEW YORK CITY

INDEX TO VOLUME XXVI

TEXT AND ILLUSTRATIONS

Names of articles are set in capitals and small capitals. Titles of works are set in italics.