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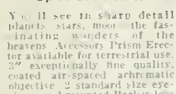
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Letters

Eruption in Java

SIRS:

Following the account of the San Juan volcanic outburst of Oligocene times in your November issue, it may interest your readers to see an example of a peculiar phenomenon in contemporary vulcanism.

Shortly after midnight on June 17, last year, Mount Merapi—in central Java—began emitting smoke after a few premonitory rumbles. Just at dawn, the following day, the face of the mountain was covered by a great, glowing cloud and observers heard a roar like that of an approaching express train, accompanied by cracking reports. Avalanches of ash, great blocks and smaller rocks, and sand came rushing and thundering down the mountainside.

During the next three weeks, dozens of such avalanche-and-cloud combinations (*photograph*) scoured the slopes of Mount Merapi—nine of them on a single day. (June 19)—before the giant returned to its slumber.

Although simple ash avalanches have been observed before, notably at Vesuvius in 1900. I believe that the combination of avalanche with eruptive cloud, as at Merapi, deserves a different name—to distinguish it from the Vesuvian phenomenon, where the avalanches were set off by local tremors. I therefore propose the expression, “ash whirlstorm.”

M. I. ADNAWIDJAJA
Observer
Volcanological Survey

Bandung, Indonesia

News from Q'eros

SIRS:

With reference to the article concerning the Indians of Q'eros in your November issue, you should be informed that—after a decade of complaints by these Indians against the proprietor of their territory—the Peruvian Government has now taken measures to expropriate this hacienda and distribute its lands among the unfortunate residents.

The owner of the Q'eros lands (and by the way, the correct term is *hacendado*, not *haciendista*, as in your article) had, among other things, failed to observe the law that requires landowners to support a school in any isolated community that contains forty or more children of school age. Early last November, following the Government's action on their longstanding petition, a delegation of Q'eros men came to Lima and gave President Prado a poncho, a headdress, a mantle and a shirt—all of their own distinctive and excellent weaving—as an expression of gratitude.

RICARDO TELLO DEVOTTO

Huancayo, Peru

Poison Beads?

SIRS:

A friend has received a very attractive belt from Puerto Rico, made of seeds. She intends it as a gift to her daughter but has become alarmed because of an article in your magazine

(continued on page 50)

The Magazine of the American Museum of Natural History

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January, 1958

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STANDING in its nest among the black mangroves of Cotton Key, in Florida, this young Great White Heron, *Ardea occidentalis*, is the sole survivor of a trio of nestlings produced by a parental pair of different colors—a Great White and a Great Blue. Soon dubbed "Big Whitey" by the two young men who were observing his progress, the survivor flourished during his sixty-three-day nest life, which is documented in exceptional photographs—several in color—on page 52 ff.

Told there, also, is the story that underlay the Meyerriecks brothers' study: the hundred-year-old question of the Great White Heron's true position in the Class Aves—a full species, or a color phase? The observations described in their article have gone a long way toward giving at least an interim answer to this question.

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Reviews

MUSHROOMS, RUSSIA AND HISTORY

by V. P. & R. G. Wasson
(Pantheon, 2 vols., \$125)

Reviewed by
RICHARD EVANS SCHULTES

THIS is a rare book. It is rare, first of all, in its manufacture, for the volumes were printed in Verona (on paper handmade in Pescia) and bound in Milan; the illustrations were executed in Paris and Florence—all this to produce only 512 copies, of which no more than 350 are for sale at the price of \$125. Harvard's late Professor Oakes Ames used to say: "The result of a scholar's research is a jewel worthy of a proper setting." Those lucky enough to own or have access to these volumes will vividly remember Ames's words, for they are truly jewels of research mounted in the best setting the printer's art can offer.

Mushrooms, Russia and History is also rare in the aura it breathes. It is a work of amateurs, of dilettantes in the best and literal sense of those words—people who love their subject and have cultivated their knowledge with real pleasure, with an unhurried savoring. There is something about the leisurely pace that the reader feels in these volumes, the richness of their style and the course of their elaboration—the Wassons have meandered through their subject for over thirty years—that seems to put them in a more reflective age than ours.

Because of the extraordinary devotion and thoroughness with which the Wassons have pursued their theme, it is not easy to give an even idea of the contents and method of the book. Its structure is extremely agile, the erudition marshalled with brilliance. The roads the authors travel are what were previously merely byways—when they were known at all. Still, these volumes are part of what has come to be a regular genre of erudite prose, and perhaps one can give an idea of it by saying that the Wassons' approach is much the same as that of Robert Graves (a friend of theirs to whom they are much indebted, both

DIVINE MUSHROOM, *ling-chih*, is object of sage's contemplation in seventeenth-century scroll, painted by Chen Hung-shou.



九蓮山房百步竹園

N EPIC WORK IN ETHNOBOTANY

for general comment and points of detail) in *The White Goddess*.

But the Wassons have given their book a uniquely personal quality. This, in general advantageous, has several times been unfortunate. The very title of the work is inadequate, even though chosen for sentimental reasons—Mrs. Wasson is Russian-born and has acquired from the traditions of her native land a love of mushrooms, which her husband, an Anglo-Saxon, learned only slowly to value in equal measure. Nor is a true idea of the book's scope given by the first three chapters: "Mushrooms and the Russians" (they like them), "Mushrooms and the English" (they loathe them) and "Mushrooms and History"—a rather vague treatment of a scarcely perceptible link between mushrooms and times of war. But from these chapters emerges a fact of curious importance: in the whole of Europe, the Slavs (especially the Russians) and the Catalans are really the only people to have loved the mushroom and taken it really to heart. The others, from the Frisians to the Greeks, have, without exception, abhorred it. This fact is important for the Wassons' final conclusions, and we shall return to it.

With a chapter on "Mushrooms for Murderers," the Wassons begin to hit their stride. It is a brief chapter, the chief contribution of which is to tell us how the emperor Claudius, Nero's predecessor, was assassinated by his niece and third wife Agrippina, in A.D. 54. The Wassons, basing their arguments largely on the account which Tacitus has given of the murder, urge that Claudius was poisoned by the *Amanita phalloides*, the one deadly species of mushroom; and they have very cleverly found a passage in Seneca (who was privy to the crime) which supports their contention. In passing, we are offered a rather plausible interpretation of the title of a subsequent work by the philosopher, written after he ceased to be Nero's tutor: a satire called the *Apokolokuntosis*—literally, "transformation into a gourd." For if the first attempt at assassination was botched, in the privacy of the weakened emperor's chambers, another, less subtle poison could be administered. The Wassons, taking their cue from Seneca's title and a suggestion from Robert Graves, remind us of the colocynth, a poisonous gourd which, taken in small doses as a purgative, was held as a sort of "miracle drug" in Rome at that time. Their sug-

gestion is no more than plausible, but it does give Seneca's title the point and wit that so bizarre an image seems to require, and it suggests also the range and acuteness of the Wassons' learning.

But perhaps the most abundant display of these qualities is to be found in the chapter entitled "The Riddle of the Toad and Other Secrets Mushroomic," a dazzling compendium of some three hundred pages of philology, ethnology and lore, whose richness can only be suggested in the brief compass of a review. Here, in the authors' own words, is how they have proceeded: "Occasionally there are clusters of words that the philologists ought to study together, and such is the fungal vocabulary of Europe, a semantic field pervaded by related figures of speech and emotional responses. No philologist has pursued this method. Our basic fungal words of northern and southern Europe possess identical semantic attributes. They mean the same things. . . . They evoke identical turns of phrase, proverbs, epithetical use. In short, the words occupy the same semantic terrain, which would be unlikely if they descended from unrelated sources." Accordingly, the Wassons begin their exposition by asking why a mushroom is called a "toadstool," or in Danish a "toad's hat," in Irish a "frog's pouch," and so on. Now toads are always associated in folklore, they maintain, with poison, and in English as in Breton, the very word comes from the Latin *toxicum*, meaning poison, and may be related in some of its variants to the Latin *taxus*, yew—a tree known to antiquity as poisonous. In short, the Wassons hold, even in languages where the words for "toad" are philologically unrelated to those for "mushroom," the idea of poison was uppermost in the popular mind.

YET there are instances linking toads with fungi where poison is not involved. The authors are thus led still further back into the history of Indo-European languages, discovering marked similarities between the words for toads and mushrooms—venomous or otherwise—in certain Slavic regions (the Ukraine and Slovakia) and in the Basque country. This, to the Wassons, suggests "a profound substratum of folk associations between fungi and toads in the Indo-

European world, . . . that is today everywhere silted over except for the three outcroppings on the map of Europe."

Here, incidentally, is one of the great difficulties of the Wassons' method—for while the similarities between Basque and Ukrainian fungal vocabulary are unquestionable, they might be independent parallels rather than derivatives from a common source.

NOW, in such a closely-knit study, where each step of the exposition follows directly from the preceding, all links in the chain must be equally strong. The Wassons' journey takes them from toads to mushrooms through venom; from both to the diabolical and scatological symbolism of fungi, to their erotic significance; and so on. If one step in their reasoning is weak or merely hypothetical, all the others may be in some measure suspect. This is not entirely true, however, for the effect of their semantic approach is to give their argumentation two levels and two directions: one, a direct, linear development of their theme, progressing from one linguistic root or metaphor to the next; and, at the same time, a more circuitous path, which turns back upon itself, branches off and rejoins the main trunk at an earlier point. So that even if one stage of the Wassons' argument should be unproven, it is followed by a vast amount of circumstantial evidence which makes their previous suggestions much more likely, if not certain. The evidence is, however, still only circumstantial, and

(continued on page 46)



WITCHES' GOD, Robin Goodfellow, is tied with mushroom lore by nightjars and candle in this English Renaissance woodcut.

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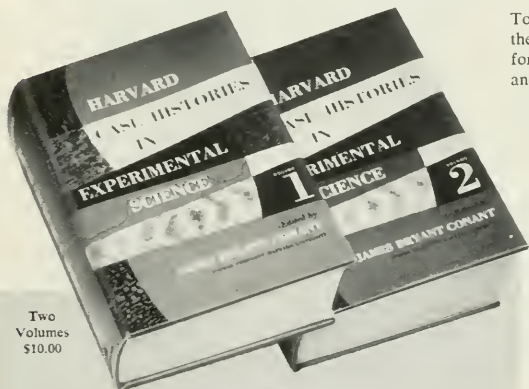
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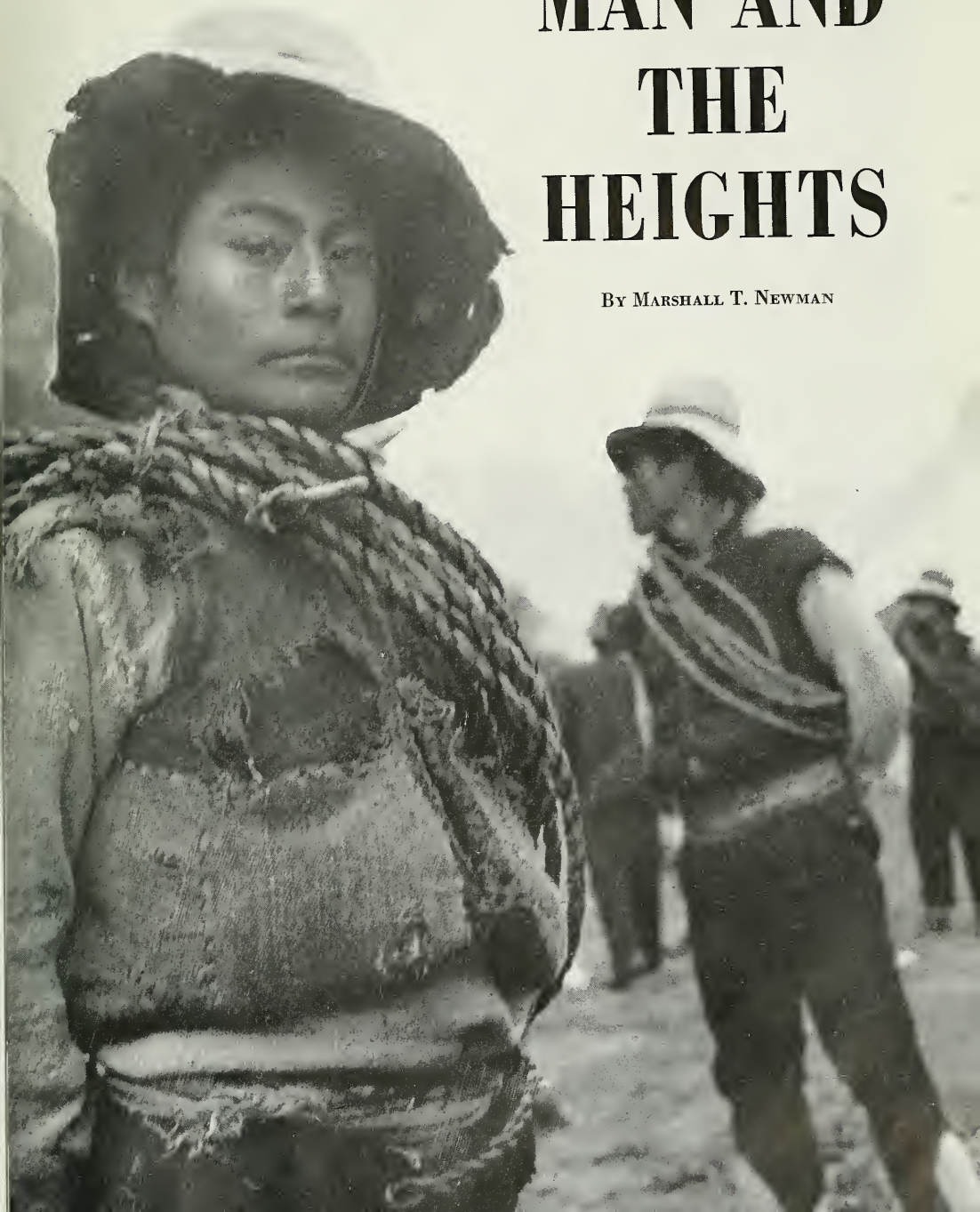
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A STUDY OF RESPONSE TO ENVIRONMENTAL EXTREMES

MAN AND THE HEIGHTS

BY MARSHALL T. NEWMAN



Mankind occupies almost all the earth, often adapting his culture to live in hostile environments. This first, in a series of articles, examines another sort of adaptation: physical change



FARMERS OF VICOS harvest a crop of beans on a steep, arid hillside, ten thousand feet above sea level.

IN HIS RANGING over most of the earth's surface, man has encountered the challenge of a tremendous variety of environments. This challenge is most urgent in three extremes — the climatic opposites of heat and cold and the geographic extreme of high altitude. In each of these three, man faces — as his principal problem — the maintenance of a proper operating balance of his body.

At either extreme of temperature, man must preserve his thermal equilib-



HACIENDA VICOS fields lie amid streams tributary to the Marcará River in the Callejón de Huaylas,

a narrow mountain valley that runs between the Black and White Cordilleras, two hundred miles north

of Lima, Peru. The Indians who live here are accustomed to hard work at altitudes of two miles or more.

rium. As a warm-blooded animal, he cannot survive if his body becomes too chilled or too overheated. At the extreme of high altitude, man must at all times maintain his oxygen balance. Otherwise, his body develops an oxygen debt, which, unless paid, will result in sickness and even death. The efforts of his body to keep in balance are immeasurably aided by man's technical know-how. Otherwise, he could not hope to maintain himself in the frigid arctic, the searing

heat of the desert and the bleak heights of the Andes or the Himalayas. The story of man's bodily adaptations or adjustments to such conditions of life, aided as they are by his culture, constitutes one of the most stirring chapters of human history.

Perhaps the most dramatic of these stories of adaption is man's conquest of high altitude. Distinct from the quick upward dash of the mountain climber, this conquest entails the gaining of permanent livelihood at

two to three miles' elevation above sea level. At such heights, the air contains only two-thirds to one-half the oxygen at sea level, yet a proper supply of oxygen to the bodily tissues must be maintained at all times. An account is presented here of how this has been accomplished, through a series of interrelated bodily changes—principally in breathing and circulation of oxygen-bearing blood—among the Andean Indians.

An observer among these Indians



is first struck by the tremendous size of their chests, which overshadows the rest of their physical development. Some are actually barrel-chested, with a decided expansion of the lower part of the rib cage. Correspondingly, their lungs are large, and are allowed even more space by a lowered diaphragm. But this is not all. Picture the lungs as a twin set of bellows, lined inside with many small pockets. When opened up or dilated by very deep inhaling, these pockets (or alveoli) provide extra lung surface. In Andean Indians, the alveoli are permanently dilated to afford maximum surface for oxygen absorption. Running close by the alveoli of the lungs are networks of small blood vessels or capillaries. The expanded inner lining of the lungs in Andean Indians makes for a doubly-rich capillary bed, capable of picking up the maximum amount of the oxygen available in the thin mountain air.

But our high-altitude Indians have

made other adaptations than in chest and lungs. One of these is having more blood — on the average, over two quarts more than their sea-level cousins. This forty-per-cent increase is due wholly to the mountaineers' greater manufacture and maintenance of red cells. The red cells, in turn, contain the vital hemoglobin, which absorbs the oxygen in the lung capillaries. As with the expanded capillary bed, there is an actual doubling by weight of hemoglobin in Indians living at three miles' altitude. Furthermore, each individual red cell is larger in the high-altitude people. While each enlarged cell contains somewhat less hemoglobin than do the red cells of people at sea level, the larger size affords a maximum surface for oxygen absorption.

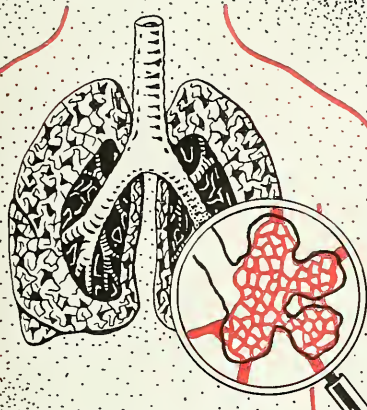
Yet even with the complex adjustments already mentioned, the hemoglobin at altitude is less saturated with oxygen than at sea level, and a larger amount of hemoglobin carries

MOUNTAIN MAN'S oversize chest and expansion of lower part of the rib cage evidence his large lungs.

SHOCKS OF BARLEY are carried on the Vicos Indians' backs from field to hacienda threshing floor.



Some Elements of Adaptation to High Altitude



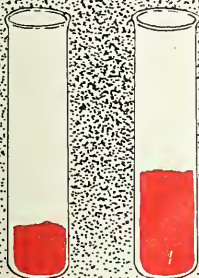
LUNG SURFACE

Among the Andean Indians, the lung packets (alveoli) are permanently dilated, making for a doubly-rich capillary bed (magnified, at left).



EXTRA BLOOD

Dwellers at sea level possess an average of five quarts of blood; mountain men, right, have seven quarts. This is an increase of some forty per cent.

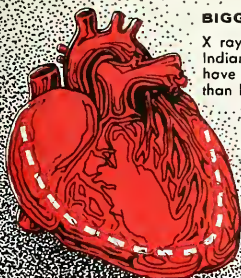


MORE HEMOGLOBIN

Although oxygen saturation of each cell is less, the Indians who live three miles up possess twice as much hemoglobin (left) as do lowlanders.

LARGER RED CELL

Mountain men's larger cell, right, has less hemoglobin (shaded area) than does the lowlanders' below; it is also less saturated with oxygen (in red).



BIGGER HEART

X rays show that a majority of the Indians living at the three-mile level have hearts twenty per cent larger than hearts of their lowland cousins.

STOCKY BUILD

The Andean Indian's compact body-build, which reduces the distance that blood must circulate, further assists in their adaptation to altitude.





BULLOCKS pull a primitive plow, as one of the better Vicos fields is prepared for the corn planting.

no oxygen on its round trip through the mountaineers' circulatory system. This is due principally to the thinness of the air taken into the lung at high altitude, rather than to failures in pick-up by the lung's capillary bed.

THERE is still another adaptation to high altitude—demonstrable only in experimental animals, but probably applicable to man. Body tissues contain a companion substance to hemoglobin, known as myoglobin, that apparently serves as storage for oxygen and sustains a muscle from one contraction to the next. In the muscle tissue of high-altitude dogs, this substance exists in double concentration, with the greatest myoglobin concentration in the diaphragm. Now, it is a common observation among Andean Indians that their breathing — at rest, or during light exercise — is principally from the diaphragm. As one watches, their abdomens heave but their chests move little. The bellows action of the chest muscles is apparently reserved for more vigorous exercise. It is postulated that an abnormally high concentration of myoglobin is involved.



All such adaptations necessarily call for other ones, to maintain total body balance with minimum strain. For example, the amount of plasma — the clear part of the blood — is the same at high altitude as at sea level. Thus, the increase in red cells, mentioned earlier, makes for thicker, more viscous blood. In addition, a given amount of high-altitude blood carries less oxygen than does sea-level blood. The heart, consequently, has to pump more viscous blood and has less oxygen to pump it with. At least partial compensation for this is provided by the larger size of the heart among Andean Indians. This larger muscle is more competent to assume an overload. Then, too, even under moderate exercise, the heartbeat at high altitude is typically slow. Blood pressures are also low; hypertension is a rarity in altitude peoples. Further relief for the heart is afforded by the typically stocky and compact body-build of Andean Indians, which reduces blood transport distances.

So far, we have noted five principal adaptations of fully-acclimated Andean Indians to high altitudes: super-ventilation by larger lung sur-

faces; more efficient oxygen pick-up in the lungs' capillary beds; an augmented blood supply as a vehicle for oxygen transport; possibly increased myoglobin storage facilities for oxygen; and a heart adapted as a heavy-duty, low-speed pumping system.

THE development of such altitude adaptations lies in part in the biological heritage of these Andean Indians. This means that, to an indeterminable extent, their ability to cope successfully with an oxygen-deficient environment is inherited. The remainder of their ability is developed during each individual's life span, particularly in his formative years. Inheritance, and subsequent further adaptation, would appear to be the unbeatable combination reserved for high-altitude residents of high-altitude ancestry. Yet we have no real gauge of just how much of this adjustment is inherited, other than two points of common observation. First, *some* coastal-born-and-raised Peruvians, partly or wholly of Andean ancestry, have unusually large chests. Second, outlanders reared in the high Andes rarely seem to be physically equipped



POTATOES are the Vicos mainstay: *left*, the seed potatoes are placed carefully in the hillside furrows.

HARVEST SCENE is indicative of Indians' capacity for heavy labor, as they carry off bagged potatoes.

to compete with native Andeans in performance of hard work. From Spanish colonial times to this day, the labor forces of the high-altitude Andean mines have been largely, if not wholly, native Indian in ancestry. Attempts to replace this indigenous labor force with other workers, imported from zones of lower altitude, have been consistently disastrous.

South America's military history provides other instances where the drastically limiting effects of high altitude may be observed. During the wars of liberation from Spain, lowland troops were victorious only on their own ground. In battles with highland forces at elevations over 10,000 feet, the lowlanders were invariably defeated, and often the defeat was a veritable rout. The Great Liberator, José de San Martín, was very careful to keep his troops out of the high country, just as was the doughty Conquistador, Francisco Pizarro, almost three hundred years before him.

INDEED, Pizarro's rapid conquest of the powerful highland-based Inca empire is attributed largely to his ruthless and adroit political machina-

tions, and the superiority of his military equipment (including horses). He was also fortunate in that, at the time he attempted the conquest, the Inca Empire was torn between two leaders. A year later, a united front might have pushed Pizarro into the sea.

Yet how did Pizarro defeat the Inca, on their own high-altitude ground? The answer to our question may be found by closely following Pizarro's timetable and route of conquest. When his forces left Peru's coast for Cajamarca (at 10,000 feet), to meet the Inca Atahualpa, Pizarro's 127 men and 67 horses took seven days to cover some 112 miles. This average of sixteen miles a day suggests a cautious advance and a careful husbanding of energies. The day after arrival at Cajamarca, Pizarro scored a surprise victory — a half-hour massacre — over Atahualpa's unarmed forces. With Atahualpa their hostage, the Conquistadores rested easily at Cajamarca for ten months — acclimating themselves to altitude. Then, when they pressed south for the Inca capital of Cuzco, they traversed the eastern slopes of the Andes at comparatively low altitudes. Pizarro

studiously avoided the high passes through the Cordillera until years later. By this time, his troops and horses had achieved enough acclimatization to operate at high altitude.

In contrast, the would-be Conquistador, Pedro de Alvarado, lost one-quarter of his 500 men and many of their 230 horses in a march to Quito, Ecuador, through a high snow-strewn pass, that was militarily unopposed. These losses are attributable to altitude, cold and starvation: Alvarado apparently did not realize that the effects of altitude would slow his forward progress, thus lengthening the time his forces were exposed to cold and simultaneously exhausting their food supply.

IT is doubtful if Pizarro's Conquistadores ever attained altitudinal adaptations approaching those of the highland Inca. Militarily they did not have to, as history shows. After the conquest, the Spanish took over the lower and more fertile intermontane valleys, leaving the higher and less productive lands for those Indians they did not enslave as hacienda and mine labor. The remaining free In-

dians either fled to the eastern jungles or retreated to higher altitudes.

IN modern times, the world's highest permanent settlement is reported to be at 17,400 feet — in the Andes. It is likely that, being pushed to higher altitudes or seeking employment in the mines there, further enhanced the pre-Columbian adaptation of Andean Indians to oxygen deficiencies. While the part Spanish, part Indian townfolk of the Andes can perform heavy work at high altitude, their capabilities in this regard are difficult to compare with those of pure Indians. If anything, the Indians' performance is superior, since they are more accustomed to harder work. The

most arduous and menial labor has been theirs ever since the conquest.

The story of bodily adaptations to Andean heights would not be complete without mention of the extreme cold and intense sunlight that go with high altitude. The average yearly temperature, at 10,000-foot Huancayo, is 55°F., with mean readings of 14°F. minimum and 83°F. maximum. At 15,000 feet, the yearly average drops to 43°F. It is always warm out in the sun. Indoors, it is always cold, especially at night. In a region where wood is too scarce to burn for heat, both warm clothing and systemic adjustments, producing more body heat, are necessary. No research has been done on bodily reactions to cold in

the Andes, but there are a few indirect indications. Before sunrise, in the intense cold under a cloudless sky, it has been recently observed that the unshod feet of Andean Indians feel warm. These Indians even act surprised when asked if their feet get cold. Yet, unacclimated whites at the same temperature may wish they had on three pairs of socks instead of two.

FATHER COBO, writing in the mid-seventeenth century, speaks of this same adaptation when he says:

"Along with being phlegmatic the Indians are red blooded to an extreme degree, from whence they derive their excessive heat, as borne out by the fact that if in the time of greatest cold



and ice one touches their hand, one will always find heat in it, amazingly; and it is also seen in the few clothing they wear, just enough to cover their bodies. When they are on a journey, they sleep, even though it be on very cold high plateaus, wherever night overtakes them under the open sky; and if a span's depth [nine inches] of snow falls on them, they go on sleeping under it as restfully as if they were in soft and downy beds."

These observations suggest an extra blood supply to the extremities to preserve their warmth. This is precisely what the high-altitude circulatory adaptations provide.

Adaptation to intense sunlight seems less complete among the Andean In-

dians than to altitude and cold. In contrast to many American Indians, those in the Andes are quite light-skinned. But they possess a high potential for tanning. This is most necessary, since the ultraviolet rays from the sun are decidedly more concentrated than at sea level. At high altitude, the skin of even well-tanned whites cannot tolerate continued exposure to the sun. For the most part, Andean Indians shield themselves with clothing and heavy felt hats with brims. Partly due to the intense light, and partly to atmospheric aridity during the dry season, Andean Indians seem to have more than their share of skin, lip, and eye troubles. Dryness and a low-fat diet may combine to

cause painful cracking of the calloused soles of the feet. This is a common Indian complaint that can be relieved by such lubricants as vaseline.

FALLING from integral membership in the once proud Inca Empire to the bottom of the modern socio-economic hierarchy has been the unenviable lot of the Andean Indians. Before the conquest, the Indians' standard of living was higher than it is today. This is attributable to the organizing genius

VIGOS MEN AND WOMEN stand by the flat threshing-ground near the hacienda church, as the horses are driven in a circle over the heaped barley straw, treading-out grain.





LUMBER is a rarity at these altitudes. Such eucalyptus logs as this one are used sparingly for roof beams and doorframes.

A DOBE is the basic building material. The mason, right, is a product of training under the Carnegie-aided Vicos Project.



GRINDING the corn is women's work. Joint project of Cornell University and Peruvian Government at Vicos improved diet.



of the Inca's ruling classes, who plowed back the taxes and other levies into public works and social security calculated for the good of the people. Inca exploitation of the Andean uplands was tremendously efficient, but this extraordinary cultural adaptation had begun many centuries before.

Information on these accomplishments is preserved today largely in archives, museum specimens and the spectacular Inca ruins visited by tourists. The glory of the Empire lies in the past, because the Conquistadores quickly lopped off the Inca's organizational top. The colonial Spanish ruthlessly stamped out all but the utilitarian arts, and organized the Indians into nothing more than a labor force and a source of tribute. At the same time, the careful adjustment of the Indians to the agricultural and herding potentials of their homelands was largely destroyed by Spanish usurping of the best Indian lands.

URBANIZATION in the Andes today has been largely shunned by the Indians, although they do congregate in mining towns for purposes of employment. The more usual settlement pattern of the Indians is the small upland village, with most dwellings scattered through the surrounding arable land. There are a few Indian towns in the Andes, but these centers are normally inhabited by the Spanish-Indian people who participate more wholly in modern Peruvian culture.

In recent times, treatment of the Indians has softened, partly because the ranks of most modern Andean armies are filled by Indians, and Army sentiment is a powerful political weapon. Then, too, this may be a matter of the same enlightened self-interest, held by the Inca rulers more than four centuries ago, that views a well-cared-for people as more productive and easier to govern. Whatever the cause, the result may be that these high-altitude people—uniquely adapted to a harsh but, at the same time, bountiful environment—will once again be permitted to capitalize on their remarkable heritage.

DR. NEWMAN, Associate Curator of Physical Anthropology at the Smithsonian Institution, learned the effects of high altitude at first hand during a study of the Vicos Indians' blood pressure. Much of the data he presents here is the work of the Institute of Andean Biology, at Lima.



FARMER AND WIFE work at winnowing the threshed grain. The Vicos Project, originated by the Cornell

anthropologist, Allan Holmberg, included studies of physique as well as material culture. Chief student

of altitude adaptation is Carlos Monge, whose Institute of Andean Biology has pioneered this field.


BIOLOG

ADVANCES in science are not the exclusive accomplishment of the professional scientist: there are many occasions on which the observations of the amateur have provided missing information and given answers to baffling questions. The week-end naturalist may make such contributions, and so may the stay-at-home. In my own field, I know of more than one case in which the amateur fish fancier has made observations that proved of considerable value to the professional biologist.

A recent case in point is the work done by amateurs regarding the life cycle of the Amazonian fish, *Symphysodon discus* — a handsome giant among the aquarium cichlids. In the quarter century since *discus* was first imported to the United States, from Brazil, many aquarists have tried to determine its breeding habits.

The first pair of *discus* bred in this country were in the care of an amateur — the Philadelphia fish fancier, Gustav Armbruster. This pair's first breeding, in 1934, resulted in infertile eggs; their second, in May, 1935, was more successful. The aquarium was maintained at a warm 85°F., the eggs were fertilized, and the embryos hatched after three days. Although Armbruster learned to feed the fry on tiny aquatic organisms, and a few of them were actually reared to adult size, he was unable to close many of the gaps in our knowledge of the *discus*'s life cycle.

About this time, another amateur aquarist, Dwight Winter, of Pittsburgh, obtained a pair of *discus* and was fortunate enough to have them spawn several times in his well-planted, hundred-gallon tank. The eggs of the first three spawnings proved infertile, but Winter's observation that the parents ate these infertile eggs helped to establish the fact that *discus* — in common with many other fish — goes to some lengths



GRACEFUL PAIR of *discus* parents hover near a plant in the aquarium of Gene Wolfsheimer, the Californian fish fancier, whose study of the breeding behavior of *discus* is recounted in Dr. Gordon's article.

The Amazonian beauty, *Symphysodon discus*, kept its family secrets well hidden until amateur aquarists undertook close watch

ND THE FISH FANCIER

to clear its spawning site of foreign objects which might infect the eggs that are about to arrive.

Winter's pair spawned successfully the fourth time round, but the parental couple transferred the hatched fry to the aquarium's water filter tube, from which the young kept falling to the bottom. Eventually, all the fry from the fourth spawning perished. On their fifth try, the parents moved the fry to a more favorable location — the roots of some water lettuce plants — and several fry survived to the free-swimming stage. At this stage, however, the parents deserted their young in order to spawn again. Winter rescued a few of the free-swimmers, but was unable to rear them. As will be seen, this interruption probably prevented Winter from observing a crucial stage in the life cycle of *discus*.

The first hint that such a crucial stage did exist came from still a third amateur fancier of tropical fish. Mrs. W. T. Dodd, of Portland, Oregon. Watching a pair of *discus* spawn successfully in her sixty-gallon aquarium, she reported to the Oregon Aquarium Society in 1949 that: "... the babies hung against the sides of the parents, receiving free rides — using the [parents] as landing-fields."

Her report, appearing in the Society's monthly mimeographed report, came to the attention of William T. Innes, editor of a fish-fanciers' periodical, *The Aquarium*. Innes was therefore on the lookout when, in 1955, he received a report on *discus* — together with a remarkable series of photographs — from still another fancier. Gene Wolfsheimer, of Sherman Oaks, California. The pictures that appear here are some of these.

Wolfsheimer reported that his *discus*, when ready to spawn, worked over the selected spot like sheep in a meadow, nibbling the algal growth from stones, or clearing the undersurface of a likely leaf. When the site

DR. GORDON, who directs genetics research for the New York Zoological Society, makes use of fish as experimental animals, and has a warm place in his heart for the amateur aquarist.

was prepared, the female *discus* extended her ovipositor, which, previously hidden, had by then become quite conspicuous. Rubbing it against the selected area, she emitted a continuous stream of clear, translucent eggs, which became instantaneously attached to the spawning site. The male immediately followed, spraying a cloud of milt over the eggs.

Thereafter, the parents hovered at the spawning site, creating a constant flow of fresh water over the eggs with fanning beats of their fins. They also frequently mouthed the developing eggs, keeping them clean of injurious

bacteria that, despite the fanning, might settle on them (see "Mouth-breeders' Puzzle," NATURAL HISTORY, October, 1957). The parents took their duties turn and turn about — one fanning and mouthing, while the other fish guarded.

After three days, the eggs hatched and Wolfsheimer noted that the fry remained attached to their spawning site, each tethered by an organic thread. Four days later, with the last of their yolk absorbed, the fry broke free of their tethers and — swimming freely for the first time — headed toward the nearest parent.

Wolfsheimer was astonished to see the fry dig their heads into the soft skin of the parental body, and jerk their tiny jaws back and forth, as if tearing loose particles of food. After a time of "nibbling" at one parent,



TRIO OF YOUNG *discus* swims by in formation, the days of parental attachment at an end. *Discus* young

were first reared successfully in the U.S. in 1949, more than twenty years after initial import of fish.



AT START OF CYCLE, the parental pair, *above*, swim in the vicinity of the tile rod that has been put into their tank to provide a spawning site. Adults are five to six inches long. Next, *below*, female

moves along tile, emitting a long stream of translucent eggs that instantly stick to spawning site. Finally, *opposite*, the male approaches the site, to spray its cloud of fertilizing milt over the eggs.







WHEN TETHERS BROKE, the *discus* fry headed at once for the parent fish, and clung to its broad side.

the fry would swim away to the other one to repeat the process.

This literal attachment to one or another of the parents continued for a week before some youngsters would depart, momentarily, to seize a tiny rotifer or a hovering shrimp nauplius. During this week, the fry grew rapidly until, at last, they abandoned their parental refuge and set out on their own. The cycle, itself, was complete.

THERE is little question but that earlier failures to raise *discus* fry to maturity were in some measure due to the absence of this week's parental nurture, reported for the first time in full detail by Mr. Wolfsheimer. But, as often happens when we learn a new fact, a number of new questions pose themselves.

Do the *discus* fry merely ride with their parents, or do they also acquire nourishment of some sort from the parental bodies? If the latter, what

is it they are actually nibbling? The parents show no evidence of skin abrasion at the end of the week. Is the hypothetical food substance some microscopic organism, that lives on the parents' skin? Wolfsheimer believes the fry are eating the protective surface slime, which all fish secrete. Ordinarily, such slime is mildly toxic. Is this true of *discus*?

Again, what accounts for that first rush to the parental body, when the fry's tether to its nest is broken? During their tethered existence, do the fry become conditioned to the ever-waving fins of the guarding parents, so that — when at last free — the adult's fanning is a "come-on" signal?


These are questions that aquarists might keep in mind. Who can say when a new fact — such as the answer to these and other questions — will be found by the amateur who considers his home aquarium as a miniature laboratory?

AFTER A TIME aboard one parent, the young fish would suddenly take off, transfer attentions to other.

WOLFSHEIMER noted that the fry dug into the parents' skin. What, if anything, was eaten is unknown.







PENCIL-LIKE crystals of stilpnomelane have been magnified three-and-a-half times. Twisting, *top*, shows the plastic nature of this mineral.

THE

BY
BRIAN H. MASON



HEXAGONAL SHAPE of vanadinite crystals, shown at eight magnifications, above, is obscured by their sheer number.

NATURE OF SYMMETRY

The world around us abounds in examples. Most elegant are the crystals, deriving their varied shapes from the inner arrangement of their atoms.

AT FIRST GLANCE, the world around us seems to present an infinite variety of forms. But when one studies the forms themselves, rather than their broad arrangements, a general sort of order is apparent. There is, for example, a repetition of parts which produces symmetry. It may be the fivefold repetition of the arms of a starfish, the eightfold repetition of the tentacles of an octopus, or the bilateral symmetry of most animals, from the reptiles upward (including ourselves).

It might be thought that such symmetry, itself, is infinitely variable. Actually the elements of symmetry are quite few, and can be described in terms of repetition around a point, or a line, or plane. However, these elements can exist together in many ways to give a wide variety of forms. Probably the most elegant illustration of such variable symmetry is provided by the shapes of crystals.

In 1830, early in the history of crystallography, a far-sighted researcher predicted that, with the elements of symmetry found in crystals, thirty-two different symmetry groups were possible. Since, at that time, only some eight such groups were known, this prediction was venturesome

indeed. The forecast has since been confirmed by the discovery of crystals belonging to each of these thirty-two groups, and to no others.

The symmetry of crystals reflects the underlying symmetry of arrangement of their atoms. One might say that atoms prefer to arrange themselves in an orderly, repetitive lattice; in the language of physics, such an arrangement is one of minimum free energy. Given this basic lattice, however, the external forms of crystals will vary. But the symmetry of such variable forms will be the same in all crystals of the same substance.

The science of crystallography began with the study of minerals, since minerals provide us with a variety of ready-made crystals. What may be called the initial discovery of scientific crystallography came in 1669. A Dane with an inquiring mind, Nils Stensen (or Nicolaus Steno, the Latinized version of his name, and by which he is best known) that year examined a number of quartz crystals of different shapes and sizes. Not content with merely admiring the variety of form, he looked at them more closely, and noticed that the crystals were always six-sided. His



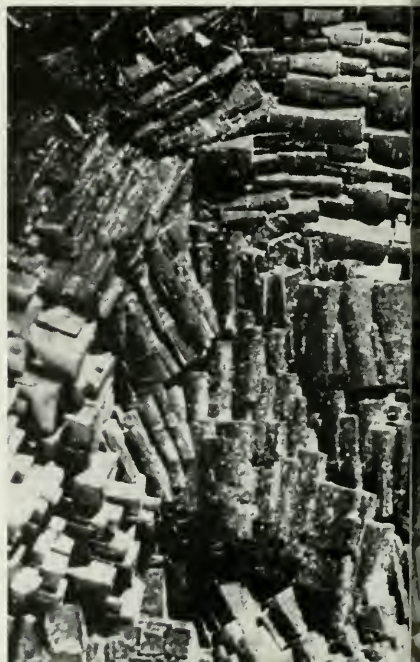
PENNINITE CRYSTAL, rising from white matrix, looks like mountain stage-set. Smooth truncations show the mineral's perfect cleavage.

CLINOCHLORE CRYSTALS, chemically and structurally similar to penninite, *above*, grow in a jumble of flat hexagonal plates instead.



TINY CRYSTAL of anatase, magnified fourteen times here, is chemically identical to two other specimens.

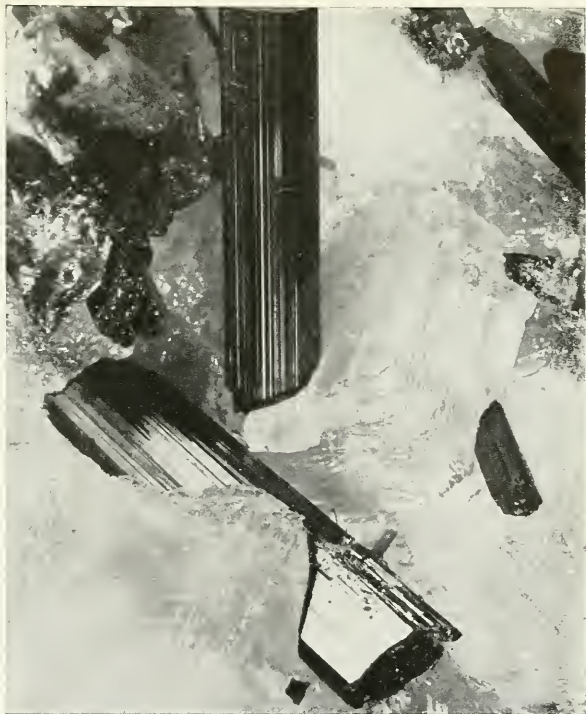
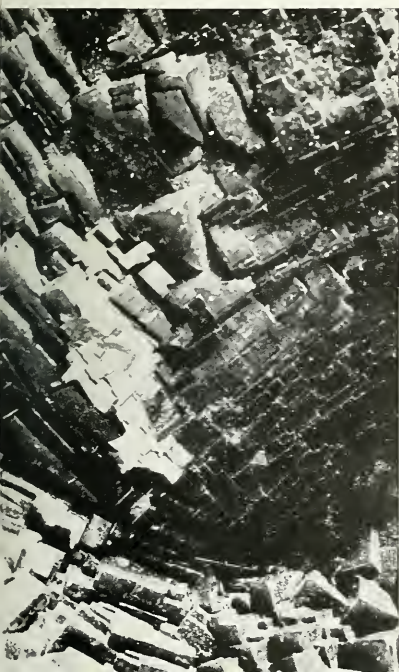
CUBIC CRYSTALS of fluoride are intergrown with this specimen, seen at nine magnifications.





A different crystal structure, however, it assume this distinctive pyramidal shape.

ent curves are caused by the growth of some
se crystals out of parallel with neighbors.



STRIATED COLUMNS, magnified six times, are crystals of deep green epidote, in a groundmass of translucent calcite crystals.

PETAL-LIKE crystal aggregates of the mineral pyrrhotite, made up of thin hexagonal plates, are called "roses" by mineralogists.





WIRELIKE TENDRILS of native silver support a cluster of rhombohedral calcite crystals. Compare these shapes with calcite groundmass shown on page 27.



"TWIGS AND BRANCHES" are intergrown crystals of native copper, their octahedral shapes elongated into treelike structures, with single crystal "buds."

DR. MASON, Curator of Mineralogy at the AMERICAN MUSEUM, selected these photographs by STEVAN CELEBOVOC from *The Living Rocks*, the first volume in an Art and Nature Series, published here by The Philosophical Library, and in England by Phoenix House, Limited.

curiosity then suggested measuring the angles between adjacent faces. No matter what the shape or size of these six-sided crystals, the angles were always 120° ! Nicolaus Steno had stumbled on the first law of crystallography—that in crystals of the same substance, the angles between corresponding faces are always the same.

The next great advance in crystallography came at the beginning of the nineteenth century and was largely the work of a French priest, the Abbé Haüy. With better apparatus, he was able to measure the angles on crystals, large and small, of many different minerals. He thought more deeply than his predecessors about what gave crystals of a specific substance their specific form. The time was also ripe for advances in understanding: chemistry as a science was developing rapidly, and the concept of atoms and molecules was taking shape. It is said that, one day, Haüy dropped a prized crystal of calcite on a stone floor and, with mortification, saw it shatter into fragments. About to throw the debris away, he noticed however that each fragment was the same shape—all rhombohedrons. He began to break up the pieces: each, when broken again, produced smaller rhombohedrons. Haüy reasoned that this process of breaking could conceivably be continued until the ultimate "molecule" of calcite would be obtained, which would itself have a rhombohedral form. He argued from this that the external form of crystals must be a reflection of the packing together of regularly-shaped units of molecular dimensions.

A CENTURY was to pass before the proof of Haüy's reasoning was to be forthcoming. In 1912, a German physicist, Max von Laue, was studying X rays. X rays had only been known a few years, and their true nature was still a matter of dispute—some scientists believed they were streams of minute particles, others that they were waves of radiation, with a very small wave length. Laue belonged to the latter school, and was searching for a grating with which to diffract X rays, as a ruled grating diffracts light. But, if X rays had a wave length a thousand times shorter than light, where was he to find such a grating, whose divisions must be of the order of a hundred-millionth of an inch? Laue recalled Haüy's concept of a crystal as built up by the packing together of small regular units of molecular dimensions. If Haüy's concept was correct, perhaps this packing of the units would provide the diffraction grating he needed. It was a simple experiment to direct a beam of X rays through a copper sulphate crystal and record the beam on a photographic plate. The photograph showed a regular pattern of spots, proving that the crystal had indeed acted as a diffraction grating, producing a series of beams from the primary X-ray beam. In one stroke, Laue established the true nature of X rays, and proved the truth of Haüy's brilliant intuition a century earlier.

Our essay on symmetry and form in nature has taken us from minerals and their crystals to molecules, atoms, and X rays. On these pages are photographs of some of the many crystal forms, themselves, that have served to lead man's curiosity along the path to such knowledge.



BLACK "FROST FLOWERS" of pyrolusite give the appearance of a counterfeit fossil plant. The mineral, in solution, has filtered along the joint surface of

a limestone mass and precipitated there. All of the photographs on these pages are from *The Living Rocks*, the first of a new series illustrated by Celebonovic.

SKY SCHEDULE

By K. L. Franklin



SOUTH PART OF THE NIGHT SKY is shown here, as it will look to an observer in the U.S. during the

first six months of 1958, at about 9:00 P.M. The straight line is the celestial equator (an imaginary

projection of the earth's equator) and the curved ribbon is the zone of the Zodiac (with its constel-

A selective calendar of

JANUARY

January 3. About 9 A.M. (EST), the earth is at *perihelion*, its closest point to the sun this year, only some 91.5 million miles away.

January 16. Just before sunrise is a good time to look for Mercury, like a bright star in the dawn sky, very low in the Southeast.

January 26. Venus is at *inferior conjunction*, passing between the earth and the sun, on its way out of the evening sky to become our morning star. It is now about 25 million miles from the earth.

FEBRUARY

February 15. Jupiter, this date, stops its apparent eastward motion among the stars, and begins its westward—or *retrograde*—motion. This turnabout is because the earth, moving faster than Jupiter in the planets' race around the sun, is catching-up with—and getting ready to pass—the fifth planet.

DR. FRANKLIN, an Associate Astronomer of THE AMERICAN MUSEUM-HAYDEN PLANETARIUM, will offer a selective list of events during the rest of 1958, in our June-July issue.

MARCH

March 3. Mercury is now at *superior conjunction*, on the opposite side of the sun, passing from morning to evening sky.

March 16. Venus and the moon, the planet close to the waning crescent in the dawn sky, will be a spectacle seen best in the West.

March 20. At 10:06 P.M. (EST), the sun crosses the equator, from the southern to the northern hemisphere, marking the start of *Spring*. Those west of New Guinea at high noon will see the sun directly overhead.



lations named, *above*). The names of the months, reading from right to left, stand below that part of the sky that lies to the south at mid-month. Also from right to left, the brighter stars shown are Alde-

baran, Rigel, Betelgeuse, Sirius, Procyon, Pollux, Regulus, Spica, and, at the far left, Arcturus.

celestial events for the first half of 1958

APRIL

April 17. Jupiter, now due south at midnight (in Virgo), has reached a point, some 413.5 million miles away, exactly opposite to the direction toward the sun from the earth. It is, thus, in *opposition*.

April 18. The moon, this day, passes before the sun and casts its shadow on the earth. Invisible in the U.S., this *annular eclipse* may be seen in Thailand and Formosa.

April 26. Daylight Savings Time begins in many areas. Remember to set your clocks one hour *ahead*.

MAY

May 3. The moon may be seen in partial eclipse from western North America. At 3:00 A.M. (PDT), the southwest part of the moon will enter the earth's dense shadow, and leave it twenty-six minutes later. This is the only *lunar eclipse* that will occur during 1958.

May 14. Mercury has again reached its most western position from the sun, rising in the East a little before sunrise (see January 16).

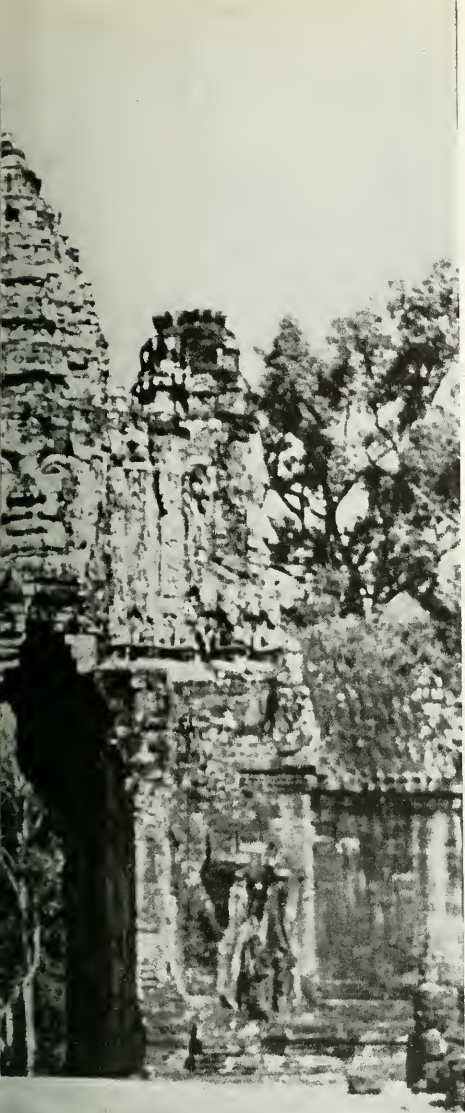
JUNE

June 13. Saturn, some 841 million miles from the earth, is now in *opposition*—due south at midnight, shining brightly in the Milky Way.

June 19. Jupiter has now been passed by the earth. After tonight, it will resume its usual *direct* motion, eastward among the stars.

June 21. At 3:57 P.M. (EDT), the sun reaches its most northerly position over the earth for 1958. At this instant, the sun will be directly overhead at a point some 500 miles northeast of the Hawaiian Islands. The first day of *Summer*.





LEGENDARY ANGKOR

The Khmer civilization, dead for five centuries, lives on in its monuments

CAMBODIA is a vast plain circled by mountains, creased by rivers and dotted by hills—five hundred million acres of the richest country in southeast Asia, a great expanse of alluvial deposit brought down from the mountains by the sluggish Mekong and washed by the monsoons that overtake the land each June. It is a region where life depends on rice fields, and these, on an immense irrigation network which nourishes the plain, channels the floods during the monsoons and catches enough water for the dry months ahead. In the ancient Khmer society, the king was high priest of this land, ensuring by appropriate rites the fertility of the soil and supervising the hydraulics on which agriculture depended. He also bore the title “King of the Mountain,” for mountains, according to Hindu belief—which the plain’s geography reasserted—were the abodes of the gods. Of this universe, the temple was a replica: shrine of the king, in its towers and pyramidal ascension like the home of the gods, in its moats and canals like the plain itself. And of these temples, the greatest were those at Angkor, from the Sanskrit *nagara*: “city,” but “The City” par excellence, such as Rome was to the ancient and medieval West.

Angkor, rescued fifty years ago from the invading jungle by French archeologists, can now be admired in a magnificent volume—by B.-P. Groslier, with photographs by Jacques Arthaud, published by Praeger—from which this presentation is taken.

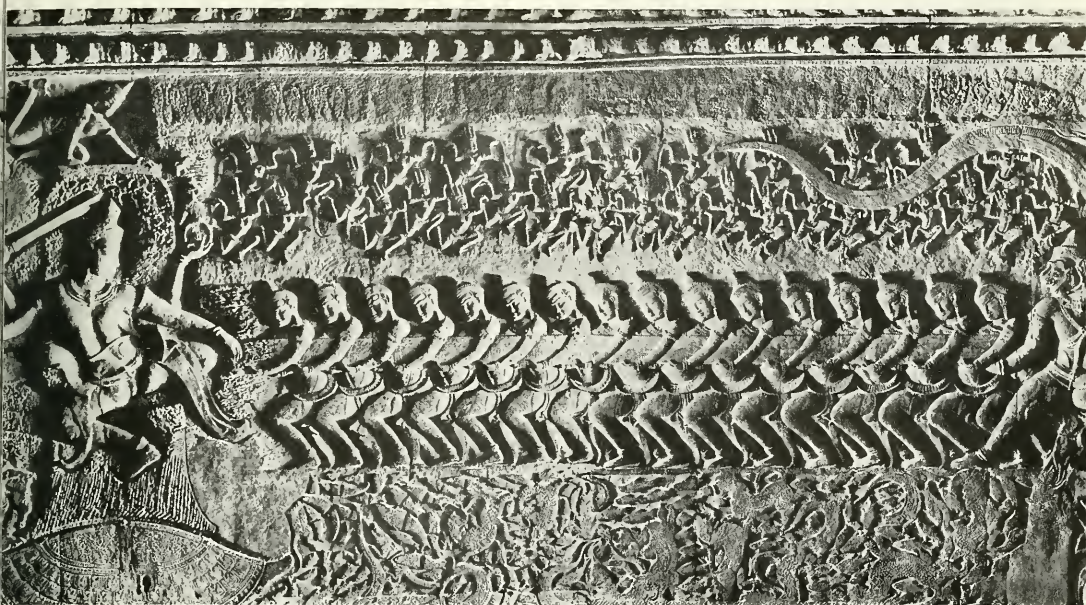




THE KINGS AND THEIR MYTHS

FOR THE KHMERs, as we know from their inscriptions, the sovereign alone could offer such sacrifices as "bind the gods forever." The royal cult was the very basis of the realm, and even the form of Angkor Thom, the center of the Angkor region, built around A.D. 1200, confirms its necessity. For, according to Hindu legend, the gods and demons encircled their Holy Mountain with the serpent Vasuki, god of the waters; and, by pulling the snake's body back and forth, they made of the mountain a gigantic churn that produced—from the Sea of Milk—which was the primal void—ambrosia to make the gods immortal. Angkor Thom was built as a miniature of the cosmos—the whole city enclosed by moats and canals with the circular tower of the royal shrine at its center. This shrine is the Holy Mountain; the gods at the south gate's causeway (see p. 34) grasp one end of the snake; the demons on the north, the other. Symbolically, they turn the central temple, which churns the canals encircling it and the rice fields they nourish. Thus did the royal cult "call down a shower of riches" on the land of the Khmer.





Bas-relief version of Churning of the Sea of Milk was done at Angkor Wat fifty years before monument version at Angkor Thom. The god Vishnu, *above*, symbol of king, presides on Holy Mountain with gods by serpent's tail, demons at head. *Top*, nymphs born of the sea foam; *bottom*, sea creatures convulsed by churning.

god Krishna, *left*, is carved victorious possession of Maniparvata, which with his army has wrested the demon Naraka. god is another symbol of the basis of Khmer monarchy.



Wealth the gods gave Cambodia was not without responsibilities, according to Khmer thinking. Detail, *right*, of the hell reserved for all who, "being in the enjoyment of plenty, have still committed sinful acts," shows damned flung down to be tortured by demons. Scene recalls art of medieval western cathedrals.

HISTORIC WARS BECAME HEROIC LEGENDS

PERFECTLY BALANCED in its plan and symmetry, Angkor is the image of Khmer ideals; yet Khmer history itself is a chronicle of turbulence. In A.D. 944, after a century and a half of dynastic quarrels, Angkor became the nation's capital; the following year, the interminable Champa wars began. From that time on, one finds inscribed how the Khmer monarchs "delighted in battle," how "the dust of their armies did blot out the sun." But, as strife grew, the art of Angkor became increasingly serene. The Baphuon, first of the great Angkor temples, was built during the first Siamese campaign. Suryavarman II (A.D. 1113-1150), who built the exquisite Angkor Wat a century later, was a mere usurper, and his foreign wars, begun in brilliance, were marked by defeat at the close. Jayavarman VII, builder of Angkor Thom, erected a vast cosmology in stone that seems, by its massiveness, a protest against the insecurity of his time. A usurper had preceded him; the Siamese invasions which followed his death, in about A.D. 1213, broke the greatness of Angkor. Yet so strong was the Khmer kings' concept of their divine role that even their wars and intrigues were depicted under the guise of epic legends, as fitting adjuncts to the annals of the gods and the gallant deeds of godlike heroes.

Swordsmen and spearmen fight hand-to-hand in detail from 150-foot relief illustrating conquests of Suryavarman II, twelfth-century ruler who usurped the throne and built Angkor Wat to his glory.





Relief, seen in larger section above, represents king's wars in guise of legendary episodes from Indian epic, the *Mahabharata*. Semi-divine heroes are used to express idea of gods' guidance of Khmer monarchy.





Suryavarman II's army on parade is depicted in section of a 300-foot-long panel. The perfectly disciplined Khmer troops are preceded by Siamese "barbarians" in outlandish garb and marching out of step—whimsical proof of the Khmer artisan's ability to infuse even vast historical pageants with life. Siamese, subdued a century earlier, were used by Suryavarman II in campaign to the East against Chams and Annamites. Vassal states gained freedom a century later, ultimately shared spoils of Khmer realm.

THE LIGHTER SIDE OF LIFE

KHMER SOCIETY was stratified, and if ultimately this fact contributed much to the kingdom's fall, for some time it lent luster to its wealth. The sovereign assured in fact as well as in theory the well-being of the land through the network of waterways he ordained with his shrines: while the elite of princes and brahmins was at first in balanced rapport with the farmers composing the mass of the Khmers. At its height, Angkor combined all the color of an Asiatic populace with the supreme refinements of the court. The palace chambers, today of stone, were once adorned with ceilings of carved wood; there were outer walls of red laterite, tiles of green and gold on the roofs, gold tridents and bronze braziers, silk veils.... "The legion of banners streaming in the breeze, the strains of music mounting to the sky, the grace of dancing-girls—all made the shrines an image of paradise," runs a Khmer poem.



Twin decorative panels from the Baphuon, great shrine of Angkor Thom, show how deftly Khmer chisel caught the playful grace of everyday life.



Fluid gestures of a sea nymph, jewelled splendor of dancing-girl are fused in this svelte form, here restored to original luster.



Cockfight scene from Angkor Wat finds carefree
Khmer nobles afloat on poop of junk, shaded by parasols
as oarsmen ply one of Angkor's many lakes.



Face-towers in the Bayon—gigantic temple which forms nucleus of Angkor Thom—are the creation of Jayavarman VII in late twelfth century. Each side of temple's fifty-four towers is fronted with a head.

Huge lake borders Banteai Kdei, edifice built earlier in reign by Jayavarman VII. Lions and serpents looking out over vast vistas characterize monarch's style, more architecture than sculpture.

ANGKOR THOM: CITY AMID THE WATER

KHMER CIVILIZATION remained rooted in the soil from which it drew its wealth. Since life depended on rice and its cultivation, the function of religion was to insure the fertility of the soil, and art was in the service of religion. To build a town or erect a temple was to dig canals, create reservoirs, open up fresh land for cultivation. The very site of Angkor reflects this function: the city sits on the northern shore of the Great Lake where the deltaic marshes merge into the dryer upland and the Mekong River splits in two. In the spring, when the northern snows melt and the first rains fall on the river's upper basin, these two branches cannot contain the mass of water that swirls downstream. The flood backs up; the Great Lakes increase to thrice their size; Cambodia is then a land of ochreous skies and drowned forests.

But water is unevenly distributed by the seasons, falling in torrents and overflowing the plains—only to fail, subsequently, for months on end. So that, beyond such natural lakes as existed, the Khmers drew their water from



Anonymous portrait, probably of Jayavarman VII, wears beatified expression, mirroring eternal life king hoped to win from his shrine. Face suggests bodhisattva. "future Buddha," who protects mankind as king did during reign.

use artificial reservoirs called *baray*, which at Angkor reached the enormous size of six by twenty-four miles in some cases, linked to the streams by canals, which caught up the raging seasonal floods. This vast water system sustained the enormous population—for the region of Angkor literally swarmed with people, probably more than a million—which formed the economic and political base of the nation. A strong administration, animated by a supreme monarch, carried out this undertaking—a major feat in hydraulic engineering which, far from exhausting the kingdom, created its wealth.

THE BUILDING of Angkor Thom, by Jayavarman VII, was the culmination of the complex water-way system, connecting all the canals previously constructed in a magnificent synthesis of stone and water. He, above all others, was the king who, as an inscription puts it, "by raising a highly barrage has made water to flow where before there was little or none, a reservoir beautiful as the moon."





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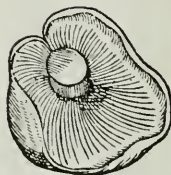
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Reviews (continued from page 5)

111. Genus esculentorum F.



*Tertium genus
fungi esculenti.
Sunt Gyc-
vrigi garna-
taria.
C. Quetzg
schrodeni.*



Natalis

*Parandis ra-
tio.*

*di, quæ inter binas lances repofiti
per prunas coquantur: aur cum
Germani Milttraum appellant.*

it rests no longer on the bedrock of philology or provable fact but on the much looser—if more fertile—soil of folklore and metaphoric associations drawn from people of all regions and in all ages.

AT ANY RATE, we shall follow the authors a little farther in their researches, having established the very close connection between toads and mushrooms. They now take up the curious Old French word *bot*, meaning "toad," a word now unused except in the expression *piéd bot* (club foot). What links the nimble toad with club feet, as the authors go on to show, is that both are associated with the Devil, who was represented in medieval iconography as a cripple. Beliefs of this sort are tenacious, and the Wassons are able to produce an English caricature of Napoleon and the unscrupulous Talleyrand, in which Talleyrand—who was called *le diable boiteux*, "the lame

GENVS II.

TRA Balatonis lacum Vngariae, in
rva infula cui nomē *Favor*, Simidien-
itatu, Aprilis etiam mēse nasci intel-
l. Fungi genus delicatissimi saporis,
omen indicare nemo poterat: sed illi
sfe ferebatur, qui inter perniciosos &
Decimum sextum genus est, & ab
Kygio *gamba*, à Germanis *Matter*
ten dicitur: pyramidalis tamen do-
liq; apice & angusto hunc fungū effe.

GENVS III.

R T I I generis, quod Vngari *Szent*
györgy gamba, à Germanis *Sant Gys*
ten appellant, quia circa diē D. Geor-
gii (qui in vicesimum tertium Aprilis
invenitur, unicam observabam
h. autem illa est, duarum unciarū am-
nem vix aequans, orbiculari ferē for-
pernē quidem aliquid tantum extube-
quodāmodo pulvinatā: infernē verō
heratā, & quibuldam veluti venis dif-
fediculo crasso, brevīq; coloris exal-
i havi quidpiam admittit sit.
ic in sciccioribus arque palcuis pratis:
sfe is erit fungus, quem Horatius fa-
arta lib. 11. Sermonum, optimum
ciat his verbis,
— *pratenfibus optima fungis*
ura est: alijs male creditur.
erō Tertium hoc genus, aliorum fun-
modo pręparandus, qui repurgati, ut
um elixari solent, & in frusta conciu-
rum vel butyro, & pipere addito, su-
um ex laetis cremore paratum, quod

EARLIEST description of mushroom species *tricoloma gambosum* was published by French naturalist Carolus Clusius in 1601.

devil"—is graphically represented in this malformed fashion.

Now the word *bot* came to be applied not to Satan himself but to the creatures into which he was thought to transform himself: the nightjar, known in parts of France as *le bot volant* (the flying Devil)—or *le crapaud volant* (the flying toad); hence, incidentally, the introduction into English of the word *bat*, for that most evil of creatures. And, not long after this word came into our language, there was published a poem called *The Mad Pranks and Merry Jest of Robin Goodfellow*—the horned, cloven-hoofed deity depicted in a woodcut, illustrating the text, as flanked by two nightjars and holding a witch's broom, for the celebrants of the nocturnal rite of the witches' coven wore this costume in imitation of their horned god.

All of this may seem rather remote from mushrooms. But the Wassons re-

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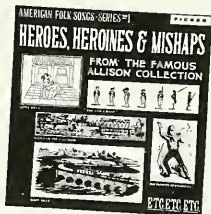
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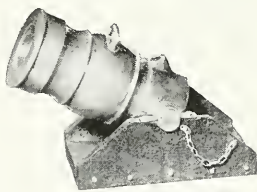
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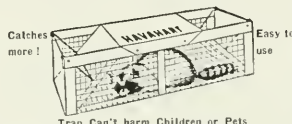
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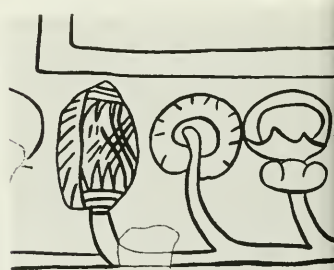
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mind us that Robin's sire was Oberon, whose name comes from the French *auburon*, the large, fleshy, white mushroom known as *Lactarius piperatus*. Further, the woodcut depicts Robin holding, in one hand, a lighted candle, and the Wassons brilliantly develop the connection between this phallic symbol and another, the mushroom. They conclude by recalling that *bot* has given to current French dialects many words for the mushroom: *bo, botet, boutarel, boutareau*, and so on—and that in Gascon, one word for a kind of mushroom is *cracnaenaudit*, literally, "cursed toad."

THIS SUMMARY, unfortunately, does absolutely no justice to the Wassons' general theme and presentation—or even to the brief section, "The Cripple, the Toad and the Devil," which goes on to explain in detail both the toad symbolism in a sixteenth-century tapestry of the Conversion of King Clovis and the mushrooms in Bosch's great painting, *The Hay Wain*. We can only assure the reader that, by the time the Wassons have finished, they have covered an immense area of cultural history, and that what they have to say hangs together in an almost uncanny coherence—through sacs and pouches, puffballs and sponges, punk, gourds and truffles (these sections setting forth the erotic symbolism of the mushroom), and so on down the annals of an ancient lore, until finally we—and the Wassons—are rewarded with a final revelation. A revelation in the strict sense of the word, too, for in Mexico, at Huautla de Jiménez, Mazatlán de los Mijes and San Agustín Loxicha, in rites still practiced in these remote areas, the authors first heard of and later partook of certain hallucinogenic mushrooms that opened to them, or so it seemed, the very gates of Heaven.

This part of their exposition is rather well known, having been described in *Life* on May 13, 1957. There is, there-

HALLUCINOGENIC mushrooms along border hint at meaning of rite depicted in Teotihuacán fresco from pre-Columbian era.

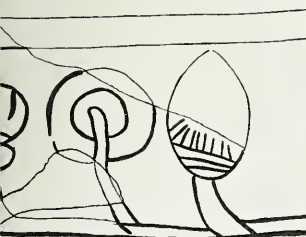


fore, no need to summarize it here. What the Wassons found by studying the traces of sacred lore in Mexico gave them the key to the puzzles they had encountered, the questions they had asked without being able to answer. For the divine mushroom, called by the Nahua "God's flesh," "holds the key to a mystical union with God" that the Wassons had skirted in the Greek mysteries and the medieval witches' cult, and "the odd phenomenon of mycophilia vs. mycophobia" itself appears as "a latter-day echo of man's shattering experience when he discovered the potent mushroom, a response, positive and negative, divine and diabolic, to these holy miracle-workers." The widespread and ancient taboo on mushrooms seems ultimately to be a religious one, expressive of the awe that was felt in the presence of an agent of the divine and of the need to conceal from the profane what was the original core of religious life.

AS THE AUTHORS sum up, "In Europe the secret of the mushrooms was lost long ago, but it lingers on, fossilized and misunderstood, in our vocabulary, as when the Greek spoke of mushrooms as the 'gods' food,' the Flemings of 'devil's bread,' the demonic *crapaudin* of France, the demonic 'toad's stool' of the English. . . . Our legacy of mycophobia, what is it but a simple taboo, the aftermath of the emotional hold of those [divine] mushrooms on our own ancestors?"

Mushrooms, Russia and History is indeed an epic, whose detailed investigations open up the broadest vistas. It must be read to be understood. It must be studied at leisure to be appreciated. One can only hope that the vast range of knowledge and interests that has gone into its analyses will be duly noted, admired and, best of all, emulated by future scholars in this and related realms. Work in the field of ethnobotany has seldom, if ever, risen so high.

DR. SCHULTES, curator of the Ames Herbarium at Harvard, is a specialist in the ethnobotany of Latin America.



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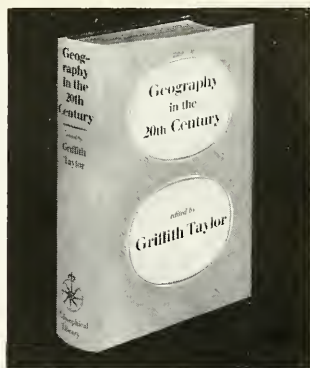
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ROLAND PIERSON PRICKETT

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Letters (continued from page 1)

("Beads from Seeds," March, 1955)
which states that a similar seed, called
the black-eyed-Susan seed, contains a
deadly poison in its meat.

The seeds shown in that article came
from the Hawaiian Islands. Does the
same plant also grow in Puerto Rico?
They appear to be exactly like the seeds
that are in my friend's belt. Can you tell
me what danger, if any, there may be?

LOUISE ARTMAN

Sumner, Iowa



RED BODY, BLACK TIP are distinctive
marks of toxic "black-eyed-Susan seed."

VEGETATION STUDIES replies:

The so-called "black-eyed-Susan
seed," also known as the ro-ary pea,
crab's-eye or jequirity, is *Abrus precat-
orius*. A native of Eurasia, it is now
widespread throughout the tropics, oc-
curring in the New World in lower
Florida, Mexico, Central and South
America, and the West Indies. The scar-
let seeds, black at one end as though
dipped in paint, are highly valued for
beadwork and rosaries.

These seeds contain a toxic protein,
known medically as abrin and used in
the treatment of trachoma, which can
be a lethal poison if taken internally.
Because the seed's outer coat is hard
and impervious, it would be necessary
to chew the seed thoroughly to obtain
this toxic effect. However, the amount
of abrin in a single seed is sufficient to
kill a human.

Bullhorns in Brooklyn

SIRS:

Readers of your November article
concerning the symbiotic acacia, who
reside in the New York area, may be
interested to know that, in our green-
houses at the Brooklyn Botanic Garden,
we have two *Acacia sphaerocephala*—
flourishing, although antless. They are
welcome to come see these plants.

Our acacias-without-ants go on pro-
ducing these ant-edible Beltian bodies
at the ends of their leaflets, and ant-
potable juices from the raised gland at
the base of the leaf-stalk, although they
have never housed ants in their "bull-
horns" (modified stipules, by the way,
and not bracts) and we don't promise
them any. In fact, they don't really need
the ants, because we never attack our
acacias, being a rather peaceable group.

At their bases, our plants do not have
a straight-growing stem, but—in-
stead—tied themselves into extremely long com-
pound knots before growing upward.
The cause of this frustration is as yet
unknown and I am not prepared to
attribute it to their antlessness. Perhaps
we need more plant psychiatrists.

GEORGE KALMBACHER

Taxonomist

Brooklyn Botanic Garden

Brooklyn



KNOTTED STEM of bullhorn acacia plant
growing at the Brooklyn Botanic Garden.

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Great White Heron

A true species or a color phase? Although the birds have been studied for a hundred years, this question still has not been settled finally

By ANDREW & ROBERT MEYERRECKS

OF THE multitude of fascinating problems facing bird biologists at present, probably one of the knottiest is the task of sorting the birds into their correct positions on the phylogenetic "tree." The major divisions — the twenty-eight or so orders — of the class Aves — are reasonably well agreed on. Below this, there are many conflicting opinions, and, at the tips of the "tree's" branches, the question of assignment to species — and, indeed, agreement on a common concept of what makes a species — remains very much an open matter.

One widely-accepted concept states that species are groups of actually or potentially interbreeding populations, which are "reproductively isolated" from other such groups. This is to say that such groups interbreed freely only among themselves.

Such a definition of species is, of course, substantially more sophisticated than that used by the early field naturalists who, as often as not, depended on superficial structural differences to characterize species. Let us look at a few examples, from among the bitterns, egrets and herons — of the family *Ardeidae*. With these birds, many individual species contain distinct color phases.

The Reddish Egret of North America, *Dichromanassa rufescens*, has both a normal, dark phase and a white phase. The Reef Heron of the western Pacific area, *Demicregretta sacra*, occurs in gray, mottled, and white phases. At least one species, the Little Blue Heron, *Florida caerulea*, shows striking color phases at different ages. The Least Bittern of North and South America, *Ixobrychus exilis*, occurs in two phases — a normal one and a very dark one. The latter, almost black

phase — once considered a separate species, known as "Cory's Least Bittern" — is extremely rare. Another example of such confusion in the past relates to the white bird once known as a separate species — "Peale's Egret" — but now recognized as a white phase of the Reddish Egret.

Field observation dispelled this taxonomic error: naturalists discovered numerous mixed matings of Reddish and Peale's Egrets, together with many mixed broods. If the white-phase birds had constituted a separate species, we would have found them reproductively isolated from the dark-phase birds, the whites mating only with other white birds, and the dark with other dark ones. This, then, is today's rule-of-thumb: if an apparent color phase represents a

true species, field observation will show that the two phases do not interbreed freely with each other.

With the stage thus set, let us examine the hundred-year-old problem surrounding the Great White Heron. The first Great White Heron ever collected was taken by Audubon in the Florida Keys in 1832. Three years later, he described it as a species new to science, naming it *Ardea occidentalis*, in contrast to the Great Blue Heron, *Ardea herodias*. In 1858, the American ornithologist, Spencer Fullerton Baird, received a heron specimen — pale blue in color — from Gustavus Wüldemann, who was collecting in Florida. This specimen appeared to be intermediate between the Great White and the Great Blue, and Baird gave it full species rank,



NECK BENT in preening, a young Great White Heron, left, stands in its nest at Florida's Cotton Key.

LONG HOURS of young bird's day are broken into times of activity and times of rest, above, when the

heron squats awkwardly in shadiest part of its nest. This heron was known as "Big Whitey" to authors.

ANDREW MEYERIECKS is a PhD candidate at Harvard, specializing in behavioral studies, and his brother, ROBERT, is a gifted newcomer to the ranks of wildlife photographers.



PATTERN of nestling's activity includes much preening. Above, the bird works on long primary feather.

"THREAT" posture, with feathers erect and beak poised, is assumed in response to authors' approach.



naming it *Ardea würdemanni*. At the same time, however, he suggested that *würdemanni* might only be a hybrid of the White and Blue.

BAIRD's famous protégé, Robert Ridgway, tackled the heron problem a number of times from 1873 to 1896. At one time, Ridgway felt that all three forms were distinct species. Later, he concluded that Würdemann's heron was a hybrid of the other two. At last, he suggested that all three forms were merely color phases of a single species. Until 1956, the last word on the subject had been that of another American ornithologist, Ernest Holt. After both museum and field studies, Holt came to Ridgway's median view: the Great White and the Great Blue were distinct species, with Würdemann's heron a hybrid of the two. There the situation remained until 1956, when Ernst Mayr, of Harvard, published a paper on this heron problem.

Professor Mayr, who believed that the Great White was only a locally distributed color phase of the Great Blue, realized that a final solution to the question could come only from field observations, and not from further study of museum specimens. Accordingly, he outlined the problems to be solved in the field. First, mated pairs of herons should be observed, in order to determine whether the mating between the two colors was at random or not. Did blues prefer to mate with blues, and whites with other whites, or did blues and whites choose mates of the other color equally as often? Breeding of color with like color *only* would be strong evidence of reproductive isolation. Second, when mated pairs of like color are found, do blue pairs and white pairs observe the same breeding season, or does one color pair breed earlier than the other? If such a time difference was observed, it would be further evidence that the two color phases were reproductively isolated and, by modern definition, true species.

Mayr posed a third question for the field observer: in nests where both parents are the same color, are any of the offspring the other color? Detailed observations on this last point



RETCHING of wing and leg on the side is one of the nestling's means of exercise. As the bird ma-

tures, more and more time is given to preflight activities, such as flapping of wings and jumping from

nest to nearby branches. Skill in these jump-flights soon increases, and heron is ready to abandon nest.

Decline of Bluey and Ascendancy of Big Whitey



BIG WHITEY, eldest of the three nestlings observed at Cotton Key, is seen at left, above. His nestmate,

Bluey, was second to hatch. The third to hatch, **Little Whitey**, had died before picture was made.

would be fundamental to determination of the mode of inheritance of the color phases, if—indeed—the color difference was a matter of phase, rather than species. From December, 1955, to May, 1956, my brother and I were in the Florida Keys, observing and photographing the herons of this wonderful area. Thus, we were in a fine position to assist in the effort to unravel this taxonomic knot. At the suggestion of Robert P. Allen, Research Director of the National Audubon Society, we moved onto Cotton Key to start our search.

COTTON KEY—a tiny island in Florida Bay—is about two miles north of the town of Islamorada. A fringe of red mangroves surrounds Cotton Key, and its interior is a tangled mass of black mangroves and saltwort. On our first reconnaissance, we were greeted with hoarse croaks from the startled parents, and metallic “tick-ticks” from the hungry nestlings of no less than eleven pair of herons.

All eleven nests were quite accessible, but no two nests contained birds at the exact same stage in the breeding cycle. Hence, we selected a nest with three newly-hatched young, so that we might observe and photograph as much of the nest life as possible. Of the young, two were white and one blue: one of the parents was white, the other was blue.

Now, among herons, the hatching of eggs is said to be asynchronous. Hence, the three young in the nest we selected already differed greatly in size. This is because the eggs are laid at intervals of one to two days, but

incubation begins with the first egg.

One of the three young, which we soon dubbed “Big Whitey,” had been the first to hatch, so it was the largest. The blue bird, “Bluey,” had been second to hatch; the last to hatch was the second white bird. “Little Whitey.” In most cases, the last young heron in a brood cannot compete for food with his older, larger and more vigorous nestmates. In this case, “Little Whitey” soon succumbed and, not long afterwards, “Bluey” also lost in the race for survival, leaving “Big Whitey” alone in the huge nest. We watched and photographed “Big Whitey” throughout most of his sixty-three-day nest life, climaxed by his first successful flight to the shore of Cotton Key. This flight—only a matter of a hundred yards to us—represented a major achievement for a brand new Great White Heron!

Our observations, in relation to Mayr’s questions, showed parentage of mixed color both in the case of “Big Whitey” and at two other of the eleven nests on Cotton Key. Thus, we knew that the two color phases did mate, nest, and rear young together. Seven of the eight other nests on Cotton Key had at least one white parent, although the color of the other parent was established in only one case. All the young of these seven broods were white. We found no pairs of blues nesting, so that no firm answer can be given to the second of Mayr’s questions. The two young in the eighth nest were white and blue, but—strongly as we suspected both parents to be white—the wariness of the adults kept us from establishing

this suspicion as hard fact. “Almosts” do not count in science, so we are also unable to answer Mayr’s question concerning color-phase inheritance.

Although “Big Whitey” was the sole survivor in his nest, it should not be deduced that being white insures survival: blue birds were sole survivors in two other nests. Indeed, at only one nest on Cotton Key did the parents succeed in rearing three young to the flight stage, and only four pair of adults managed to rear two young successfully.

BECAUSE the Great White Heron is found not only in Florida, but also in the West Indies and along the coast of Yucatan—where no detailed studies of these problems have been made—we are reluctant to attempt any present conclusion that the Great White Heron is not a species but, instead, a white color phase of the Great Blue. We do feel that the evidence from Cotton Key has tipped the scales heavily in favor of that view, but the framing of a final conclusion will require further fieldwork. Allen, of the Audubon Society, is keenly interested in such problems; he is continuing his counts of the frequency of the white and blue phases throughout the Florida Bay region. Such censuses are most important: they could reveal striking differences in the ratio of the two phases at different localities. Further nest observation is also necessary.

Our interim conclusion, therefore, is that, while we lean heavily toward the color phase hypothesis, the final word regarding the Great White Heron problem has yet to be recorded.



ALTHOUGH only a day or two older than his nestmate, Big Whitey clearly shadows him after three weeks.



WITH parents' return, Big Whitey "s" his nestmate. Billing action stimulates the parent to disgorge food.



LAST DAYS, Bluey barely matches Whitey's height, even standing on edge. Shortly after this, Bluey died.



NESTING DAYS nearly over, Big Whitey rises to stretch his untried wings.



SOLE SURVIVOR of initial trio, Big Whitey now receives undivided attention. Here, the white parent disgorges.



BLUE PARENT takes a turn at chore of feeding Big Whitey, who is now half way through sixty-three-day nest life.

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Letters

City Winter

THE enclosed photographs of a variety of ice-crystal patterns may be of some interest to your readers. Still better, they might stimulate a more capable photographer to collect more varied—and much clearer—representations of Nature's urban artistry.

None of these pictures is exaggerated or retouched in any way. I used a portrait lens for the close-ups of windowpane frost. The picture that I call "Black Plumes" is a record of what happens when lightly frosted areas melt, leaving behind a whitened background of heavier frost.

One of the street scenes (I call it "Silver Dollars") shows a number of evenly spaced air bubbles, trapped under a thin coating of transparent ice in a black-topped pavement. A hail storm had been followed by melting that turned some of the stones to slush. The temperature then turned to freezing before all the air had escaped from between the hailstones.

WOLCOTT CUTLER

St. John's Rectory
Charlestown, Massachusetts

Bear Behavior

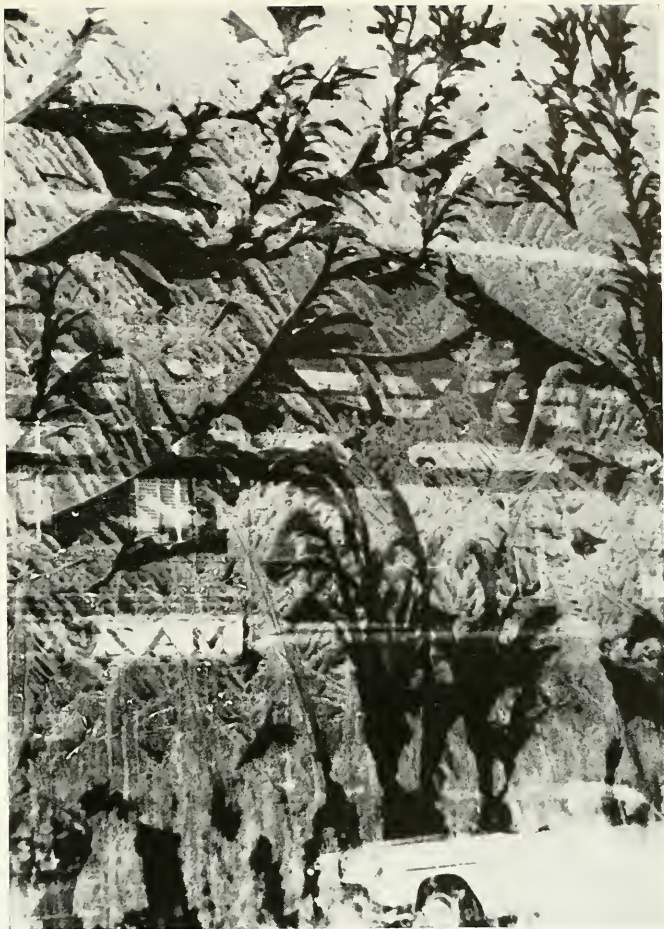
RECENTLY, I have had the opportunity to study at first hand several captive specimens of the Himalayan black bear. With great curiosity, I have observed a rather strange form of behavior. Several times during the course of the day, the bears would place their forefeet together, like a beggar requesting alms, and proceed to suck their pads alternately. The sucking was accompanied by a vibrating noise, coming from deep in the throat. This sucking action would continue for several minutes, during which time the pads were covered with a white, creamy paste.

On discussing this phenomenon with several experienced woodsmen, I found that opinions varied considerably. The native people called the action "bear fever," but the animals I saw were otherwise quite normal, with none of the symptoms that suggest a fever.

A second opinion was that the bear derived some nourishment in this way, and thus was able to sustain itself during periods of hibernation. But I fail to see why it should be necessary for the bear to *extract* nourishment from its body in this fashion. Stored-up food material is surely assimilated internally in the process of hibernation.

A third view held that the bears pos-

(continued on page 110)



THE URBAN ARTISTRY OF NATURE: "Black Plumes," above, and "Silver Dollars," below.



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February, 1958

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THE LONG BLUE shadows of a winter sunset serve to exaggerate the forms of boat and beast alike, as this party of Lapp reindeer-herding nomads travels across the bleak Scandinavian landscape. The reindeer and their harness are the same as from time immemorial, but the Lapp leader is wearing modern skis and the sledges that carry boat and baggage are also in the modern style. Less than a generation ago, there might not even have been such a boat, but—instead—one of the traditional boat-shaped Lapp sledges, useful equally on snow, bare ground, marsh or stream in this roadless terrain.

Today, although the reindeer herds are more populous than ever before, the number of nomadic Lapps has dwindled. To see something of the life of these unique and ancient people, turn to page 70.



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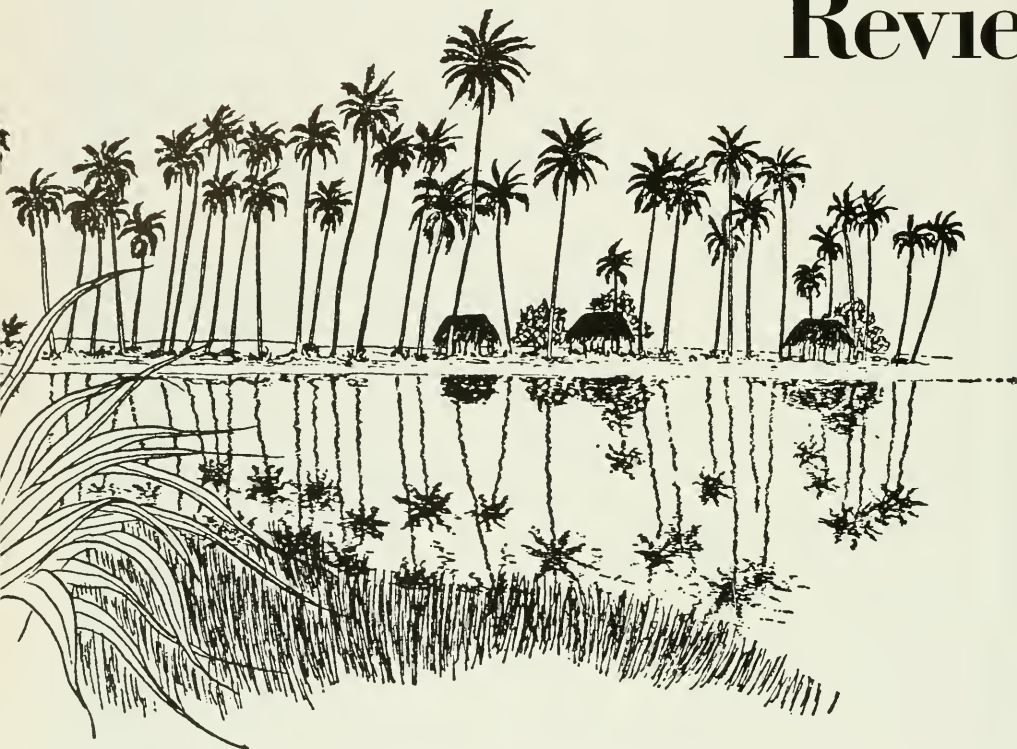
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Review



THE LAST CANNIBALS, by Jens Bjerre, (*Morrow*, \$4.50). RETURN TO THE ISLANDS, by Sir Arthur Grimble, (*Morrow*, \$4.50). YULENGOR-NOMADS OF ARNHEM LAND, by Wilbur S. Chaseling, (*Essential Books*, \$3.30).

IN ITS EARLIEST STAGES, the science of anthropology owed much of its raw material to the observations of far-wandering men whose interests were primarily far from scientific. Today, the debt has been more than repaid: these three books are evidence of the profound effect that anthropology, in its turn, has had upon three very different types of professional rover—the globe-trotter, the missionary, and that nearly extinct species, the British colonial civil servant.

On its surface, *The Last Cannibals* is another in the endless series of entertainments that begins at a port where cruise boats do not yet stop and ends on the lecture platform. With movie cameras, tape recorders and a modest smile, Mr. Bjerre, like how

many before, went on the road to prospect for marketable adventures. What sets his book apart from most of its kind is that the primitives, rather than the visitor, occupy stage center.

The first stop on Mr. Bjerre's junket, was in an aboriginal reserve in the central desert of Australia, and for a few weeks he pitched his tent among the tentless nomads he found there: long enough to see the Stone Age at first hand and take some interesting photographs. Like others who better know the aborigines, he was struck both by the extraordinary efficiency with which they extract a living from an arid and hostile wilderness and by the baroque complexity of their family relationships. He was also obviously a little disappointed. Having journeyed all the way from Denmark to empathize with cannibals, he found none.

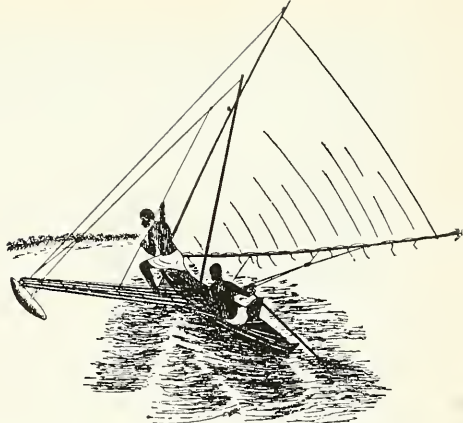
He was somewhat luckier in New Guinea. Of the three tribes he visited there, the Kukukuku's of the eastern highlands were occasional man-eaters and chronic murderers. Again no an-

thropophagy, but Bjerre helped arrest a murderer and observed the grisly smoking process by which the tribe mummifies its dead. And from what he learned, at first and second hand, he came to the view that in a jungle, where game is scanty, cannibalism "derives mainly from a shortage of meat, a deficiency of proteins." Elsewhere, with the Morombo's of New Guinea's central highlands, and on a trip up the Sepik River, he observed feasts and initiations and collected myths and songs which add to the interest of his book. His adventures—and he had some—are the more exciting for being subordinated.

At Kambot, far up the Sepik, Mr. Bjerre heard firsthand accounts of the Cargo Cult, that extraordinary demonstration of dynamic mythology which has swept many widely-separated Pacific islands, particularly after the second World War. This cult, as he encountered it, held that the shiploads and planetloads of manufactured goods arriving on the islands had been sent by the spirits in heaven to the

CIFIC PRIMITIVES

Reviewed by
CHRISTOPHER GEROULD



Islanders themselves, but had been wrongly intercepted and used by the whites—whom the New Guinea natives, at least, regarded as the pallid reincarnated ghosts of their own ancestors. Convinced that they were being defrauded, the tribes used every available form of traditional magic to insure that the cargoes be delivered to them, and not to the whites.

In many places, this postwar belief crystallized into the more traditional Cargo Cult prophecy—a ship was on its heaven-sent way, bearing all kinds of heaven-sent trade goods. In anticipation of its arrival, all work was neglected, while banquet tables and warehouse huts were set up to celebrate the arrival of the cargo and to store it. Some villages went so far as to destroy the crops, and slaughter the pigs in anticipation of the heavenly cargo.

The Vailala madness, as the cult was called locally in New Guinea, led its believers into actual frenzy and into attacks of hysterical cramps which seized whole villages. After Mr. Bjerre's account of this and other religious cults arising from attempts to reconcile alien religious teaching with traditional beliefs, it is encouraging to read that anthropology is required study for civil servants going to New Guinea, and that anthropologists and psychologists are employed by the government to study and analyze such cults. Perhaps this should have been done earlier.

SUCH is precisely the conclusion reached by a long-time British colonial civil servant of the pre-anthropology days, Sir Arthur Grimble, looking back over his early career as an administrator in the Gilbert Islands. He points out with some force that colonial executives of his own generation—he went to the Gilberts first in 1914—knew nothing whatever of the people they were to govern, and succeeded, when they did succeed, only through the

politeness and forbearance of those governed. "We did not stop to think then," Sir Arthur states, "how much more the maintenance of *Pax Britannica* owed to their marvelous patience and courtesy with us than to the inherent virtue of ourselves or our system."

Return to the Islands, however, makes perfectly clear that not all the patience and courtesy were on the side of the villagers who were Sir Arthur's subjects and his teachers. Whether he was learning island etiquette from a little girl, trying to administer legal monogamy to a group of convinced and ribald polygamists, or preventing a group of Chinese laborers from im-

mulating themselves by attacking a group of Gilbertese, he obviously went armed with the British empire-builder's most notable weapons: an earthy sense of humor and, especially, an inbred ability to take seriously any rigmarole of protocol or ritual, including his own.

Written not long before Sir Arthur's death, *Return to the Islands* is episodic, nostalgic, but above all, likeable, as was its author.

THE AUTHOR of *Yulengor* has lived a highly-specialized life and turned out a highly-specialized book. Wilbur Chaseling is a Methodist missionary who has spent most of his working



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years in Arnhem Land, the monsoon-swept wilderness that lies to the west of the Gulf of Carpentaria in northern Australia. Since 1933, he has shared 34,000 square miles of aboriginal reserve with a few white men and a few dozen "hordes," or small nomadic communities, of aborigines.

Mr. Chaseling has chosen not to talk about himself but to give with insight and affection a very complete account of aboriginal life as he has observed it. His book covers all their activities simply and directly, reaching what can only be described as a high pitch of matter-of-factness in his report on cannibalism.

"I saw hordes behind Boucaut Bay practicing a form of cannibalism and eating their dead. A wealth of tradition lies behind this custom, which originated with the eating of their tribal Ancestress. . . . All hair is scraped off and burnt, intestines are removed and buried, and the head is severed from the trunk. Meanwhile, relatives prepare an oven by digging a trench, lining it with stones, and lighting a fire on top. When the tempo of singing and dancing has increased to fever-pitch, the skull is pierced and the brain removed, wrapped in bark, and given to the mother to guard. The skull is cooked, separately cleaned, painted, and hoarded. Removing the bones is a lengthy process and must be done carefully so as not to sever the limbs. All bones are exposed in a tree to bleach . . . and be hoarded till it is convenient to pack them in a burial post.

"When the stones in the trench are hot, the coals are scraped away, and a relative grasps the hands of the now boneless and headless body, drapes it over his shoulders, and dances among the chanting, wailing horde. It is lowered into the trench-oven, covered with bark and sand and allowed to cook to the accompaniment of singing and dancing. Most chants relate to the departing spirit, and, in them, the strength of the dead man is urged to enter the bodies of those who have consumed his flesh."

This could hardly be bettered for sharp observation, terseness and temperateness. Mr. Chaseling's emotions are reserved for his very real admiration of these people—who live naked in the wilderness far more by choice than by lack of initiative or intelligence, and whose lack of material possessions is balanced by a subtle social structure and a moving mythology.

Among their other accomplishments, the Yulengor are excellent linguists in their own multiple dialects, in sign language and even in English. Mr. Chaseling tells of a naval officer who tried to question an aboriginal youth in his best pidgin English. The boy looked puzzled, then asked: "Excuse me, sir, are you a 'New Australian'?"

MR. GEROULD, a reporter of science for many years, regularly contributes book reviews to NATURAL HISTORY.

All the drawings
are from *Return
to the Islands*.



IN BRIEF

By JOHN HAY

Zoology

VERTEBRATES OF THE UNITED STATES by Blair, Blair, Brodkorb, Cagle, and Moore (McGraw-Hill, \$12.00; 319 pp., illus.)

THIS compact, well-illustrated volume covers every known species of vertebrate within the continental limits

of the United States, plus birds and mammals of adjacent waters. The authors point out that some errors may be inevitable in as extensive and detailed a work as this, and some arguments may be raised over their classifications. All the same, the material is very well presented, and the book should prove to be

(continued on page 108)

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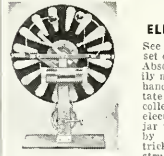
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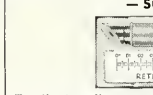
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ORIGIN OF THE DOG

By EDWIN H. COLBERT

THIS MONTH, for the eighty-second time since its inception in 1877, the Westminster Kennel Club will hold its annual show in New York City. Some twenty-five hundred dogs, representing over a hundred different breeds, will be put into competition for the highest honor in U. S. kennel circles—"best in show" at the Westminster. Each will already have won recognition at one or more of a thousand dog shows in the U. S. or Canada, and each will represent a special effort at selective breeding.

Among the countless millions of dogs in this country, only a handful will be represented at the Westminster show—indeed, the fanciers of pure-bred dogs are a minority in the ranks of the nation's dog-owners. But selective breeder and ordinary owner, alike, are harboring, in their canine companions, a mammalian lineage substantially more ancient than man himself.

The spaniel on the warm hearth rug twitches his feet and utters short, sharp whines as he sleeps. Perhaps, we think, at this moment he remembers neither rug nor the comfort of the fireside; he dreams of the fields,

Domestic creatures today, dogs have a long history. Lack of anatomical specialization has allowed their development from far-ranging predator to fireside pet

running in hot eagerness after a bounding fluff of white cottontail, across the tall grass and the rough bushes that mark the forest's edge. Suddenly, the spell is broken—our spaniel wakes with a start and looks around him. Perhaps a bit astonished, we think, to find himself not in the cold fields but, rather, here by the fire's warmth, shut in from the outdoors by house walls.

Why should our spaniel—or a hundred other breeds of dog—be here, living the comfortable life of vassal to his master, rather than ranging the fields and woods as a free predator with his fellows? Why should he accept, with obvious delight, dinner from a can, rather than closing-in on wild prey with a final burst of savage speed? Why should our spaniel carry long, floppy leathers—that get into the feeding d'sh—rather than short ears, erect and alert for the sounds of the wild? Why should his coat be silken and curly, rather than of the short, rough hair that would protect him from thorns and branches and the biting winds of night?

THE ANSWER, we know, is that he is here, partly, because his ancestors were hunters and, partly, because his kind and his master's kind have grown up together, in mutual affection and understanding, for unknown millennia—before the time of Roman and Greek, before the earliest Egyptians, back to the days before polished stone, when all men, too, were hunters. For both human and canine discovered, those thousands of years ago, that by joining forces in the chase they could help one another.

But, even beyond those remote events, the dog owes his presence to a vastly more ancient evolutionary history—one that must be measured in millions of years, rather than thousands—going back to days when the world was a much different place,

In those distant days of earth history—some sixty million years ago, after the disappearance of the dinosaurs, but before the evolution of the mammals we know today—the continents were inhabited by hosts of animals that would seem strange and wonderful to our modern eyes. Geologists call this the Eocene epoch: the continents were blanketed with tropical and subtropical forests, extending far into northern latitudes, and among these great expanses of jungle were low, lush savannas. There were no upland prairies, as we know them today, no towering mountain ranges to intercept the movements of warm air masses, no caps of ice covering the poles. In short, this was a rather uniform world and in this world lived the primitive mammals that inherited the earth after the dinosaurs' extinction.

Some of these early mammals were ancestors of our modern ones; many, however, were early "experiments" in mammalian evolution, destined for extinction. Among these early mammals, as we trace the origin of the dog, we note a group of small carnivores, called "miacids" (after *Miacis*, the characteristic genus).

Miacis, in general appearance, was small, long-bodied, long-tailed and rather short-legged—probably very similar in general appearance to some of the Old World civets of today. Indeed, certain jungle-dwelling civets of the Orient today apparently have changed very little since the days of their miacid ancestors. Among the inhabitants of the late Eocene forests, *Miacis* and his cousins were inconspicuous animals that occupied no very prominent place. Yet, of all the great array of carnivores that hunted their prey

across the continents of those times, they were—to the modern student of evolution—the most significant. For the miacids were the direct ancestors of all modern carnivores: the wolves and foxes and their relatives, the bears, raccoons, pandas, weasels, skunks, minks, otters, badgers and the like, the Old World civets, hyenas and cats, and even the sea lions, seals and walruses.

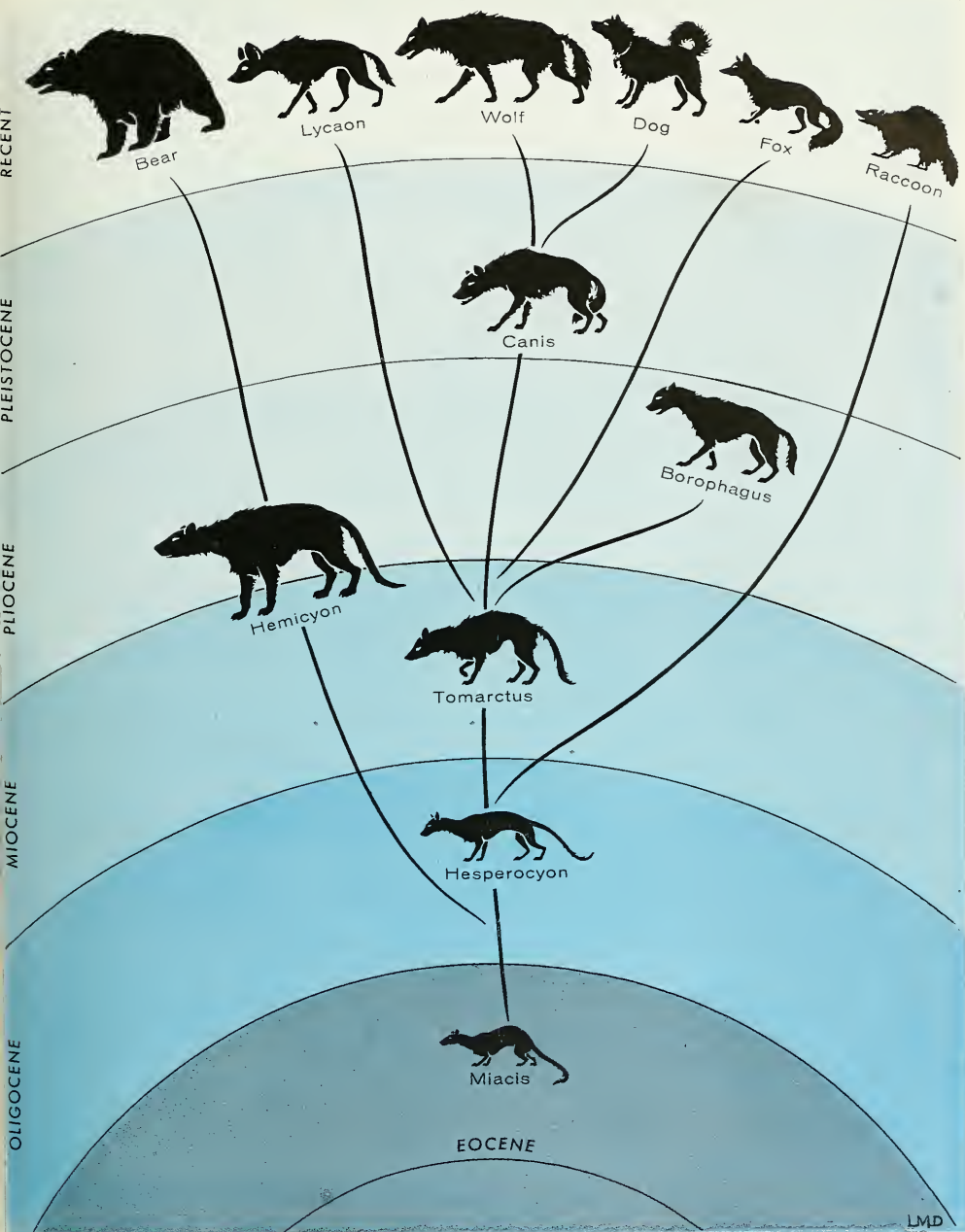
WHY should miacid progeny have multiplied so successfully, eventually to displace the larger carnivores that had preceded them as the hunters of plant-eating animals? What did the miacids have that made their descendants so much more efficient? The answer probably is to be found above all, in brain size. The miacids had comparatively large brains: it may follow that they were intelligent to a degree that gave them some distinct advantages over their primitive contemporaries. In the evolution of the meat-eating mammals, we believe, this intelligence has prevailed. At least, it is certain that the primitive and smaller-brained carnivores that preceded and lived with the miacids were, in time, crowded off the face of the earth.

In addition to their larger brains the miacids had another physical advantage. Two teeth on each side of the jaw—the last upper premolar and the first lower molar—were specialized as shearing blades. This forward position of special cutting-teeth, called carnassials, also appears to have given the miacids an edge over their contemporaries, whose carnassial teeth were farther back in the jaw.

It is to this combination—a relatively large brain and forward carnassial teeth—that we attribute the evolutionary success of *Miacis*, and his descendants, for more than fifty million years of the earth's history.

During the Oligocene epoch, the geologic period that followed the

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LMD

Evolutionary "Tree," in simplified form, shows rise of selected modern carnivores from the civet-like *Miacis* of the late Eocene, with its comparatively larger brain and forward carnassial teeth, bottom. Above is *Hesperocyon*, ancestor to all of the canids, and to the raccoons as well. At left,

above this, is the "bear-dog," *Hemicyon*—astride the dividing line between Miocene and Pliocene—ancestor to all the bears. Right, above *Tomarctus*, is the "experimental failure," *Borophagus*. And finally, in the Pleistocene, stands the genetically plastic *Canis*, ancestor of modern dog and wolf.

Eocene, carnivores that can be recognized as canids (the "dogs"—using this word in a very broad sense—and their relatives) first appeared. There were two important types of Oligocene canids. One was a small, slender carnivore—obviously not very far removed from its miacid ancestors of the Eocene. The other was a large, heavy, long-tailed type. The first, *Hesperocyon* (formerly called *Cynodictis* or *Pseudocynodictis*), was the ultimate common ancestor not only of the dog family but also of the raccoons. The second, *Daphaenus*, was ancestral to the bears.

As they evolved, the latter group—large doglike carnivores that derived from *Daphaenus*—became ever larger and heavier. During the next geologic epoch, the Miocene, this trend led to a genus known as *Hemicyon*, a "bear-dog" almost as large as a modern bear. Indeed, *Hemicyon* was the direct ancestor of the early bears, which made their first appearance in the following Pliocene epoch. While the bear-dogs were thus growing into bears (from a base exemplified by *Daphaenus*), the dogs and the raccoons, meanwhile, were evolving from a base exemplified by *Hesperocyon*. The trends in these two groups were quite divergent.

THE RACCOONS (some of which eventually gave rise to the Oriental pandas of today) became versatile carnivores, good at scrambling over rocks, and wading or swimming in rivers and lakes: fond of eating almost everything—crayfish, small animals, and even berries and fruits. The dogs, following a different trend, became fast and tireless running predators, in all probability working together to pursue and bring down their prey. The perfection of their anatomy for fast running—especially the development of long, strong legs, compact paws and powerful back muscles—together with our postulated evolution of co-operative behavior, made the canids what they are today. A gradual development, it involved several different lines.

One such line leads straight from *Hesperocyon* to today's wild hunting dogs of India and Africa. The main evolutionary line, however, goes first

to a Miocene canid, known as *Tomarctus*, and thence on to the wolves and foxes of our modern world.

From *Tomarctus* also arose an interesting side line of canid evolution—one that parallels the development from *Daphaenus* to the bear-dogs. This branch is characterized by a Pliocene genus, *Borophagus*, a large heavy canid of the New World, with a massive skull and powerful jaws. But *Borophagus* and its relatives had no place to go, for the bear-dogs had preceded them and had grown into bears. Large and impressive as were canids like *Borophagus*, they apparently could not compete with bears

(which were larger) or with other dogs (which were certainly faster).

SO IT WAS that the central line of canid evolution became dominant. Through the Pliocene epoch and on into Pleistocene times, when the great glaciers advanced and retreated to the north, the wild dogs of the world developed, step by step, into their modern types: the wolves, coyotes and jackals, the foxes and fennecs and, as a separate and parallel line of canid evolution already noted, the hunting dogs of India and Africa.

The Eurasian and North American wolves hold an ugly place in the



LEONARDO DA VINCI drawing shows close study this great master gave to dogs.



FLORENTINE painter, Andrea del Sarto (1486–1531), did this intimate sketch.

folklore of our culture. To our not so very distant ancestors, wolves were the dread enemies of winter nights—powerful, cunning adversaries that would pursue an unfortunate late traveler through forests and across fields, to pull him down at the very gates of a town. The howl of the wolf pack and the gleam of eyes in the starlight have been a terror to men for thousands of years.

YET these very traits of cunning and ferocity, of co-operation in the hunt, of tireless pursuit, are what have led to the long history of fellowship and interdependence between man and dog. Wolves have been sociable and intelligent hunters at least since the beginning of the Ice Age, and so have men. All evidence points to the derivation of modern dogs directly from the wolf of the Northern Hemisphere. Modern dogs show the same behavior patterns characteristic of wolves and, moreover, crossbreed readily with wolves—a sure sign of close genetic relationship. We may hypothesize a captured wolf cub as the start of this chain, but speculation is idle until the archeologists give us many more reports on early associations between dogs and men. In any case, both the association and the original stock constitute known facts.

If our spaniel by the fire—and the millions of other dogs in homes and farms and camps round the world—are, in this sense, tractable wolves, why are most of them so different from wolves in appearance? We have seen that the central line of canid evolution has been characterized by quite limited anatomical specializations—for example, the developments associated with fast running. Indeed, canid evolution, extending through the millions of years from late Eocene to modern days, has produced a generalized, rather than a specialized organism. This, we hold, has left the later canids genetically plastic.

It may be useful to emphasize this point by comparing dogs with cats. During Oligocene times, when the canids had hardly begun their long history of development and *Hesperocyon* stood a long way removed from today's wolves and foxes, the cats had already become full-fledged cats. Since the Oligocene, cats have continued through millions of years with very little structural change. Nor are today's cats subject to much genetic variation, in spite of man's efforts to breed varieties. Our house cats may come in different colors and hair styles, but anatomically they are all very much alike.

There has been no such anatomic rigidity among the canids. As long as man remained a hunter, his dogs fulfilled their primary function as hunting companions. And they apparently remained pretty much of one type—very likely, a sort of generalized “yellow dog” not much different from the modern Dingo of Australia. But when man achieved leisure as an agriculturist, he had time

to experiment with dog breeds, and the dogs were no longer limited to the function of the chase. Some could be used as watchers of herds and flocks; others could be bred purely as companions in the home. With leisure, it was not difficult—nor undesirable—for man to seize upon sudden mutations among his dogs, and breed for the characters that so fortuitously appeared. This appears to be the means whereby the dooryards of men are now populated by big dogs and little ones, short-legged and long-legged, by dogs with pug noses and dogs with long faces, by dogs with long hair, short hair, and even with almost no hair at all.

ACTUALLY, few of the hundred or more distinct breeds of dogs that grace our mid-twentieth century can be traced back more than a few hundred years. Today's business of producing and preserving a myriad different sort of dogs is largely an aspect of today's culture—in which many dogs are more ornamental than utilitarian and few, if any, are hunters in the aboriginal fashion.

So we return to our spaniel by the hearth. Certainly there is little resemblance between this small, long-haired, droopy-eared pet and the great gaunt wolves that harried the reindeer across Europe when France was a region of polar snows. Yet, basically, our spaniel is the sport of some tractable wolf that abandoned a wild and independent life to become the willing servant and companion of man. This rewarding association for both man and dog bids fair to continue so long as there are men and dogs in the world.



PERHAPS BEST animal artist of Italian Renaissance was Pisanello (1397–1455).



THE LAST OF THE REINDEER LAPPS

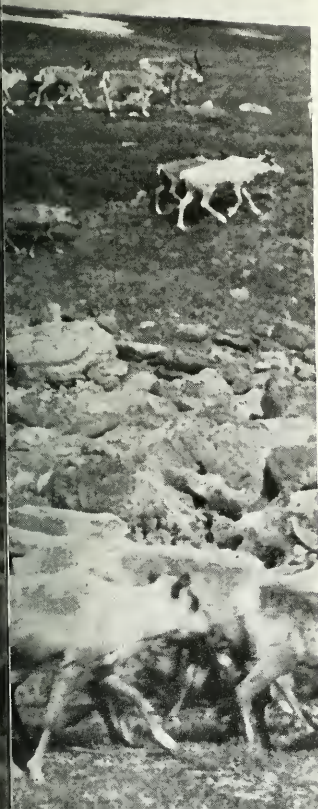
Among the *Samer*, these herding nomads
are on the verge of extinction today

By ERNST MANKER

EXACTLY WHEN it was that the Lapps—those distinctive boreal nomads who lived by hunting and fishing—first came to the Finno-Scandinavian region is not known. In all probability, the event occurred while glacial ice still covered the central parts of the Scandinavian Peninsula. North of the present Baltic basin, where the gigantic glacier calved its icebergs into the Yoldia Sea, there

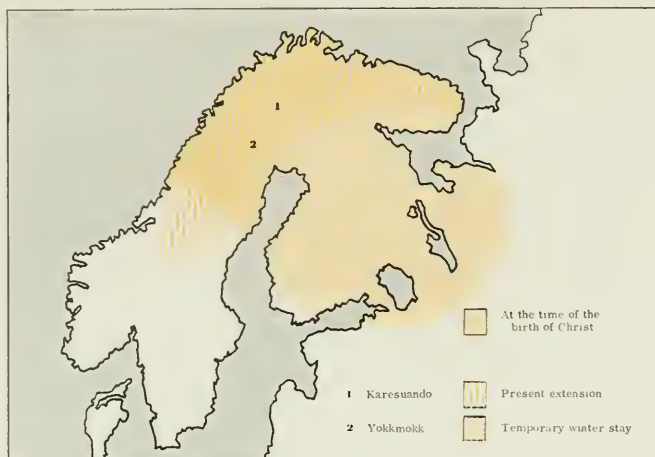
existed from early times an ice-free corridor stretching westward along the coast of the Arctic Ocean. Remains dating from Paleolithic times—the so-called “Komsa” findings—quite probably stemmed from these first inhabitants of the area, the ancestors of our present-day Lapps.

Large herds of wild reindeer followed the line of the ice and, in their wake, followed the early hunters. On



IN LATE SPRING, the reindeer leave the lowlands and head for summer pasture—in the high mountains—a torrent of

antlers and flanks pouring over the land. *left*. The nomad family follows, with its baggage on carrier reindeer. On



LAPP TERRITORY, some two thousand years ago, extended south and west of their present range, *tone*. Now, they

inhabit only the Kola Peninsula and northern Finland. Sweden and Norway, *bars*, with winter extensions in south.

land, they pursued the reindeer and other animals; on the sea, they fished or hunted the seal and the polar bear. They were people from the East, who had wended their way from the region of the Urals over the Karelian Peninsula and across what is Finland today.

AS A RACE, the Lapps of today can claim to be unique. Neither Mongoloid nor Indo-European, they seem to be the remains of a paleoarctic race of their own, sprung up somewhere between the white and the yellow varieties of mankind. Their main physical characteristics include short stature (about five feet to five feet, two inches for men and four feet, nine inches to four feet, eleven inches for women); low skulls, triangular-shaped faces; fair, almost sunburnt skins; dark hair and brown eyes. Linguistically, they speak an old form of Finno-Ugric.

For thousands of years, the Lapps



—known to the writers of old as the *Finns* (Finns), and to themselves as *Sámi*—lived only as hunters. Then, the day dawned when those Lapps who dwelt in the central regions of the country realized that it was better economy in every way to follow and tend a given herd of reindeer, rather than to squander the animals and slay many of them away by the massacre of thousands in pits and gullies. And so, the ancient Lapps started to herd the reindeer—on a primitive scale at first, but, as time passed, in much the same way as do the Lapps of today.

Of the reindeer, there are two varieties: mountain and woodland. The mountain reindeer migrate in the summertime—to the highlands or out to the Atlantic coast. The woodland reindeer remain in the forests all year round—although, in summer, they end to move up to the low mountains.

(continued on page 77)



DAY'S MARCH OVER, the pack-deer are unloaded and camp made. The carrier reindeer are more wild than tame, and

breaking them for baggage animals is often a struggle. Each herder's tent fits on its portable framework, *below*.



TENT RAISED, the women's work is begun: unpacking household goods and rations. *below*. Most of the reindeer-

herding Lapps, today, dwell in Sweden. They number some three thousand, but very few of these are still fully nomadic.





STAPLE OF LAPPS, reindeer are used for every purpose. *Above*, meat from reindeer is hung up to dry on wooden rack.



HIDE BOOTS, one of many reindeer products, are stuffed with a thick lining of grass, *below*, used instead of socks.

ONE STEP in the curing of hides is shown, *above*, as a Lapp woman spreads skins out for softening in an icy stream.

INTENT LAPP HERDER, *right*, whittles harness pin to be used with new gear in foreground, also made of reindeer hide.







FEAR AND BOLDNESS are mingled in the expression of this Lapp youngster, who, true to the traditions of his people, will

spend much of his time, from his earliest childhood on, amidst the reindeer of his family's herd. Even today, when

reindeer herding is becoming increasingly industrialized, some entire Lapp families still journey with their herds.

(continued from page 73)

In winter, both varieties seek protection and grazing in the woods which border the Gulf of Bothnia.

The Lapps who chose to tend the woodland reindeer became only semi-nomadic, living in permanent wooden shacks during the summer and needing to travel with the herds only in the wintertime. The Lapps who, instead, chose to follow the mountain reindeer became completely nomadic. Carrying their tents with them, they moved with the migrating herds, both summer and winter, up from the Baltic coast to the highlands or across to the Atlantic coast—in all, covering a migratory range of 250 to 300 miles.

By nature, the migrating reindeer herds follow customary routes, generally limited by the main waterways, and the Lapps follow the same trail. A team of herders, a *sita*, consisting of one or more families, thus arrives in much the same area at each turn of season—summer, autumn, winter and spring. This annual movement follows a definite cycle, even though not determined by clock or calendar. The Lapps divide their year into eight periods: "winter-spring," "spring," "spring-summer," "summer," "summer-autumn," "autumn," "autumn-winter" and "winter"—the latter followed again by "winter-spring." By and large, "winter-spring," "spring-summer," "summer-autumn" and "autumn-winter" are the migratory periods: during the remaining four seasons, more permanent camps are set up. This is especially so in autumn, the best time for the annual slaughter, and the time of the reindeer rutting season. It is also true of spring, when the calves are born.

ALTHOUGH the Lapps are popularly known in the outside world as, primarily, nomads and herders of reindeer, only a minority of them ever became truly nomadic. By far the majority of Lapps lived on as hunters and fishers along the Atlantic and Arctic shores. Eventually settling by lakes and rivers, they turned to fishing and primitive farming for a livelihood. The eastern Lapps—those living in Petsamo and on the Kola Peninsula—also followed the custom of their kinsfolk in northern Finland and Scandinavia in that they, too, lived off the reindeer. But they remained in a stage midway between herding and hunting. An eastern Lapp *sita* had a common winter abode, from which they ven-



LASSO PRACTICE is a necessary part of the early education of Lapp youths brought up in the old style. In these pic-

tures, young Lapp learns how from big brother, *top*, himself tries, *center*, victoriously draws the rope tight, *bottom*.



WHEN GROWN UP, Lapp youngster will seldom use his lasso in open country, but rather within the enclosed corral

where, twice a year, the "rarkning," or separation of reindeer, both for identification and breeding purposes, takes place.





VERSATILE LAPP HERDERS are also expert at hunting and fishing, use other animals for food and clothing, as well

as trading. *Above*, the skin of a glutton, small animal akin to marten or sable, is stretched on a simple frame to dry.



DOMESTIC CRAFTS are shared between men and women among Lapps, with women sewing and weaving, *above*, while

men do carving in wood or bone. Patterns embroidered on Lapp fabrics originate in designs of Scandinavian bronze age.

tured radially in the summer toward fishing waters and hunting grounds, while some of the more tame reindeer grazed within the group area.

THE LIFE of the truly nomadic Lapp, made known to the world by the writings of the seventeenth-century author, Johannes Schefferus, is thus the culture of only one group of Lapps—those of the Scandinavian interior. This culture reflects a remarkable adaption to natural conditions and available assets. Much Lapp equipment is ingenious. The design of the ambulatory tent, the *kata*, is unique among dwelling forms conceived by man. The boatlike sledge, the *akja*, glides smoothly over snow, through reeds and brush, and over bumps and stones. The harness and reins for draft and pack-reindeer are simple but effective. So are the lasso and the techniques employed when slaughtering, gelding and taming reindeer.

A further example of adaption is the social organization of the *sita*, which evidences a happy combination of private and communal ownership. The individual notches cut into the reindeer's ears are clear evidence of the strength of the private-ownership concept. To see his herd increase gives each owner the will to work ever harder. Yet, the practice of communal-herding guards all the animals against such hazards as bad weather, dangerous terrain and wild predators.

IN A SIMILAR WAY, one may see elements in the old Lapp religion derived from contact with the hard forces of nature. The sun, the thunder and the wind were reckoned divine forces and every district over which the Lapps wandered was governed by its ruling spirit. The Lapps sought to appease these deities to ensure the growth of their herds, the successful crossing of difficult mountain passes, and the general life and health of the people. For a people living in such close contact with nature, it was not unusual that they should credit natural phenomena with spiritual powers. The Lapps were animists and their religion involved a shamanist worship of nature. The main instrument of the *naid*, the Lapp shaman, was the drum, and the Lapp drum was perhaps the most unique of all shamans' drums. The *naid* was capable of using his drum to reach a state of ecstasy in which he cast off his earthly shackles and came into



PENSIVE YOUNG COUPLE seated beside the fire breathe a wordless prayer in their tent before their evening meal.

Tents, or "cots," their earthen floors covered by a layer of brushwood, are sometimes the only home these nomadic

people know. The "cots" are made from thin canvas, not hides, stretched upon either curved- or forked-pole frames.

contact with the Lapp gods and spirits. He adorned his drum with mystic and symbolic figures—applied with his blood-red saliva, a result of chewing alder bark—and could use the drum as a soothsayer uses his crystal, interpreting these drawings as the answers of the spirits, to foresee the future.

The old Lapp religion died some two hundred years ago, when Christian missionaries made concerted efforts to convert the people. Today, the time is not far distant when all of the old Lapp culture will similarly belong

to the past. Of the approximately 35,000 Lapps now spread over northern Scandinavia, northern Finland and the Kola Peninsula, not more than one-fifth still herd reindeer. In Sweden, where most reindeer-herding is still carried on, only about 3,000 of the 10,000 Lapps derive their livelihood from reindeer. Reindeer-herding today, like the Lapp's traditional way of life, has developed along new lines.

During the past few decades, the Lapps have been quickly absorbed into modern ways. Herding has become increasingly industrialized, with its main object the production of meat. Herders' families have become more and more urbanized, with only the men—equipped with the latest accessories—going out to tend the beasts.

Rather than the custom of former days, when the pack-reindeer were loaded and whole groups of families moved with the herds, today, one family, at the most, or a few members of one family, will move up to the summer land for a period of a few weeks—just like city dwellers spending their summer's week or two in the country.

BOTH the herders and their families now use modern means of communications: motorboats, cars, buses and even airplanes. In the remote Sarek district, where there are neither roads nor canals, the airplane is now competing with and ousting the pack-reindeer. Today, instead of tents or turf huts, the Lapps are building modern dwellings—in some places, fully

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modern houses with hot and cold water, toilets, electricity, and stainless steel kitchen units. This is proving a boon to the men: at the close of the tent epoch, it was very difficult for a bachelor herder to persuade the girl of his choice to set up house in no better home than a tent.

However, even now, a few families in the Yokkmokk and Karesuando regions still pursue the old nomadic life. The *kata's* are no longer carried when the family moves up to the mountains—the last one passed through Sarek in the summer of 1954—but these people still spend certain

times of the year in permanent *kata's*. The reindeer are still used as pack animals or to draw the Lapp sledges. This may continue for a few more years—and then these habits will have given way to new ones.

But, even when all this has passed away, the reindeer will still be there. The present census of reindeer in the Swedish Lapp territories is 300,000, the largest figure ever. Nor are these unique people dying out. As they gradually forsake the old nomadic way of life, the reindeer-herding Lapps are slowly becoming a part of modern Scandinavian society.

SLAUGHTER OF REINDEER takes place in autumn, when superfluous bulls, *below*, are herded and slain before rutting time.

WINTER FAIR is held in one of the larger church villages, *above*. Lapps offer mainly skins and handicrafts for sale.





INSECT ACROBAT: FEATS OF THE HOUSEFLY

How the common—but agile—housefly can make its upside-down landings and manages to escape sudden danger through its instantaneous take-offs

By C. HOWARD CURRAN

HOW DOES the common fly manage to land so neatly upside down — on the ceiling of a room or the underside of a leaf? The answer to this question has eluded investigators for years, while the question itself has been posed, with increasing frequency, since man, himself, has become a creature of flight.

His own experiences with flying have led man to investigate the aerodynamics of insects and birds. Paradoxically, despite all that has been learned from these studies, modern aircraft have almost nothing, aerodynamically, in common with animal methods of flight. Nonetheless, these researches have resulted in many valuable additions to knowledge and a number of practical applications.

In the field of insect flight, in particular, it was not until the development of high-speed photography that many questions could be investigated. Photographic studies of the drone fly ("How Flies Fly," *NATURAL HISTORY*, February, 1948), for example, clarified many points — among them the actual motion of insect wings, the method of steering and the way sudden turns are made by "feathering" one wing. Another discovery — use-

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ful to gyroscope research — is the role played by the rapidly vibrating halteres of the drone fly. This pair of knoblike organs, located behind and below the wings of every fly, vibrate as rapidly as the insect's wings and serve as gyroscopic stabilizers during its times of flight.

This research, however, confined itself to principals of flight and no attempt was made to study techniques of take-off or landing.

Recently, a professional photographer — Don Ollis, of Santa Barbara, California — solved the major problem in studying insect landings: the task of making the specimens perform. He noticed that a fly, placed in a darkened box, was attracted to a not-too-bright spot of light. This behavior permitted Ollis to preset his camera at a fixed point and then attract the insect into perfect focus. Thereafter, it was a relatively simple matter to induce flies to land on an illuminated spot on the ceiling of a darkened box.

FLY'S UNDERBELLY is exposed to camera through glass ceiling of box in which experiments were conducted. Light spot

on ceiling of the darkened box was used to attract fly toward top. Note large suction pads on the insect's feet.



IN THE FIRST STAGE of landing, fly is anchored to ceiling by front legs, held over its head since early in flight, *left*.

and photograph the insects in action.

MANY amateur theorists — chief among them, fliers — have suggested the half-roll as the fly's means of upside-down landing. What Ollis' pictures show, instead, is that a fly, en route to an overhead landing, approaches the ceiling at a rather sharp angle, stretching its front legs upward on either side of its head. When the fly's sharp claws and pulvilli (the pads at the end of the feet) make contact, the insect is thrown into a half-somersault, coming to rest directly opposite to its motion in flight. If one





SOMERSAULT is key to landing. Flight momentum and kicking legs flip insect onto belly, front legs acting as pivot.



LANDING IS COMPLETED as fly sets other legs on ceiling. It now faces exactly opposite to the direction of its ascent.



FLY RESTS on ceiling, firmly attached by pulvilli (foot pads), which grip surface by suction, not sticky secretion.

front leg catches before the other, there is a slight yaw and the insect lands at a lesser angle of opposition to its flight direction.

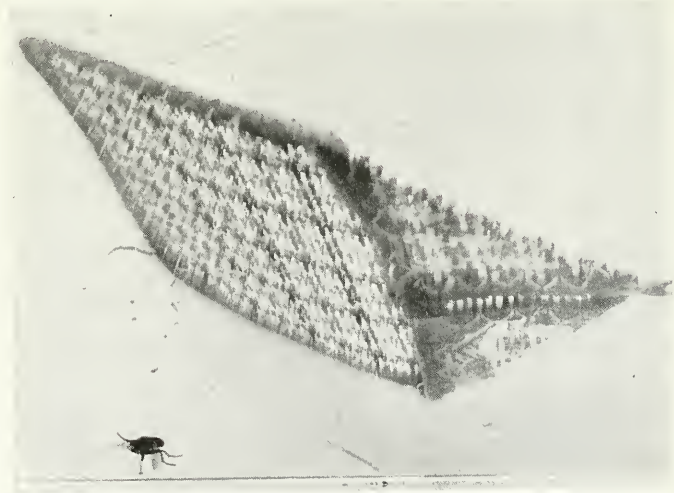
In taking off, the fly throws its front end violently into the air at the same instant that its wings begin to move. The direction of flight varies according to the cause of take-off. If a fly is frightened by a disturbance from the front, it will throw itself upward until its body is vertical and depart on the opposite heading as soon as airborne. If the disturbance is from behind, the fly will take off gracefully on a forward heading, climbing

at an angle of thirty to forty-five degrees. If the disturbance is to one side, the fly will also take off forward, but immediately change course to fly away from the disturbance.

THERE has been much discussion concerning the function of the pulvilli, which are more or less well-developed in all flies and which some observers believe exude an adhesive substance. While there is no doubt that the pulvilli facilitate a fly's grasp on vertical and inverted surfaces, very many insects, that do not even possess pulvilli, can perform the same upside-

down feats. The contention that the pulvilli are sticky is almost certainly mistaken. What is certain is that the pads act as suction cups, serving to anchor the fly firmly.

This feature, combined with the innate advantage of six-leggedness, is clearly an asset. At each forward motion of the legs, three of the fly's feet remain in contact with the surface, so that the walking fly is supported by a tripod. And, as is well known to anyone who has done his share of summer swatter drill, a fly — on six legs or three — is always prepared for instantaneous take-off.



JUMP TAKE-OFF is caused by sudden disturbance as fly throws its front end violently into the air and at the same

moment begins to move its wings. Direction of fly's take-off varies according to source of the disturbance.

SYMBIOSIS:

Part II

AT THE PRESENT TIME, when travel into outer space seems increasingly possible, interest is rising over the question of life on the other planets of our solar system. "Scientist Finds New Evidence of Life on Mars," ran a recent headline. According to this account, Dr. William Sinton, of the Lowell Observatory at Flagstaff, Arizona, has been making spectroscopic studies of the red and green fourth planet. He has found that the wave lengths absorbed on its surface agree with the spectrum obtained from some forms of terrestrial plant life, notably the lichens.

Although Dr. Sinton is careful to point out that the spectroscopic findings do not necessarily imply the existence of actual lichens on Mars, many who have given attention to the problem hold the opinion that the lichens—more so than most other terrestrial plants—approximate the type of plant life most probably to be found in the Martian environment.

True, most of these expressions of opinion have come from astronomers rather than from botanists. But what is it about the lichens that qualifies these plants uniquely in the minds of space scientists, professional and amateur alike, for a foothold on the reddish Martian plains?

Most people who have noticed lichens at all have been impressed by the fact that many species grow on absolutely bare rock surfaces, often in such extremely exposed positions as mountain summits. These are, indeed, the hardest plants in existence: the lichens not only ascend to the highest altitudes, where rock surfaces project from the cover of eternal snow and ice; but also range closer to the earth's poles than any other form of plant life. On Admiral Byrd's second Antarctic Expedition, in 1934, Dr. Paul Siple found lichens as near as 237 miles to the South Pole.

In view of the frigid and inhospitable conditions known to exist on the surface of Mars, what then is more natural than to consider the lichens as



COLLECTING LICHENS, the author has traveled from Finland and Norway to Newfoundland in the north, and to the

Argentine Alps and Antarctica in the south. Above, he inspects an alpine variety, high on Vulcan Peak, Oregon.

The Remarkable Lichens

the class of plant organism most eminently qualified to grow there? Those botanists who have made a special study of the lichens would, on general principles, be in some measure of agreement with this assessment of their ability to survive the rigors of such a harsh environment. Of all the types of plant life which occur on our planet, with the possible exception of the bacteria and the blue-green algae, the lichens seem to be the best-fitted to cope with the combined conditions of aridity and low temperature known to be characteristic of the Martian climate. A terrestrial lichen, from alpine or polar habitat, might stand quite a good chance of survival if it were transplanted to Mars.

But, for the botanist, the question of whether lichens could ever have independently originated on Mars is quite another matter. In fact, a consideration of the nature and evolutionary origin of lichens makes the possibility of such an independent origin seem quite remote. For the lichen is *not* a single organism; instead, it represents the highest expression of symbiosis to be found among plants; and perhaps among *all* organisms.

Every lichen is part fungus: a plant without chlorophyll, and hence incapable of manufacturing its own foodstuffs by photosynthesis. This fungus, we find on examination, has evolved the ability to make use of the photosynthetic activity of another, quite unrelated, chlorophyll-bearing plant — one of the green or blue-green algae. And this partnership results in a compound organism — a nutritional unit — which behaves in a totally unfungus-like manner.

Among the lichens in existence today, we can find various stages of perfection in this fungus-alga union. These stages give us a picture, at least in approximate terms, of the various steps in the evolutionary development of this symbiotic life-form.

In the most primitive lichens, the assimilative body, or thallus, is a thin layer, spreading like a crust over a

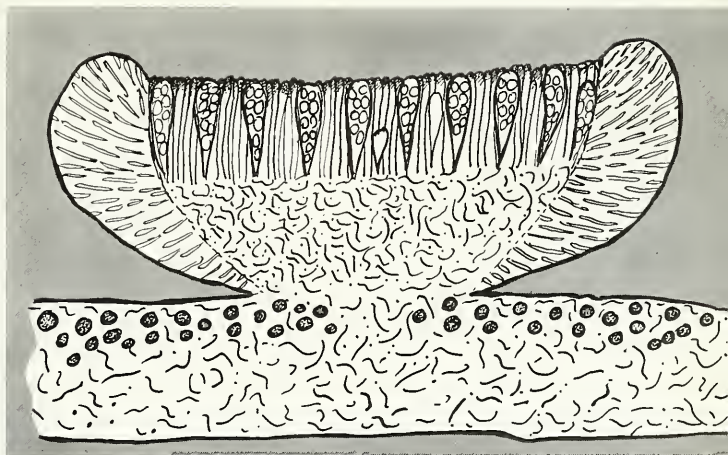
substratum — of rock, bark, wood or soil. This thin layer consists of fungal tissue, interspersed with the green algal symbionts. The latter may lie in a definite layer of their own, just below the fungal surface, or may be scattered uniformly throughout the thallus. The fungal hyphae embrace the associated algal cells tightly, by means of modified branches called "haustoria." In some species, these branches actually penetrate the alga cell wall, and so come into direct contact with its internal protoplasm. When growing on hard, unyielding substrata such as rock, lichens of this type frequently develop cracks that divide them into small island-like portions, not unlike the network of cracks that form on a dried-out mud surface. When the thallus is moistened, these "islands" swell up and come into contact.

In its most primitive form, such a crustose lichen thallus is merely a thin, scurfy coating over the substratum, the undifferentiated fungal hyphae interspersed with symbiotic algae. This condition probably approximates

closely to the structure of the earliest lichens. We can envision an evolutionary past, in which such an association of certain cup fungi with terrestrial algae — at first no doubt a fortuitous parasitic relationship — began to stabilize and become increasingly symbiotic in nature.

When and exactly how this symbiotic association of certain fungi with algae first took place, and the first lichens were formed, we do not know with certainty. Lichens do not fossilize readily, and although some fossils considered to be lichens have been recorded from Mesozoic sediments, the only ancient lichens of which we are sure come from relatively recent Cenozoic deposits, such as amber beds, and from Pleistocene peat formations in which some have been preserved in a subfossilized condition.

Our conclusions on lichen evolution must therefore be based on inductive speculation. One thing, at least, is clear: before the lichens evolved as a biological group, both the component organisms — fungus and alga — must



PRIMITIVE LICHEN, in cross section, shows purely fungal nature of the cup-shaped fruiting structure, *top*, with its

spore-sacs. Only the flat thallus, *bottom*, contains the algal symbionts that carry on the vital work of photosynthesis.

Dr. LAMB was educated at Edinburgh University and spent nearly a decade with the British Museum (Natural History). He is now Director of the Farlow Herbarium and Library at Harvard.

have already been in existence independently for some time.

Let us look at the varieties of available fungi. With a few exceptions, all of those that enter into the formation of lichens belong to the group known as Sac or Cup Fungi (*Ascomycetes*). In these, the reproductive process gives rise to spores, usually eight in number, enclosed in sacs called *asci*. In a typical *Ascomycete*, these sacs are grouped together in large numbers, in the form of a flat disk or plate, surrounded by a raised rim of sterile, protective tissue. The whole, saucer-shaped fruiting structure is termed the apothecium. And, in other *Ascomycetes* the sacs, instead, are borne inside closed, flask-shaped structures, the perithecia, that open to the outside by a narrow orifice.

Now, from the point of view of such fruit-body construction, the more primitive families of lichens have apothecia or perithecia of purely fungal composition, with the thallus alone containing the symbiotic algae. But, as the degree of interrelationship between the two organisms increases, we find in more highly evolved families, that the fruit bodies also have become equipped with algae — converted thereby into assimilative, as well as purely reproductive, organs. Such fruit bodies, clothed on their outer margin with a layer of alga-bearing thalline tissue, represent an evolutionary trend toward increasingly complete integration of the fungal and algal cohabitants.

Originally, the relationship of fungus to alga was probably that of parasite to host. Rapid destruction of the algal host, of course, would be tantamount to killing the goose that laid the golden egg. Natural selection must have operated in the direction to encourage a less virulent relationship, in which the fungus, although living off the earnings of its photosynthetic protégé, at least refrained from outrageously non-social behavior.

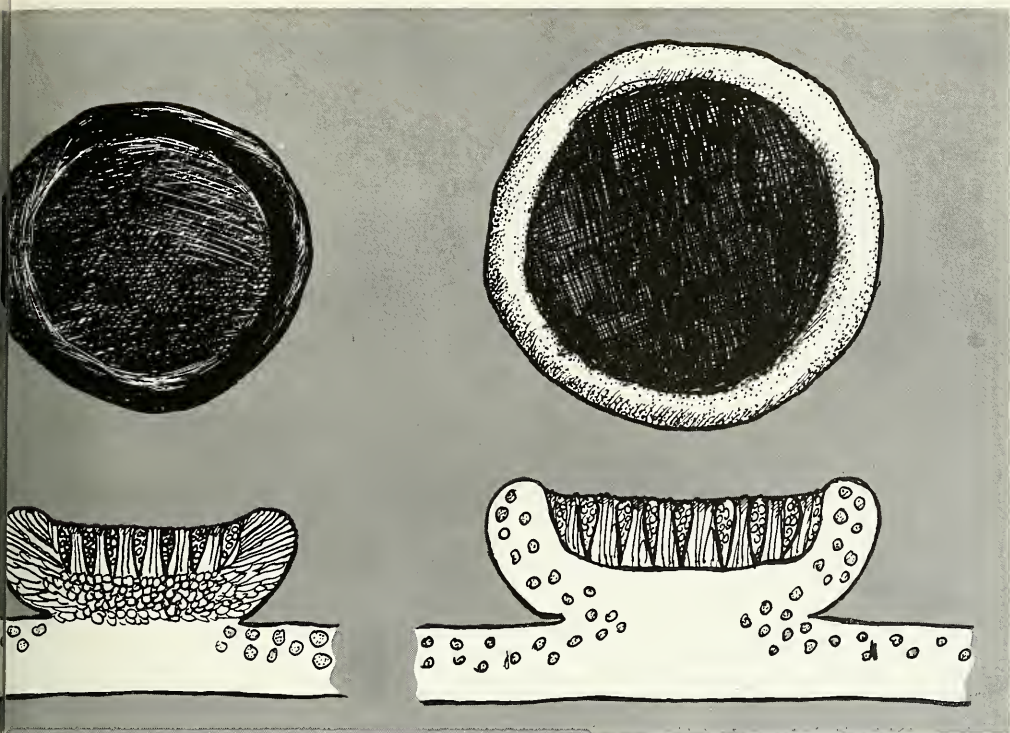
In a state of symbiosis, properly speaking, each organism offers the other certain compensatory advantages. What is the *quid pro quo* for the alga's life of unending captivity



FUNGUS MEMBERS of lichen partnership are usually of *Ascomycete* group, with reproductive systems like those shown, *above*, in top view and cross section. At

left is the flask-shaped variety of spore-sac container, with a narrow mouth. At center, is the typical primitive cup, totally fungal. Right, a more advanced

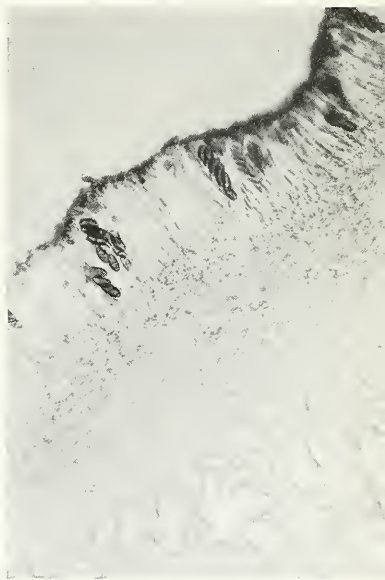
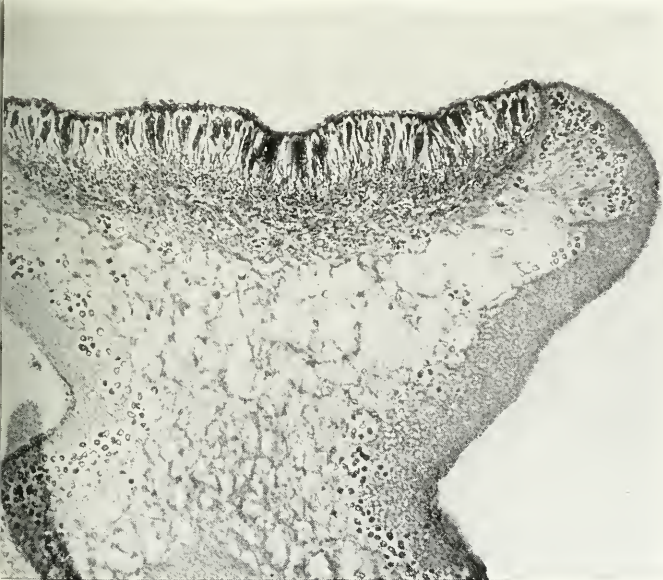


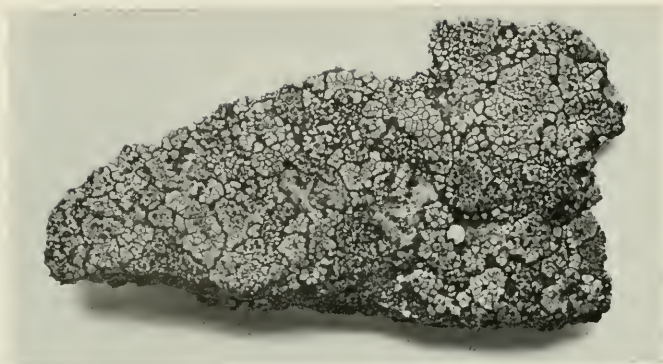


form, in which algae are included in the apothecium. The photographs, *below*, the work of Roman Vishniac, show, first, the cup-shaped fruiting bodies in

an early stage of development, their thick, toothed thalline margins in prominence. Next, in cross section, both algae and spore-sacs are readily distinguish-

able in the apothecium. Finally, spore-sacs are seen under high magnification. When spores land, they must acquire new algae partners to resume the symbiosis.





STRUCTURAL VARIETIES include the crustose lichens, such as *Rhizocarpon geographicum*, above, so named for its "island"-like divisions when it is dry.



OTHER FORMS: the foliose, "leafy" lichens, such as the edible Rock Tripe, *Umbilicaria*, above; and fruticose "shrubs," like "reindeer moss," below.



within the fungal thallus? Among the advantages are, first, protection against desiccation and harmful isolation. Secondly, the alga benefits from a more efficient extraction of mineral nutrients from the substratum, the work of the fungal hyphae.

SOME lichenologists regard lichen symbiosis, perfect though it is, as essentially nothing more than a controlled parasitism and speak of the alga, not in terms of symbiont, but as the algal host. Although this view may well be the correct one, in most lichens the host-parasite relationship — if such it truly is — has become so gentlemanly an affair that we are fully justified in applying the kindlier term, symbiosis. The alga remains in good health and multiplies normally within the thallus, even though it does so only by asexual means.

With very few exceptions, the algae do not, however, become intimately associated with the lichen's spores. This means that reproduction by ascospores transmits only the fungal element in the association. Thus, after landing and germinating, the further development of a new lichen from a spore is dependent on *chance encounter* with suitable algae, that can be accepted to form a new lichen thallus. Fortunately for the lichens, *Trebouxia*, the unicellular green alga which forms the symbiont of most lichen species, occurs in a number of different strains, not only within lichen thalli but also free-living — on bark, rocks and soil.

Propagation by spores, therefore, involves some elements of uncertainty, depending on encounter with suitable algal cells and re-establishment of the symbiotic association. It is therefore not surprising that many lichens, in addition to ascospore formation or sometimes as substitute for it, have evolved other, more sure-fire methods of dissemination — purely vegetative in nature and analogous to multiplication by bulbs and tubers in the higher plants — which have the substantial advantage of propagating the dual organism as a single unit.

On the thallus of certain lichens, for example, minute, cylindrical or club-shaped branchlets are produced in large numbers. Each contains a layer of algae covered by a rind, or cortex of fungal tissue. These tiny outgrowths are very easily detached by abrasion or wind action and each

is, in fact, a miniature, prefabricated thallus — which can start its growth from the moment that it arrives in a suitable environment.

Even more effective from the point of view of dispersal is a second type. These are powdery masses of tiny particles, each consisting of a few algal cells loosely enmeshed in fungal hyphae. Because of their small size, these particles are very readily transported by wind, and probably represent the most effective type of dispersal found in the lichens.

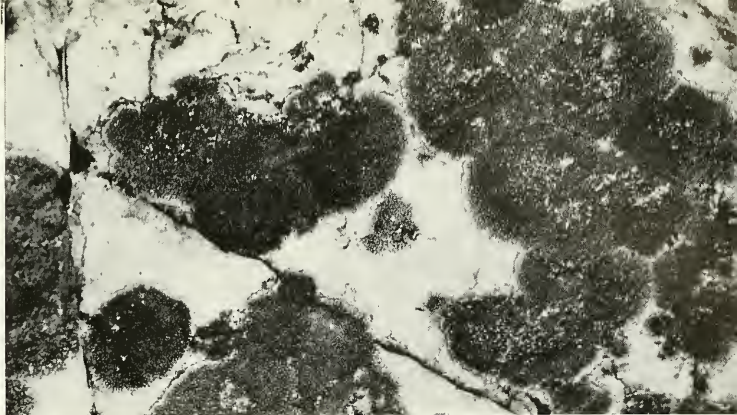
Nevertheless, the fact that very many species of lichens possess neither of these accessory means of propagation, and yet are of widespread occurrence, proves that spore dissemination — despite its handicaps — must be quite effective.

When a fungus has become photosynthetic by proxy, so to speak, as in the case of the lichenized *Ascomycetes*, it is subjected to the same influences of natural selection as operate on naturally green, chlorophyll-containing plants. It can no longer grow in darkness or dense shade, but requires the wide open spaces, or at least the more open parts of woodland habitats.

But this is not all: natural selection also comes to favor the genetic fixation of structural modifications that promote the efficiency of photosynthesis. An increase in the area of assimilative surface exposed to light and air is brought about by elongation of the thallus into extended, branching forms, and often also by the formation of special assimilative branchlets or scales — analogous to leafy structures in the higher green plants. The Reindeer Lichen (*Cladonia rangiferina* and related species), which covers countless square miles of the tundras of the north, and forms the staple diet of the caribou, is a good example of this elongated, shrubby form.

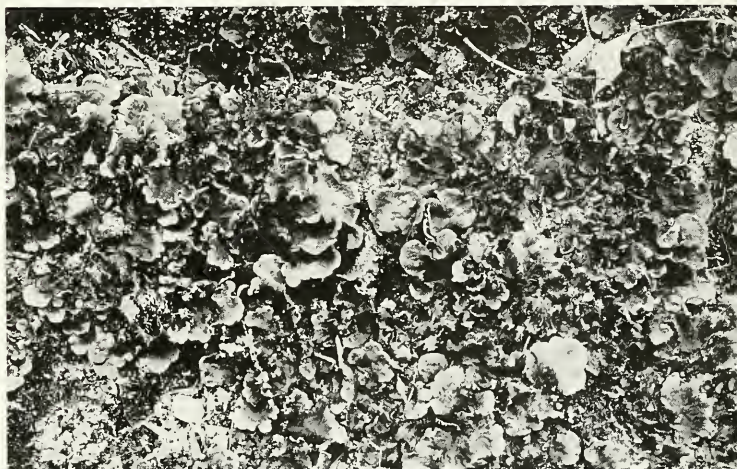
OTHER LICHENS, presumably by the action of the same selective factors, have evolved flattened, leaflike forms, with the greatest possible area of assimilative, alga-bearing tissue exposed to the rays of the sun.

In highly differentiated lichens of these types, we find the algae now relegated to a special position — in a thin layer immediately below the outer surface of the thallus, covered only by a relatively thin protective layer of fungal tissue — where they can function with maximum efficiency.



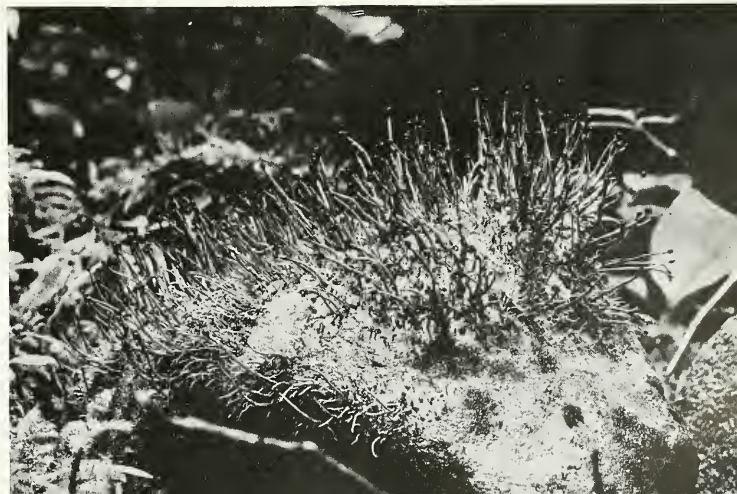
CRUSTOSE LICHEN, *Rinodina oreina*, grows on rock, above. This specimen

is near the summit of Mt. Monadnock. The "island"-like divisions are apparent.



FOLIOSE LICHEN, *Peltigera*, above, grows on mossy tree-trunk. Transition to

the fruticose form is exemplified by the Matchstick Lichen, *Pilophorus*, below.



Equal in importance to these structural effects of symbiosis are the physiological results of the co-ordinated existence of the two dissimilar organisms. Now, a fungus — by itself — must exist either as a parasite, growing on another plant from which it extracts the foodstuffs produced by the latter's metabolism, or as a saprobe, living on decaying organic matter which supplies it with the necessary substances for its nutrition. In both cases, it is closely bound to certain specific types of habitat. Once lichenized, however, a fungus carries its photosynthetic food source within its own tissues, and becomes a self-contained nutritional unit. So far as metabolism is concerned, its needs are now satisfied by the minimal requirements of light, air, and a few inorganic salts. No longer restricted to larger host plants, or to accumulations of decaying debris, the lichenized fungus is in a position to colonize such inhospitable substrata as bare rock surfaces. This gives it an open field for exploitation, with a minimum amount of competition from other forms of plant life.

BRIEF MENTION appears suitable, in this connection, of certain species of lichen in which not one, but two, types of algae are found in association. The second is always one of the blue-

green type, *Myxophyceae*, occurring in localized tumor-like outgrowths on the thallus, called *cephalodia*. A number of blue-green algae have been proved capable of fixing atmospheric nitrogen; if this capability is exercised on behalf of the lichens that possess *cephalodia*, it *could* be as useful as are the nitrogen-fixing root nodules of the various legumes in the case of higher plants.

As an additional advantage in these bleak habitats, or perhaps as an adaptation to them, the lichens have evolved a remarkable degree of resistance to drought and desiccation. They can go into long periods of suspended growth in a completely dry condition, and can imbibe the little moisture which they need from saturated air and dew, as well as from direct rainfall.

Considerable tolerance to low temperature is also shown by many polar and alpine lichens. When in Antarctica, I saw lichens—apparently healthy and abundantly fruiting—which passed their existence under a cover of snow and ice several feet thick for nearly ten months each year. Other lichens, perhaps even more resistant to cold, grow on the wind-blasted faces of completely exposed rocky nunataks, high up on the continental plateau. Here, a summer's day on which the temperature rises more than a degree

or two above freezing is the exception rather than the rule; the temperatures which these lichens tolerate, without benefit of snow cover, throughout the long winter, are even more extreme.

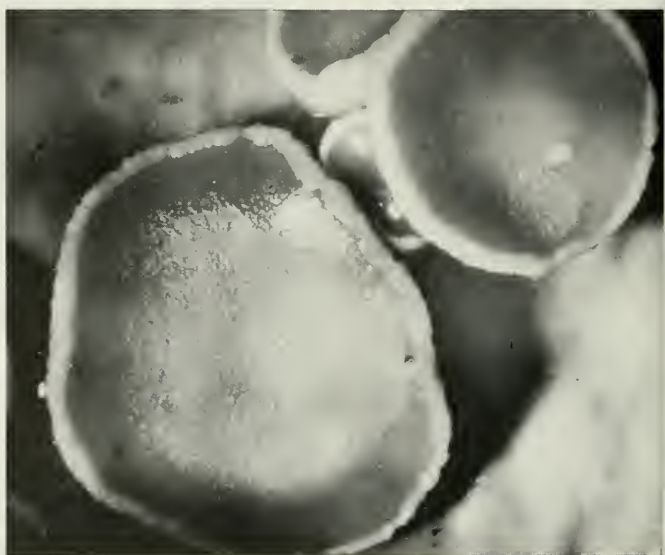
TO RETURN, then, to our opening speculations: what more suitable organisms than the lichens, in all our terrestrial plant world, for the Martian climate? Self-contained and self-supporting; highly resistant to dryness and to cold; capable, whenever conditions become frankly impossible, of almost complete suspension of growth and activity over considerable periods, they seem ideally suited.

But no matter how attractive such speculations may be, we must face the fact that the lichens are not primeval plants, but, instead, represent a successful union of (geologically speaking) comparatively recent date, long after the independent evolution of specialized, modern types of both algae and fungi. The crux of the matter is that, of the two organisms forming the biological association we know as the lichen, the fungi at least must have known millions of years of life in a temperate, moist climate, with abundant organic matter from other vegetation for their nutrition, before they, at last, became lichenized and branched off as a separate group.

ROBUST LICHENS can survive extreme aridity and cold. *Below*, the fruiting bodies of *Lobaria* are seen, during a dry

spell and after rainfall. At right is the most notable of the shrublike lichens, *Cladonia rangiferina*, better known as

"reindeer moss." Staple diet for the caribou, this hardy variety covers countless square miles of the subarctic tundra.







TOO YOUNG TO FEAR HUMANS, the baby skunk, *above*, allows itself to be fondled by an eleven-year-old playmate. Although brought up in the city, girl now knows common animals as

intimately as most country children, has favorites she often returns to visit, and has come to recognize their special feel—like the soft fur and prickly claws of this skunk.



BABY POSSUM BARES TEETH to one young visitor, evidently displeased by having its tail stroked and not a bit disposed to "play possum." By trial, error and perhaps a few nipped

fingertips, children learn the animals' reactions. They also meet animal families they otherwise might not know at such close range: opossum is North America's only marsupial.

CHILD AND NATURE

**Nothing quite takes the place of personal contact:
the reader is here invited to share the experience**

Photographs by **ARLINE STRONG**

TO GROW FAMILIAR with the world around us, in our hurried lives today, we necessarily place primary reliance on the written word—from the textbooks at school to the flood of newspapers, magazines and books that are part of adult life. Learning, in this secondary fashion—where we accept the observations of others—has tremendous advantages: ease, speed and a wide variety of experience that no one person could hope to equal. Yet, when this secondary learning is our sole reliance, we are robbed of a great deal: in particular, the enrichment that comes from personal observation, and its accompaniment of tangible experience, against which we may judge for ourselves the reported experiences of others.

This use of our own senses is of value in any field of

inquiry, but it may be that it is nowhere of greater value than in the study of nature or more vividly demonstrated than with young students. Take a child—or a group of children—for a walk outdoors—in a city park or to the edge of country woods, along the shore of a pond or the ocean's sandy fringe. Go slowly, and stop frequently—not only to look, but to listen, to touch, to smell and taste. The contents of your pockets, on return, may seem to be a mixed and worthless accumulation of leaves, sticks, stones, shells and even living things, such as insects, but in the child's view these are an assortment of rare treasures!

Excerpted here, under the headings of the different senses, are some children's comments following such direct observation. In some cases, the children had been in out-



STROKING A BIRD, the girl *above* also listens to a record of its song over a speaker. The silken feathers and sprightly song help to recreate the living unity of the woodland world.

door groups: in others, their experiences came from contact with plants and animals at THE AMERICAN MUSEUM'S Peter Van Gerbig Natural Science Center for Young People where the accompanying photographs were made. The remarks, themselves, were recorded by Mrs. Martin Goldwasser, of the Natural Science Center.

SEEING: "the shiny wet backs of water turtles, swimming: slow movements of large land turtles, lumbering along. A toad's jeweled eyes. The whipping movement of a frog's tongue—too fast to see—and a snake's forked tongue, darting in and out. A tiger salamander, leaping for his dinner. Herring gulls, soaring against the blue: mallards sailing beside their own reflections."

HEARING: "the screech owl—buzzing a low, clattering buzz. The splash of turtles, diving from their logs. Swishes of snakes, rustling through deep grass: so quickly, they're heard and then gone into the quiet. Croaks of hungry frogs, like the noise of the brook that was theirs. And the first sounds of Spring, remember? The shrill noise in the marshes when the spring peepers mate? The fiddler crabs, shuffling across loose sand: the seaweed that pops

A TINY NATURALIST inspects a wood turtle, *below*, as a staff member lends helping hand. The "turtle-sandwich," as children call turtle with head withdrawn, is a perennial favorite.



in your fingers, where the green crabs hide. The trill of crickets on a hot afternoon."

TOUCHING: "the soft, silky fur of the skunk: the stiff, coarse hairs of the woodchuck. Slimy skins of frogs and warty skins of toads. Hard bodies of wet turtles, thrashing eathery legs between their sandwich shells. The smooth skin of a black snake, tightening its coils about my arm."

SMELLING: "musk . . . you can always tell a gartersnake from a DeKay's. Stale, musty odors from the owl: it was good we released him—he was cooped-up too much. Fishy smells along the shore and seaweed in the sun. Wood smells in the rain . . . moss and earth. and rotting logs."

TASTING: "the disappointing flatness of the maple sap, but the sweet syrup when we boiled it down. The emony taste of 'Indian chewing gum': remember the resin oozing from the hemlocks in Bronx Park? Wintergreen flavor in the birch, too. And (What's the mitten tree? The sassafras!) the sassafras leaves under the George Washington Bridge. Yum! And the tang of the wild onion there. And water! No taste, but so cool."

A PILOT BLACK SNAKE has aroused the timid curiosity of this boy, *below*, who finds, to his surprise, that its dry skin is smooth, not slimy, and quite pleasant to the touch.

ANIMAL SOUNDS



NATURAL SCIENCE CENTER of New York's AMERICAN MUSEUM has two sound systems, public address (*opposite page*) and earphones, *above*, to bring the world of nature to city children.





GRAND CANYON OF THE COLORADO



First discovered by a Spaniard who sought the seven cities of Cibola, this classic example of erosion and weathering is now our best-known National Park

THIS IS the scene which, in 1540, burst upon the startled eyes of Cárdenas, the first white man ever to see the Grand Canyon. He was searching for the mythical seven golden cities of Cibola, and neither admired the view nor asked how it came there. Instead, he merely turned aside to pursue elsewhere his fruitless quest. Nearly three centuries were to pass before the sight was seen again by men disinterested enough for either aesthetic appreciation or scientific curiosity.

Most visitors today experience at least a modicum of both. For this is also the vista which many tourists first see—at Yavapai Point, on the South Rim. Most are stunned into silence, and many simply go away, carrying with them an unforgettable picture. Some may exclaim—as the startled cowboy is said to have done—“Something happened here!” Or they may demand, in the idiom of the moment, “What done it?” To this question, the simplest answer is “The Colorado River.” For this mighty stream flows through the Canyon, nearly a mile below the rim, and so deep within its narrow, black, inner gorge that it cannot be seen at all from most points along the Canyon’s edge.

Some Indian tribes have a different story of the Canyon’s origin. It was, they say, opened by the gods to furnish a passage from this world to the next. The guesses of today’s visitors are often equally unrealistic: one favorite is that the Canyon is a crack, formed when the earth cooled. But the fossil record of the successive layers of the Canyon’s walls proves clearly enough that the earth was not hot when these rocks were laid down. Only the mighty river, given aeons of time, could have sliced so neatly through this vast layer cake—itsself composed of rocks laid down by water and wind during a stretch of time that makes the aeons required for the cutting seem only a moment.

Did, then, the river once run up on top, where the visitor now stands? Certainly not. From every direction, he must climb a high, domed plateau to the rim. The river could never have been where the rim is now, unless its waters had run uphill. Only one explanation is possible. The Colorado once meandered over a flat plain, its bed at just about the same height above sea level that it is today. Slowly, the land rose until it, even more slowly than the silt-and-sand-laden river cut downward. Had the land risen faster, the waters would have been dumped the shortest way down its sides. Instead, the waters kept their bed, so that the Canyon still follows the ancient meanderings of the once sluggish stream. When did the cutting begin? A few million years ago, the geologists say. How old are the rocks of the inner gorge, through which the Colorado River now flows? These rocks were new, so the same geologists tell us, more than a billion years ago.

DR. KRUTCH, a student and teacher of English literature and the drama in New York for many years, has resided in Arizona since 1952. He published *The Voice of the Desert* in 1955; a book on the Grand Canyon is now in preparation.

THIS is the river that did the work, the Colorado pushing toward its ultimate rendezvous with the Gulf of California. Its swirling, silt-laden waters are now locked within the high banks of the Inner Gorge, a world of granite from which the high rims of the Canyon, itself, are seldom visible. Of the thousands who visit the Grand Canyon each year, few ever leave the rim to venture this far—in distance, a descent of a mile, and in time, a day's journey. Yet these few are richly rewarded for their effort, as will be seen here.





THE WIDTH of the Canyon, on an average, is about eight miles. We look from Bright Angel Point on the North Rim. On the horizon, beyond the knifelike edge of the South Rim, rise the volcanic San Francisco peaks, more than twelve thousand feet above sea level. The Canyon's size increases, day by day, as water and ice detach bits and

boulders, which tumble, sometimes with a crash, into the depths below. The result: this intricately sculptured world of buttes, "towers" and "temples." The geologist's prosaic term for the process is "differential weathering." What he means is that, because each successive layer of stone differs in texture and hardness, each wears away at a different rate.



SHALL WE CROSS the Canyon? It is only ten miles as the raven flies, but no other ten miles is so long. By car, the only possible route will take you two hundred miles around the east end of the Canyon, and then back to a point ten miles from where you started—and that wide detour is the quickest way. On mule-back, down one side, across the only foot bridge over the Colorado River, and up the other

side is a strenuous two-day journey, during which a billion years or more of the earth's history is exposed. At the rim, the surface is Kaibab limestone, laid down under a shallow sea something like two hundred million years ago, *above*. At the bridge, near the bottom of the inner gorge, *right*, the Colorado River is now cutting into some of the most ancient rocks exposed anywhere on the face of the earth.





ONCE ACROSS the river, the weary may bathe in this pool, *left*, filled by Bright Angel Creek, and look back to the rim from which they have descended, where the upper layer (of Kaibab limestone) is plainly separate from the underlying Coconino sandstone. And, once within the Grand Canyon's gorges, other sights are available to the traveler. Closed snugly in by the walls of a branch canyon, for example, is an astonishing oasis, inhabited by what is probably the most isolated group of aborigines in the United States—the Havasupai. A Franciscan missionary, Father Garces, was the first to find them there—in a year generally remembered for other reasons, 1776. They are still there today, *below*, living much the same life they lived then—although Government agents have taught them certain improvements in their methods of agriculture. Their village is composed of only some thirty-four families—and this number has changed little since Father Garces' time. Their fields and orchards are watered abundantly by Havasu Creek—one of a number of streams that enter the Grand Canyon to pour their clear waters into the turbid Colorado. A few miles below the ancestral fields of the Havasupai, the Creek drops over travertine ledges to fall one hundred and ten feet into the jeweled, blue-green pool below, *right*.





Shadow And Sun
Create A New Vista
At Every Hour



ASCENDING AGAIN, those who elect to visit the North Rim the hard way must climb a trail that follows the side canyon cut by the waters of Bright Angel Creek, where yesterday they bathed. It is not easy going, but the trail leads through such spectacular scenes as "The Devil's Backyard," *upper left*. Once at the North Rim, the visitors discover a startlingly different world, for—although the strata of the Grand Canyon are perfectly matched on the two sides—this rim is a thousand feet higher. The North Rim is cooler in summer, much colder (and snow-blocked) in winter, and—chiefly because of the more abundant precipitation—bears a dense forest of yellow pine and fir, in contrast

to the sparse piñon pine of the South Rim, *lower left*. Here, the Canyon, itself, even "looks" different, largely because the Colorado River lies farther away, while the various buttes, "towers" and "temples"—which erosion has detached from the rim—are close at hand.

The rocks of Grand Canyon have been at least a billion years in the making, and the Canyon itself several million: it has changed little since the white man first saw it. But it is equally true to say that it changes from moment to moment. Every hour seems to reshape each plateau, butte and side canyon as the shadows change the relief of its sculpturings: at twilight, *below*, it takes on new mystery.





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IN BRIEF (continued from page 62)

an invaluable text and reference work for some time to come.

GUIDE TO THE FISHES OF NEW MEXICO by William J. Koster (*University of New Mexico Press, \$1.00; 116 pp., illus.*)

PUBLISHED in co-operation with the New Mexico Department of Game and Fish, this is a guide to the eighty-five species of fish found in that state. There are drawings to aid identification and the descriptions of the principle species are thorough, and clearly written. A reliable guide for sportsmen and naturalists alike and, incidentally, some good preliminary comments on fish requirements and conservation problems.

FISHES OF THE WORLD by Edouard Le Danois (*Countryside Press, \$12.50; 190 pp., illus.*)

AN extremely handsome book, which anyone should be proud to own. The accompanying text, while factual and learned enough, evidently suffers in translation from the French and often seems vague and awkwardly written. But the photographs, from numerous sources and most areas of the world, are superb, especially the color reproductions.

STRANGE WONDERS OF THE SEA translated and adapted from J. Forest's *Beautés du fond des mers* by H.

Gwynne Vevers (*Hanover House \$4.95; 96 pp., illus.*)

SOME interesting black and white photographs, some beautiful ones in color of sea anemones and corals. For unknown reasons, one has to turn to the appendix for captions to the color plates. The captions too often seem inadequate as descriptions of the animal in the pictures, and the book is perhaps not as imaginatively assembled as its companion volume, *Exotic Plants of the World* (see below), but it would be a nice one to own.

Paleontology

AN ILLUSTRATED GUIDE TO FOSSIL COLLECTING by Richard Casanova (*Naturegraph Co., \$1.50; 78 pp.*)

A USEFUL little pamphlet for the amateur fossil collector, telling where to look and how to classify. There is a brief history of fossil collectors, and sections on classification, on the geologic time scale, and on preparation and display. Collecting localities also are listed, state by state, but only in a very general fashion. It is conveniently illustrated.

Botany

EXOTIC PLANTS OF THE WORLD translated and adapted from Marcel Belvianes' *Beautés de la Flore Exotique* by Anthony J. Huxley. (*Han-*

EXHIBITIONS OF INTEREST

CINCINNATI PUBLIC LIBRARY (through February 8): 100 photographs of Scandinavian Bronze Age rock carvings.

HUNTER GALLERY, Chattanooga (through February 16): "The Anatomy of Nature," photographs by Andreas Feininger.

NEW YORK STATE MUSEUM, Albany (through February): "Wild Animal Photographs," the work of Charles Ott, McKinley Park, Alaska.

PEABODY MUSEUM, Cambridge, Mass. (permanent): a new exhibit of Middle American archeology, including pottery, gold, jade and sculpture (see photograph).

ILLINOIS STATE MUSEUM, Springfield (permanent): the second of three casts of *Latimeria chalumnae*, the Comoro coelacanth, made available to U.S. museums by the Paris Natural History Museum (NATURAL HISTORY, September, 1957).

U.S. NATIONAL MUSEUM, Washington (permanent): a new North American Indian Hall, opened in December, 1957; also, the third cast of *Latimeria*.





Exploring by Satellite

ver House, \$4.95; 93 pp., illus.)

THE choice of photographs in this book is aesthetically motivated, and the descriptive material is held down to captions, plus a brief introduction to each group shown—the orchids, some cacti and other succulents, marvels of form, plants at high altitude, and caves. The photographs, on the whole, are striking and well reproduced. Some of the flowers of Africa seem not only exotic but downright animal-like to eyes accustomed to the Temperate Zone of North America.

ORCHIDS FOR EVERYBODY by Lee Wickham. (McBride Co., \$5.00; 63 p., illus.)

THE author of this book had the chance to give us some solid information about orchids, but on the whole he muffed it: "muffled it" may be a better phrase. "The Secret of Hidden Paradise Unfolded," as the last chapter is titled, contains some practical talk on orchid culture. Otherwise the book is lost under a steamy blanket of sentimental and fake-religious verbiage. There is one such sentence: "All of the orchids, wherever they live and by whatever ways, are loyal to the royal within them." The photographs, all at the end are poor, and badly reproduced.

BE YOUR OWN NURSERYMAN by Robert Scharff. (M. Barrows & Co., \$3.50; 223 pp., illus.)

A PRACTICAL book, with many useful directions on how to grow new shrubs from old, how to plant in the right place, how to transplant and graft, and how to maintain your own nursery economically.

Astronomy

ARIZONA'S METEORITE CRATER by H. H. Nininger. (American Meteorite Museum, \$3.75; 232 pp., illus.)

THE author, director of the American Meteorite Museum Staff in Sedona, Arizona, has packed this book with information of value both to the student of meteorites in general and to students of the celebrated Arizona crater, itself. Some laymen may find it hard going; well worth the effort, though, for those interested in the subject.

EXPLORING BY SATELLITE by Franklyn M. Branley, with illustrations by Helmut K. Wimmer. (Crowell Company, \$3.00; 41 pp.)

THIS very timely book was evidently not written in haste but in its own good time, with care and clarity, by an associate astronomer of THE AMERICAN MUSEUM—HAYDEN PLANETARIUM. Expert illustrations, and an account of satellite construction (Project Vanguard is the inevitable prototype), the theory of satellite flight, and its potentialities.

CONSTRUCTING AN ASTRONOMICAL TELESCOPE by G. Matthewson. (Philosophical Library, \$3.00; 97 pp.)

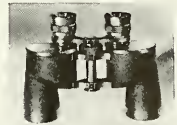
A STRICTLY practical, tersely written little book for those interested in making telescopes "without involving a large capital outlay." Useful drawings, chapters on grinding, polishing, testing, figuring, parabolizing and silvering, plus a brief discussion of prism and eyepiece, and how to build and mount your telescope.

Anthropology

ANTHROPOLOGY AND HUMAN NATURE by M. F. Ashley Montagu (Porter Sargent, \$6.00; 390 pp.)

THE expressed purpose of Professor Montagu's book is to show how physical and cultural anthropology increasingly extend the body of human knowledge and understanding. The papers which comprise the book have a great deal of material in them: a kind of pot-pourri, sometimes repetitions and not always unified, but usually provocative. The author's basic premise is that what divides mankind is not so constant as what unites it, and that the behavioral sciences will lead to a better understanding of that constancy.

MR. HAY, president of the Cape Cod Junior Museum, is a Harvard alumnus, active in natural history education.



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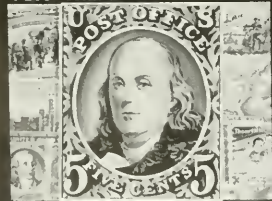
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Letters (continued from page 57)

essed special glands in the pads of the forefeet, which exude a substance used by the animals to aid digestion I must, however, add both that I can find no record of such glands existing and that the bears which I observe, sucked their feet as often before meal—when the stomach was empty—as they did afterwards.

A final suggestion, more amusing than probable, was that the bear "talked" to each other in this way. Although I have noticed that all the animals—and I have kept five of them together—started sucking simultaneously, the animals, when alone, would also suck their paws regularly, and it can be assumed that such a bear was not "talking" to itself.

As I have not kept any other species of bear, I do not know whether paw sucking is a general habit of all bear or a peculiarity confined to the Himalayan black bear.

I shall be very grateful if you can enlighten me on this point.

SAMIR SE

Darjeeling, India

THE DEPARTMENT OF MAMMALS replies

Paw-sucking among bears has been observed on various occasions, in number of modified forms, but it is practice apparently indulged in by very few individual bears. Many men who have been associated with captive bear for years have never witnessed the ac-

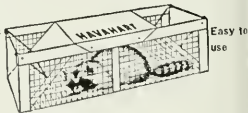
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PHOTOGRAPH SHOWS APPEARANCE OF "DRY VALLEY" AT TIME OF DISCOVERY BY SCOTT EXPEDITION. CENTER IS LAKE BONNEY.

"DRY VALLEY"

This Antarctic bare spot has remained the same for a half century

By WALTER SULLIVAN

ANTARCTICA is a continent blanketed beneath the greatest ice sheet on our planet. Exploration in recent years has indicated that, in places, the ice is several miles thick. Any appreciable melting of this white crust would raise the earth's oceans enough to flood many continental shore lines, cities and agricultural lands.

Hence, one of the goals of exploration during the International Geophysical Year is to establish a basis for future determination of growth or shrinkage of Antarctica's ice sheet. It is interesting to note that earlier exploration of the Antarctic has furnished at least one place where immediate comparison is possible.

This is the "Dry Valley"—discovered by the British explorer, Robert Falcon Scott, as he descended from the ice sheet plateau in 1903. This expedition was prelude to his ill-fated race to the South Pole in 1911-12. In a world of blizzards, he found this valley nearly free of ice and snow.

Evidence that the then-empty valley had once been filled with ice was etched on the valley walls, up to 3,000 feet above Scott and his two companions. "Hanging glaciers" crept down them, like waterfalls frozen in mid-air, but the

force of ice behind them was no longer enough to push the glaciers out over the valley floor—dramatic proof that the ice sheet had shrunken from a former maximum.

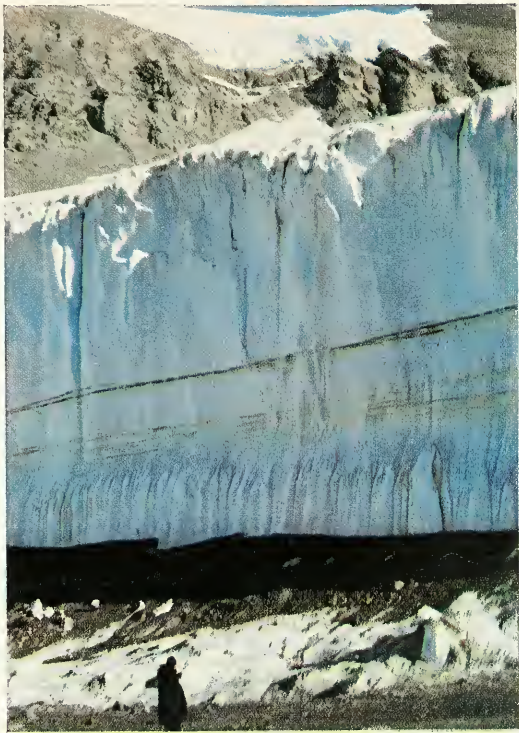
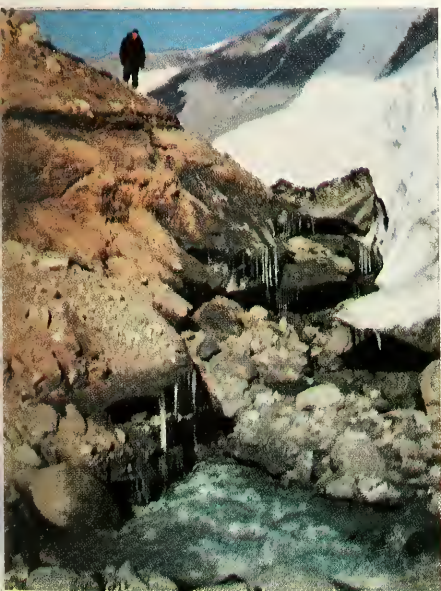
To see if there was any evidence of change since Scott's day, the author, in 1957, visited "Dry Valley" in a helicopter of *Operation Deep Freeze*, the Navy's I.G.Y. expedition to Antarctica. As shown by comparison of the 1957 photograph (taken from the helicopter) with that taken some fifty years ago by the Scott expedition, there seems to have been little or no change in "Dry Valley." Even the smallest patches of snow and ice seem to be of the same size as a half-century earlier. At the head of the valley, the snout of Taylor Glacier ends at the edge of Lake Bonney, just as it did when Scott descended the glacier from the hinterland ice plateau. But this is a single case. Only the I.G.Y.'s subsequent studies can tell us if the stagnant condition of "Dry Valley" is typical of all Antarctica.

MR. SULLIVAN, of *The New York Times*, went to Antarctica with the U.S. Navy's 1956-57 I.G.Y. expedition, and was responsible for the visit to "Dry Valley" here reported.



AERIAL VIEW (1957) SHOWS VALLEY ESSENTIALLY UNCHANGED, WITH ITS "HANGING GLACIERS" NEITHER LARGER NOR SMALLER.

TAYLOR GLACIER now terminates at the head of "Dry Valley," which it formerly filled. Under its flank, *below*, a melt-water stream has carved a channel. The lofty ice-cliff, *right*, is the glacier's "snout," and the horizontal bands show where debris—probably ash from volcanic eruptions—covered its onetime surface.





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Visitors will always be grateful to the ladies of the Natchez Garden Clubs, who have remembered and restored the splendor of a golden age in our nation's history. They have made it a living part of the heritage of *all* Americans.

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Letters

Nuée Ardente

SIRS:
Mr. M. I. Adnawidjaja's letter (NATURAL HISTORY, January, 1958) mentions the "ash whirlstorms" which have come from Mount Merapi in Java in the last year. I would like to point out that such "ash whirlstorms" have been observed in many volcanic outbursts. The first detailed description dates to 1902 and refers to the terrific *nuée ardente* which was produced on May 8 of that year by the Mount Pelée eruption in Martinique. In textbooks on geology, eruptions of this kind are therefore called "pelean" or "glowing avalanches."

In Java they have been observed many times, in particular with eruptions of Mount Merapi, and also with that of the Agung in 1919. Before 1932, in fact, they had been studied in detail by Dr. G. L. J. Kemmerling, staff geologist of the Geological Service of the former Government Geological Survey. During a visit to the Netherlands, Dr. Kemmerling came to see me at the time I was professor of aero- and hydrodynamics at the Technical University of Delft, and we had occasion to discuss the peculiar features of this phenomenon.

The material flowing down the mountain is a mixture of volcanic ashes and spalls with hot gases, in a state of high turbulence. The presence of these gases gives a degree of fluidity which permits the material to flow down the slope of the mountain under the influence of its specific gravity, which, of course, is much higher than that of the surrounding air. Steam constantly escapes from the material and causes the cloud above. In consequence of the relatively high density of the material and its high

speed, the avalanche's kinetic energy is so great that the flow is only slightly deviated from its course by accidental features of the terrain: it moves on, almost irrespective of ridges and valleys.

J. M. BURGERS

Institute for Fluid Dynamics and
Applied Mathematics
University of Maryland

Big Bone

SIRS:

I enclose a photograph (*below*) of what I assume to be the humerus, probably of a *Brachiosaurus*, discovered by friends of mine in the famous Morrison formation (Upper Jurassic), west of Delta, Colorado.

My friends, Mr. and Mrs. Eddie Jones, of Delta, came upon this specimen completely buried and in perfect condition within its original bed of clay. They are part-time prospectors, not fossil hunters, and were led to their find by Geiger counter: much of the bone contains uranium ore. Not realizing that a bone that is an inch over seven feet in length, and two feet, two inches wide at its broadest end, was particularly remarkable, the Joneses pried it up with a crowbar and carried the biggest pieces home with them as ore.

I have heard (but cannot vouch for) tales of uranium prospectors finding even bigger bones than this one. In the case of this particular find, I am happy to report, the U. S. National Museum will be the ultimate custodian. But who can say how many similar accidental discoveries have never been reported?

Meanwhile, the Joneses and I, and quite a few local people would like to know whether Eddie has the biggest dinosaur leg bone ever found and, if not, where is there a larger one?

CRESSON KEARNY

Montrose, Colorado

THE DEPARTMENT OF GEOLOGY AND PALEONTOLOGY replies:

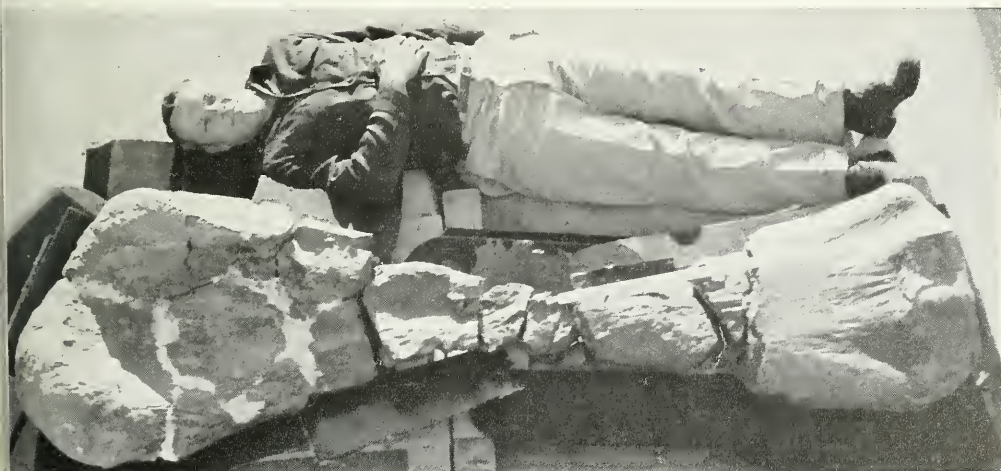
Give Mr. and Mrs. Jones a solid "A+" for having found one of the largest (if not the largest) dinosaur leg bones to be reported.

From the photograph it is quite evident that the bone is a left humerus (the upper arm bone) of *Brachiosaurus*, the greatest of the gigantic, swamp-dwelling dinosaurs. *Brachiosaurus* was not as long an animal as some of the other giant swamp-dwellers but it was a very bulky one.

In almost all of the dinosaurs, the hind limbs were larger and longer than the front limbs—a reflection of the fact that the reptilian ancestors of the dinosaurs were active, bipedal animals that ran round on rather birdlike hind legs. But in *Brachiosaurus*, just to make things confusing, the front limbs are larger than the hind limbs. Thus, this dinosaur had an elevated shoulder region, and the back sloped, giraffe-fashion, to a hip region that was lower than the shoulders.

The only *Brachiosaurus* skeleton on exhibition is one in the Berlin Museum, this specimen having been found in East Africa shortly before World War I. It is impressively large and, as mounted, the skull looks down upon the footsore museum visitor from a height of about forty feet.

From the literature, it appears that the Berlin specimen has a humerus slightly less than two meters—say about six-and-a-half feet—in length. A *Brachiosaurus* humerus, excavated in Colorado by the Chicago Natural History Museum a half-century ago, is 2.04 meters in length—a little over six feet, eight inches. So it is quite possible that the Joneses' seven-foot-plus humerus is, indeed, a record breaker.



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March, 1958

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THE SEASHELLS, above, specially photographed for NATURAL HISTORY by LEE BOLTIN, are the hard parts of five animals that belong to two separate Classes of the Phylum Mollusca. The cap-shaped shells are "true" limpets, of the Class Gastropoda; the elongated ones are chitons, of the Class Polyplacophora.

"Like things belong together": on this principle, the ancients began to classify things in the world around them. The ordering of life-forms into such groups and classes continues to occupy many kinds of scientists today, as they seek new clues to the tangled record of five-hundred million years of evolution. For the history of one such search, that has recently brought about a new arrangement of the Phylum Mollusca, turn to page 148.

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Reviews

HOW THE ANIMALS GOT TO WHERE WE NOW FIND THEM

Reviewed by
GEORGE GAYLORD SIMPSON

ZOOGEOGRAPHY. The Geographical Distribution of Animals, by Philip J. Darlington. John Wiley, New York; \$15.00; xi + 675 pages; 80 text figs.

WHEN CHARLES DARWIN—a young naturalist on H.M.S. "Beagle"—visited the Falkland Islands en route to the Pacific, he noted the presence there of a special kind of fox. Although obviously similar, in some way related, to the foxes of the adjacent Patagonian mainland, the Falkland fox was a distinct and peculiar species. Later in the voyage, Darwin spent some time on the Galápagos Islands, 600 miles into the Pacific from the coast of Ecuador. Here, among other animals, were numerous finches, again possessing some affinities with mainland birds, but again—and even more decisively—distinct species. Not only that, but, within the small archipelago, the generally similar faunas of all the islands were in part differentiated into related, but peculiar, groups confined to each separate island.

After long study of these facts of geographic distribution, Darwin could find only one reasonable and sufficient explanation. The ancestors of the Falkland fox and of the Galápagos finches *must* have come from the mainland. Then, after their isolation on those islands, the animals must have developed into new species, still with signs of true, blood relationships among themselves and with the mainland species. In short, they must have *evolved*. Thus, Darwin, who started the voyage with little doubt of the divine creation of species, forever separate and unchanging, was led to examine the alternative hypothesis: evolution. After years of gathering and test-

ing all available evidence, he concluded that evolution must be a fact; his work eventually convinced the scientific world.

Darwin's first clues to the fact of evolution were rooted in geography. The *Origin of Species*—published in 1859, nearly a hundred years ago—laid a firm basis for modern zoogeography—the rather clumsy compound word that means the study of the distribution of animals over the face of the globe. Although we have now added immeasurably to the extent and precision of the data, the broadly essential facts of zoogeography were already well known in Darwin's time.

It was clear, even then, that major land-areas have faunas generally similar throughout a definable region and markedly different in different regions. Africa has widespread giraffes and zebras, but those animals occur on no other continent. The mammals of the whole of Australia (and of certain adjacent islands) are mostly marsupials, but no other region on earth has a predominantly marsupial fauna. The overall pattern of the distribution of land animals (based on birds, but also applicable to most other groups) was well described by P. L. Selater, the English ornithologist, in a study that—coincidentally—was made public in the same year (1858) and in the same place (the Linnean Society of London) as Darwin's first announcement of his theory.

Selater attempted to explain the existence of these regional faunas—and the differences among them—as representing multiple separate centers of divine creation. Such an explanation was obsolete by the time it was published, but Selater's observational data were, in the main, correct and his regional pattern-

ing of major recent land faunas is still accepted with comparatively unimportant modifications.

The facts being pretty well in hand, what Darwin's synthesis provided—and Selater's did not—was an adequate theory with which to explain this assembly of zoogeographic facts.

The subject has been a lively one ever since, and the technical literature of zoogeography is considerably more extensive (and also considerably more complex) than that of, say, nuclear physics. General examinations of the subject, however, have been rather few—the fingers of both hands would not suffice to count them, but fingers and toes together would. In turn, the number of distinctly original contributions at the level of world-wide zoogeographic patterning and of basic zoogeographic theory has inevitably been still less—the count would not go much, if any, beyond the fingers of a single hand.

Selection of works worthy of this designation, of course, involves personal opinion, but I would say that the first—after Darwin—was a two-volume work (1876) by A. R. Wallace (co-discoverer with Darwin, of the principles of natural selection) and the most recent—until now—was a short, but extremely pithy monograph, published in 1915, by the American Museum's notable paleontologist, the late W. D. Matthew.

It is thus to be considered an outstanding scientific event that Philip J. Darlington, Jr., Curator of Insects at Harvard's Museum of Comparative Zoology, now adds a substantial volume to the short list of truly basic contributions to the literature of zoogeography.

Despite Darlington's subtitle, "The Geographical Distribution of Animals"—

this work is *not* a general zoogeography. The author, a professional entomologist, completely omits the zoogeography of insects, for example. The limitation of scope is justified both by precedent—most work on zoogeography is understood to be confined to non-marine vertebrates—and by the fact that here, alone, the data are adequate for reasonably full and conclusive study. (There is no good summation of the zoogeography of land and fresh-water invertebrates; a fairly useful book on marine zoogeography—published by S. Ekman in 1935 and already out of date—suffers from inadequacy of data and, in part, even of principles.) An accurately descriptive title for Darlington's work would be: *The Geographic Distribution of the Living and of a few Extinct Vertebrate Animals on Land and in Fresh Water*. The publisher can be excused for not using such.

As to the plan of the work, after an introduction on background and working principles, the primary data on distribution are summarized and discussed in five chapters, and more fully presented as reference material in five chapter supplements—the latter totaling 135 pages in small type. Heavy going at times, this part of the book provides an essential basis for the broader material that follows in the last five chapters: on continents and their faunal regions; on islands; on the evolution of zoogeographical patterns; on geological history as related to zoogeography; and on general principles and the geographical history of man. Supporting all this are good lists of references, an adequate index and eighty diagrams and maps—the latter being orthographic projections devised by the author, who feels this to be the best solution to the problem of showing our spheroid on a flat page.

Darlington's straightforward, clear exposition, with its occasional personal touches that take the reader into the author's confidence in a pleasant way, is best shown in examples.

In his preface, Darlington states: "When I was a young man, more given to argument than I am now, I was told that an author has the right to define words in his own way and that readers are to blame if they do not take the trouble to understand. But I do not want to be misunderstood, not even if it is the readers' fault. I have therefore tried to use ordinary words in ordinary ways, as well as to write simply and clearly. 'As demonstrated almost conclusively,' 'according to the best scientific opinion,' 'in my carefully considered judgment,' etc., are favorite phrases with scientific writers, but they usually mean no more than 'probably,' and that is the word I shall usually use here. I shall also say 'I think' and 'I guess' without circumspection...."

"Zoogeography," Darlington says

later, "if it is to tell things about the past, should be consulted with forethought, common sense, an open mind, and a remembrance of human fallibility. Some zoogeographers urge these things on their opponents, but that is not how I mean them here. I mean simply that I shall try to practice them myself."

Again, "...the whole process [of mankind's geographic expansion] has been one of gaining and utilizing successive advantages more than escaping from disasters, although escapes have sometimes been necessary too. I do not mean this philosophically, but as a plain matter of fact."

Now let us consider, with Darlington, a few of the more important issues and exciting problems of zoogeography. Tapirs, to cite one extreme example, occur in tropical America and in Malaya—nowhere else. Because the tapirs were not separately created in each of these places, their ancestors must somehow have spread between the two. On a lesser scale, the ancestors of the Galápagos finches must have come from somewhere else and by some means. South American fauna shows a tripartite division: partly unique, partly quite like that of North America, and partly of scattered apparent affinities with the animals of places as remote as Africa or Australia. Such facts as those, and the whole subject of animal dispersal and faunal resemblances, raise a basic question: what have been the past relationships of the lands and, particularly, the continents?

One school of thought has insisted that today's land masses were formerly united by a vastly intricate, shifting system of land bridges—or even of whole other continents—athwart our present seas. Even in Darwin's day, the building

of these imaginary land bridges was such a popular sport that he waxed sarcastic on the subject.

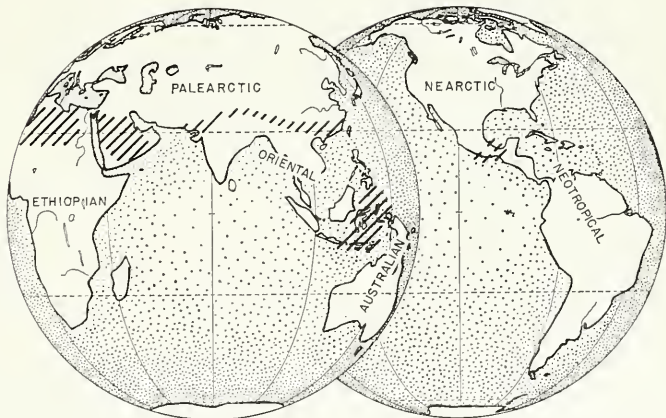
Others, more recently, have theorized that today's continents once formed a single mass (or, in another version, two masses) that split asunder and literally drifted to their present positions, like vast ice floes drifting in an arctic sea. Still a third school has maintained that the continents have had approximately their present relationships and positions at least since times so remote as to have no bearing on the distribution of life as we know it today.

The answer to this problem really lies in the realm of geology, but the geologists have not solved it. Very well, says Darlington in effect, let us then ignore the geologists and see whether we cannot solve the problem on purely zoogeographical grounds. The three main alternatives should have recognizably different effects on the distribution of animals.

If there was a land bridge, say from Australia to South America—one of the most popular of the bridges—it must have had a definite time and place and have served as a migration route for animals to which the time and place offered appropriate opportunities.

If South America and Africa were once a single continent—the *sine qua non* of continental drift theory—they must then have had virtually identical faunas. If that connection was fairly recent, say within the last hundred million years, the former community of these faunas should still be evident.

If, as the third alternative, continents and seas are highly stable, the spread of animals must (with certain otherwise readily explainable exceptions) have been between continents now connected or obviously connected in the past. In



SIX FAUNAL REGIONS of the continents and their boundaries, proposed by Sclater, were established by Wallace in 1876. Hachures show the transition zones as plotted today.

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fact, there is only one such obvious past—and not present—intercontinental connection: that between Siberia and Alaska, now drowned by waters so shallow that slight changes in relative sea level could make it (and, beyond the slightest doubt, repeatedly in the past have made it) dry land.

The correct choice among these alternatives was pointed out by Matthew more than forty years ago in the monograph previously mentioned. Yet acquiescence in Matthew's solution has been far from universal. Some of his data were inevitably shaky, and the total evidence was not sufficient to convince all other students. In a similar fashion, several naturalists in the eighteenth and early nineteenth centuries reached essentially correct theoretical conclusions about evolution, but the world of science remained unconvinced until Darwin established the theory on an unshakable mountain of evidence.

Darlington is Matthew's Darwin. In the light of the great mass of evidence now brought together, the first two alternatives are simply impossible. There can no longer be any reasonable doubt that Matthew was right in maintaining that the continents have been stable for the last hundred million years or so. Their condition before that was probably stable, too, but in any case would have no bearing on present zoogeography.

THERE is a second, related series of problems also correctly solved by Matthew, also debated thereafter, and also placed on a virtually irrefutable basis by Darlington's work. I do not mean that these questions will never be argued again, but only that they should not be. Sad to say, not all students are thoroughly informed and, even sadder, not all are really good at evaluating the evidence they do have.

This second area of debate concerns the faunas of various islands and how they got there. There are many islands that raise no questions: parts of continents cut off only recently, geologically speaking, by arms of the sea. Their faunas plainly show this history: they are essentially the same as the faunas of the adjacent continents, only not so large because there is less room on the islands. Japan, Sumatra, and the British Isles fall in this category.

The real problem involves islands that have a good many land animals, but mostly of species quite distinct from those on the continents, and of oddly limited or erratically assorted stocks. Among the classical examples are Madagascar, off the east coast of Africa; the West Indies in and around the Caribbean Sea; and (old friends of ours and of Darwin's) the Galápagos, off the coast of Ecuador.

Among its now-living mammals, Madagascar (continued on page 166)

EBONY

Once again we have obtained some handsome ebony figures from Africa. The native couple shown here is carved from a solid block of ebony and polished to a sleek black gloss. Hand carved by native craftsmen in Tanganyika, this figure represents two dancers.

Since each piece conveys the individuality of the craftsmen, you will find some variance in style details and perhaps some slight difference in proportion. This, of course, adds to their appeal and all are as beautifully carved as the one illustrated. It will make a perfect decoration for your mantelpiece, table, desk or bookshelf, and will be admired by all who see it. Each carving weighs approximately two pounds and is about 8 inches high.

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AQUALUNG ARCHEOLOGY

In Lake Amatitlán, Guatemalan divers
have found a wealth of Maya remains

By STEPHEN F. DE BORHEGYI

THE PERFECTION of free-diving apparatus has given the archeologist a new field for search—one that makes digging in the earth almost prosaic by comparison. The sea has long been a storehouse of treasures, but scientific exploration under water is no older than the beginning of the twentieth century.

In the Old World, the Mediterranean—that highway of the ancient world—has received the most extensive investigation. But, since the days of 1905-8, when a Harvard group dredged the great limestone sinkhole at the Maya ruins of Chichen Itzá, little underwater archeology has been

done in the New World. The "Sacrificial Cenote" at Chichen yielded objects of finely-wrought gold and copper, jade jewelry and sacrificial knives, and a number of human skeletons, both male and female. Except for these finds, however—and the chance discovery of an Inca ruin in Lake Titicaca—underwater research has not been of much concern to American archeologists.

I spent the summer of 1957 in Guatemala with a group of students, working at the large Mayan site of Kaminaljuyu on the outskirts of Guatemala City. In July, I was invited to see some archeological specimens



ONE OF SEVEN Guatemalan skin divers who turned amateur archeologist. Jorge Samayoa surfaces with incense burner.

brought up from beneath the waters of nearby Lake Amatitlán.

What had been described to me as a "small" collection turned out to consist of literally hundreds of offering bowls, incense burners and covers, ranging in size from a few inches to four-and-a-half feet in height. Many bore unusual designs: cacao trees and beans, quetzal birds, jaguar heads, bats and even human skulls—motifs hitherto rare or unknown in this "highland" Maya area. My students and I decided to finish our dig quickly and spend the remainder of our stay at Lake Amatitlán.

This beautiful lake—a popular resort area, seventeen miles south of Guatemala City—is over seven miles long and three wide, and has a maximum depth of 131 feet. At its western end are a number of weekend cottages and hot baths and the quiet little town of San Juan Amatitlán is located about a mile away.

In 1954, a group of young Guatemalan aqualung enthusiasts began exploring the lake for good fishing grounds. In April, 1955, one of them, Manfred Töpke, was diving in the southwest corner of the lake when he discovered the first archeological specimen to be found. Thereafter, an enthusiastic amateur group—Töpke, Jorge Samayoa, Raúl Minondo, Rodolfo Robles, Luis Canella, Enrique Salazar and Carlos Springmühl—continued a systematic search of the bottom. By 1957, they had brought up over five hundred pottery vessels, incense burners and stone sculptures.

The first task of our archeology



HUMAN HEAD AND SKULL are paired in decorative detail on this offering vessel, left, one among hundreds recovered.

SCENE OF DISCOVERY, Lake Amatitlán is set in volcanic landscape, covers some twenty-five square miles in highlands.



CAPING JAWS of an unidentified animal frame the human head that has been modeled on the side of this fragment of a clay incense burner. Head is decorated

with ear and nose plugs, in Maya style. Emergence of the head from animal jaws is also a common Maya art motif. To the left, vegetable shape represents fruits

of the cacao plant (the source of chocolate), from which a sacred drink of the Maya was prepared. This burner forms a part of the Samayoa-Delgado collection.



QUETZAL FEATHER headdress tops this fine-featured Maya face, molded to the body of another incense burner from the lake. Note different style of ear plugs.



ALMOST INTACT, this tubular incense burner bears the serene likeness of the Maya rain god, Chac. Mustache may link with the deity's other feline features.



LOW RELIEF FIGURE on upper portion of this burner fragment appears to hold sacrificial knife in hand. Bloody elements, such as this, echo traditions at Chichen.

group was to make an accurate map of the lake. Once this was ready, we attempted to locate on it the exact sites of all underwater discoveries made by our skin-diving friends. We photographed nearly four hundred specimens in various private collections and catalogued each piece according to its original location on the lake bottom. We mapped all the archeological sites on or near the lake shore and then correlated these with the underwater sites. The oldest of the

shore sites dated to the Maya "Formative" period (approximately 1000 B.C.): the latest site had still been occupied at the start of the "Historic" period (marked by the Spanish Conquest in A.D. 1524). Thus, the area had been continuously inhabited for over twenty-five hundred years.

OUR NEXT QUESTIONS were why and how these amazing specimens happened to be at the bottom of the lake. There seem to be two possible

answers. Many of the bowls were found on the slopes of the lake floor—in piles of six or seven—fitted neatly one into the other. Some of the incense burners were also found in groups of four or five—standing erect and occasionally embedded in lava. This clearly suggests that many of the objects had been placed along the shore when the lake's water level was lower than at present.

Other artifacts were found at so great a depth and so haphazardly



NEARBY LAND-SITE of Kaminaljuyu is the source of this burner—with a grotesque, red and black face. Lake pieces, stained black by water, have lost their colors.



FULL VIEW OF BURNER, seen in detail on p. 120, shows the repeated skull-and-head motif. Although work at Amatitlán has not yet turned up human remains, it

is such evidence as this that suggests possibility of human sacrifice at lake in early times, paralleling practice at the sacrificial cenote of Chichen Itzá.



JAGUAR EFFIGY, above, was the handle for an incense burner's cover. Head is about six-and-a-half inches in height.

HUMAN EFFIGY, below, ten inches high, was also once a cover handle. The open mouth and closed eyes may denote death.



LEAVING his native Hungary in 1943, DR. DE BORHEGYI taught in Guatemala and worked there on research grants. Since 1954, he has directed the Stovall Museum, University of Oklahoma.

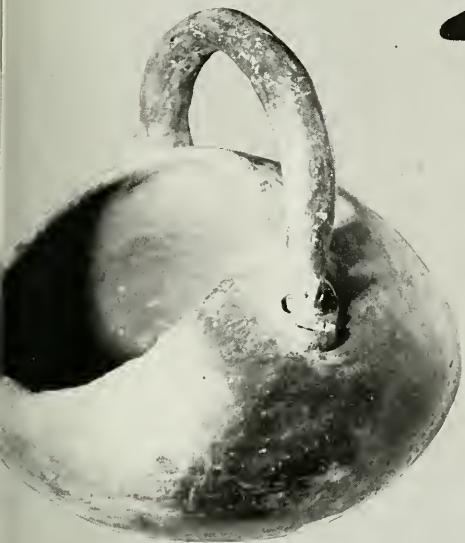
strewn over the lake floor, however, that they must have been thrown deliberately into the lake. There seems little doubt that these—like the objects recovered at Chichen Itzá—had been offerings to the gods.

LAKE AMATITLÁN could easily have possessed some ancient religious significance. On its south shore, geysers appear and disappear periodically. Both on the shore and in the lake itself, sulfurous water bubbles up at such a temperature that an egg can be hard-boiled in a few minutes. The volcano, Pacaya, whose four-peaked cone overlooks the lake, has erupted a number of times during the last five hundred years.

Now, the predominance of jaguar features on the incense burners (p. 123, top center, and p. 124, top) suggests that the Maya's powerful rain and water gods—commonly associated with this much-feared beast—were the recipients of the Amatitlán offerings. Although no skeletons have yet been found, both the depiction of skulls on some of the vessels and the sacrificial knife noted in the hands of one figure (p. 123, top right) suggests that, as at Chichen, human or animal sacrifices may have taken place.

Today, Lake Amatitlán still occupies a place in native religious beliefs. Each year on May 3, the day of the Festival of the Cross, the *Santo Niño de Atocha*—a charming wooden figure with a miraculous history—is taken from the church in a magnificent procession across the lake to a spot where legend says it made its first appearance. Hundreds of gaily-painted boats follow the statue on its journey, and flowers and fruits are thrown into the lake by the pilgrims. Can this colorful Christian festivity contain within it a survival of ancient pagan rituals?

MUCH MORE material probably remains to be discovered in the Americas by aqualung archeologists and further discoveries would add to the wealth of study material that affords us almost our only insight into the lives and beliefs of our New World predecessors. For examples from one rich collection, see the following pages.



TRIPOD FORMS, as represented by these two vessels, are the ones most commonly found in and around Lake Amatitlán. The spiked decoration of vessel, *above*, may represent the bark of an immature ceiba, deemed by the Maya to be a sacred tree.

BASKET SHAPE of vessel, *above*, is uncommon. Note happy and sad faces at the base of handle. The shoe-shaped vessel, *below*, is characteristic of the earliest period at Lake Amatitlán. Both pieces are in the collection of Manfred Töpke.



This onyx head is of classic Veracruz origin and is probably a representation of a victim of human sacrifice, as shown by the knobs of his ceremonial haircut.



Pottery figure of a warrior and a woman at work. Both wear headbands designed to make them look c

A COLLECTION OF PRE-COLUMBIAN FINE ART

The result of thirty years' acquisition is on display in Washington

Photographs by NICKOLAS MURAY

IN 1912, a young American career diplomat was taken by a friend to visit a small art gallery on the Boulevard Raspail in Paris. He saw there a small group of art objects which had originated in Peru before the coming of the Spaniards. They were of a style totally unfamiliar to him, although he had spent several tours of duty in South America and was quite familiar with the silver work of Spanish colonial days—the only “antiquities” then known and admired in South America.

Shortly thereafter, the diplomat, Robert Woods Bliss, bought a green jadeite figure that had been fashioned in Mexico perhaps a thousand years before Christ and thus began a collection that has since become world-famous.

The Bliss collection has been on public view since 1947 as a loan to the National Gallery of Art in Washington. Now this remarkable assemblage is available to an even wider public through the publication of a complete and sumptuous catalogue (*Pre-Columbian Art*; Phaidon Publishers, Ltd.; distributed in the U.S. by Garden City Books).

The catalogue is a collaborative labor of love—first for the collection itself, second for the extraordinary photographs of every piece in the collection, and lastly for the masterly work of the engravers and printers, which has brought each photograph to the printed page with a clarity and freshness rarely equaled.

The illustrations on this and the following pages have been taken from this book. All are the work of Nickolas Muray, whose love of the material is self-evident.

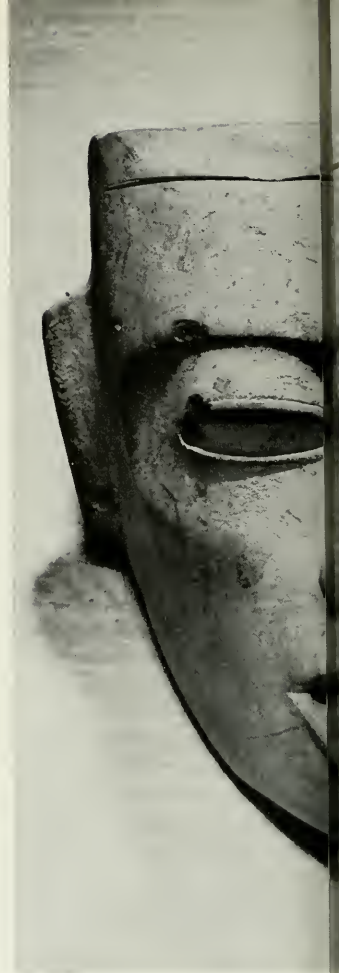
It is only within this century that pre-Columbian art—and “primitive art” in general—has been recognized as art at all. It took the tumultuous upheavals of “modern art” to show us the virtue of these artifacts, which are so far from modern. In general, people see what they are taught to see, which is both the strength and weakness of great artistic traditions, such as that of Western Europe.

Most of the revolutions and counter-revolutions of “modern art” have been aimed not so much toward the destruction of the Western tradition as toward opening





Basalt ceremonial axe, or *hacha*, shows face of a dead warrior wearing an eagle mask. Object dates from late Veracruz culture.



This limestone Teotihuacan mask, from Valley of Mexico, probably adorned a building. Eyes and teeth have been looted.

tradition-blinkered eyes to other actual and possible worlds of tradition and feeling. Whatever we feel about their own works, we owe the modernists an eternal debt for showing us that there are other classics and other traditions at least as valuable as our own.

AMONG these traditions, none is richer than that of the loosely related cultures that flourished from Mexico to Peru before the coming of Columbus. Cortes and Pizarro, products of a well-developed Western culture, burst into the dazzling courts of Montezuma and Manco Capac not very differently than Alaric and his Goths burst into Rome. They took the soldier's view of the native masterpieces they seized, dividing them into negotiable loot and souvenirs.

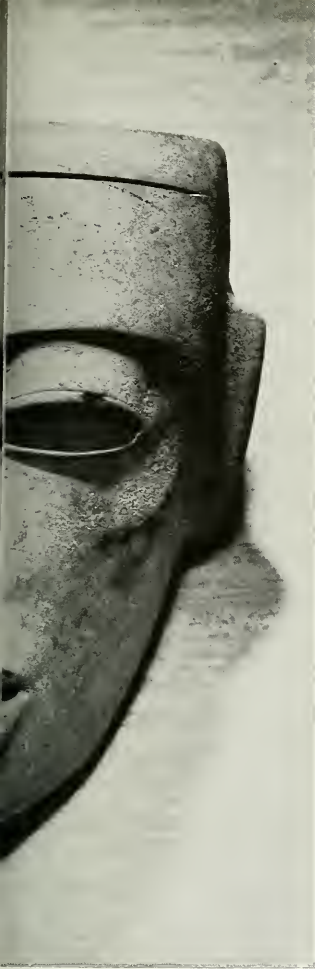
Spain's Royal Historian, in recording the first shiploads of Mexican treasure to arrive in Europe, remarked in passing, "I do not marvel at gold and precious stones. But am

in a manner astonished to see the workmanship excel the substance." But his was only a passing observation; the greatest part of the New World's workmanship disappeared into the melting furnace. Only a few objects that the Mexican treasure fleets brought to Europe are still in existence; while not a single object from Central or South America remains.

For the bulk of the Bliss collection—and other public and private collections which are gradually increasing in number—we are indebted to the spades of archeologists and their free-enterprising competitors, the grave-robbers.

In looking at pre-Columbian art objects, such as these, today's viewer has some important advantages; most especially, he is not burdened with preconceptions about what is beautiful and what is "good art." In this field, at least, he can look with the innocence so envied by art critics.

He can, for example, apply to these objects two of the most severe tests of value in art—directness and craftsman-



Another dead, masked warrior in pottery from Veracruz. Agonized, but oddly peaceful. face seems to echo maker's acceptance of death.

ship. The hand of the great artist is sure and he moves from his idea to his finished work on a calculated course, without detours or accidents.

EVEN the most superficial look at these objects shows that their unknown makers knew exactly where they were going and how to get there. Their sculpture and carving is simplified down to basic forms: it has enormous solidity even in low-relief work. Their decorative surface patterns are equally positive and stripped to essentials. And the craftsmanship of the work is obvious even in photographs. Their carvings in hard stone are smooth and sure: the details of their metal-smithing are precise and workmanlike: the fineness of their textiles, woven on the most primitive of looms, is beyond the skill of most modern hand-weavers (some Peruvian textiles have wefts of 400 threads to the inch).

These values are obvious ones, but further study leads

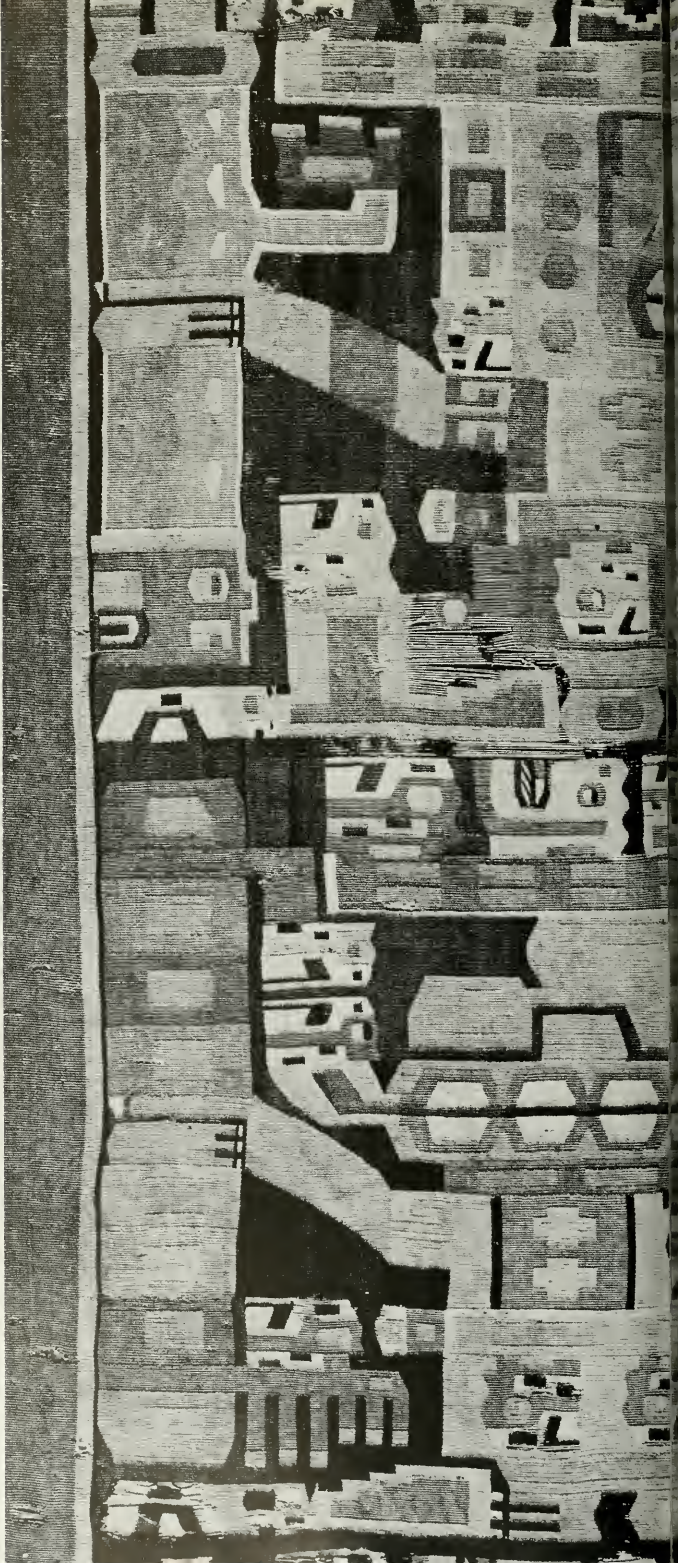
to extraordinary new perspectives. As a single example, consider the attitude toward death shown in three of the objects pictured here—the human sacrifice in the carving on p. 136 and the dead warriors pictured in bas-relief and in the pottery mask (*left and right, above*).

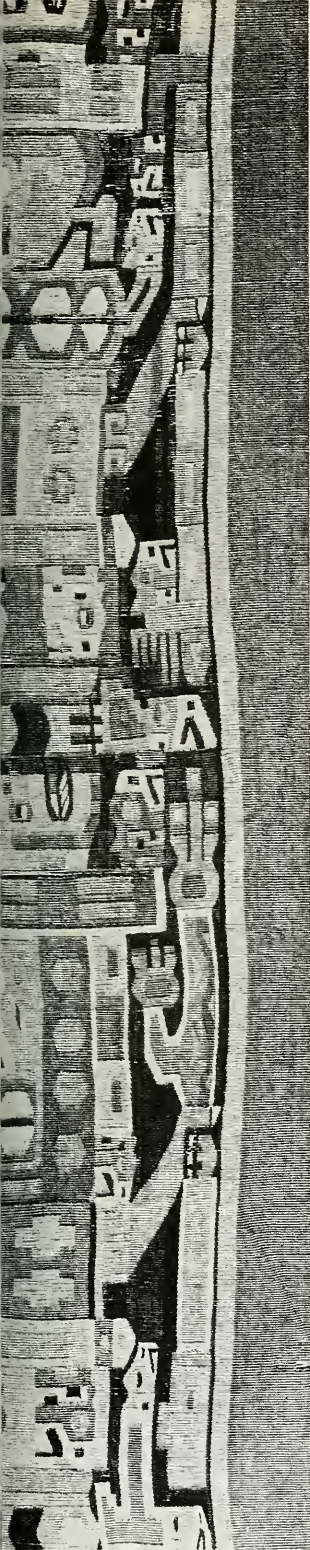
In terms of our own culture, the art of ancient Mexico, in particular, is heavy with images of death that echo savage warfare and human sacrifices. Yet these dead faces show no trace of brutality or morbidity. They are the expressions of people who felt the dignity and fitness of death as "the right true end of life." These faces, and the people who made them, took pride in the fact of dying.

The attitude is alien and perhaps repugnant to us but, at the same time, the directness and fervor of its expression in this art is proof beyond prejudice that it was not, for these artists, a "morbid" attitude. It was, rather, an expression of a different mode of human experience and of a philosophy—now lost to us—that sprang from that experience.



This silver figure from Peru is drastically simplified in form, but delicately wrought from individual sheets of hammered metal that have been soldered together to make the finished statue.





Mummy mask from Huarney, Peru, was tied by cords to outside of the wrapped mummy bundle. It is made of intricately joined gold sheets.



Portion of a tapestry-woven poncho from coastal Peru shows fine work in red, yellow and black wool and cotton. Decorative elements include stylized figures of birds and animals.

This Maya pottery figurine was originally painted blue, a sacred color. Both its face and posture are strongly reminiscent of serene sculpture found in China and India.



Grotesque Olmec figure, from Mexico, is carved from serpentine stone. Sculptors of pre-Columbian New World world in hard stone with the simplest of tools, but smoothly and surely



Graceful stone clubhead

Peru, is also a utilitarian weapon. The symmetrical shape may have been suggested by a cactus, but very similar weapons were made of metal in El

Tlazolteotl, the Aztec goddess of childbirth, carved from aplite, was also goddess of carnal sin—the "Eater of Refuse" who consumed sins of penitents who confessed to her priests.







THE INDONESIAN

Largest of lizards,
the Komodo monitor
is among the world's
least-known animals

By A. HOOGERWERF

THERE ARE STORIES of twenty-foot-long "dragons" dwelling in the islands of Indonesia. These fictitious accounts have been inspired by a creature quite astonishing enough without exaggeration — the giant, or Komodo, monitor (*Varanus komodoensis* Ouwens). Considering that this is the largest of all living lizards, the paucity of information concerning the Komodo monitor is surprising. This monitor, we know,

is restricted in range to the islands of Komodo, Padar and Rincha, situated between Sumbawa and Flores in the Lesser Sunda Islands chain, and to the west coast of Flores, itself. Measurements made by Dutch biologists have also informed us that, ordinarily, the male may reach a length of ten feet, and females, six feet. Yet, in the rare accounts of the Komodo monitors, more of the fantastic than the scientific is to be found. One

GRASS-COVERED HILLS of Komodo Island, one of the four areas where giant monitors may be found, are savanna-like in the dry season, *left*. Author found these monitor tracks, *below*, on the beach at Padar Island.



GIANT

such account was published in 1930, in *De Nieuwe Gazet* of Antwerp: "Don't think that this is a meek little lizard," stated this article. "It is a plump animal, very much like a dinosaur. . . . It only finishes its meal when everything is eaten, regardless how big the prey is. . . . A peculiarity is that, if aroused, the beast spreads a horrible vapour."

In my former capacity as Chief of the Game and Nature Protection Di-



vision of the Indonesian Government. I was leader of an expedition in 1953, especially organized for the study of these lizards. This article summarizes some of the findings of our expedition.

The Komodo monitor's habitat is one of the driest portions of the Indonesian Archipelago. The islands are all hilly, and creeks are only filled with water during the rainy season. Large sections are covered with tall grasses and, during the dry season, the countryside resembles an African savanna landscape. Here and there, the hills are entirely covered by monsoon forest, where the trees are generally tall but small-trunked.

Despite the great dryness of the environment, there is a reasonable amount of game. On all the islands where the monitors occur, one finds deer and wild pigs. Monkeys are also to be found on Flores and Rincha, wild horses on the latter and wild water buffalo on Komodo.

THE Komodo Lizard resembles other monitors, although—in large

specimens—the head and, especially, the neck make a more powerful impression. The young have a dark body, which is closely covered by red circles, and their necks have well-marked vertical bands of yellowish green and black. Very little remains of these striking marks in the adult except the reddish-brown circles which are still visible.

LIKE other lizards, the Komodo monitors are active during the warmer part of the day. They generally appear not earlier than 8:30 A.M. The night is apparently spent in holes between stone heaps or tree roots.

In foraging for food, which consists primarily of carrion, the monitors depend mainly on their sense of smell. They can locate a decomposing corpse at a considerable distance. It is possible that their tongues aid in locating the carrion. At least, I observed several times that a lizard, in approaching its prey, continually sticks out its tongue. When they approach close enough to a cadaver, the monitors are also finally

guided to the spot by their vision.

During our expedition, we set out several carcasses in order to study the monitor's habits. I noted that mutual relationships were generally poor. Large lizards dominated the smaller ones, and also fought among each other round the bait. The smaller lizards usually ran off when the larger ones arrived, but they would come back to the vicinity of the bait, staying at a respectful distance from their larger cousins. Occasionally, a big lizard would come close to a smaller one and then hit it with a sideways sweep of its tail—a powerful weapon.

When one of the lizards reached the bait, it would touch the cadaver with its tongue. I noticed on two occasions that the bait animal was first opened by a bite on the back, although this is a place where it is difficult to take off skin and flesh.

Komodo monitors can eat large quantities of food in one single meal. Subsequently, they may sleep for days. De Jong, the Dutch biologist who has written several papers about



the Komodo lizard, observed an eight-foot zoo specimen eat the largest portion of a deer. It then remained motionless in its cage for a full week, to allow its digestive juices to do a proper job!

Several aspects of the life of these interesting reptiles are not well known. These include the details of reproduction. According to de Jong's observations, mating takes place in July, eggs are laid in August, and hatching is supposed to occur the following April. Observation of the monitors in a zoo indicates a growth of only forty inches in a five-year period. It may take this long before breeding takes place.

ALTHOUGH the range inhabited by Komodo monitors is rather restricted, there seems to be no serious threats to their survival. Game populations on the islands are adequate, while the human population is rather scanty and human take of game does not appear to be excessive. Both the southern half of Rincha and Padar islands have been set aside as special

A note on the Varanidae

NATURALISTS have suggested that monitor lizards, the Varanidae, may well have served as the prototype of the dragon so often seen in oriental art. Indeed, the Komodo monitor is often called the "dragon lizard"—for it is the giant of its own family, as well as of all the other lizards, often reaching a length of ten feet. At the opposite end of the scale is the short-tailed monitor of Western Australia, only about eight inches in length. First described by the Dutch zoologist Ouwens in 1912, the Komodo "dragon" has not been intensively studied in his natural environment. Even in Western zoos, the total number of Komodo monitors probably does not exceed a dozen.

The twenty-three species that compose the family Varanidae are essentially tropical in habitat, and are carnivores. While their size limits most monitors' diet to insects, eggs or even chickens, the Komodo is able to tackle bigger prey. It is noteworthy that monitors—unlike other lizards—do not chew their food, but usually tear the flesh with teeth and claws and swallow it in large chunks. In this latter characteristic, they resemble snakes. Indeed, their anatomy includes a feature rare among the lizards: in order to protect the brain case from the pressure caused by the ingestion of large food objects, the monitors have developed a bony sheath about the brain—another point of similarity with snakes.

CARRION-EATERS. the monitors quickly located bait, *left*, which the author set out to attract beasts for study. Facing pair, *below*, give appearance of sociability, but author found that the larger Komodo monitors actually dominated smaller ones.



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refuges for the lizards, and their export to zoos during the past twenty years has been restricted by issuance of very few permits.

Although monitors apparently subsist mainly on carrion, they will kill living animals. De Jong describes how he once heard a deer cry out and, on arriving at the scene saw a monitor bending over a young deer, about three feet in length. The animal was still warm and had a large bite wound on the left side of the neck. The lizard had started to open the deer's abdomen to feed. It may be assumed that the deer had been surprised by the hiding monitor.

TO ME, one of the most interesting findings of our expedition was that the lizards are also capable of surprising and killing monkeys. While on the island of Rincha, we heard the screaming of a group of gray macaques (*Macaca irus*). Heading for the spot whence the noise came, we saw a large monkey on the ground, screaming excitedly. The monkey disappeared when approached more closely. We checked in the jungle near the spot, and found some blood on the vegetation.

Soon, I came upon a monitor, of average size, holding in its mouth a monkey which was bleeding from a wound on one of its legs. The still-living monkey was held by its head in such a position that the whole face was free, enabling it to look around. Oddly enough, the behavior of the monkey indicated neither fear of death nor panic. The macaque could easily have scratched out the monitor's eyes, but nothing of the sort happened. When the lizard moved off, the monkey did not resist being dragged away, but moved its legs as though to walk along! Apparently the macaque was in some sort of shock condition that suppressed any efforts toward escape. When three-quarters of the monkey's body had disappeared into the lizard's mouth, breathing was still to be noted. Finally, the hind legs and tail disappeared; the process of ingestion had lasted only about twenty minutes.



LIVE PREY, as well as carrion, forms a part of monitors' diet. On the island of Rincha, author surprised a lizard that had seized a macaque, and obtained this remarkable sequence of photographs. At onset, *above*, monkey's head is gripped.



IN SHOCK after seizure, macaque makes no effort to escape, although it could easily have scratched out lizard's eyes, as position of arm shows. Author notes that the monkey's behavior indicated a lack of either panic or fear of death.



LAST STAGE OF INGESTION is quickly reached, with only hind legs and tail remaining outside monitor's maw. The time from start to finish, author notes, was some twenty minutes.

Capture of living prey has also been reported by the Dutch biologist deJong, who discovered a monitor that had killed a deer three feet in length. Carrion, however, is main diet.



OMORIORI: SMELLER OF WITCHES

A field anthropologist presents
an eye-witness report on Black
African witchcraft in practice

By ROBERT A. LEVINE

HEAD SHAVEN, the widow Kerubo leads the mourning by her husband's empty bed, *above*. The "witch smeller," Mochama, followed by aide, *below*, works up his frenzy by wild run.



THE BELIEF that witchcraft can cause death, disease and misfortune is still widespread in Africa, south of the Sahara. Although such beliefs take many different forms among the inhabitants of different regions, almost invariably there is a common faith in some practitioner who claims to be able either to counteract or to prevent the evil effects of witchcraft. When serious trouble strikes, many African families turn to one of these "witch doctors" for the prevention of future disaster.

Witchcraft and its supposed effects are sources of major concern to the Gusii tribe, in southwestern Kenya, with whom I worked for some eighteen months in 1956-57. The Gusii live in a cool, fertile, highland region, about twenty miles east of Lake Victoria. Untouched by the recent Mau Mau disturbances, the Gusii are progressive agriculturalists who have added coffee—a profitable cash crop—to their customary maize and millet cultivation. Overpopulation and the

shortage of land, which have long been major social problems in other parts of Kenya, are only beginning to be felt in Gusiiland. Despite their peace and relative prosperity, however, the Gusii have their share of anxieties, and witchcraft is a major focus of anxiety for them.

According to Gusii belief, witches (*abarogi*) are usually women who run naked at night and conspire to kill their neighbors and relatives. Such witches secretly plant "poisonous" substances in the roofs and floors of their victims' houses, and these substances eventually cause their victims' death. A person may discover that he is being bewitched, by finding a dog's tail or a dead rat on a path near his home. Even without such evidence, should a succession of misfortunes befall a man and his family, he well may suspect that he has become the target of witchcraft. Someone so troubled will visit a female diviner—whose oracles usually confirm his suspicions. The vic-

tim then faces a triple choice: either to hire a sorcerer (*omonyamosira*) to use black magic against the witches; to make a formal accusation to his Chief and the local Elders against the person he most suspects of the witchcraft; or to hire the services of a "witch smeller" (*omoriori*), who will detect and remove the poisonous substances the witch has planted. This last choice is considered highly effective, and is often used.

While the Gusii tribal group—some 300,000 in number—contains many professional sorcerers and diviners, only one man among them today is a full-time witch smeller. Named Mochama Mororomba, he is a one-eyed man, whose high-pitched voice and comic manner would detract from his prestige were he not generally regarded as a trustworthy practitioner.

Mr. LEVINE, now engaged in graduate study at Harvard, did his East African field work with the help of a grant from the Ford Foundation.





ONE-EYED MOCHAMA, *below*, is clad in the borrowed clothing he wears to show that he hides "nothing up his sleeves."



GOAT'S BLOOD, rubbed on his hands, is sniffed by the "witch smeller," *above*, in prelude to frenzied run through village.

MIGHTY LEAP brings Mochama onto roof of hut, *right*, where he snatches armful of thatch to be inspected for "poison."



Mochama's services are constantly demanded, not only by his own tribesmen but by the adjacent Kipsigis tribe, and even by white farmers with African employees. He is accorded great respect by the Gusii, and practices with the official blessing of the local Chiefs.

WHAT is the secret of Mochama's success? Although he claims to have inherited his skill from his father and grandfather, there are others whose fathers practiced *okoriora* and none of them is a successful practitioner. I believe that Mochama's reputation comes from the fact that no one has been able to catch him at sleight-of-hand. When, at the end of a search, Mochama produces the sought-for witchcraft substances, he does so with

"nothing up his sleeves," while upstart witch smellers have often been caught planting the objects in advance, or producing them by legerdemain. Indeed, before Mochama starts his hunt, he ostentatiously changes clothes with some bystander to "prove" that he is concealing nothing. Although the Gusii are skeptical and suspicious, they are convinced that Mochama finds only what is really already there—in the roof, floor or walls of a house.

I saw Mochama operate on several occasions, but was never able to detect signs of trickery. When I suggested to my interpreter and others that the witch smeller had sent assistants in advance to plant the "discovered" evidence, they insisted that the objects Mochama turned up all



looked quite old enough to have been planted by witches long ago, and furthermore that there were no marks of disturbance on the thatched roofs or mud walls or floors where the objects were found. Personally, I was unable to find out how Mochama managed his performances.

The Gusii are thus willing to credit Mochama with wide supernatural powers. They believe he has the ability to predict the future accurately, and that he can tell if a person is committing witchcraft simply by looking and sniffing at the suspect. Consequently, Mochama is shown great deference. Crowds gather wherever he goes, and people who have never met him greet him avidly. When he sends his bag of medicines ahead to a village, with the order

that no one may eat on the day of his coming, people wait all day without eating. And, if he does not appear, they eat that night and repeat their fast the following day.

MOCHAMA capitalizes on his power. His fees are very high, and he usually demands additional payment above the price agreed upon. In the case illustrated here, Mochama was paid a cow (worth about \$42), a goat kid (worth about \$5), a considerable amount of goat meat, and \$5 in cash. He refused the first two cows offered to him because of their poor quality, and personally selected the best one in his client's herd. Thus, his fee for one morning's work amounted to more than \$50.

In the case illustrated here, a vil-



FOREIGN BODY is triumphantly plucked out of thatch, exhibited to audience. A search of other suspect areas follows.

lager named Ogise attributed his ailment to the black magic of a neighbor. Having stopped taking food, Ogise wasted away and finally died, one year to the week after his eldest son had died of an undiagnosed disease. An infant grandchild had also died a few days before Ogise's death and, when the body was examined, signs of witchcraft were found.

At this point, Ogise's elder widow, Kerubo, began making accusations of sorcery against several neighbors, and eventually brought charges against one of them to the local Elders. The subsequent trial brought many old family conflicts to the surface, for the accused was a cousin of Ogise. Friendly relations among a number of nearby families were broken off and suspicion and hostility ran high. The accused was convicted of sorcery, but not penalized, and Kerubo planned two more law

suits against him. Then, her only grandchild fell ill with fever, and Kerubo, convinced that her family was still being bewitched, began again making violent accusations.

Her deceased husband's brother, Sabani, finally decided to call Mochama and have a witch-smelling.

THE GRANDCHILD's fever had gone even before Mochama arrived. After Mochama discovered and removed "poisonous" objects from the bewitched houses, he made several cuts on the two widows' bodies with a razor. He rubbed a caustic powder into the wounds, to protect the widows from future witchcraft and sorcery. Then he announced that suspicion and accusations were to be at an end. The combination of the removal of the "poisonous" objects and the protective medication made Kerubo feel that she and her

family had nothing further to fear.

Mochama should not be dismissed as a mere self-seeking profiteer. Actually, he performs an important role in alleviating community conflict and tension. The many professional sorcerers who operate among the Gusii sell black magic (*omosira*) to the people, and also try to identify and kill witches. The sorcerers thereby augment the suspicion, hostility and violence within Gusii families and communities. Mochama, in contrast, abjures all sorcery and black magic, and rarely attempts to identify witches. Instead, he shifts Gusii attention from the supposed human agents of misfortune to the "poisonous" objects which are allegedly the immediate cause of trouble. Then, by removing the objects, Mochama gives the afflicted family a sense of security without having accused anyone or increased conflicts in the process.



CLIMAX OF ACT involves the dissection and neutralization of the "poisonous" objects, *left and above*, followed by casting of lots, *right*, which "prove" that family is no longer threatened by witchcraft. Mochama's final step was a sort of vaccination against the danger of future attacks. The author concludes that such "witch-smelling" helps quell divisive community fears.

After a search, when the crowd has gathered round him, Mochama will aggressively question individuals on their use of black magic, and warn them against any such practice.

In the case illustrated here, Mochama's witch-smelling may not have improved anyone's health, but it did result in quelling divisive tensions in small community.

Where witchcraft and sorcery are considered real dangers in life, there must be ways of averting or combating them. It is only natural that enterprising individuals will take advantage of this situation by taking payment for alleged cures. The Gusii regard themselves as lucky in having a Mochama a witch doctor whom they trust and who, for all his varice, often brings about a peaceful resolution of their problems, rather than inciting them to further hostility and fear.



CASE CLOSED, Mochama, *third from right*, puts on own clothes, poses amid retinue.



THE NEED TO CLASSIFY

On the basis that like things
belong together, science works
to unravel life's tangled record

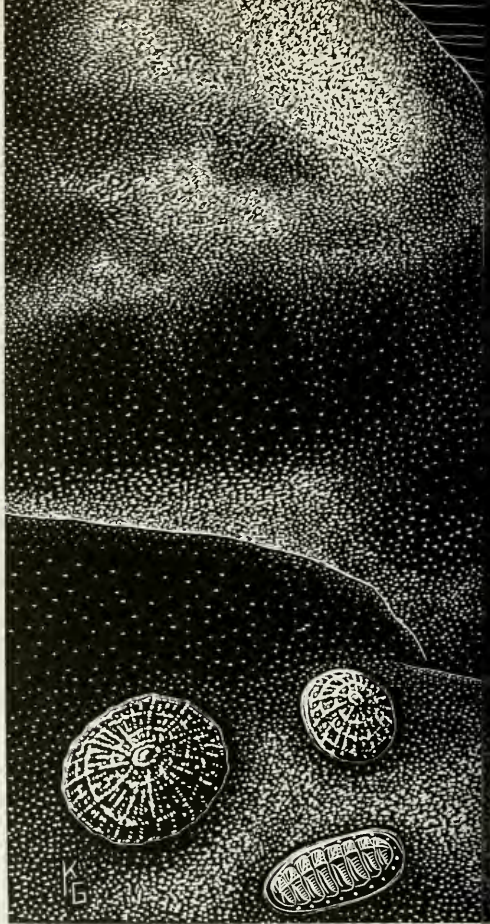
By ROGER L. BATTEN

ONE OF MANKIND's earliest intellectual endeavors was the attempt to gather together the seemingly overwhelming variety presented by nature into an orderly pattern. The desire to classify—to impose order on chaos and then to form patterns out of this order on which to base ideas and conclusions—remains one of our strongest urges. This same desire is the basic stuff of Science.

The scientific classifying of living forms is a complex endeavor. It is also a constantly changing one. Even to this day, as new organisms are discovered, we are often faced with the need to revise past systems of classification—and we are never quite satisfied with the latest system.

How do these classifications of life serve us? One of their most exciting uses is in unraveling the extremely tangled record of life's evolution during the 500 million years for which we have records of organisms.

In biology, the descriptions of newly discovered organisms is not so common today as it was fifty years ago. In paleontology—the study of the fossils of formerly living organisms—however, the job is far from complete. This is because it is not nearly so easy to obtain fossils as it is to collect living specimens: even after fossils are found in rock, it requires much painstaking preparation just to see the characters by which they can be classified. Almost



ROCKY SEASHORE provides a natural setting for this group of marine mollusks, *foreground*. The five cap-shaped mollusks are patellids, rock-clinging "true" limpets, members of the

daily in the field of paleontology, newly-discovered fossil forms are being analyzed, and described.

IT IS EASY to see that such discoveries require almost continuous change in our systems of classification. For it follows that, as more information accumulates, the "new" forms must be incorporated in the classification and our concepts of the relative positions and interrelations between various groups of organisms must also change. For formal classification is, in essence, a rather artificial structure—a tool used to express the scientist's current ideas regarding the relationship of organisms one with another.

From the first, mankind classified the things he observed by a method which declared that "like things belong together." This method was implicit in the first scientific classification of living things and remains the chief method of classifying today. But it is a method that must be used with discretion for—as we shall see—one can very easily classify objects on the basis of their superficial resemblances, while overlooking a number of important

DR. BATTEN, who took his Ph.D. in geology at Columbia after World War II, studied under Dr. J. B. Knight, of the Smithsonian, a leading authority on the older fossil gastropods. He now teaches invertebrate paleontology to undergraduates and graduates at the University of Wisconsin.



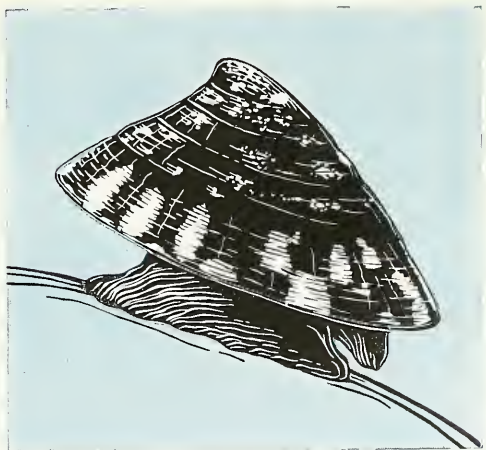
Class Gastropoda. *Below*, the long, narrow mollusk is one of the chitons, of the Class Polyplacophora. Early classifiers believed that all cap-shaped gastropods belonged in one group.

basic characteristics which may be somewhat less obvious.

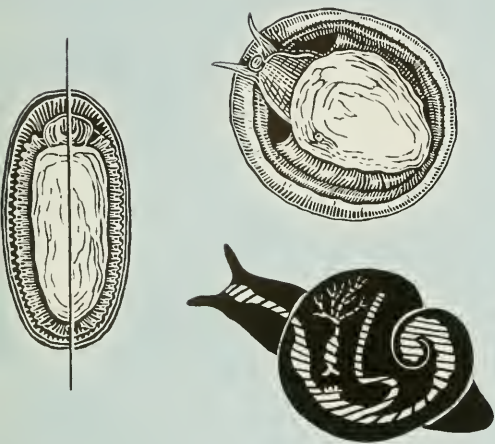
As an example, we might say, "I will construct a category for animals that fly." Such a single category would include many flying animals that were more or less related. But birds and bats would occupy the same category, because both possess flying appendages. Upon closer examination, however, we would note that the wings of a bird and a bat are actually quite different. Further examination of the other organs of birds and bats would show that, while these two animals are superficially alike, in detail they are not at all closely related. If we were sensible, we would change our classification to recognize these differences.

REFINEMENTS of a classification—although considerably more subtle than in this example—are a daily and important part of scientific work today that aims at achieving a framework which reflects the relative degree of relationship both between contemporary organisms and between the animal forms of the evolutionary past.

Let me now relate a case that demonstrates how our



LIVING LIMPET, *Acmaea*, is shown attached to a rock, its shell somewhat raised above its fleshy foot—the normal position when undisturbed. Limpet's front faces to the right.



BILATERAL SYMMETRY of chiton, *left*, with mouth and anus at opposite ends, contrasts with curled, one-sided patellid and snail, *right*, where same organs lie in close proximity.

EARLY CLASSIFIERS put all cap-shaped mollusks, including the fossil monoplacophoran, *bottom*, in a single line of limpets extending to early times. Chitons, *left*, were separate.

knowledge has increased over the years and show some of the effects that this increased knowledge has had on classification. We will take the phylum Mollusca, and, within this phylum, chiefly the snails (which in classification are called the Class Gastropoda). In addition to the snails, three other classes belong to this same phylum, as follows:

PHYLUM MOLLUSCA

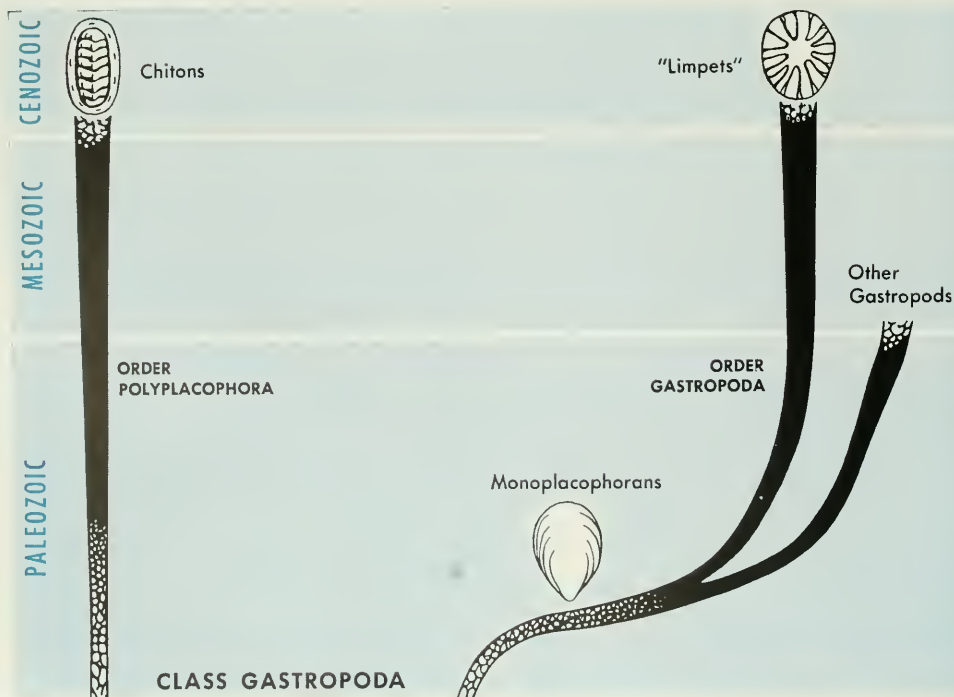
Class Polyplacophora (chitons)

Class Pelecypoda (clams)

Class Cephalopoda (octopus—chambered nautilus)

We know that, among all the myriad of snails that make up the Class Gastropoda (some 50,000 species are known to exist), there are several groups, collectively known as the "limpets," which are peculiarly adapted to a rocky environment where swift currents or surf present rather rigorous conditions for life. These limpets have cap-shaped shells, and possess powerful muscles that enable them to adhere to the rocks, even under the stress of pounding surf.

As we know today, there are several families of gastropods having representatives adapted to life in such rough and rocky environments. All of them possess shells that are superficially quite similar, since they share a common habitat. Early zoological classifiers, looking at these cap-shaped shells, assumed that these different gastropods were members of the same group. The paleontologists, too, when they began to turn up such shells in the fossil record, classified all the cap-shaped shells as members of the limpet group. The classification, as formed by them, showed one group of "limpets" from very early geologic



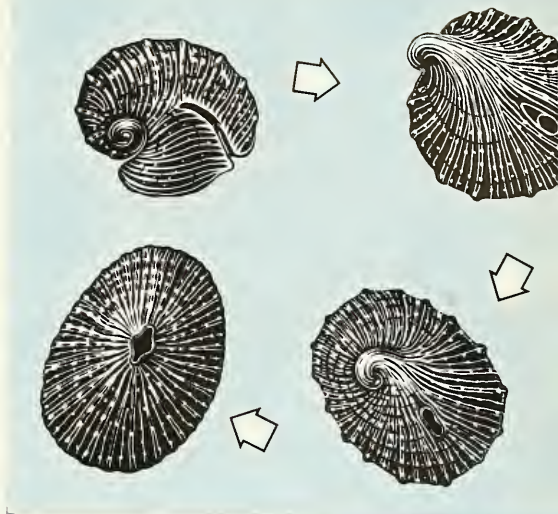
time to recent times. Such a classification would look like the illustration shown on the opposite page, *below*.

Meanwhile, the biologists—who were studying living limpets—soon recognized that, in addition to the “true” ones (which they called patellids), there actually were several other more- or less-distantly related families of gastropods, members of which resembled true limpets.

This discovery was possible because the biologists studied the living tissue and organs. Unfortunately, the paleontologists had only the shells available, and were unable to study the differences in the organs between the various cap-shaped forms. For many years, in consequence, little change occurred in classification of the extinct forms.

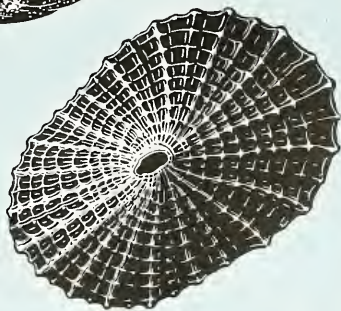
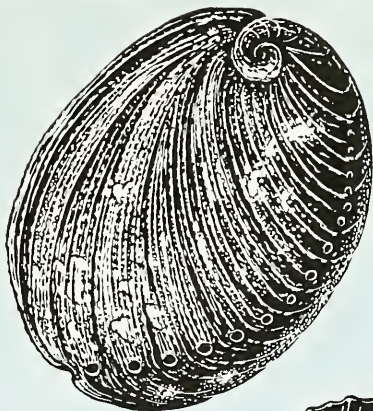
Before we go further, we must learn something more about the gastropods. Most organisms, we know, possess some sort of symmetry in their bodily arrangement. The commonest type of symmetry is a bilateral arrangement—in which one side of the organism is a mirror image of the other, and the organism’s head and tail lie at opposite ends of the body. Now most gastropods are asymmetrical, having lost one “side” sometime in the course of their evolution. When we look at a snail, we see that the soft parts of its body are contained in a shell which, although often coiled, is a long, narrow cone, open at one end.

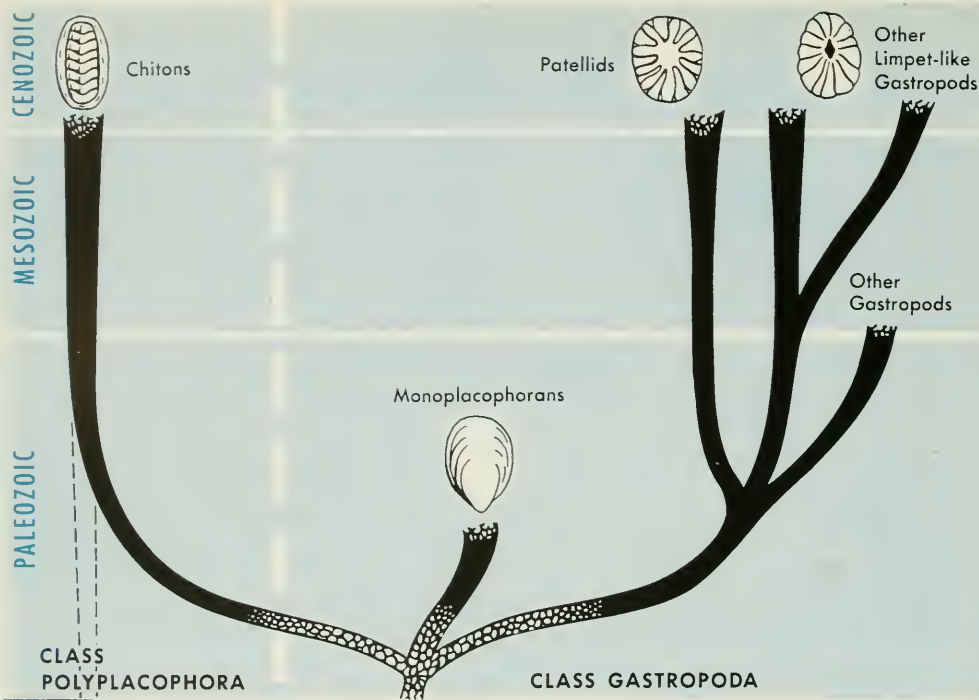
AN EXAMINATION of our rock-clinging patellids—the true limpets—shows that, while they have cap-shaped rather than long, narrow shells, here, too, only one “side” of the organism is present and anus and mouth are in close proximity. In other words, all of the limpets are typical, coiled asymmetrical gastropods.



GROWTH OF ROCK-CLINGER—from early whorl to final, cap-shaped form—is seen here with *Fissurella*, the keyhole limpet. First three growth stages are shown greatly magnified.

ONLY “TRUE” LIMPET among these rock-clinging gastropods is the patellid at *bottom, left*. The others, quite similar in form, are—clockwise—*Crucibulum*, *Haliotis* and *Diodora*.





REVISED CLASSIFICATION incorporates both the biologists' analysis of differences between "true" limpets and the rest of the rock-clingers and the paleontologists' discovery of

bilateral symmetry in arrangement of fossil monoplacophoran muscle scars. New arrangement envisions latter as ancestral stock not only for all gastropods but also for the chitons.

We have already been introduced to another class in the order of mollusks—the polyplacophorans, or chitons. Now, these chitons share a rock-clinging environment with the limpets, but they are a much more primitive form of mollusk. Anus and mouth are at opposite ends of the chiton's body and the body, itself, is bilaterally symmetrical. The chitons' shells are different from those of the patellids, also. Chitons have eight separate plates instead of a single shell. It was thus obvious—even to the early classifiers—that, while these two organisms shared a similar environment, they were vastly different from each other. What was not so apparent, however, was that some of the gastropods that possessed cap-shaped shells were very different from other gastropods that also possessed cap-shaped shells.

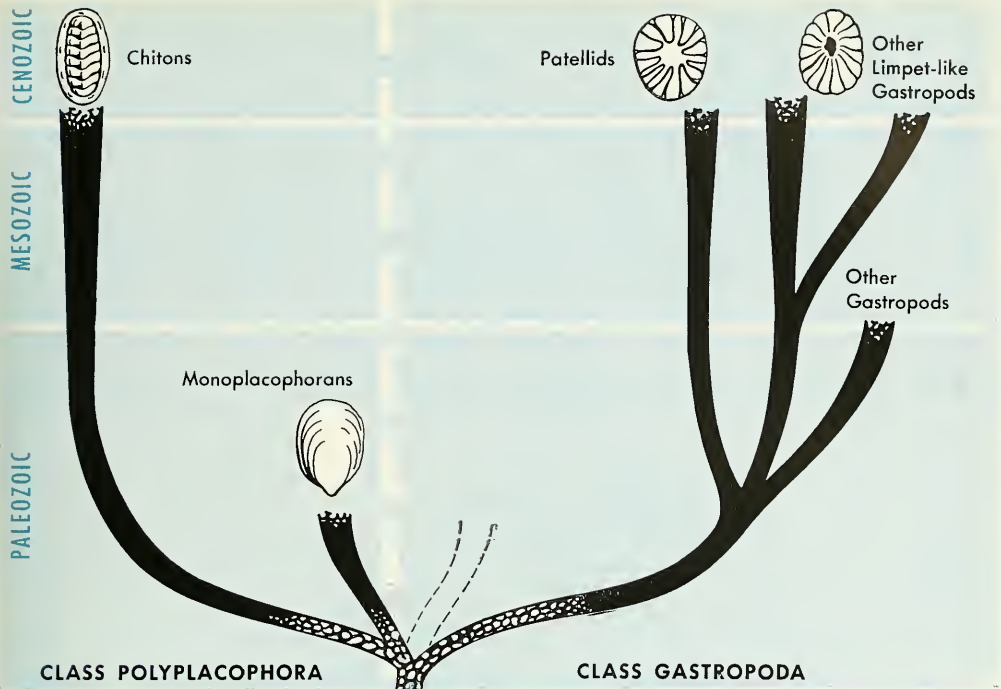
A FEW YEARS AGO, paleontologists attempted to reclassify some cap-shaped, fossil shells that dated back to very ancient geologic times. With no soft parts to examine directly, they carefully studied these shells for characteristics that could be related to the absent tissue. In the study of living patellids, it had been noted that a continuous "muscle scar" ran round the inside of their shells, marking the attachment area for the limpets' powerful muscles. The paleontologists found that many of the ancient shells exhibited such a continuous "muscle scar." Therefore, they felt safe in assuming that the missing soft parts had been similar to those found in living patellids.

However, the paleontologists also discovered that other

cap-shaped shells possessed, instead, two to eight pairs of distinct "muscle scars." Two things were curious about these ancient muscle scars: first, they were mostly eight in number and, second, they were arranged round the shell in bilateral symmetry. The paleontologists could only speculate that these shells were, in fact, so primitive that the organisms had not yet lost one of their "sides." They concluded that these primitive forms, unlike most gastropods, had possessed bilaterally symmetrical soft parts.

If this conclusion was true, then the paleontologists had discovered the probable ancestral group from which later gastropods were derived. Indeed, it seemed possible that not only were these forms (which we will call the monoplacophorans) the basal stock for the gastropods, but for the eight-plated chitons as well. Here then, was some evidence with which to construct a new classification—one that for the first time brought together two groups that had previously been widely separated: the Class Polyplacophora, and the Class Gastropoda. Such a classification would look like the illustration, *above*. This new interpretation made it possible, for the first time, to relate two diverse groups as well as to understand something of the evolution of these groups.

Now, the never-ending labor of classification, whether it is the work of the biologists or the paleontologists or others, receives contributions from all. Shortly after the paleontologists' announcement of this particular revised classification, a serologist—studying blood types in the



MOLLUSK BLOOD-TYPE STUDY, however, proved that chitons and gastropods could not be so closely related as the classification, *opposite*, had proposed. Thus, a further revision

of the classification was made, *above*. This put the fossil monoplacophorans in with the chitons, and the gastropods off as a branch of the chiton stock. This view stood until 1957.

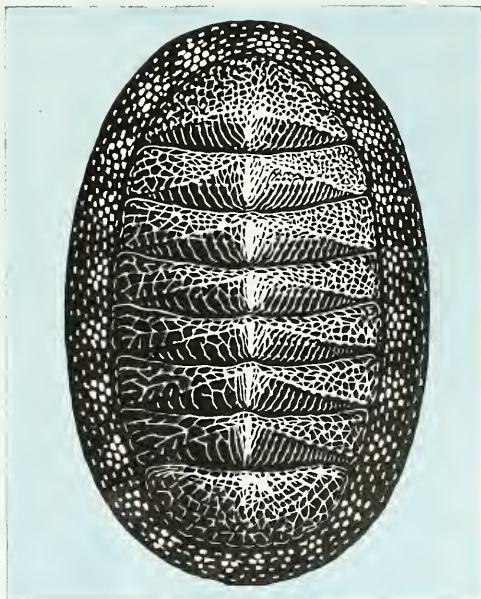
mollusks—proved that the gastropods and chitons could *not* be so closely related as the revised classification proposed. It was necessary, therefore, to revise the classification further, so that the monoplacophorans were placed in with the chitons, while the gastropods were viewed as a branching-off from this revised chiton stock.

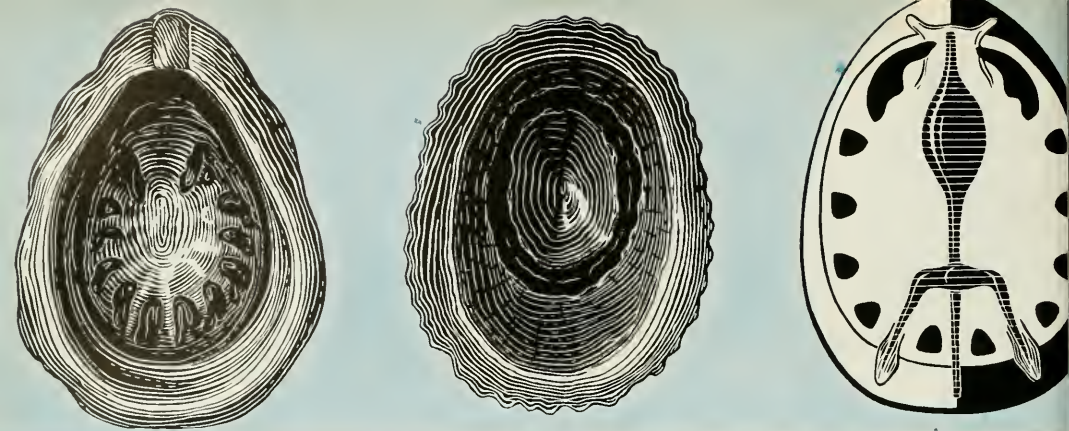
Again, a major change in classification had been made, in order to fit newly-discovered facts (illustration, *above*).

Thus, up to 1956, stood the classification of the primitive forms of gastropods—a far cry from the first classification, that had viewed all the limpets as members of one family.

Now, looking at the fossil record, we can make another observation. The primitive monoplacophorans were not a successful group of animals: they apparently became extinct about 230 million years ago—probably giving way to the more advanced limpets, which could successfully adapt to the environment of that time. But about six years ago, during the expedition of the Danish vessel, “Galathea,” several tiny cap-shaped shells were brought to the surface by the deep-sea dredging operations. The natural first impression was that they were limpets, because no other group of cap-shaped shells were known to be extant. Upon careful examination in the laboratory, however, some sharp differences were noted between these forms and the usual gastropods adapted for rock-clinging environment. This new form, duly described and named *Neopilina galathea* was presented to the astounded scientific world

TOP VIEW OF CHITON shows eight separate plates of its shell



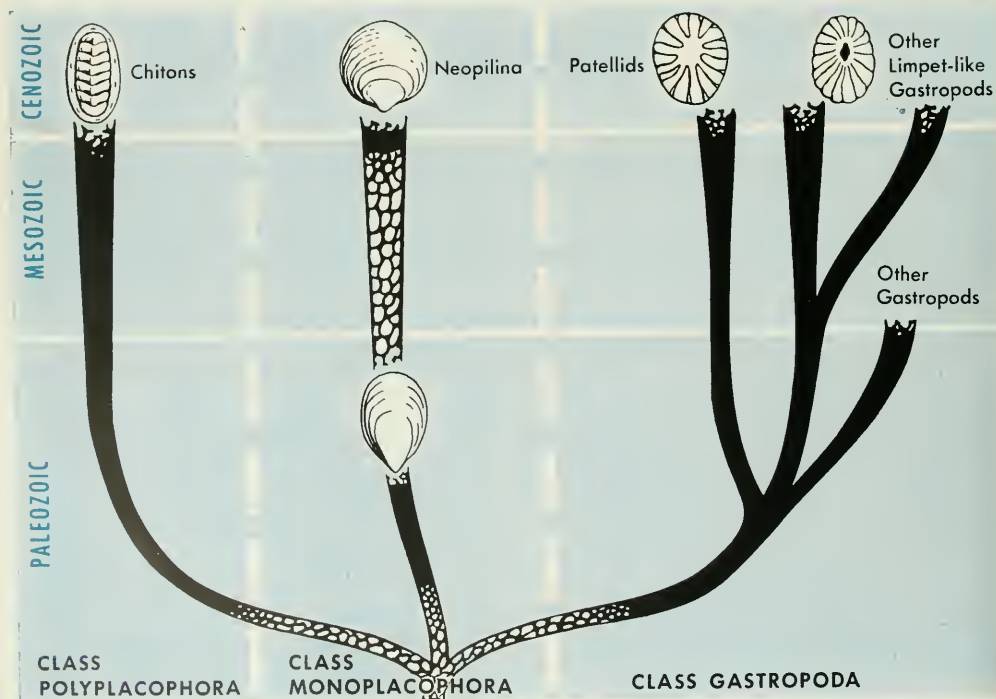


MULTIPLE MUSCLE SCARS of fossil monoplacophoran, at left, are contrasted here with the continuous, ring-like muscle scar of a fossil patellid. With this clue to bilateral sym-

metry, the paleontologists reconstructed a hypothetical set of symmetrical body organs for the monoplacophorans, above, in which anus and mouth lie at opposite ends of the animal.

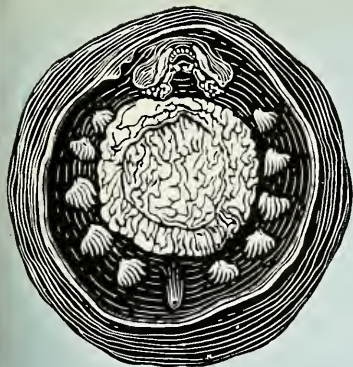
early in 1957. For here was a living monoplacophoran, previously thought to be extinct for 230 million years! *Neopilina*, with its eight distinct muscles and bilateral symmetry—mouth and anus at opposite ends of its body—is the very organism hypothetically constructed by the paleontologists five years before.

Many of the characters of *Neopilina* predicted by the paleontologists were found; several other characters that could not have been predicted were also present. These additional characteristics are bringing even further changes in classification. One major discovery is the presence in *Neopilina* of what appears to be body-cavity segmentation,



LATEST CLASSIFICATION, which incorporates the first major revision of the mollusks since 1876, establishes a new category, the Class Monoplacophora, center. This revision stems

primarily from *Neopilina* discovery, but author points out that new version—like the earlier ones, subject to change in light of new facts—combines findings of many sciences.



The astonishing recovery of a living monoplacophoran by the Galathea Expedition in 1951 (bottom view, *above*) gave confirmation to the paleontologists' hypothetical reconstruction.

and a separate gill for each of the paired muscles. Now, segmentation of the body cavity is considered by zoologists to be a primitive characteristic. Such segmentation is shared by several very different phyla, including the worms and the arthropods (that great group which includes such diverse forms as lobsters, spiders and insects).

LIVING MONOPLACOPHORAN, found by Danes off Costa Rica in 1951, was christened *Neopilina galathea*; that is, a "new" *Pilina*, discovered by the Galathea Expedition. Top and bot-

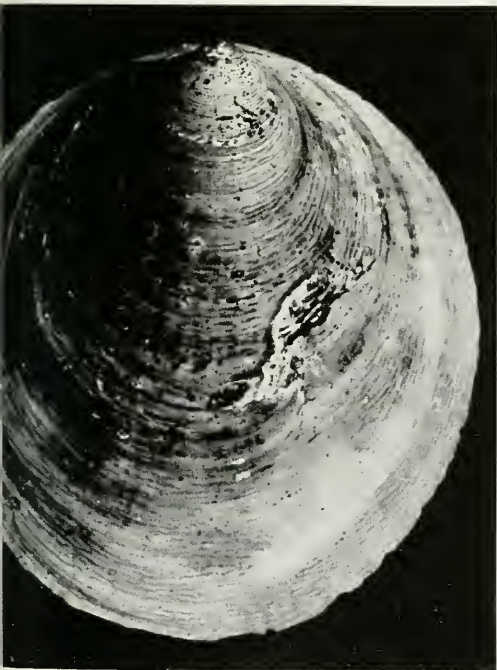
One suspects that there will be a strong temptation to revise classification in a manner which will relate some of these diverse forms more closely than is the case at present.

In our own task of unraveling the complex relationships between various primitive mollusks, the discovery of *Neopilina* has sent the paleontologists back to further study of their collections. Perhaps some minor feature, overlooked before, will now have great significance. Already, some of the rather vague muscle scars of fossils that had been placed in other gastropod families indicate that these belong, instead, among the monoplacophorans.

The search is far from completed; it will take several years for all of us to understand and reevaluate our data. So far, we know much more about how the gastropods and other mollusks came to be and, yes, we have made still another change in the classification! We know now that the monoplacophorans are *not* gastropods and—even more important—are *not* chitons, either. How are we to represent this in our classification? We will erect a brand new class, the Class Monoplacophora, the first new class to be erected since 1876, when the chitons were separated from the gastropods. The new classification will then look like the illustration shown on the opposite page, *below*.

Thus, the work of a variety of scientists—a discovery off the coast of Costa Rica, the study of blood types, and the examination of obscure fossils—have wrought major changes in the classification and by so doing, have moved man toward a better understanding of the great stream of life.

tom views, here, come from the expedition's leader, Anton Bruun. Detailed study of new mollusk, whose fossil cousins have been extinct for 280 million years, appeared in 1957.





A Tidal Zone Resident

Although much is known about the goby's life, each year millions of fry vanish out to sea

By WILLIAM N. TAVOLGA

CLOSE TO SHORE, in the warm tropical seas, lives a small fish, known as *Bathygobius soporator* and commonly called a "goby." This particular goby is only one of the several hundred species of the large family of Gobiidae, separated from all other fishes by the characteristic fusion of their two ventral fins into a sucker-like disk on the underside of the body. Members of the *soporator* tribe—two to three inches in length as adults—can be found almost anywhere along the Florida coastline, southward throughout the Caribbean and on to the Brazilian coast. The same, or a closely-related species, lives among the western and southern islands of the Pacific, along the coasts of Indonesia and India, and on into the Red Sea.

Throughout this range, *soporator* has chosen to live in the tidal zone—a rigorous and demanding environment, where the shallow water is often restricted to small pools at the ebb. Both temperature and salinity in these goby-inhabited pools will vary greatly. The tropical sun can raise the water temperature to 100° F., and the concomitant evaporation will double the usual salt concentration. The daily return of high tide brings a new infusion of comparatively cool sea water to these pools, while nightfall and a rainstorm can tumble the temperature to 60° F. and considerably dilute the salt water. The gobies resist the pull of tides and waves both by living in the shelter of shells or crevices and by use of their sucker-like disks.

One of *soporator*'s most remarkable characteristics is the chameleon-like character of its pigmentation. In general, these fish are predominantly brown in color, with either crossbands or spots of a darker shade. However, the goby can change his entire color pattern within a few seconds. The variety of these changes is astonishing: the number, width and darkness of the bands will vary, as will the size and contrast of the spots. At one end of the scale, gobies can turn a solid black; at the other, a light, patternless tan; and such a range can be covered within less than twenty seconds.

In studying these fish, one of my first problems was to catch them. Ordinary seines and nets do not work well in small tide pools. In some cases,



HALF-BURIED CONCH SHELL has been selected as shelter by this male goby, who starts housekeeping with sweep of tail.

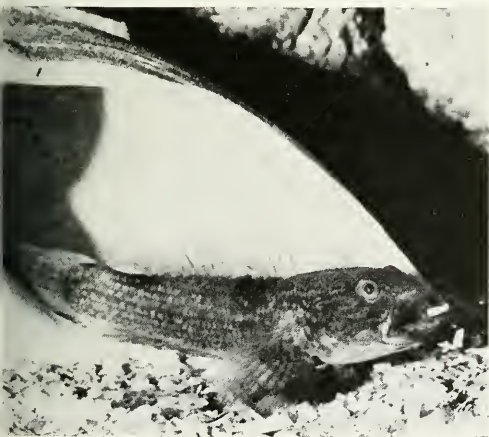


BITS OF COQUINA SHELL, which remain after sweeping, are picked up by the mouthful and carried outside the shelter.



DISTINGUISHING MARK of the Gobiidae is this sucker-like appendage, formed by the fusion of a pair of ventral fins.

Separate in larval stage, fins have fused by the time goby returns from sea to turbulent tidal zone of its adult life.



GOBY SPITS OUT FRAGMENTS at threshold as housecleaning continues. All photographs of gobies were made in aquarium.



A PIECE OF COCKLESHELL, too large for either sweeping or spitting, is grasped in mouth, lifted out of conch's interior.

After doing graduate work at NYU, DR. TAVOLGA joined the Biology Department of CCNY as Assistant Professor. He also does research in animal behavior at THE AMERICAN MUSEUM.

the gobies' habit of living in loose shells made collecting easy. All I had to do was to lift a likely-looking shell quickly from a pool and shake it over a net. In the open, however, I found that the gobies were extremely difficult to see and their movements hard to follow. They swim in quick darts along the bottom. When they come to an abrupt stop, one's eye tends to continue along the expected track and, by the time one looks back, the fish has either gone off in some other direction, hidden itself under a rock, or "frozen," causing its coloration to fade into the bottom pattern.

Although a goby may use any crevice or shell as a dwelling place, empty snail or oyster shells, with smooth inner surfaces, are most frequently chosen. Male gobies are more selective about their shelters than females, and such selection is more than a matter of merely entering and staying inside. A male will systematically sweep out any loose sand and shell fragments from his chosen spot. Much of this sweeping is done by vigorous fanning of tail and fins, but the male will also pick up large mouthfuls of sand and gravel, swim outside his shelter, and spew them out. On occasion, I have seen a male pick up a piece of shell almost as big as himself and, with quick lunges, push it out of his home.

THE anthropomorphic observer would consider these gobies antisocial. Males, in particular, will stake out a territory—that is, an area in the vicinity of their shelters—and fight any goby intruder who ventures into it, although they will be indifferent to other sorts of fish. Female intruders, and small males, are usually just nipped-at and quickly chased away by the territory-holding male; but, if the intruder happens to be another male of about the same size, a violent encounter may follow. The two males turn a very dark color and begin to circle each other. Each will gape widely and puff his throat, as a spasmodic tremor shakes his entire body. Usually, after a number of snapping feints, the intruder darts away, but biting can occur as a last resort. For, small as they are, these little fish pos-



BASIC COLORATION MECHANISM of *Bathygobius soporator* involves variation of body hue to match different environments. This male, a light tan, blends into background.



INTRUDER AND DEFENDER quickly reach high pitch of excitement. Spasmodic tremors shake each male's entire body, the fins are stiffly erected, and the nipping that



STRONGLY TERRITORIAL GOBY makes a sudden switch from tau to velvety black as another male, also turned dark, enters forbidden zone. Opponents circle and bump.



follows bumping in earlier stages of encounter may turn into serious biting if the intruder does not withdraw from the defender's territory. Severe damage can result.

sess sharp and numerous teeth. In close quarters, such as a blocked-off pool area or an aquarium, severe damage can easily be done.

THE female *soporator* is usually smaller in size than the male, and has slightly shorter fins, but females are otherwise not very distinguishable from males. However, a gravid female, whose ovaries are swollen with mature eggs, secretes a substance into the water which the male detects with his olfactory organs. The nature of this secretion is not yet known, but it acts on the male as all the most seductive French perfumes rolled into one.

With the first sniff, the male turns pale, only his chin and throat remain their normal dark color. The effect is striking. He lunges from his shelter, his body trembling violently. He alternately circles around the female and dashes back into the shelter. When she turns to follow, his courtship becomes even more vigorous as he leads her into the shelter. After the female has made several hesitant entries, both fish finally remain inside—where, eventually, she will spawn.

During this active phase of courtship, the male is often observed snapping his head sharply downward. By use of an underwater microphone, we have learned that the goby's head-snaps are synchronized with low thumps, or grunts. Exactly how the male produces these grunts is not yet known, but such sounds can be detected only from males and only during courtship. The effect of these sounds on the female is to increase her activity and, we suspect, her responsiveness. Under experimental conditions, females will not respond to the sound unless they also see another goby. Apparently, although females can hear the sound, they require this additional visual stimulus in order to become oriented toward the courting male. But these sounds have another effect, as well. Because they can also be heard by other gobies, neighboring males are often attracted to the source of the racket, whereupon they compete for the gravid female. Usually, under these circumstances, it is the largest male that goes off attended by the female, and the winning suitor is not always the one who started the courtship.

We have now traced a part of the life-cycle of *soporator*—from adult stage up to the point of spawning.

(continued on page 162)



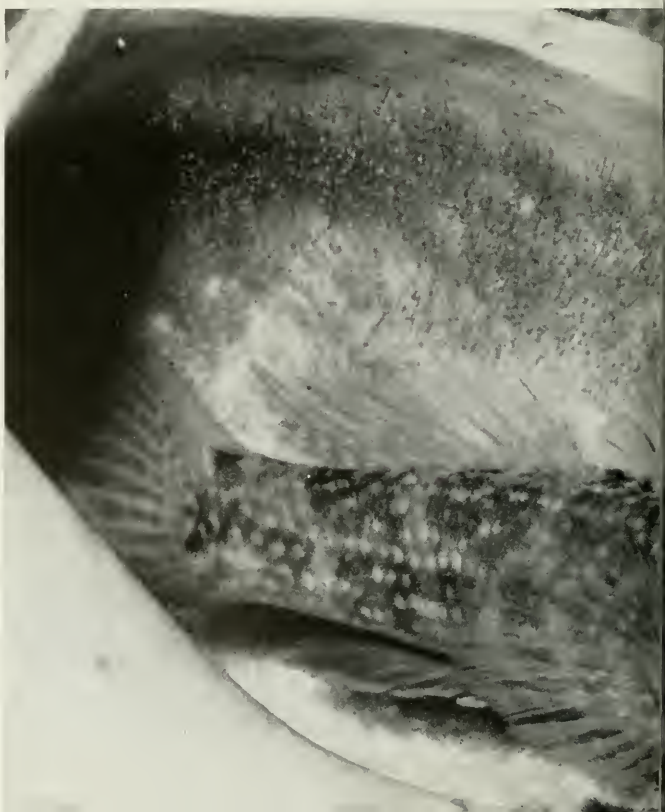
ANOTHER GOBY COLOR CHANGE is induced by presence in water of the faintest trace of gravid female's ovarian secretion. Male turns pale, his throat and chin darken.



CLIMAX OF VIGOROUS COURTSHIP sees female, *left*, inside the male's shelter.



SOME TEN THOUSAND EGGS now emerge in short bursts from female's papilla and instantly adhere to surface of shelter. Female is then ousted from nest by male.



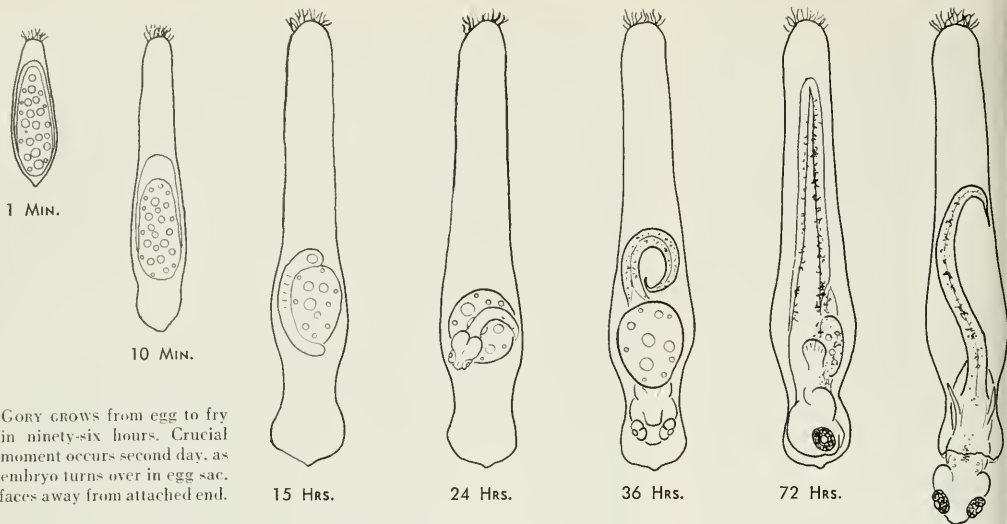


Reacting to male's swimming and grunting, female is ready to deposit her eggs.



FOR THE NEXT FIVE DAYS, male guards developing embryos, ventilating them by steady fanning. Goby embryos seen here in elongated egg sacs are five days old.

DROP IN WATER TEMPERATURE stirs male to violent brushing, whereupon egg sacs dissolve. Male follows clouds of larvae out of shelter, scattering them widely.



GORY GROWS from egg to fry in ninety-six hours. Crucial moment occurs second day, as embryo turns over in egg sac, faces away from attached end.

(continued from page 159)

Because these are hardy fish, that do well in the research aquarium, we also know the spawning part of the cycle in great detail. But, as will be seen, we are approaching a portion of our goby's life which, in his natural habitat, is as yet a complete mystery. For no one has ever found the free-floating larvae of the goby in the field—only maturing and adult specimens are to be found, and these only in the tidal zone. Newly-hatched fry are known only from aquarium studies. Let us trace what we know from these studies.

Once inside the shelter, the goby's courtship changes to a different phase. The male turns dark, stops grunting, and systematically brushes the inside surfaces of the shelter with his urogenital papilla, a small, conical organ, situated just back of the anus. After a time, the female begins to lay her eggs. This procedure may take her a few hours, since she carries some ten thousand. Each egg is a tiny, bright-yellow ellipsoid, less than a millimeter in length. One end is sticky and adheres to any surface at a touch.

The female looses her eggs from her uro-genital papilla like bullets from a machine gun, constantly maneuvering her body to cover small patches of the shelter's surface with her sticky eggs. She clambers up and down inside the shelter, using her fused ventral fins as a vacuum cup. Gradually, bare spots are filled in as she literally feels her way along with

her sensitive papilla. The male, meanwhile, darts about within the shelter, releasing great quantities of sperm. As the female begins to exhaust her egg supply, the male nudges and nips her until she either completes her depositing or leaves the nest. Once outside, the female does not return, nor does she ever see her offspring.

THE male remains with the eggs until they hatch. During this period—four to five days in length—he rarely leaves the nest and almost continuously brushes and ventilates the eggs by rhythmically fanning with body and tail. Within the first ten minutes after fertilization, a remarkable change takes place in the eggs. The transparent shell begins to grow until it becomes tubular and more than twice its original length, finally taking on a shape reminiscent of a wrapped mummy. The egg proper is round, and lies midway in its long casing.

By the twenty-four hour stage, primordial eye-buds are visible in the egg proper, and muscles have developed to the point where the embryo twitches its tail slowly. The embryo's head always grows toward the attached end of the egg sac, with the tail pointing to the free end. In the course of these slow twitches, the embryo reverses its position so that the head then points toward the unattached end of the casing. This reversal is most essential, since, later on, the larval fish must hatch out through

this free end. If the embryo does not reverse its position now, it will soon grow too large to do so and will be trapped in a tightly-fitting prison.

By the end of its second day of life, the embryo is more than half the length of its sac and, by the end of the third day, its large eyes take on an iridescent appearance. On the fourth or fifth day, it is ready to hatch and fits snugly inside its sac. The hatching will take place through the unattached end, as we have noted. With the help of a few convulsive wriggles, the larvae darts out into the freedom of his new environment.

What ruptures the sac? In the course of collecting *soporator*, I have often come upon males who were guarding a batch of eggs. In such cases, I would take the male and his nest back to the laboratory in a bucket. In every instance where the larvae were at a stage close to hatching, I noticed that the hatching took place in the bucket, and all ten thousand or more larvae would be swimming about freely by the time I reached the laboratory a half-hour later. This happened so consistently that I wondered whether the male had somehow stimulated the larvae to hatch, and whether my rough handling had caused him to do so.

I began to experiment with laboratory spawnings, disturbing incubating males in various ways. None of these experiments had the same result as did the bucket transfer. Thinking

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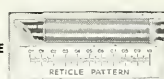
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back on exactly what I had done to the freshly-caught males. I recalled that I had always collected at low tide and that, during the course of the half-hour trip back to the laboratory, I had always replenished the water in the bucket—to keep it from overheating in the Florida sun.

Could it be this replenishment that was causing the mass hatching? Essentially, what I had done was to change the temperature in the bucket very abruptly—from the warm 30° or 90° of the tide pool to a cooler 65° or 70°. I tried this temperature reduction in the laboratory, using a male who was gently fanning a batch of eggs almost ready to hatch. When the temperature in his aquarium had dropped about 5° in a minute or so (this was done by slowly pouring refrigerated sea water into the tank), he began to brush the eggs violently. He continued to do so for about five minutes and then reverted to his usual gentle fanning.

I was disappointed—not a single larva had hatched. I kept watching, however. About twenty minutes later, when I was ready to give up, the larvae began to escape from their egg sacs by the hundreds. As they swirled about, the male began to fan harder, thereby sweeping them out of the nest. Within another ten minutes, almost all the larvae were hatched and floating in clouds through the aquarium.

Further repetition of this experiment confirmed the following interpretation: a rapidly-lowered temperature stimulates the male to brush his eggs strongly; if the embryos are advanced enough, this brushing stimulates the larvae to lit-

erally digest their way through the free ends of their egg sacs. Brushing the goby eggs with a soft camel's-hair brush duplicated the effect of the male's violent fanning. The time required for secretion and action of this enzyme is about twenty minutes; thereafter, the presence of the free-swimming larvae stimulates the male to further fanning activity which sweeps them out of the nest. The existence of such a hatching enzyme has been demonstrated in a number of other species of fishes.

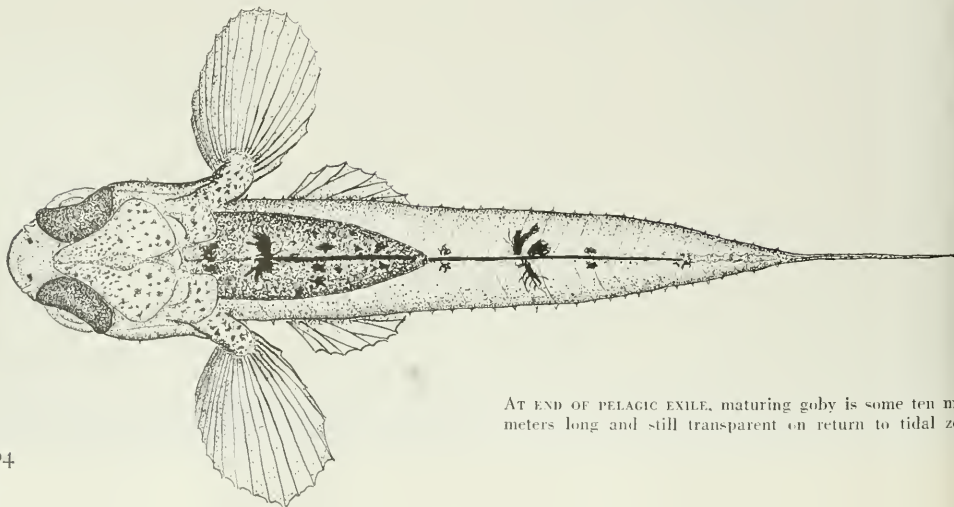
WHAT is the significance of this correlation between temperature change and hatching? Since hatching tends to take place as a result of the temperature drop associated with an incoming tide, it is my belief that the survival of the larvae and their dispersal is enhanced, for the rising tide would help to disperse the goby larvae, which are quite different from the adult goby. As in most marine fishes, the goby larvae are specialized for a free-floating, pelagic life. They join the billions of other tiny, living creatures of the open sea, collectively known as "plankton." Goby larvae are about two and a half millimeters in length, quite transparent, except for a few star-like pigment cells and their big shining eyes. They cannot swim very well; except for occasional short darts, they are helplessly wafted about by currents. Many thousands are probably eaten by larger animals in the sea, but many manage to survive, and find a tidal zone in which to settle down, and reach maturity.

The immense numbers of potential gobies that are spawned can only be

guessed. During the spawning season—from May to September in the tropics—the female spawns every seven to ten days and can produce at least two hundred thousand eggs in a year.

What happens to these gobies, free floating, planktonic larvae, which have never been collected in their pelagic state? How long does it take them to mature and return to the tidal zone like their parents? In an attempt to study the second of these questions, we tried to maintain goby larvae under laboratory conditions. Invariably they lived for four or five days after hatching and then all died. We made efforts to provide the larvae with various kinds of food—finely suspended egg yolk, protozoa, various planktonic micro-organisms. The results were monotonously consistent. After four or five days, all the larvae died. If the water temperature was kept a bit lower than the usual 30° F they lived a day or so more, but nothing we could do would make them survive longer.

This difficulty in raising larvae through their pelagic stages is not unique to the goby. It is seldom that any marine fish larvae can be raised to maturity under artificial conditions. My own trials, both with larval gobies and other marine fishes, have been both tantalizing and frustrating. Yet the gobies, and a myriad other marine fishes whose larvae contribute their millions to the plankton of our seas, all attain maturity and repeat their life cycle, generation after generation. It is evident that detailed studies of the plankton are required to fill the gaps in our knowledge of this endless vital process.



AT END OF PELAGIC EXILE, maturing goby is some ten millimeters long and still transparent on return to tidal zone



AQUARIUM WATER IS ALIVE with hundreds of free-floating goby larvae, each about two and a half millimeters long. In

their natural environment, they rise to become part of the vast aggregation of surface life at sea, known as "plankton."



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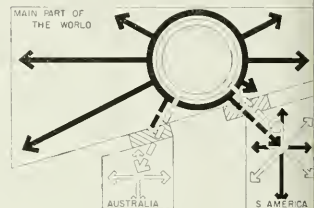
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Reviews (continued from page 118)

gascar has peculiar insectivores, a
swarm of pre-monkeys (lemuroids), a
few rats, carnivorous allies of the civets,
many bats, and that is all. Except for
some of the bats (and they are no mys-
tery, because they flew there), all are
decidedly unlike the mainland animals.
And the commonest African mammals,
innumerable rodents, true monkeys,
antelopes, big and small cats and all the
rest, are completely absent.

The West Indies also have, or had
until recently, a few mammals quite dis-
tinct from mainland forms, and also lack
the vast majority of the groups that
warm on the mainland. Aside from bats
the Galápagos have only one native



MAMMALS' RADIATION early in Tertiary
placentals in black; marsupials, white

mammal, a small rat; but they have tor-
toises, several lizards, some snakes, Dar-
win's finches (which do not fly far), and
a few other birds.

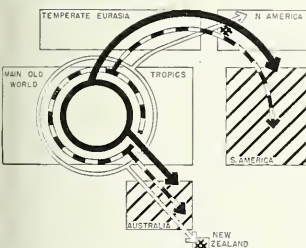
How did these animals get there? The
late Thomas Barbour (to whom Darlington's
book is dedicated) was one of those
who, in Darwin's words, made land
bridges "as easily as a cook makes pan-
cakes." He made one to the West Indies
and carried on a bitter feud in print with
Matthew, who tore the bridge down (of
paper, they were good friends). Matthew
insisted that you cannot get such oddly
selected faunas as those of Madagascar or
the West Indies, or the Galápagos over
bridges. The ancestral forms, instead
must have crossed the water barriers—
more or less accidentally and at long
intervals. Some swam or floated; some
drifted on logs or natural rafts; some
were blown there by high winds. (Ever-
such creatures as mice or frogs can be
blown tremendous distances, as Darlington
has shown.) Darlington not only
agrees with Matthew, but also puts the
finishing touches on the proof.

In a third main field of zoogeographic
theory, Darlington violently dis-
agrees with Matthew, and he is human
enough to stress this disagreement more
than the debt implicit in the agreement
on other points. Because this is the most
original part of Darlington's book, it is
by that very fact, the most controversial

Within the vast, kaleidoscopic shiftings of animals, their comings and goings, spreadings and contractings, fanings-out and crisscrossings, Darlington detects one central and, in his opinion, usual pattern. For him the Old World tropics are a zoogeographical "heartland." There, he holds, most groups of animals (among the vertebrates, at least) arose. From time to time, some of them became especially potent or, as Darlington puts it, dominant: they spread out into the rest of the world, into the Temperate Zone, over to North America, and down the two continental axes to South Africa and to South America. With the usual exceptions and contradictory details, nothing of much importance is supposed to have originated outside these tropics, and most definitely not in the (present) Temperate Zones.

Matthew, on the contrary, held that the North Temperate Zone was the central theater of evolution, that most progressive animals evolved there, and that earlier groups tended to be pushed out from there into the tropics and finally to the southern ends of the earth. This part of Matthew's theory further supposed that the spread of animals southward was influenced by climatic changes, especially during the Age of Mammals and the subsequent Ice Age.

It is clear that, sixty or seventy million years ago, climatic zones were far less sharp than they are now and that northern regions, although not literally tropical, were then far warmer. Since then, there has been a fluctuating but progressive sharpening of the zones and a movement toward the equator of cli-



HUNDRED MILLION YEARS OF DISPERSAL is diagrammed for three frog families.

mates with cold winters. Although Darlington recognizes these facts, I feel that he has underrated their importance and, indeed, may underrate the whole historical approach to zoogeography. For instance, he regularly assumes that the region *now* richest in species of a given group is the center of evolution for that group. There are well-established historical examples to the contrary.

The part of Matthew's theory that concerns centers of dispersal was based primarily on data regarding mammals.

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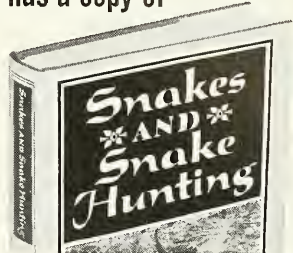
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Matthew, undoubtedly, overgeneralized—even as regards mammals—and his extension of the theory to other animals was sketchy and involved some errors. Darlington bases his opposing theory (first published in a technical journal in 1948) on cold-blooded vertebrates, especially the fresh-water fishes.

For those animals, Darlington's theory is quite convincing, if one is willing to subordinate a great many details. Darlington does not ignore these details, but he has an Olympian way of brushing them aside—as is, indeed, necessary if one is to find fundamental underlying principles. But now, in extending his theory to the warm-blooded vertebrates (birds and mammals), Darlington overgeneralizes, just as Matthew did in the opposite direction, and—as did Matthew—subscribes to some very doubtful statements, if not positive mis-statements.

Yet it cannot be doubted that Darlington's work will stimulate and aid sound reconsideration of the whole dispersal-center problem. I, for one, do not anticipate a single main pattern for all vertebrates as the outcome. I venture to predict that a version of Matthew's theory—modernized and certainly profoundly modified—will prove to apply to the warm-blooded vertebrates, while the essentials of Darlington's theory will hold good for those of cold blood.

Indeed, the exact identification of the place of origin or main dispersal center of a group of animals is rarely possible. While it has interest, it is less important, fundamentally, than principles about which, as adumbrated by Matthew and now fully developed by Darlington, there should no longer be much disagreement. All inhabited land areas have been centers of dispersal on a smaller or larger scale. Dispersal on the largest scale has occurred in and from the largest land mass, the Old World "heartland" (not exclusively tropical). Dispersal has involved expansion and contraction of animal populations on a world with essentially the geography of today. East-west (and west-east) dispersal on the widest scale has been across the northern and central parts of the Eurasian-North American blocks. North-south (and south-north) dispersal has occurred more or less independently on several axes: between Europe (plus southwestern Asia) and South Africa; between northern (and central) Asia and the tip of India—down to Ceylon, recently a geographic part of India; between Asia, through the East Indies without a continuous land connection, and Australia (to Tasmania); between northern (and central) America and the tip of South America (to Cape Horn). In each main area along those routes, fauna have re-radiated. Toward the end of each route, fauna become attenuated. Away from

the main routes—especially out into the islands of the seas—faunas are still more attenuated and peculiarly assorted. Those are the main principles of zoogeography which illuminate and underlie literally millions of detailed observations.

A good book makes one want to discuss things with the author, even to argue with him. Darlington's book is superlatively good in this, as in many other respects. A summing-up, tribute, but, in this instance, true, is that this book is a "must" for any serious naturalist.

The expression "serious naturalist" suggests a final point: this country does not have enough of them. The serious naturalist, professional or amateur, is one who is interested in the essentials of the subject as a science. We have an old and fine tradition of nature writing that is basically literary rather than scientific. Its best products are the armchair equivalent of an afternoon's stroll in the woods with a companion of high culture, humanistically speaking. There is nothing wrong with that; quite the contrary. But it is not science; it is even, in some examples, antiscientific.

This book is not a popularization. It is a technical study, requiring some prior knowledge and some effort from the reader. Nevertheless, it can be read by anyone with a respectable amateur interest in zoology. Technical and truly scientific works on natural history are seldom reviewed for and recommended to a non-professional audience, as I have done here. It seems to be assumed that no one will tackle a work of some little difficulty unless he must for professional reasons. Perhaps that is true, but I hope not. No one expects to read James Joyce (to choose no harder an example) without some difficulty, but everyone seriously interested in literature assumes that the effort brings an adequate reward. Why should the same not be true for those interested in natural history? Not all scientific works on natural history can be recommended on that basis, but Darlington's can and, hereby, is.

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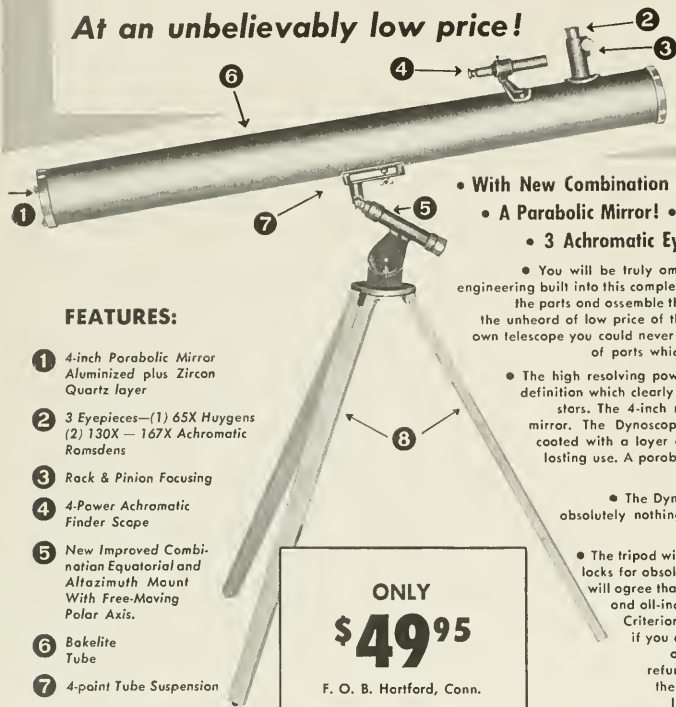
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Mating Flight

SIRS:

Your September, 1957, article, "LISTEN. NATURE IS SPEAKING TO YOU!" brings to mind an observation in which I have found sound, rather than sight, most helpful.

It first happened when, in a nearby orchard at dusk, I chanced upon a woodcock in mating flight. Approaching with care, timing my advances with the male's upward climb, I came to within a few feet of the chosen arena. The start of each display found the cock on the ground, turning in various directions and, at intervals, sounding a nasal "bzzi" (not unlike the nighthawk's cry) that carried surprisingly far. After a number of such cries, the cock would take off and, as evening grew deeper, I found I was following its skyward spiraling more by the sound of its trilling than by sight of the climbing bird.

At the height of this flight, there came what is to me one of the most thrilling sounds in nature: an ethereal. Panpipe chirping that floats down from the dark sky. It was too dark to see the bird's movements, but the ebb and flow of song spoke of tumbling swoops and turns and somersaults. Then, with a sudden rush of wings nearby, the cock plummeted to the ground, to resume the whole cycle.

My first experience with the woodcock's mating flight was over five years ago. Since then, although I have been told that few have witnessed this event, not a year has passed when, between April and June, I have been unable to catch at least one such display. For those who will use their ears, as well as their eyes, here is a most rewarding experience.

JOSEPH W. VALENTINE

Sherborn, Massachusetts

Unidentified Eggs

SIRS:

Last October, we planted a small tree in our yard, temporarily protecting it with some bricks around the base. Later,



when the bricks were removed, we found a nest of clear eggs on the cold, wet ground (photo). The temperature during the period had ranged from 27° F. at night, going to 60° F. in the daytime.

Could these be the eggs of the slugs or snails that leave slimy trails on our walks? Occasionally, in our yard, we find a very small black snake, with a pink collar. Could such a snake be the source of these eggs?

LAURA M. CLARK

Tulsa, Oklahoma

THE DEPARTMENT OF FISHES AND AQUATIC BIOLOGY replies:

While it is impossible to state so with certainty, the Clarks' eggs appear to be those of the slug, *Limax*. There are several European species of these large slugs, three of which have been inadvertently introduced to the U.S. Largest of the three is *Limax maximus*, a common dweller in city and suburban garden plots, whose nocturnal forays are marked by the glistening trail it leaves behind on hard surfaces.

Limax maximus was first observed in the U.S. in 1867 in Philadelphia and was reported as far west as Texas by 1886. Neither *maximus* nor the other two species, *flavus* and *marginatus* have been specifically reported from Oklahoma but this may be due to a simple failure to record the presence of this humble, if voracious, gastropod rather than proof of its absence from the state.

More Sucking Behavior

SIRS:

The letter by Mr. Samir Sen (NATURAL HISTORY, February, 1958), regarding

the phenomenon of paw-sucking by bears, prompts the following comments:

I once owned a kitten which acquired a habit of sucking the tip of its tail. It had been taken from its mother when quite young and I always supposed had simply substituted its tail tip for its mother's teat. Psychologists tell us that an infant feels secure and contented while sucking and this is often why a child sucks his thumb. I have seen several mature cats suck on some object, such as a piece of woolen goods, which could represent their mother's body.

I have raised several calves, all of which were taken from their mother several months before they would naturally be weaned. In all cases, after gulping down their dinner, they would frantically suck at the empty pail—often for many minutes. In some cases, when the pail was promptly removed, for a time the calf would suck any convenient projection, or even at the edge of its stall. I once had a cow that carried this infantile habit into her mature life, sucking at length on her feed pail after eating. Usually she produced a quantity of foam, suggestive of the creamy substance which Mr. Sen reported having seen on the paws of his captive bear after a period of paw-sucking.

Since sucking by all mammal infants must have become associated with a sense of comfort and security, isn't it probable that in all such cases, including Mr. Sen's bear, it is an attempt on the part of these older animals to re-establish this behavior?

HENRY F. DUNBAR

Kingston, New York



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April 1958

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Photographs by Hal Roth 223



THE IMPLEMENTS above—a sculptured club, a palm-leaf fan, a fishhook and a pestle for the making of poi—were photographed for NATURAL HISTORY by LEI BOLTIN. They suggest a cross section of the life of the Marquesas—its wars, its domestic arts and its principal ways of obtaining food.

A group of six inhabited islands—plus a few rocky outliers—within the vast Polynesian archipelago, the Marquesas were first discovered in 1595 by the Spaniard Mendaña, on a voyage from Peru to the Philippines. Other explorers subsequently called, but on the whole the Marquesas remained little visited—remote even from the other islands with Polynesian populations—until the nineteenth century. For the tragic history of their contact with the West, turn to page 208.

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Reviews

THREE STUDIES IN ECOLOGY

Reviewed by JOHN HAY

WORLD BENEATH THE WAVES, by Dr. Gilbert Doukan. *John deGraff*, \$6.00; 356 pp., illus. THE NORTH AMERICAN DESERTS, by Edmund C. Jaeger. *Stanford University*, \$5.95; 308 pp., illus. OF MEN AND MARSHES, by Paul L. Errington. *Macmillan*, \$4.50; 150 pp., illus.

HERE ARE three books of very different character and unequal value. Each is a study of the ecology of its chosen area—of the interrelatedness of different forms of life within a particular biological community; yet only one author, Errington, has taken his approach seriously enough for it to yield important conclusions and impart a certain significance to his subject. Another, Jaeger, has contented himself with giving us a great deal of information about his subject, and his book will be most welcome on that account alone. As for Dr. Doukan, he is by no means lacking in experience and enthusiasm, but his book about the underwater world is both talky and fragmentary—it leaves us paddling on the surface, with only an inkling of what a plunge to the depths may hold.

The greater portion of the book, it should be said at the outset, has the merit of usefulness. Dr. Doukan, a doctor of medicine who has been directly associated with the advances of underwater

diving in Europe—he already has a previous book on the subject to his credit—knows the practical aspects of diving as well as any man. There is a great deal of information about skin diving, diving suits, benthoscopes and bathyscaphes, and about the dangers to the human anatomy of underwater breathing.

Regrettably, however, the reader who, armed with the information Dr. Doukan has proffered, decides to plunge to the depths, will not know what to look for once he gets there. This is admittedly a vast domain: ichthyology, oceanography, botany, even physics enter into it. It is true, also, that the study of much of the submarine world is in its infancy; the behavior of most submarine organisms, the nervous structure of even the higher ones, have only quite recently become objects of serious study, while the first general text on submarine geology appeared only in 1948.

There is, nonetheless, a considerable amount of work available in these areas, which have been enjoying a certain vogue in the scientific world of late. Here would have been a perfect chance to assemble the data and translate it for a wider public. Dr. Doukan has muffed the chance. We are told something of submarine archeology and of underwater hunting—the subject of the author's previous

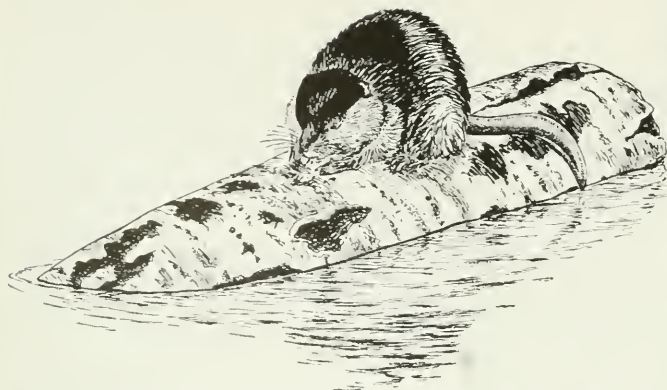
book—but the vast domain of the underwater biologic community in all its complexity and interrelatedness is mentioned only cursorily.

There can, in a sense, be no great objection to this—one writes about what one knows. But the author might well be taken to task for presenting his book as a contribution to submarine knowledge, when it is this knowledge of which he imparts so little. Perhaps the book's principal value lies precisely in this incompleteness, in the suggestion of what remains to be done. Certainly a thoughtful reader will find unanswered questions everywhere, avenues traced out but left, alas, unexplored.

Edmund C. Jaeger, former head of the zoology department, and now professor emeritus, at Riverside College, California—by way of contrast—has been able to study his subject in scholarly detail. This discipline has given both point and color to his firsthand knowledge of the desert.

Jaeger has not attempted a vast synthesis, nor has he tried to reach any new conclusions about the communities of animals and plants peculiarly adapted to desert life. His is a descriptive approach, for, before one can draw conclusions, one must first have the facts on which to base them. A perusal of *The North American Deserts* will show how few of these facts were generally known. Jaeger, as much for the tourist and exploring vacationist as for the serious student, takes up each of the five North American deserts individually, for there are five of them—the Chihuahuan, Sonoran, Navahoan, Mohavean, and the Great Basin—and their flora and fauna are astonishingly varied. So is their climate; they know temperate sea breezes from the Gulf of California, dust storms in the Mohave and Colorado, snowfalls on the Navahoan uplands.

Jaeger devotes the greater part of his attention to the flora of these regions—for, of all desert organisms, the plants must achieve perhaps the most difficult adaptations if they are to survive. The soil at White Sands, New Mexico, for example, consists of 94 per cent granular gypsum, 3 per cent table salt, plus 1 per cent silicates. The adaptations of



MUSKRAT ON BIRCH LOG is among the marsh dwellers discussed by Professor Errington.



WATERFOWL OF SUMMER MARSH include Western Grebe, foreground, terns and ducks, aloft.

North American desert plants are discussed in some detail—from the annuals, which survive the seasons of heat and drought as seeds, and thus “escape the drought rather than withstand it,” to the perennials, with their inflated stems for water storage, their very deep root systems and wax-coated leaves of such diminutive size as to reduce the extent of evaporation from them.

Desert animals are not neglected, however; their adaptive specializations are scarcely less interesting, or less necessary. It is suggestive, incidentally, to remark that while, in certain areas, the desert's big game—antelope and bighorn sheep—is in danger of extinction, most of the animals of these regions are on the whole holding their own. It would appear that to men, the desert is forbidding enough for them to leave

it to the indigenous animals. The desert still keeps its sanctity.

The same cannot, unfortunately, be said for the marshlands of this nation, discussed in Paul L. Errington's volume *Of Men and Marshes*. These marshes and their abundant wildlife have been gravely threatened in recent years by the pressures of population and technology. Vast areas have been drained and reclaimed for farm land. Many of the marshes, left by the Pleistocene ice sheets, have also been filled in by dust and silt as a result of soil erosion. The conservationists are putting up a stout, and in some degree successful, fight for their preservation or restoration, but millions of acres of marshland are gone for good—that is, until after the next glaciation has done its work.

It is against this background that

Errington's forceful book takes on its value. Errington, now professor of population dynamics at Iowa State College, grew up on a farm in South Dakota—his familiarity with the great marshes of the northern midwest, therefore, began early. He has hunted, trapped and traveled in the marshlands of the Dakotas, Iowa, Minnesota and southern Canada for years. He knows their weather, their character—with all its amenities and dangers—and the habits of the animals that live there.

Drawing on this great fund of familiarity, Errington has gone about writing his book very simply. His procedure is merely to describe the life of these marshes in casual, discursive fashion, with no further structure than what the rhythm of the season imparts. If this procedure is simple, it is nonetheless

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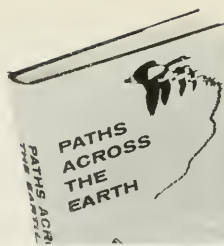
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extraordinary: it enables him to encompass the entire life of the marshlands and to present that life with more or less the pace and richness of its occurrence in nature, in the most tangible sort of way. There are very few books which can even approach it in ability to re-create the fiber of a living community in all its density and detail.

HERE is some of what Errington has to say about marsh life in winter.

"With the continued sinking of the frost line, the seeming isolation of aquatic animals from winter's problems may be transformed into a series of patent emergencies. Crises may be of gradual onset or abrupt; their sequences are complex or of direct cause-and-effect relationships. The clear water of marshy shallows naturally freezes before the deeper clear water of the centers, but the mud about cattail rootstocks and some other plant growths may long remain unfrozen. Snowdrifts over emergent vegetation not only impede the freezing, but ice that formed before the drifting may also melt away under the protection of the drifts. At the same time, snow over the ice, by cutting off the sunlight required by submerged plants for photosynthesis, introduces its own complications... oxygen depletion and the accumulation of toxic gases.

"In the course of a killing freeze-out



MARSH IN WINTER is scene of predatory activity, with the mink—seen here out

the last places on a marsh where fishes keep alive include the plunge holes and channels of muskrat burrows and lodges. The water there may be packed with bullheads; almost all other marsh fishes die before this stage. The bullheads gulp air, trying to live, whether the oxygen is all gone from the water or not, whether the water reeks with hydrogen sulfide or not. A few die, or many may, and the living wriggle among masses of floating dead...

"The muskrats, not being as dependent upon the water as the fishes, have more leeway in meeting freeze-out crises. But they can winter-kill. As a rule, those living in food-rich environment having little water get along better than those in food-poor environment having more water. In the shallows that are grown to cattails and bulrushes, the muskrats can still dig out nutritious underparts, even though considerable freezing of the bottom muck occurs.

"If the muskrats are forced to come out on the surface to feed in cold weather, some of them may still find something edible in the exposed plant crowns and rootstocks. They gnaw the favored parts right down into the ice and may almost stand on their heads, hind-quarters braced above, as they tug and twist. They eat the river bulrush rootstocks sticking here and there from the outside of a lodge. The gnawed

(continued on page 216)



side a muskrat lodge—playing a leading role, and the muskrats frequent victims.



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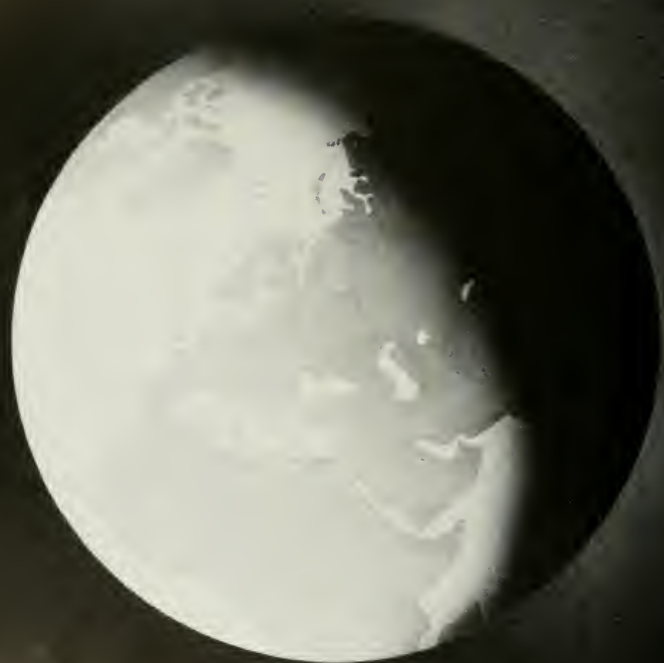
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EASTER AND THE



CALENDAR



The year's holiest day may fall on any one of thirty-four different dates in spring. The reason leads us back to the calendar's past

By

THOMAS D. NICHOLSON

EASTER SUNDAY falls on April 6 this year. Yet, the wide variation in the date of Easter Sunday, from year to year, is such that few could easily calculate that next Easter will fall on March 29. And this, despite the fact that the date of Easter stands as one of the most important in the spring calendar. A host of schedules and events must be adjusted to it: religious observances, industrial and commercial schedules, school recesses and the like. Each year, these and a hundred other activities must be timed to a date that can come as early as March 22 or as late as April 25. How did this come about?

Initially, Easter was very closely associated with Passover: indeed, the adjective "paschal" (often used regarding the Easter season) is derived from the Hebrew word Pesach, or Passover. The Resurrection occurred on the third day (counting inclusively) after the Last Supper, as related in the New Testament, and the Last Supper was the Passover supper. Among early Christians, there was some dispute over what specific day should be celebrated as Easter. Christians of the Eastern world preferred

FULL MOON OF SPRING, which sets date of Easter, brightens a schematic view of heavens shortly after the vernal equinox. West of the moon, Leo—one spring constellation in the zone of the zodiac—is marked by bright Regulus, lower right.

H. K. WIMMER

A Chief Officer aboard merchantmen by age 20, MR. NICHOLSON joined THE AMERICAN MUSEUM—HAYDEN PLANETARIUM after instructing at the U.S. Merchant Marine Academy.

to celebrate Easter and Passover together, considering that the Resurrection (symbolic of Christian rebirth) added a new significance to Passover (symbolic of the rebirth of the Hebrew people after their Egyptian exile). But Passover is a variable calendrical event. It comes each spring on the fourteenth day of the moon in the month called Nisan—the first month of the Hebrew year, which begins with the new moon occurring on or about the vernal equinox. The fourteenth day of Nisan, on the eve of which the Passover supper is held, always came after the vernal equinox. Among the Eastern Christians, then, Easter and Passover were celebrated as one, regardless of the day of the week

or the month on which they occurred.

Western converts to Christianity, however, pointed out that the Resurrection had taken place on a Sunday. They preferred to observe Easter on that same day each year, regardless of its date during the month. For the first few centuries of Christianity, in consequence, different days were observed by different groups each year.

The controversy over the date of Easter was finally resolved at the Council of Niceae, in A.D. 325. The day of Easter was established as a Sunday, after the practice among Western Christians. The rules for determining the date of this Sunday in the month, however, were patterned after the method of dating Passover.

Easter Sunday, the Council declared, would be the first Sunday following the first full moon on or after the vernal equinox. This ruling assured three things. Easter would always come on a Sunday early in the spring. The day could never co-

incide with Passover supper, since Passover began on the eve of the full moon and Easter was the Sunday following that. And, finally, this rule assured pilgrims, journeying in the Holy Lands at the Easter season, bright moonlight to guide them. One other regulation was added by the Council: for calendar purposes, the vernal equinox was fixed at March 21 (the first day of spring at the time the rules were established).

THESE RULES, still in effect today for determining the date of Easter, practically insure that Easter Sunday must fluctuate through the spring calendar from year to year. Imagine trying to celebrate one's birthday according to a similar rule. Suppose you had been born on October 3, a Tuesday marked by a full moon. According to current usage, your birthday would be October 3 each year, regardless of the day of the week or phase of the moon. But, if you followed the system used



EGYPTIAN YEAR

Twelve months—each of thirty days—plus extra five days at end gave 365-day year. Calculation was short.



ROMAN YEAR

Institution of "leap years" added average quarter-day to the length of each year. This was an overcorrection.

for Easter, you would have to select a Tuesday, each year, and the Tuesday you selected would have to be one that followed a full moon. Now the full moon need not come early in October each year; it might come later or at the end of the month. And, because there could be thirteen, rather than twelve full moons during a year, you would have to choose a full moon that would keep your birthday early in the autumn, when you were actually born. With all these variables, you might well establish a rule for yourself, declaring that your birthday would be the first Tuesday that came after the first full moon on or after the autumnal equinox (September 23). This would at least give many

people a good excuse for not being able to remember your birthday.

THE FLUCTUATING DATE of Easter and the rules which govern it illustrate one of the basic problems that faces the builders of calendars: the task of fitting together several periods of time which are actually independent of one another. Let us review these periods. First, there is the "year" of the seasons—the period of the earth's *revolution* as measured by the changing position of the sun. Secondly, there is the solar "day"—the period of the earth's *rotation* as measured by the sun. Third, we have the "week"—established from antiquity as a period of seven days. Finally,

there is the lunar "month"—the period required for the moon to go through a complete cycle of phases as it revolves around the earth. Continuing to use Easter as an example, we see that all four of these different periods must be considered in setting the date. As to the earth's revolution, Easter must come when the sun is in the spring position for the Northern Hemisphere. Each of the possible days on which Easter may fall, in turn, is a unit of the measure of the earth's rotation. But the day selected must be the same one out of an arbitrary measure of seven in the week. And, finally, this day must always follow a fixed point in the lunar cycle.

But none of these works out evenly.

There are 365.242199 solar "days" (and this number could be carried out further) in one "year" of the seasons. There are 29.530588 solar "days" (this number, too, goes on) in one lunar month. Although, by definition, there are exactly seven solar "days" in a "week," the year of the seasons contains fifty-two weeks, plus one or two extra days, while the lunar month contains four weeks plus a day and a fraction, and there are between twelve and thirteen lunar months in one year. Thus, no exact number of solar days and weeks, lunar months, or solar years will equate precisely with one another.

From the beginning, men have been trying to build a calendar which will keep track of the seasons, count the years successively, and maintain anniversaries or festivals in the season in which they originated. But they have been trying to do so by counting lunar months or solar days as the units of measurement for a year which is essentially solar. Among the earliest calendars, the year was equal to twelve lunar months, counting these months, alternately, as twenty-nine and thirty days long. Such a year was only 354 days long, and its users kept losing on the seasons by slightly more than eleven days per year. To catch up again, an extra month was interpolated at intervals, generally about once each three years. One such calen-

dar—still in use for Hebrew religious purposes—adds an extra month on the third, sixth, eighth, eleventh, fourteenth, seventeenth and nineteenth year of a nineteen-year cycle.

Thousands of years before the time of Christ, the Egyptians realized the folly of a calendar that measured the solar year by a lunar month. They developed a calendar containing twelve months, each thirty days long, and added five extra days at its close for a year of 365 days (as close as they could calculate the true length of the solar year). But even this was nearly a quarter-day short of the true length of the year of the seasons and, in a little over 700 years, winter events were taking place during the calendar's "summer" months.

JULIUS CAESAR, in 46 B.C., instituted a calendar change that finally began to take into account the impossibility of measuring the year of the seasons by an exact number of solar days. He introduced a leap year, by adding an extra day to the year at regular intervals. The Julian calendar added this extra day once each four years, making the average length of the year 365.25 days. But .25 isn't .242199, and the Julian year was too long by .007801 of a day (or by about eleven minutes and fourteen seconds). This amounts to a full day once every hundred twenty-eight years.

As we have seen, at the time of the Council of Nicaea, the vernal equinox fell on March 21 by the Julian calendar. By the sixteenth century, the Julian calendar had gained ten days and the vernal equinox was actually falling on March 11.

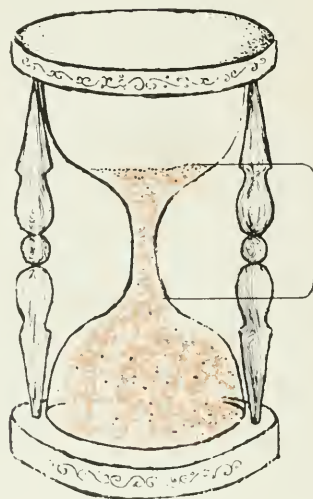
In 1582, Pope Gregory XIII decreed a change in the Julian calendar which restored Easter to its proper position in the year of the seasons and corrected the error that had caused the slippage. The Gregorian change dropped ten days from October, 1582: the day following October 5 became October 15, thus restoring the true vernal equinox in 1583 to March 21. Next, the leap year rule was changed. Each of the century years were now to be ordinary years, except that century years divisible by 400 would continue to be leap years. The average length of a Gregorian year, therefore, came to 365.2425 days, some twenty-six seconds a year too long.

Such a difference amounts to one day after the passage of 3,323 years, so that our descendants of A.D. 4906 will again have a dislocation to grapple with. It has been proposed to correct even this slight error by declaring all century years divisible by 4,000 to be ordinary years. By dropping leap year's extra day once every 4,000 years, the calendar could follow the seasons without as much as a day's error for some 200 centuries.



SHORTAGE

Egyptian miscalculation, shown in hourglass analogy, above, meant the loss of a full day every four years.



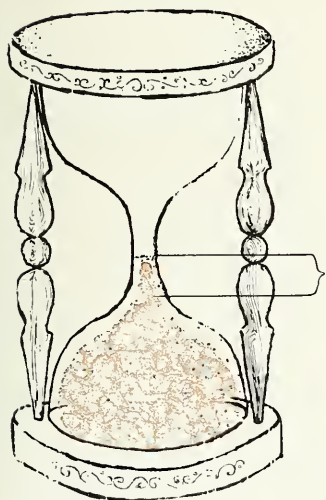
surplus

Nearly a quarter-hour of extra time per year put the new Julian calendar a full day ahead every 128 years.



GREGORIAN YEAR

Papal change brought Easter back to spring season and cut annual accumulation to a mere twenty-six seconds.



26 SECONDS
GAINED
PER YEAR

REDUCTION

Gregorian reform, in sixteenth century, sliced Julian surplus so that day is gained only every 3,323 years.



4½ SECONDS
GAINED
PER YEAR

REFINEMENT

Presently proposed elimination of some leap years is aimed at reducing gain to one day every 20,000 years.

THE FIRST VOICES OF SPRING

Frogs' calls are known to serve a mating purpose. Is that all?

By CHARLES M. BOGERT

IT IS PROBABLE that the first voice in the earth's history was that of a frog. The *Salientia* have been in existence for nearly two hundred million years, a clean lead of more than a hundred million years over that "mob of irresponsible and shifty-eyed little shrews," to borrow Archie Carr's phrase, that "swarmed down out of the trees to chip at stones, and fidget around fires, and build atom bombs."

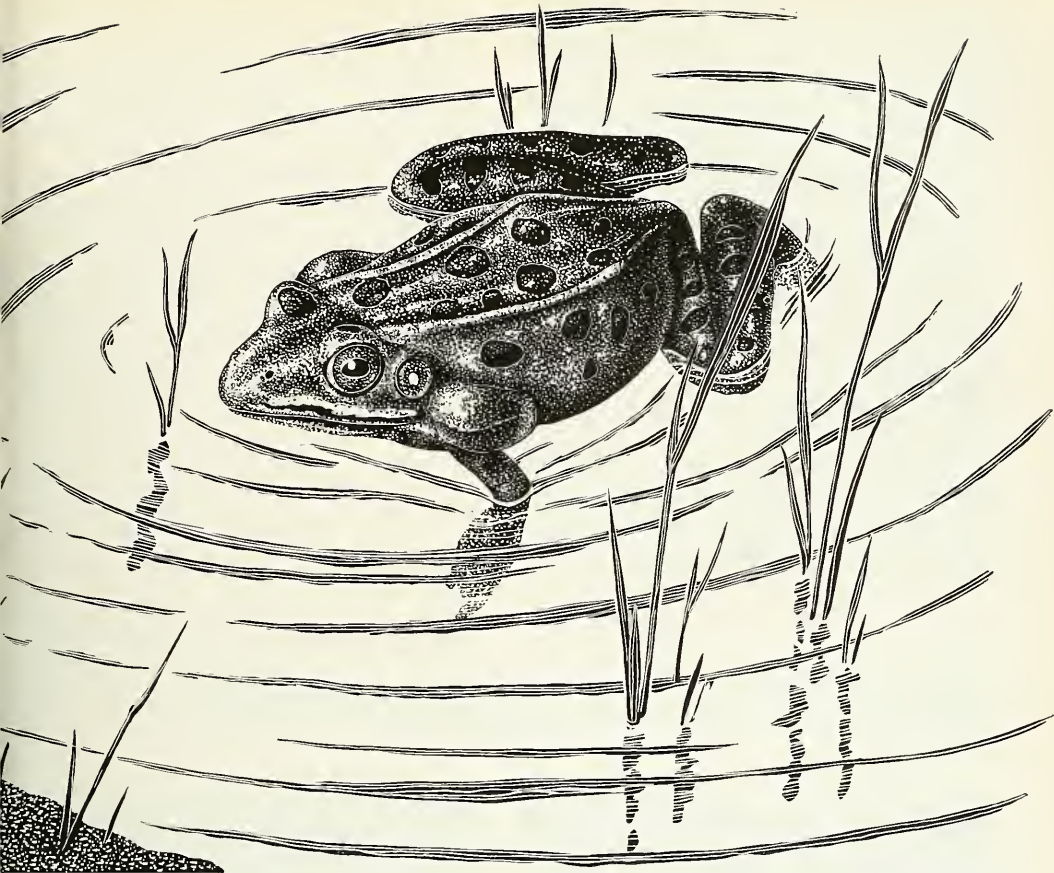
To judge from what is now being learned about the sounds produced by fishes, the ancestral amphibian stock—that turned fins into limbs and ventured onto the land those many millions of years ago—may have been able to make noises. At least, some of the earlier amphibians—of Carboniferous times—apparently had a tympanum, or eardrum; hence they probably also had ears and could hear. Whether any of these fossil amphibians had voices, however, we shall never know for certain.

It seems probable that the use of voice—as an adjunct to mating activities—evolved somewhat later, largely as an attribute of the tailless amphibians. Voice, for example, plays no part in the courtship of salamanders and, indeed, salamanders were long believed to be deaf. In 1939, however, Ferhat-Akat demonstrated that they not only could hear, but were able to distinguish frequencies as narrow



in pitch-difference as a fourth or fifth musical interval. In contrast to the salamanders, it had generally been assumed that frogs *could* hear, principally because the earliest field observation showed that, when one frog started to call, it was often joined by others. Not until Yerkes carried out a series of experiments in 1905, however, was this point actually proved. There is still no proof, however, that frogs can discriminate between one pitch and another. Indeed, field observations, thus far, do no more than suggest that frogs can discriminate the mating calls of their own species.

Not all early naturalists realized that most frog calls accompanied breeding activities, nor did anyone make a very serious effort to find out why frogs called until after Yerkes' demonstration. To set the general, but unsupported, belief that voice plays an important role in attracting frogs to their breeding site, we ran a series of experiments in 1954, at the Archbold Biological Station in Florida. Southern Toads (*Bufo terrestris*) were marked for future identification and liberated in a paved plaza. A loudspeaker, shifted from one end of the plaza to the other in successive experiments, was employed to broadcast a taped recording of a chorus of the species. The toads



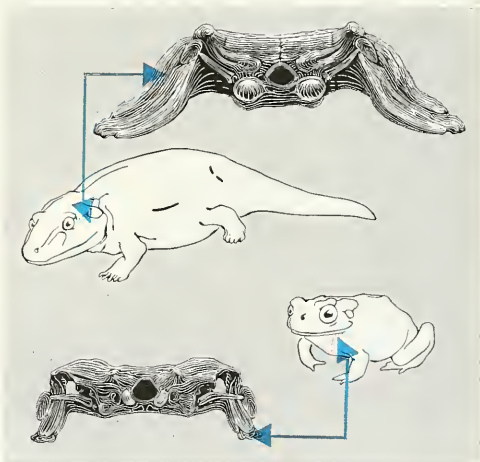
AFLOAT IN A POND, this male Leopard Frog, *Rana pipiens*, is distending his paired vocal sacs to utter "mating call."

had been gathered at random, but most of them were not engaged in breeding activities when captured.

Liberated in the plaza, when the loudspeaker was silent, the toads of both sexes showed no tendency to move in any one direction in preference to any other. When the taped chorus was broadcast, however, we observed a negative response from a number of male toads liberated over a hundred feet away from it. In every test, more male toads went away from the speaker than went toward it.

FEMALE toads behaved somewhat differently from the males. Well over half of them headed *toward* the sound source. Unfortunately, from our viewpoint, several of these females—which had been captured in breeding choruses—had laid their eggs in the laboratory before they could be tested with our taped chorus. It seems doubtful whether such spent females would respond to the call of the male. We were thus inclined to attribute our limited success with the females to our inability to prevent all of them from depositing their eggs prior to being exposed to our broadcast of the taped choruses.

We ran these experiments again in the summer of 1957. Results essentially similar to those of 1954 were obtained,



SKULL STRUCTURE of fossil amphibian, *top*, indicates ear-drum in position similar to that of a modern toad. *bottom*.

although a somewhat larger percentage of females went toward the sound, and a larger percentage of males went the other way. Judging by these results, it seemed extremely doubtful to us whether there was any positive response of one male to the call of another.

Then, late in August, while we were at Cape Haze, a storm brought some five-and-a-half inches of rain. Sometime after midnight, we encountered a Southern Toad breeding-aggregation of moderate size. We recorded this chorus around 3:00 A.M., and then caught all the toads that we could find—thirty-nine males and fourteen females.

These were taken to the Station the following night. Despite their isolation from males, we found that—as usual—most of the females had deposited their eggs before we reached the Archbold Station. We released the toads, both males and females, in a light rain at 9:00 P.M. that evening, while the chorus was being broadcast at the north end of the plaza, 130 feet away. After half an hour we ceased the broadcast, and retrieved all the toads we could find. This time, twenty-four out of the thirty-nine males had gone toward the source of sound; a majority of the twenty-four were lined up in a semicircle, facing in the direction of the loudspeaker, some ten or fifteen feet away.

The outstanding difference between this experiment and those that preceded it, we believe, lies in the fact that *all* the toads employed had been actively engaged in mating activities when captured the previous morning. Presumably the majority of them were in suitable physiological condition to engage in breeding activities. It seems probable, therefore, that toads (at least those of the species employed) respond to mating calls only when they are in breeding condition.

In Florida, many, but not all, toads are apparently in

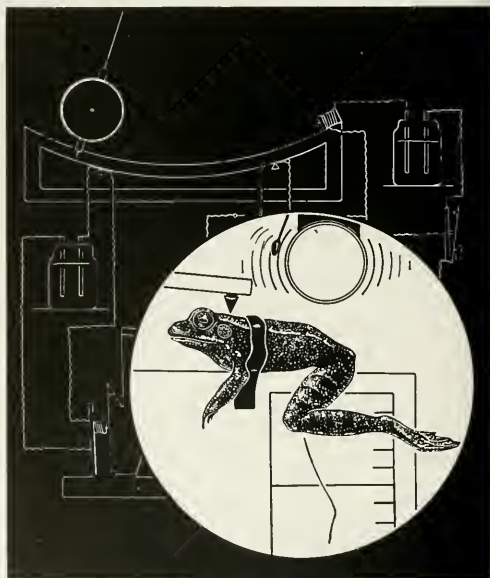
suitable condition to breed throughout the summer. Precisely how the advent of heavy rains provides the stimulus for these toads to migrate to breeding sites remains obscure. There would seem to be an interaction of physiological and environmental factors, with some sort of mechanism to trigger sexual activity only under suitable weather conditions.

When two or more species of frogs live in the same region, the likelihood of interbreeding between different species is inhibited or prevented by various means. Each species may breed at a different time, or in a different sort of place—for example, some frogs prefer quiet pools; others, running streams. Or mating may be mechanically impossible—our adult male Southern Toad is unable to clasp a female of the much smaller Oak Toad species (*Bufo quercicus*) and, hence, could not remain with her to fertilize her eggs. Or, to return to our vocal theme, there *may* be a specificity of response to mating calls, with the females particularly attracted to males of their own species.

NEVERTHELESS, the occurrence in nature of hybrids between species shows plainly that frogs may err in their choice of mates. For example, we found (and recorded the call of) a hybrid resulting from the cross between the Barking Treefrog (*Hyla gratiosa*) and the Green Treefrog (*Hyla cinerea*) in chorus with a group of Barking Treefrogs. The hybrid was intermediate in size between the parental frogs, but in pattern and color it was much like the Green Treefrog. It is noteworthy that, in addition, this hybrid's voice was intermediate to both parents' in dominant frequency but, as the comparative sonograms (p. 187) demonstrate, the higher-pitched harmonics of both parental species were lacking.



COMMON ASSUMPTION that frogs could hear was put to test by Yerkes in 1905. *Above*, point on rod taps tethered frog's back; frog responds with slight reflex movement of its leg.



IN SECOND INSTANCE, bell rings just before tactile stimulus; frog's reflex action is greatly increased. Reflex was noted for a sound range from 50 to 10,000 cycles per second.

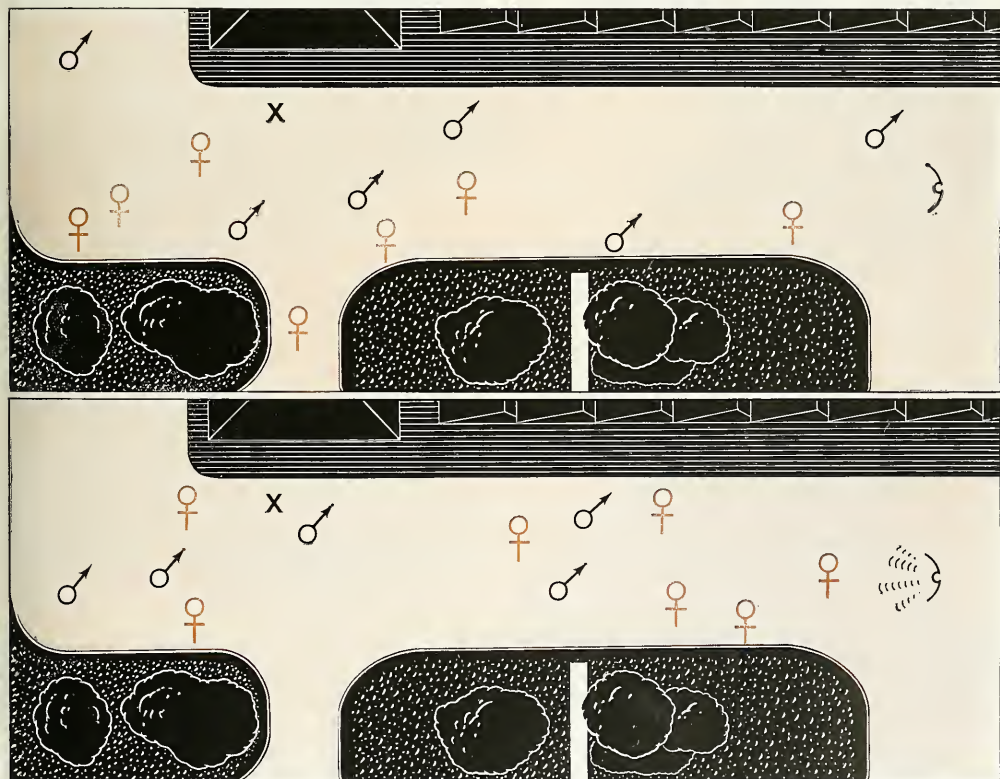
Now, animals, like human beings, are not evenly distributed over the lands they occupy. In the case of frogs, some are restricted to low elevations, others to mountains; other species, largely restricted to wooded areas, may shun the open plains. When the range of a species is wide, several local populations in one part of the range—usually where there are environmental differences—often are alike in characters that distinguish them from other members of the same species elsewhere. Such local populations, when they inhabit more or less extensive regions, have often received recognition as subspecies.

For example, one of the common amphibians in the eastern part of the United States is Fowler's Toad (*Bufo woodhousei fowleri*). It differs in minor respects from toads of the same species in the western, more arid, portion of our country, most notably in size. As to voice, the larger western subspecies, *B. w. australis*, of the desert regions, appears to have a lower-pitched call. Again, the population of Red-spotted Toads (*Bufo punctatus*) at Austin, Texas, consists of individuals that tend to be grayish in color (and smaller) than those in the population at Cave Creek, in Arizona's Chiricahua Mountains, where they tend to be reddish. Perhaps correlated with the difference in size, there is also a difference in voice pitch. For those at Austin,



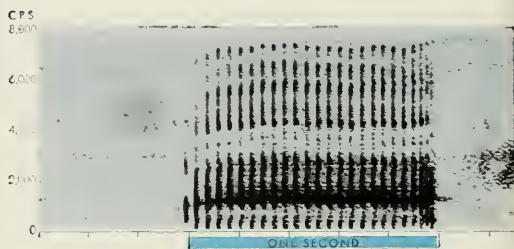
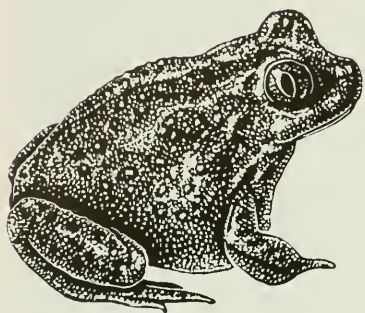
SOUTHERN TOADS scatter at random, top, when no sound is broadcast. Hearing chorus, bottom, more females approach sound than go away: more males go away than approach sound.

SAME EXPERIMENT was repeated with toads captured during mating. Twenty four out of thirty-nine males were attracted by broadcast of own chorus: many lined up near the speaker.



Variety of Voices

Cross-breeding among different species may be discouraged by distinctive mating calls



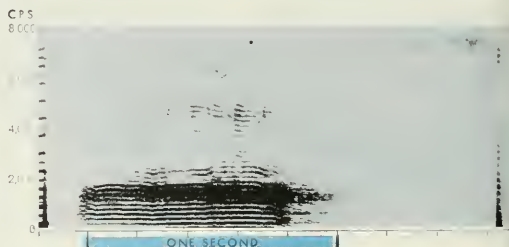
WESTERN SPADEFOOT

Scaphiopus hammondi is often to be found breeding at the same time and in the same pools with the two other species of spadefoot toads shown here. The sonogram, above, shows that its call is second-long trill, with dominant frequency at 1,500 cycles. It sounds like a bouncing Ping-pong ball.



PLAINS SPADEFOOT

Scaphiopus bombifrons, in contrast, utters quick series of brief bleats, each one-fifth of a second in duration. Dominant frequency is around 1,800 cycles, with a harmonic at 6,000 cycles. Such sharp contrasts mean that voice characteristics are of little or no use in the definition of generic groups.



COUCH'S SPADEFOOT

Scaphiopus couchi is also a bleater, but its call is a long, drawn-out one, lasting close to a full second. Again, the dominant frequency is low—about 1,500 cycles. Different qualities of voice among these three species may discourage accidental cross-mating at time when all breed in same pond.

A Hybrid

Voice of the offspring is intermediate

BARKING TREEFROG

Hyla gratiosa (shown below with accidental mate, *Hyla cinerea*, the Green Treefrog) produced first sonogram at right. Last sonogram is from other parent. Between the two is voice of offspring, with a dominant frequency intermediate to that of the parents.

C. P. S.

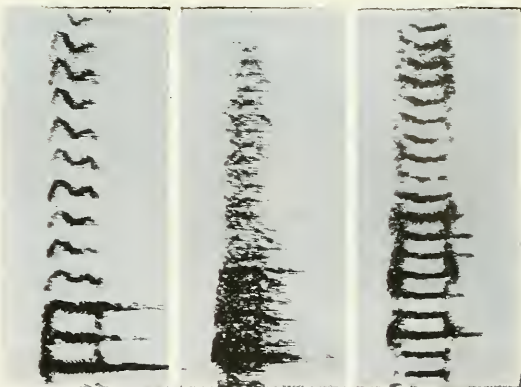
8,000

6,000

4,000

2,000

0



HYBRID OFFSPRING

Hybrid treefrog's voice has dominant frequency of some 900 cycles, in contrast to 600 for *gratiosa* and 1,200 for *cinerea*. Hybrid was recorded as it joined a *gratiosa* mating chorus.

Chairman and Curator of the Department of Amphibians and Reptiles at THE AMERICAN MUSEUM. MR. BOBERT was born in Colorado and educated at UCLA, where he later taught. He has been at THE AMERICAN MUSEUM since 1936.

the frequency varies from 2,510 to 2,700 cycles per second, whereas those at Cave Creek vary in frequency from approximately 2,000 to 2,300 cycles per second.

YET, the Red-spotted Toad populations in these two locales are not even deemed subspecies, while the mating trills of local populations of each subspecies of *Bufo woodhousei* are so variable that the nature of the differences remains to be worked out. Indeed, the recordings obtained thus far suggest that voice differences between subspecies usually are not great. Ordinarily, anyone well acquainted with the mating call of one subspecies would readily recognize others of the same species.

In contrast to this, and despite some exceptions, where various species inhabit the same area, conspicuous differences between mating calls seem to be the rule. Therefore, data so far available offer little hope that voice characteristics will be of much value in defining generic groups.

For example, three species of Spadefoots (*Scaphiopus*) that occupy separate but adjoining regions—*holbrooki*, *huerteri* and *couchi*—have quite similar voices. Other Spadefoot species, which overlap the habitat of the larger Spadefoot, *couchi*, are sharply differentiated in voice character. This is particularly notable in the case of *hammondi* and *bombifrons*, both of which may breed in the same pool with *couchi*. These three also have different calling habits: *hammondi* usually calls from the middle of a pool; *bombifrons* and *couchi* from shallow water near the pool's edge. Nevertheless, the two smaller species sometimes interbreed, and I have heard hybrids—with the body markings of *bombifrons*, but with voices that appeared to be intermediate—calling from the middle of a pond, together with a chorus of *hammondi*.

Although conspicuous differences in voice are indicative of the specific distinctness of populations, similarities in voice reflect relationships only to a limited extent. Many listeners could scarcely distinguish the call of the Pine

Barrens Treefrog, (*Hyla andersoni*) from that of the Green Treefrog (*Hyla cinerea*), even though the frogs are so different in appearance that no one would question their assignment to separate species.

Thus far, we have taken note of frog voices in association with breeding activities, and as a possible species-isolating mechanism. But frogs produce other sounds that are not associated with reproduction. One of the more interesting of these appears to involve territoriality. Frogs, particularly those of the genus *Rana*—which spend much of their time feeding in shallow water or round the edges of streams and pools—sporadically give vent to grunts, or similar sounds. These grunts are commonly to be heard round ponds or streams inhabited by the Green Frog (*Rana clamitans*), the Pig Frog (*Rana grylio*) and the Leopard Frog (*Rana pipiens*).

To the casual observer, these occasional grunts appear to have little if any biological significance. Studies of the Green Frog by Martof, published in 1953, suggest, however, that such calls are associated with a sort of territoriality. In the areas where Green Frogs were breeding near Ann Arbor, Michigan, he found that males were spaced at astonishingly uniform distances of some six to nine feet. Moreover, when the whole aggregation shifted, several individual frogs made approximately the same movements at the same time. Certain frogs tended to remain together, with some sort of orientation that permitted them to maintain the same general spatial relationships to one another. Frogs in any cluster tended to remain in it for periods of about two months. Martof suggests that this orderly spacing may have been accomplished by means of either auditory or visual cues.

However, in my opinion, Martof's studies are strong evidence that the observed spacing is primarily connected with vocalization. As to the value of the mechanism, maintenance of such territories would be advantageous during the breeding season in permitting males to detect the presence of females, while, after breeding, when frogs seek out any moving prey that comes in sight, individual spacing would ensure efficient coverage of the available prey.

FROGS, like other widely distributed animals, are represented by a vast number of species—around 2,000—each of which is adapted for some particular combination of environmental conditions. The habits of each species have evolved, along with the structural characteristics that fit them for some more or less specialized mode of existence. Natural selection tends to retain those characteristics advantageous to the species, and to weed out those that—either alone or in combination—inhibit survival. But a species is made up of individual animals and, since these evolve as integrated machines, so to speak, natural selection produces effects on the creature as a whole, rather than on individual parts. Thus, differences in voice may reflect the evolution of structural differences that have arisen in isolated groups of animals, for such groups are slowly but continuously changing to meet the changes in their respective environments.

The frogs' mating calls, often the first voices of spring, may thus have evolved as parts of a complex of isolation mechanisms. What is irreducibly significant is that, ordinarily, no two species of frogs inhabiting the same area have mating calls that are not easily distinguishable—at least to human ears, and quite possibly to the *Salientia*, of ancient and honorable lineage, that produce them.



BARRIER TO INTERBREEDING in nature is disparity in size of many species. Large Southern Toad, *Bufo terrestris*, seen here, could scarcely grasp the tiny Oak Toad, *Bufo quercicus*.



VARIETY OF CALLING STATIONS is shown, clockwise, from upper right: Pinewoods Treefrog on low bush; Squirrel Treefrog near pond's edge; Green Treefrog out on limb; Oak Toad

in grass; Narrow-mouthed Toad in shallows; Cricket Frog at rim; Southern Toad in shallows; Leopard Frog afloat; Barking Treefrog on high perch. Diversity discourages interbreeding.



Naturalist's Notebook

ON ESTIMATING

In which a hoary legend is spiked and a number of nature's real and supposed clues to age are examined



IN THE TONGA ISLANDS of the Pacific, there is a giant tortoise that has, for years, enjoyed the reputation of being the world's oldest living animal. According to sturdy legend, the tortoise was brought to Tonga from the Galápagos in 1777 by the famous English explorer and navigator, Captain James Cook. As recently as July, 1957, this tortoise—known as *Tui* ("King of") *Malila* (an ancient name for Tonga)—was to be seen in and around the palace grounds. While it was still believed that *Tui Malila* had come with Cook from the Galápagos, a bit of finger-counting gave it the venerable minimum age of 180 years—plus the unknown years preceding its capture.

But it has recently been established by Dr. James Oliver, Curator of Reptiles at the New York Zoological Society, that *Tui Malila* is one of the Radiated Tortoises, from Madagascar (*Testudo radiata*) and not a Galápagos specimen (*Testudo elephantopus*).

Thus the legend dies, and all that is certain is that someone brought the animal to Tonga and that its true age, while probably great, remains both unknown and unknowable.

There is a lesson in all this. In seeking to determine the age of any animal or plant, what is to be done? Unless the very moment of birth is witnessed, or hatching, or germination, it is necessary to depend on a variety of indirect clues. Often, interpretation of these clues brings a realization that the organism under study is far younger than was suspected, or, very much older.

The largest known animal that has ever lived is today's great blue, or "sulfur-bottom" whale. Its 150 tons' weight is treble the estimate for the biggest of the extinct dinosaurs. How old is a 100-foot blue whale?

In 1940, scientists in both Norway and the U.S.S.R. independently discovered a clue to age in the bone plates of the blue whale's mouth, which serve

AT ROYAL MEETING with Queen Salote of Tonga in 1953, Elizabeth and Philip had opportunity to view the venerable, scar-shelled *Tui Malila*, seen close up, below.



AGES

By

LORUS and MARGERY MILNE



ANNUAL GROWTH OF BALEEN, in mouths of the various whales that possess these feathery-edged, bony plates as strainers

for their food, proved an indifferent clue to animal's age. In Antarctic whaling scene, *above*, baleen is being cut away.

Man and wife, the Drs. MILNE are Professor of Zoology and a research associate, respectively, at the University of New Hampshire. Their latest book is *Paths Across the Earth*.

to strain out the krill on which it feeds. These plates grow larger annually, at a rate which varies with the seasons. In consequence, lines are discernible which give some measure of the whale's age. The only difficulty is that the plates wear down continually along their leathery edges, thus eliminating the record of early years in an older whale.

IN 1955, a new clue to whales' age was developed by Dr. P. E. Purves, the English biologist, and his associates. These scientists knew that the external ear tube of all baleen whales (among which is the sulfur-bottom) is filled completely by a waxlike plug. They reasoned that the plug must grow to keep up with growth of the skull and, if whales grow at non-uniform rates as the lines on the baleen plates indicated, the ear plugs might also show distinct growth zones. Investigation proved that they did. An extensive collection of such ear plugs has now been made. From them, it may be possible to learn a good deal about the ages of many kinds of whales.

Great care is necessary in choosing such indirect clues to age. The telltale mark of a rattlesnake, for example, consists of interlocked pieces, each

the dry remains of a previously molted skin. If the snake molted once each year and never lost the "button" at the end of its rattle, the number of pieces would correspond to the reptile's age. But end-pieces frequently break off, and snakes may molt several times in a single season. Consequently the number of a rattler's buttons cannot be taken as an accurate count of its years.

The growth and welfare of clams, scallops and oysters are economically important to many people. Are new shellfish attaining marketable size as rapidly as the crop is being harvested? To continue as a valuable food resource, the average age of the population must not be allowed to drop too far. The biologist can read something about age in the rings of each shell, but care is essential to his reading. All of these shells are enlarged as the soft animal grows within. At first, each shell is small, but eccentric additions are made to the inner surface and edge. Most of the new lime is laid down along the edge opposite the hinge, and least in the region of the hinge itself. So long as the animal is undisturbed and well nourished, new shell is formed smoothly. During winter, however, the growth rate is greatly reduced and this reduction shows as a groove in the shell.

Recently, it was discovered that bad weather could produce "false" annual rings. Normally, the shellfish live where the water is reasonably clear, and feed by filtering out microscopic bits of plant and animal life. But if a series of storms churns up the water and muddies it with inedible debris, each shellfish suspends both feeding and growth. This interruption may result in a "storm ring" in the shell that is indistinguishable from a winter ring. For this reason, the biologist must be well informed regarding the local storm records before he can read the growth rings in his shell as a reliable record of its age.

Fisheries men can place far more reliance on the growth rings which mark the scales of brook trout, and other fish with overlapping armor. This covering develops at a very early age and, although the total growth during the first year is comparatively small, a well-fed fish enlarges both its body and each scale at a far faster rate thereafter. Most of this growth occurs during the spring and summer. Fall and winter rarely provide as much to eat, and the oxygen available



NUMBER OF RIDGES on horns, like these above, indicates age with fair accuracy.

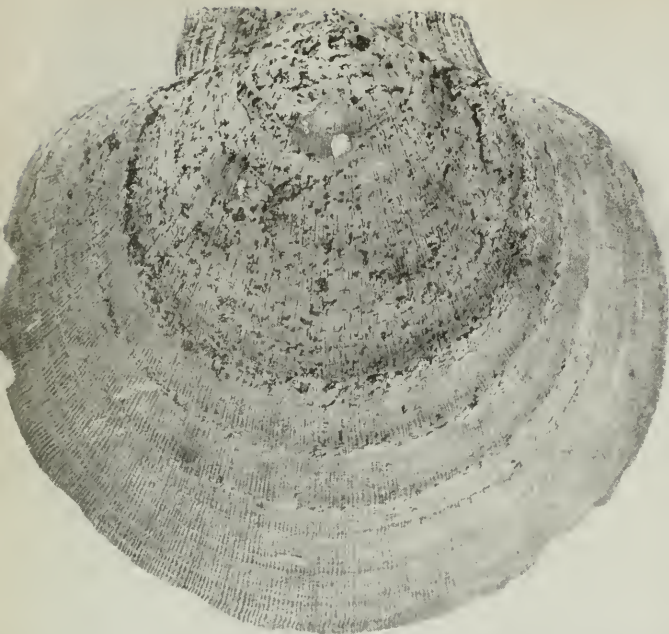
to the fish may be enough less to make them remain relatively inactive. These differences are recorded in eccentric growth lines in each scale. Rings close together mark months of poor feeding. Those spaced farther apart show more favorable living conditions. With a little practice, the total age of a fish can be read by examining a single scale from its body. That the method is accurate has been proved both by the study of fish added to new lakes, and by periodic examination of fish bearing identification tags.

For fish with scales that do not overlap, such as the sturgeon and gar, the scientist must turn to other hard parts in his search for clues to age. We know that the sturgeon adds annually a new outer layer to its fin bones. Hence, the age of the fish can be learned by examining a cross section of such a bone. Growth zones also show in the vertebrae of catfish, and additional evidence may be found in the part of a fish that corresponds to our inner ear—where hard bits of lime, called "earstones," often form and grow at rates which correspond to changes in nutrition. These stones can be cut across to expose the consecutive inner layers for counting.

WOODSMEN judge the age of deer by their antlers and compare notes on the patriarchs of the forest. A twelve-point buck, in many instances, is deemed an oldster approaching the trophy class. But the twelve-pointer may be no more than eight years of age. Antlers are a mark of the male among deer, elk and moose, and are worn by both sexes of caribou. They develop in the young animal, only to be shed at the end of the mating season. As the individual grows older, the rack of antlers is larger each year.



NUMBER OF POINTS on antlers (above, a caribou) does not indicate years of age.



SLOW WINTER GROWTH, alternating with faster growth of summer months, causes the contrasting narrow bands on scallop

shell, *above*. Each pair of bands would thus record a year's growth, except that storms can produce "false" winter bands.



SEASONAL VARIATION is also evidenced in broad and narrow growth rings on the scales of fish, like this trout, *above*.

Better supply of food during spring and summer months, together with reduction in oxygen during winter, makes contrast.



ANOTHER MEASURE of annual growth may be used for fish that lack scales, such as this Columbia River sturgeon, *above*.

Remarkably, too, the successive sets of antlers grow in length and weight faster than the animal itself. Astonishing amounts of lime must be obtained in the diet every year merely to produce these temporary outgrowths from the head. But no law of nature neatly adds a point each year.

The bighorn sheep, the mountain goat, and the bison are more like domestic cattle in retaining their horns from year to year, enlarging them only gradually. In bighorn sheep, the rate of growth resembles that of buck deer and moose in being faster than increases in body weight or length. And from the ridges on their massive horns, the ages of big rams can be estimated with fair accuracy.

PLANTS, too, show juvenile characteristics. The first pair of leaves spread by a bean seedling are thick and oval, filled with food. Within a day or two the next pair open—thin, brighter green, and borne on short stalks. The leaves on a young oak sapling usually are far larger than those produced when the same tree is older.

Each perennial plant poses a still greater puzzle for the student of age. An oak may be two hundred years old at the base, but this great age does not extend throughout the tree. A human finger is as old as the individual, but the current year's growth on a tree is almost as young as a new



Here, sturgeon are being butchered for the commercial market, but pectoral fin bones will be saved for analysis. *right.*

seedling. Indeed, if a branch tip is removed and induced to root, a new tree is created, that shows no sign of its former connections.

DURING the winter, the tip of each twig bears a terminal bud. As spring arrives, the overlapping, waterproof scales covering the tip open and break off, leaving a little ring of scars. Inner parts of the bud can now extend themselves, producing broad leaves and more stem. At the end of this new stem is the terminal bud which will produce still another year's growth.

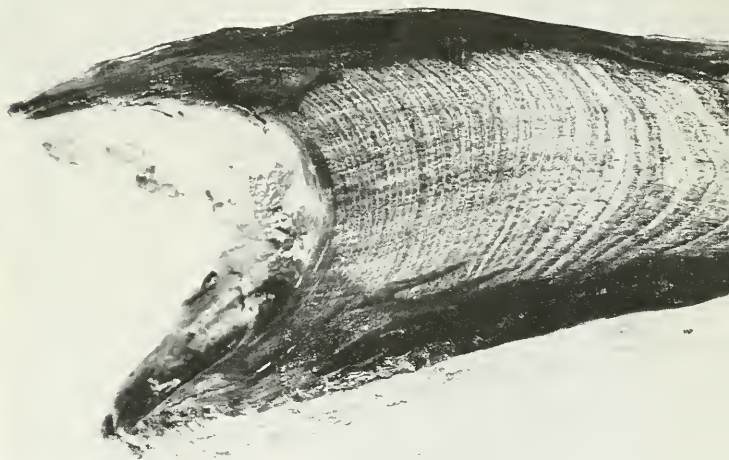
Thus, by counting back from the tip of a twig, the extent of one season's development is found at the first ring of bud-scale scars. Between this and the second ring of scars is the previous year's growth. One after another, the growing seasons can be accounted for, until increasing thickness of the bark conceals the scars.

In the current year of growth, the twig wood is soft—a single cylinder, surrounding the central pith. In the next zone—the region behind the first ring of scars which bore last year's leaves—a new layer of wood has been added as a sheath around the original cylinder. In cross section, here, the stem shows two "yearly rings." And this "ring" system extends backwards, twig to branch to trunk, permitting the measurements, known today as "dendrochronology."



THIS ANTERIOR RAY from a sturgeon's pectoral fin has been prepared in cross section by Ivan J. Donaldson. Each year,

a new outer layer is added to the bone, and a count of the layers in this specimen showed that the fish was eighty-two.

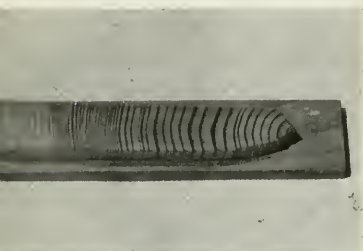


WAXLIKE PLUG from external ear tube of a balen whale, *above*, is one of the many collected by the English biologist,

P. E. Purves. Since plug grows to match whale's skull, growth zones should provide analyzable record of whale's age.



FIRST STEP in tree-ring study of live specimens is to take core from the tree with a slim, stainless steel tool, *above*.



HOUSE BEAM from pueblo ruin yielded this core. Its rings, matched with many other such cores, show A.D. 1000 date.



CORE MATCHES are made at Arizona University's Tree Ring Research Laboratory by the curator, Bryant Bannister, *above*.



Counting the rings in a stump has been the way of learning the age of a cut tree for untold generations. Modern foresters obtain the same information from living trees without doing significant harm. With a special boring tool, they remove a pencil-thick core of wood extending all the way from the bark to the tree's center. By counting the bands on the core they learn the age of the tree for the height at which the sample was taken.

For many years, the evidence from such cores has supported the belief that the "Big Trees" of California—the giant redwoods—are both the most massive and the most ancient of living organisms. Largest of the redwoods is the General Sherman Tree, in Sequoia National Park. It has a circumference of 101 feet at its base and a height of over 272 feet. These are the

measures of a solid wooden pyramid, weighing about 2,150 tons. The General Sherman Tree is somewhat more than 3,000 years old.

At the University of Arizona's famous laboratory of Tree Ring Research, a seventeen-year research program has been in progress, developing better dendrochronology. Samples have been removed from a great variety of trees. In 1956, this study—extended to the dwarfed timber that grows slowly at high elevations—led to a startling discovery.

As part of routine study, the late Dr. Edmund Schulman and his assistant C. W. Ferguson, Jr., removed cores from stunted trees between ten and eleven thousand feet elevation, in the White Mountains of California. Whole slopes, there, are sparsely set

SPARSE SLOPES of California's White Mountains provided surprise for dendrochronologists: stunted Bristlecone Pine.

GNARLED TRUNKS of Bristlecones gave cores showing over four thousand years of growth—longer than Giant Redwoods.



with grotesque growths of the Santa Lucia Fir, *Pinus aristata*, known locally as the "Bristlecone Pine." When the core samples of *P. aristata* were counted, several of these trees were found to antedate the oldest "Big Tree" by nearly ten centuries, with ages in excess of four thousand years.

Thus, the crown for antiquity has now passed from the giants to a collection of gnarled and twisted dwarfs.

Four thousand years is a long time. Yet many of the trees of this age are still alive, their life span not yet probed to the limit. Four generations of such a life span would take us back to the end of the Pleistocene. Ten of them would bring us to the time when mankind, as we know it today, had made little mark upon the world, let alone found time to puzzle over the ages of other kinds of life.



IN DARING TEAMWORK, Mandari huntsmen have cut this elephant out of herd, close in for the kill. By law, the meat-starved tribesmen may spear annual quota of elephants.

HUNTERS OF AFRICA

Game Warden of the Southern Sudan
writes in defense of native hunting

By PETER MOLLOY

THE GAME LAWS of the Sudan are designed primarily to conserve the country's game for the benefit of the indigenous population, with due regard to international undertakings in the protection of particular species. Natives are thus encouraged to hunt by certain traditional methods—i.e., spear, bow and arrow, and, in limited areas and at certain times, nets.

Except among a few of the more sophisticated Southern tribes, hunting, in fact, required no "encouragement," since the lack of meat in the natives' diet, and the consequent craving for it, drives every able-bodied villager into the bush on hunting expeditions during the four months of the dry season. There are usually about twenty in a hunting party, and they will travel



anything up to a week's march into the uninhabited wastes of the bush to a selected hunting area, generally around an isolated water-hole. There they will remain until they have accumulated as much dried meat as the party can carry. If closer to home, a shuttle service of carriers, usually women, will bring in the meat until the area is worked out.

After the introduction of cattle and other imported items of diet, when game meat is no longer such a vital necessity to the tribe, native hunting may degenerate into a haphazard business with the sole object of killing as many head of game as possible. But this is by no means always the case, and where there is a strong tribal hunting tradition and game meat is

limited, communal hunting is usually a strictly controlled affair under an appointed leader, or hunting chief. The more primitive tribal native has a shrewd idea what game can be cropped from an area in the year without depleting the basic stock, and he strongly resents any intruder on his preserves. This accounts for such tribes' obstructive attitude to outsiders hunting over their land with rifles, even if they, the natives, benefit from the meat: they are worried about depletion of the stock.

Control by a hunting chief breaks down in the next stage when rifles come into native hands and individual hunting by this modern method is shown to be more productive than the communal hunting of old; then the

race to exterminate the game is on. Many African territories have forbidden native hunting; we in the Sudan have forbidden or drastically restricted the primary evil—the firearm in native hands—and so far can afford to let the cropping of game continue by traditional native means.

There are, of course, many traditional methods which are forbidden on grounds of cruelty and wastefulness—such as ring-firing: a herd, preferably of elephant, is ringed with fire; many of the terrified beasts perish in the fire, while those that stagger out, blinded and choking, are speared.

Pit-trapping is another illegal method which was in widespread use in some areas until recent years, particularly in the dense rain-forest near the



DURING DRY SEASON, men of the Southern Sudan tribes spend as much time as they can hunting, leaving agricultural work

of the villages in women's hands. These empty-handed hunters, *above*, are Lotuka men, returning to their village, Logurum.



FOOD-GATHERING, as well as -growing, is women's occupation. Dinka girls, *above*, are collecting water lily bulbs from the

mud of Lake Nyubor. Lotuka girl, *below*, is threshing millet, a staple of tribes' protein-poor diet and a source of beer.



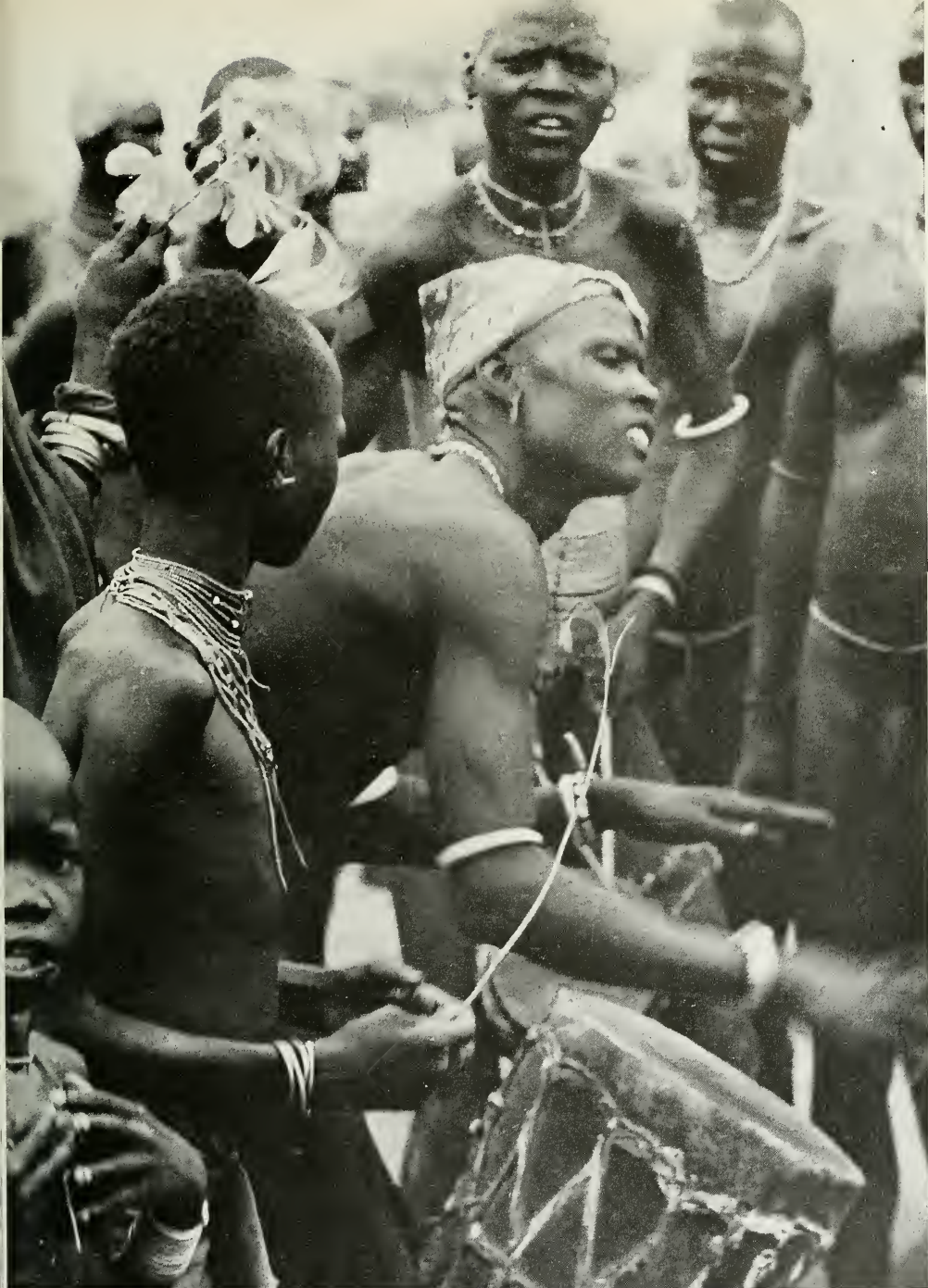
COLONEL MOLLOY, who served with the King's African Rifles in World War II, resigned from the Army in 1948 to become Game Warden for the Southern Sudan. His story, and many of his (and his wife's) remarkable photographs appear in *The Cry of the Fish Eagle* (Michael Joseph Ltd., London), whence this extract comes.

Nile-Congo Divide. Again the favorite quarry was elephant, since it provided the greatest quantity of meat, with the ivory as a monetary bonus, but rhino and hippo were also victims much sought after. A pit some ten feet deep with smooth vertical sides was dug on a frequented game trail, or a ring of such pits made around a water hole, salt lick or feeding ground. These were covered over with a matting of light branches, dusted with earth and grass so as to be perfectly camouflaged. All the hunter had to do was to visit his pits, finish off his victims with a spear, and collect the meat.

It is particularly hard to eradicate the general use in some areas of poisoned arrows, which is the basic hunting tradition of the local tribes. The poison is carried rapidly in the bloodstream to the heart and may cause death within minutes, even to the pachyderms. The bows and arrows are so flimsy that without the poison they are ineffectual against all but pig and the smaller antelope. To eliminate the use of poison, therefore, the tribes affected must improve their bows and arrows or develop a new system of spear-hunting or else forfeit a vital item in the tribal economy.

IN PRACTICE, a native hunting method may be deplored if it is indiscriminate, wasteful or cruel, and in these respects a poisoned arrow compares favorably with other native weapons and even with modern fire arms, since it kills no less swiftly and surely. But besides being banned by international convention, its lethality certainly makes it probably more destructive than any other native method, so that in the end all game in the tribal area may be eradicated.

The leg noose in various forms is another illegal method still too often used by some tribes. In principle, this is a hole in the ground large enough to take the foot of the quarry with a noose of fiber or rawhide rope laid around the mouth and attached to a heavy log buried several feet distant



THIS YOUNG MANDARI DRUMMER is warming up at the start of a three-hour dance, one of the gay notes in tribal life of the Sudan. Among the Mandari, beer-drinking at such festive

times is the prerogative of elders, while the young men and women do their dancing without refreshment. Reason: warrior cannot eat or drink in company of a girl he may later marry.



TYPICAL BEAD CORSET of Mandari warriors, *above*, is made of many strands, attached to wires laid along spine. Adornment is built on, and must be renewed when threads start to rot.

The most ingenious means of causing the noose to tighten round the victim's leg is the "bow-trap," a wooden bow with a short stick twisted into the double bowstring to a high tension. One end of the stick is placed under the edge of the noose with a trigger arrangement which releases it when the animal treads on a round wooden platter covering the mouth of the hole. The freed stick flips the noose up the animal's leg and the victim promptly draws it tight.

But these illegal practices are comparatively rare, and most native hunting is carried out under conditions which, beside being legal, call for the highest hunting skill, patience, endurance, bravery and often self-sacrifice.

Since time immemorial the elephant has been the terror and the most prized hunting quarry of the Southern

tribesman. Elephants in fact still dominate the lives of thousands of people, with their power of obliterating a season's crops in an hour, of crushing out a man's life like a beetle underfoot, or providing an orgy of feasting for two hundred meat-crazy people and a chance of long-coveted wealth from the sale of their ivory. The warfare between the elephant and the native is traditional, and until recent times was fairly even. But when firearms came to the South, the hunter gained an overwhelming advantage, and instead of the elephant being hunted primarily for his meat, he was now persecuted for his ivory by Arab, Abyssinian and European adventurers and the natives in their employ. The slaughter of elephants in the Lado Enclave during the first ten years of this century is now fabulous, and

THE CATTLELESS MURLE, who depend on game for protein, will gather a hundred men in a vast ring, surround grazing zebras and then close in. *Below*, hunters skin out their single kill.



the Abyssinian poachers were wreaking terrible destruction up to and even west of the Nile as late as the 1920's.

As the British administration gained a hold over this vast area, this indiscriminate slaughter was quickly halted, and the chief enemy of all game, the firearm in irresponsible native hands, was gradually withdrawn. Thousands of ancient weapons, mostly muzzle-loaders, have been collected during the last fifty years, and those remaining in native hands are now so strictly controlled that their illegal use cannot go long undetected.

Even though depleted, however, the elephant population was still very considerable, and its numbers had to be controlled to make room for the rapidly expanding human population. Hunting was an essential of tribal life



SUDAN'S RIVERS AND LAKES constitute another major source of food for protein-hungry tribesmen. Quartet of men, *above*, fishing with bow and arrow, have piled catch on bank behind.

IN THE SHALLOW WATER of Tapari pools, these young Mandari girls, *below*, collect fish by dropping open-bottomed basket traps over them. Fish are also speared, netted and hooked.



and game meat often the only source of protein. Spearing of elephant was therefore allowed to continue, and finally, just before the last war, chiefships were allotted an annual quota based on their average unrestricted killings over the previous ten years. This system permits the spearing of some four hundred and fifty elephant a year. The Chief pays a royalty of £E5 per elephant killed and may then sell the ivory, the proceeds being divided according to tribal custom between him and the hunters. In fact, as the hunting tradition dies out and game control becomes increasingly efficient, the present average of legitimately speared elephant has fallen to two hundred and thirty a year, and a gradual decrease can be expected for the future if the present standard of control is maintained.

The safest and most commonly practiced method of killing elephant is spearing from trees. The spear used has a blade some twelve inches long

and three inches wide, and a strong shaft three or four feet long weighted with iron or clay bound on with strips of cloth. Armed with this weapon, the hunter waits in a tree overlooking an elephant trail or water hole and plunges the spear, assisted by gravity, into the back of the passing beast, aiming for the space between the shoulder blades. A well-placed spear will drop an elephant within a hundred yards, but admittedly the spear is often placed very inaccurately, owing to the weapon's unwieldiness and various elements of chance, so that the elephant has to be followed up, sometimes for days, until it succumbs.

A few virile tribes, whose country is not favored by suitable trees for the weighted spear, practice the far more dangerous method of surrounding and spearing the elephant on the open plain. This requires thirty to fifty men, each armed with two or three throwing-spears. Having chosen a lone bull or cut one out from a herd,

one man dances in front to attract the elephant's attention while others fling spears from either flank. Screaming in fury, the elephant charges in one direction after another, always to be diverted by more spears in his flanks. Soon he becomes tired and bewildered while fresh spearmen constantly appear to keep him wheeling and turning. Finally, weakened by exhaustion and loss of blood from his many wounds, he sinks to his knees, whereupon a bold hunter will run in and thrust a spear into his heart.

SUCH practices are sometimes condemned today on humanitarian principles which do not take into account the local conditions. These tribesmen are magnificent specimens of humanity, as yet only lightly affected by the progress of civilization around them. Most of them have so far no available outlet for self-expression except within the traditional framework of tribal life, so that dance

ONE OF THE FORBIDDEN FORMS of game-taking in the Sudan is the leg noose, shown here entrapping a giraffe that author

came upon during patrol. Heavy log at other end of the rope acts as a drag that slows animal, leaves hunters easy trail.



ing and hunting are as essential to them at this stage as eating and sleeping. The importance of these two former activities will gradually decrease as education supplies other outlets and ambitions; but administrative attempts to force the pace of such a natural transition process by one-sided prohibitions would throw the whole order of the tribesmen's life into unbalance and confusion.

In the meantime, we who venture into the bush preceded by trackers, armed with the finest of modern firearms and followed by porters with the essentials for our survival, can only salute in admiration the naked native warrior, glistening with oil and sweat and decorated with wood ash and ochre, as he faces an infuriated elephant, yelling defiance, with but two flimsy spears in his hand.

Of the larger game, giraffe and rhino are rigorously protected by international agreement, but buffalo are abundant and are fearlessly hunted with

the spear by some tribes, mainly the Latuko of the Nile's east bank. When charged by a buffalo, these brave hunters will fling themselves on their backs, still facing the buffalo and thus able to roll out of the way of the murderous hooves. Though a buffalo can bash a man in this position with the broad flat boss of its horns, it cannot hook and toss him, and before much damage is done the man's companions will have flung spears into the buffalo's flanks and drawn him off. Casualties, sometimes fatal, occur in almost every hunt, but are regarded with pride or indifference by the wounded and their companions alike.

Lion are fairly scarce in the South and do not often clash with human interest since most areas have plenty of antelope. They remain a constant threat to cattle, however, and sometimes take a lone native in the bush. In such cases a Game Scout or the nearest policeman may be sent for, but by the time he arrives the villagers

have usually tracked down and dispatched the culprit with spears, as a matter of tribal honor.

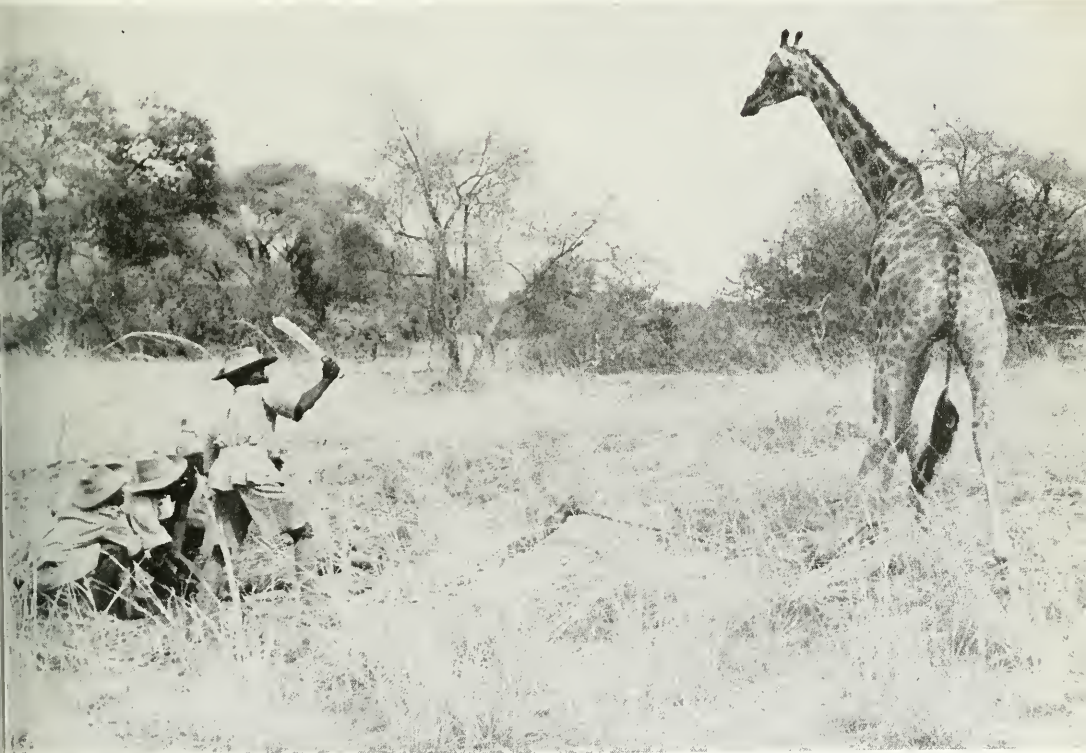
During our wanderings in the bush we have found and confiscated countless traps and snares and seen many pitiful remnants of the victims, but we have only once been able to rescue a trapped animal. It was near Atet, between Yirol and Rumbek, on a morning when we were making a wide circuit through the sandy open bush in our Land Rover, hoping to surprise a party of poachers known to be operating there. Suddenly Amtai and Game Scout Kira called out together: "zeraf! zeraf!" (giraffe!).

Well, giraffe are common in this area so that there was nothing unusual about their presence here, so I did not even turn my head till Kira called urgently: "It's caught by the leg!"

Then I swung the Land Rover off the game trail I was following and, rounding a clump of bushes, we came in view of a female giraffe with a

CAUTIOUSLY MOVING FORWARD, as other members of author's party hold down log drag, Game Scout Kira prepares to sever

the rawhide rope and release the exhausted giraffe. Nooses, pit traps and poisoned arrows are all outlawed in the Sudan.





PET CARACAL, photographed by author's wife, shows ear tip tassels from which its name, "black ears" (in Turkish) comes.

heavy six-foot log attached to her right forefoot by a twisted thong of rawhide—giraffe hide, too, incidentally. She immediately broke into a slow-motion labored canter, dragging the log behind her, but after twenty yards she had to pause to rest with heaving flanks. "Out you get everyone, and surround her!" I shouted.

"You left the ciné behind," cried my wife in anguish.

"Hell!" I said. "Never mind, do your best with the Leica, but there are only six photos left on the spool."

Our fleet-footed Mandari friend, Tali, had by this time sprinted round ahead of the giraffe and held her up, while the rest of us closed in from sides and rear. Once surrounded she made no further attempt to escape but stood passively awaiting her fate.

"Grab the log!" I called to one of the men nearest on that side. He ran and seized it, and the giraffe lurched

forward, but two more men joined him and the victim was held anchored. "Move slowly," I cautioned, "and if she comes for you, run for it. Now, Kira, take your machete and cut the thong against the log."

A giraffe has a formidable kick and will protect its young against lion or leopard by striking out with its forefeet as well as kicking with its rear legs. But this one showed absolutely no alarm or concern as we attracted her attention in front while Kira cut her free from the log with a few well-placed strokes.

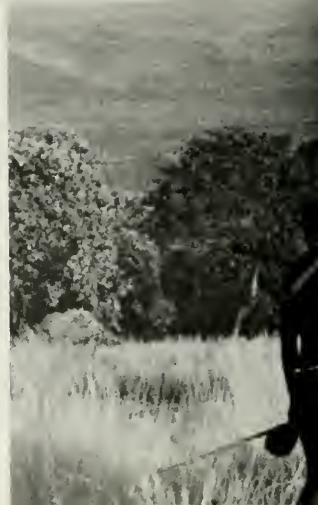
We moved back on one side, expecting her to make a dash for freedom. But she simply stood there at ten yards range for a full minute, gazing from one to another of us with her great soft brown eyes under long black curling lashes. She moved one foreleg and then the other, apparently still unable to believe she was free. She moved

WILD LANDSCAPE OF BOMA PLATEAU,



PADDOCKS AT JUBA, the Molloy's home, held variety of animals—many of them waifs brought in by native hunters. The

young white rhinos, *below*, learned to eat gruel ration from their own bowls, side by side, like duo of amiable pigs.



again and walked a few yards, turned and stared steadily at us, turned away, broke into a loping canter and vanished into the bush.

TIMES are changing and the hunting tradition is dying out with the rapid spread of education, though the hunger for meat and greed for ivory continue. The most deserving chiefs and Government servants are permitted to possess modern rifles and to shoot elephant on license when duly qualified, but the number of elephant shot on license is still only a third of that speared, and of other game maybe a tenth or less, since no record is kept of the fruits of native hunting.

It has been clearly shown that by legitimate, native hunting methods the Southern Sudanese tribesmen can obtain an adequate supply of meat (if not as much as they would like), can protect their cultivation (aided by the

Game Department) with reasonable success, can find outlet for virility and daring in youth and cunning and endurance in mature years, can obtain a cash bonus from ivory for extra hunting skill—and still make no appreciable inroads on the stock of legally huntable game in their tribal areas.

As I have said before, the greatest enemy to game in Africa is the firearm in irresponsible native hands. Demands for the benefits of civilization are a natural and laudable result of education, but education alone may not instill a sense of responsibility in the African mind towards his country's natural resources. Hunting for sport, as the European knows it, is totally foreign to him. He has been used to hunting with a spear, which will bring barely enough for his own family's needs, and now, through a firearm, he can supply meat for the whole village. Small wonder that,

dizzy with popularity, he will many times overshoot his license (if any) and, when tired, will lend out his rifle to one of many eager volunteers.

The Southern Sudan's magnificent fauna are at present still plentiful, but will they survive the next twenty years? The answer does not depend primarily on the native hunter using traditional methods, nor on the control exercised by the Game Department, but on the Government's policy over the possession of firearms; every territory in Africa shows lessons along the same lines. With his own weapons the native hunter deserves our respect and admiration, even when he does not fully adhere to our restrictions, which he cannot understand and sees no point in. But the same man with a gun in his hands may well become a hero to his village and an unprincipled, murderous menace to the limited and irreplaceable wildlife of his country.

NEAR ETHIOPIAN FRONTIER IS VIEWED BY MURLE HUNTSMAN. THIS AREA FIRST CAME UNDER SUDAN ADMINISTRATION IN 1934.





LES ILES MARQUISES

PART I

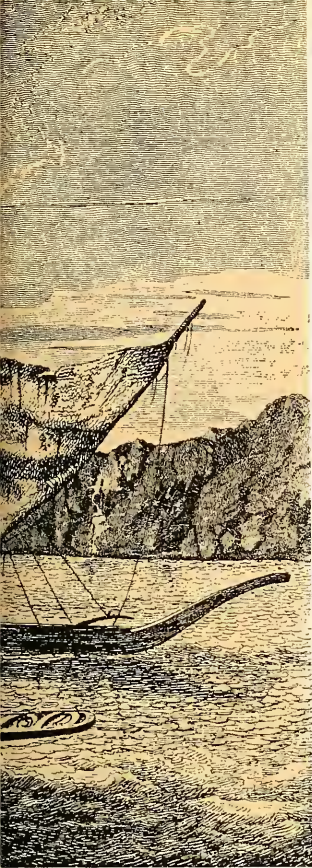
The History of Contact

By HARRY L. SHAPIRO

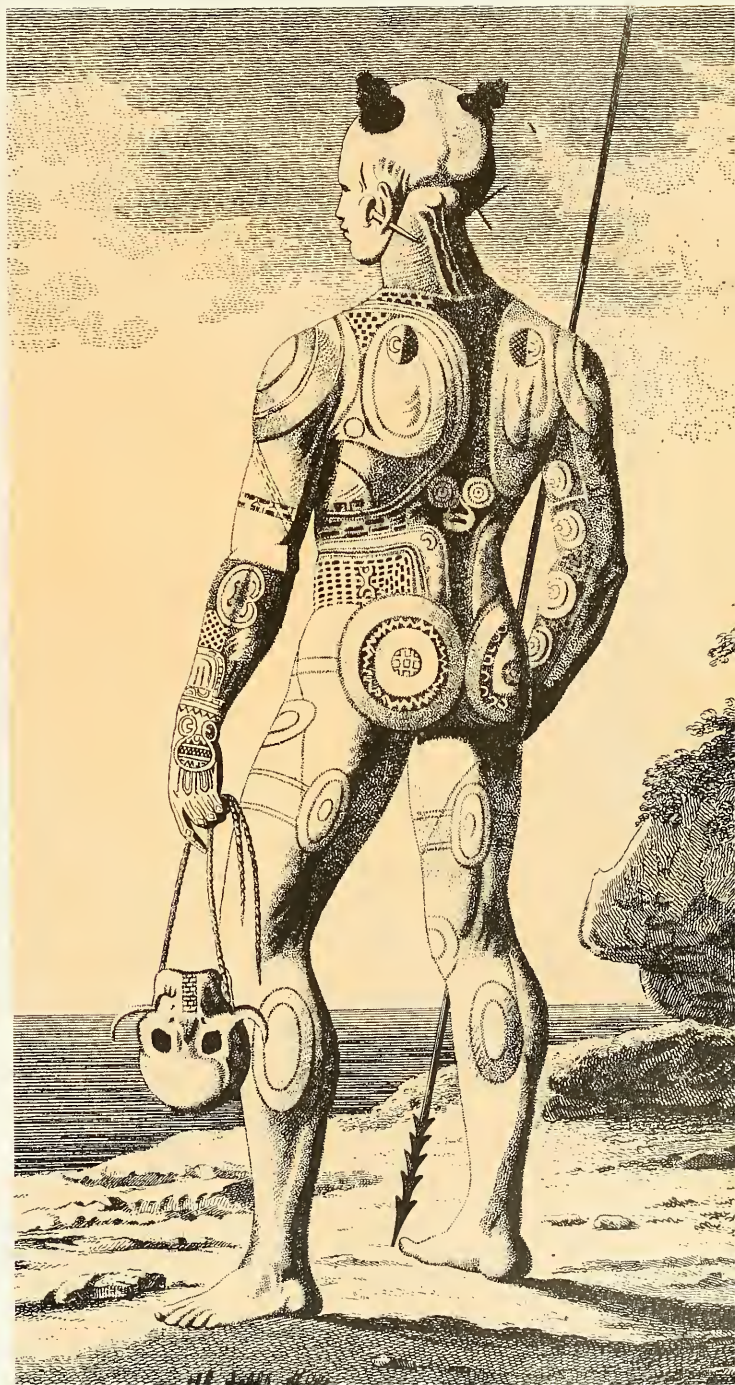
THE SIX INHABITED Pacific islands (plus a few uninhabited islets and rocky outliers) that make up the archipelago now known as the Marquesas had no collective name until the Spanish discovered and briefly visited them in 1595. The Polynesians living there at the end of the sixteenth century were divided into a number of independent tribes, with so little sense of unity they even lacked a term in their own language for the geographic unity that the Europeans bestowed upon them.

In reality, Mendaña, commander of the galleons that chanced upon these waters on one of the fabulous Spanish voyages from Peru to the Philippines, discovered only the southern islands of the group and named them *Las Marquesas de Mendoza* in honor of the Marquis of Cañete. Anglicized as the "Marquesan Islands"—a term that was extended to embrace the entire group—their official name is the French one,

THESE MARQUESAN CANOES at Resolution Bay, Tahuata, caught the eye of William Hodges, artist aboard "Resolution" on Cook's second voyage (1774).



TATTOOED NUKUHIVAN WARRIOR was sketched by Orloffsky, nobleman-artist who accompanied the Russian captain, Krusenstern, to Marquesas in 1804.



Les Iles Marquises—for they belong to that vast, but territorially and economically insignificant part of the French empire grandiloquently known as *Les Etablissements Français de l'Océanie*.

In the literature of travel, it is customary to describe the little-visited spots of the earth as "remote." Although this overworked adjective often reflects the egocentric position of the traveler more accurately than it does the place or the people he is visiting, it is apt for the Marquesas. Well off the track of Pacific shipping lanes, eight hundred miles or so from the nearest airline connection, these islands are also the last eastward insular outposts of the Polynesian world in the latitude of Tahiti. From here, until the shores of South America loom up some thousands of miles beyond, the Pacific Ocean lies unfurnished with any visible land. During the last war, because of its position on the eastern edge of the Pacific

island world, the archipelago entered into the strategy of the allied campaign as a last line of defense. In World War I, the Marquesas' isolation served the Germans well as a temporary hide-out for Admiral von Spee and his cruisers, the Scharnhorst and the Gneisenau.

EVEN in pre-European days, when all the Pacific islands were isolated, the Marquesas were one of the more detached archipelagos in the notably widely-spaced Polynesian world. Although the islands were vaguely known to other Polynesians, and the Marquesans themselves were aware that they were not entirely alone in the world, these people in effect existed in a separate little universe, virtually out of touch with any other Polynesians. Within the archipelago, itself, a constant belligerency—setting one clan against another and one valley against its neighbor—tended to create a highly parochial attitude. One has only to see, or, better still, to

explore on foot, the steep knife-like ridges that separate the valleys of the main islands to appreciate the effect such terrain must have had in encouraging a way of life organized according to such narrow physical units.

Unlike many other high volcanic islands in these latitudes, the Marquesas lack the picturesque fringing reefs that give Tahiti, for example, its romantic lagoons—with quiet waters and shelving beaches, their shallow bottoms studded with entrancing mounds and caverns of pastel corals, and the whole framed by a shoreline of nodding palms. This South Sea stereotype, beloved by photographers and travel agencies, does not fit the Marquesas. They rise abruptly from the sea; their coasts, except when broken by the mouth of a valley with its shelving beach, form perpendicular bastions of naked rock, variegated in color by the bands and streaks of ancient lava flows.

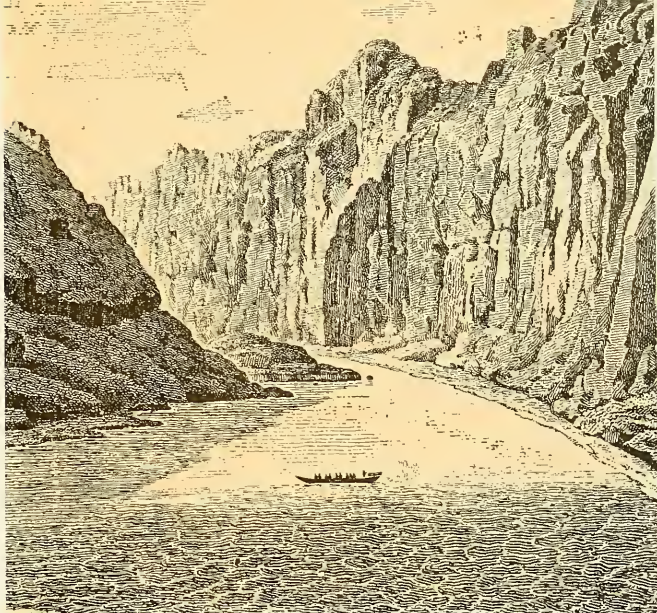
These sharply-cut coasts suggest that the islands have undergone up-

lift—an impression that is reinforced by headlands and beaches, once sloping into the sea, now lifted high and dry above it. All of the islands have high central cores—rising several thousand feet in most of them—and the impression of great height is intensified by the fact that the slope is steep and the islands small. From these central massifs, erosion of the soft volcanic rock and earth has produced a radiating series of ridges and valleys, like a half-opened umbrella. The ridges, extending to the periphery of the islands, make a series of fjord-like bays and separate the valleys one from another by steep and hazardous slopes. On the “wet” side of each island the deep valleys contain limpid streams that carry off the frequent rains. In the past, the occupants of one isolated valley were in constant guerrilla warfare with their neighbors in the next. It was this tradition of sniping and raiding that set the “Typees” against the “Happars” and gave Melville a perfect situation to



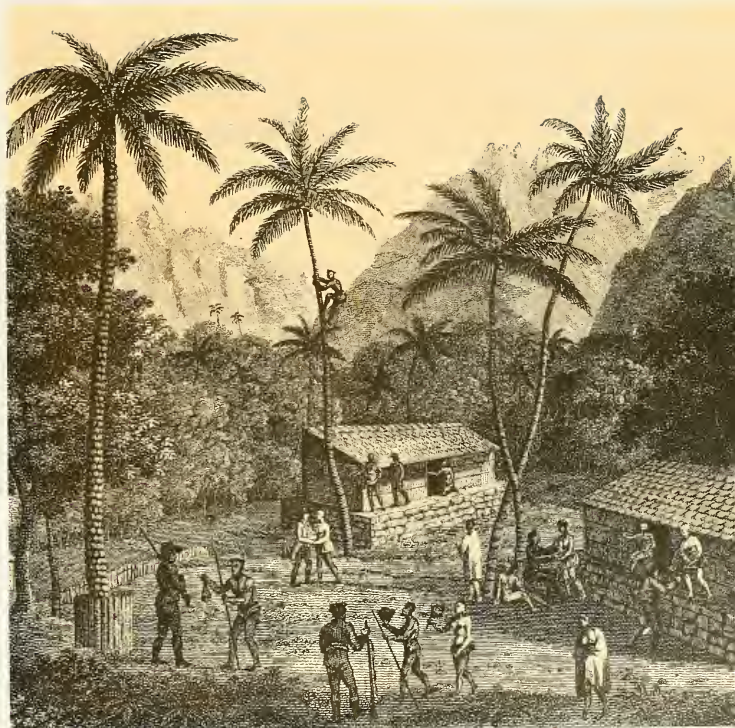
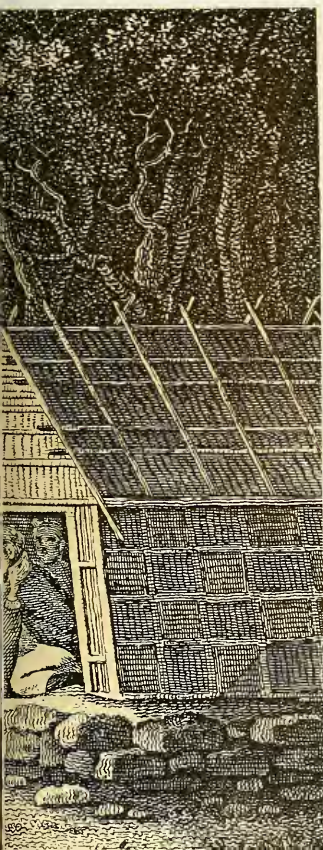
dramatize in the account of his "four months' residence" in the 1840's.

AS LATE AS the days of Melville's visit, the islanders were still the magnificent specimens that aroused the admiration of the early visitors. Captain Cook described them as the handsomest of all the Polynesians. Characteristically tall, the men were powerful and well-muscled, the women graceful and beautiful in proportion. The prevailing skin color was light brown, although some of the women were scarcely darker than southern Europeans. Their black hair, straight or slightly waved, was kept lustrous by the liberal application of coconut oil. Both men and women were tattooed, but the art was carried to its greatest heights of elaboration in the men, whose faces and bodies were sometimes completely covered with a blue-black design of lacelike intricacy. Although tattooing had been abandoned long before my first visit to the Marquesas, in 1929, I was for-



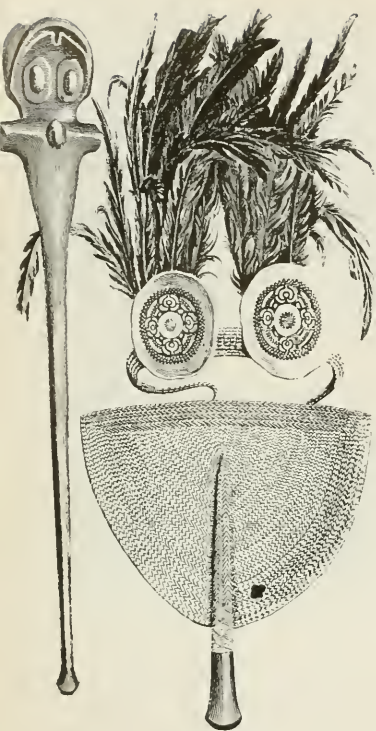
THE HIGH CLIFFS bordering this landlocked bay at Nukuhiva were recorded by

another member of the Krusenstern expedition—the Danish naturalist Tilesius.



MASSIVE STONE foundations were used for Marquesan mat-and-thatch houses. The

Krusenstern party did these sketches of a *marae*, left, and palm-climbing, above.



MARQUESAN ARTIFACTS—a war club, a shell-decorated, feather headdress and a fan—were sketched by Cook's artist.

fortunate then in meeting one old man who had been decorated in the mid-nineteenth century when the art was still active. The effect, as I was able to see it on a living body, was startling and, in its way, beautiful. From a little distance, the legs seemed encased in long, patterned stockings and the arms and torso in an openwork leotard. All this gave an impression of elegant attire on what was actually a naked body. To my unaccustomed eye, however, the face was a shock. It was covered with wide, solid horizontal bands of bluish-black pigment, which must have been excruciatingly painful in application, since the tender membranes of lips and eyelids were not spared in carrying out the design.

These graceful people lived in a manner that both enchanted and revolted their early visitors. Their neat thatched houses, clean and airy, were set on *paepae's*, raised platforms of nicely fitted, rounded, black basaltic stones, and thus kept free of moisture

and mud during the rains. Food was apparently abundant, although not very varied. Pigs and breadfruit were staple, supplemented by fruits and other vegetables. Work, either of household or of field, was light. The most laborious task for the women was making tapa cloth from the bark of the paper mulberry tree: this bark had to be stripped, soaked and beaten with four-sided clubs that had longitudinal grooves on their faces. But the work of beating was lightened by its performance in groups that were usually the occasion for social exchange. The finished product provided bed linen and garments that required no tailoring or sewing and little laundering.

Since the gathering of food never required long-sustained effort, the men spent much of their time in various leisurely occupations. Fishing was as much sport as labor, for example, and hunting the wild pigs could be exciting and exhilarating. Gardening was never very demanding, for the breadfruit grew on trees that required no special care and many fruits grew wild for the picking.

With the necessities of life so easily available, it was understandable that the young were able to lead a care-free existence, spending much of their time in pursuits of their own. And the settled householders could devote themselves to conversation, protracted siestas and the exercise of esthetic skills in the decoration and carving of their food-bowls, weapons and articles of personal ornamentation.

IT WAS perhaps this very freedom that encouraged the sporting character of Marquesan warfare, which infused a touch of danger and hazard in the even tenor of the day. And, in another direction, this freedom provided the means for the elaborate religious festivals and rituals that flourished in the valleys. Evidence of the important part such ceremonies played in past Marquesan life is still to be found in the vast stone platforms and overgrown enclosures, deep in the forests, bounded by massive stone walls. Some of the individual stones in these extensive structures are enormous. One I saw myself was well over eight feet high and wide, its depth lost in the body of the wall of which it was a part. A staggering amount of brute strength must have been required to move it and set it into place. When one multiplies this

example by the countless monoliths in hundreds on hundreds of feet of wall and platform, the measure of the labor involved is stupendous—the more so because the number of men in any one valley could never have been very large. Doubtless, what made such work possible was the abundant free time the Marquesans could devote to such community enterprises.

Much time, too, must have gone into the carving of the heroic-sized deities in stone and wood that decorated the *marae's*, or temples. The few stone figures that have survived the depredations of collectors bear mute testimony to the energy of the earlier Marquesans. Although not so large as the more famous statues of Easter Island, they share with them a generic style that can be recognized despite the differences.

FOR all the charm of the Marquesans and the attraction of their apparently carefree and innocent lives, most early visitors were repelled and even terrified by another aspect of the islanders' way of life—their unconcealed relish for human flesh. Cannibalism was once a widespread practice in the Pacific and it has been discouraged among its devotees only with difficulty. In Polynesia, as in Melanesia, the custom had an uneven distribution. The Maoris of New Zealand were in the habit of eating those defeated in war, for example, giving the act a somewhat ritualistic aspect by ascribing to it the function of acquiring the virtue of a brave enemy.

But nowhere in Polynesia was cannibalism as deeply rooted as in the Marquesas. Melville's fears that he was destined for the cook pot were not without justification: the avidity of the islanders' appetite was common knowledge to the whalers of the mid-nineteenth century. The practice was slow to disappear. Even after nearly a century of European contact, during the latter part of which the French had actually assumed control of the islands, clandestine resort to cannibalism was known to have occurred.

At this late date it is difficult, if not impossible, to determine the motives for this repugnant custom. By the time scientists—interested in discovering the truth back of the adjusted statements the Marquesans gave to shocked mariners and missionaries—had visited the islands, the local culture had been shattered. Reliable informants, free of an implanted

ense of guilt, are no longer available. Some early visitors say the natives quite frankly declared a liking or the taste of human flesh: that may have been all there was to it. In any event, in so old a custom, a more complicated original purpose could well have been lost, or overlain by later developments of taste and predilection.

Early in the nineteenth century, the J. S. Navy's Captain Porter who had passed the raider *Essex* in the Marquesas and preyed on British whalers and shipping during the War of 1812, estimated the archipelago's population at 100,000. If this estimate seems high at first glance, it is not unreasonable when we apportion this total among the six main islands. We then get some seventeen thousand inhabitants for each. But since two of the islands—Nukuhiva and Hiva Oa—are larger than the other four and have deeper, more spacious valleys, it is likely that these two islands might between them have had fifty thousand

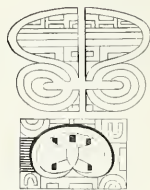
inhabitants, with the remainder living on the four smaller islands.

Such a distribution would have meant that major valleys—such as Taipivai and Taiohae on Nukuhiva—accommodated as many as five to ten thousand inhabitants. Such a concentration seems plausible in light of the many deserted house platforms now to be found buried in deep jungle, miles from the mouths of these major valleys. Further, it is supported by the recollection of an aged German sailor I met in one of Nukuhiva's more remote valleys when I first visited the Marquesas, in 1929. The sailor was living alone in the valley. He had not spoken German for twenty or thirty years—not since he had met Karl von den Steinen, the German anthropologist, who had passed through his valley on a collecting trip.

The two of us carried on a lame conversation in his mother tongue: he handicapped by a loss of words through many years of disuse, and I

by a very imperfect recollection of college German. But I had enough understanding to grasp his story. He had jumped ship around 1830 and, having married one of the native girls, had settled in her valley—the same one in which I found him. Although, even in the 1830's, the valley had already suffered serious depopulation as a result of the white man's coming, it still contained some 400 people. The year before our 1929 meeting, he and his wife alone remained, and now she, too, was dead.

IN ALL the annals of western man's expansion, there are few examples of a more tragic and devastating effect of European contact on an isolated people than the case of the Marquesans. In little over a century, this community of some 100,000 souls was reduced to a mere handful (1,600 in 1930). The story is a common one in Polynesia. For centuries, perhaps millennia, the natives had been



TATTOOING DETAILS include design for arms and thighs, *top*, and study of the work done on hand of a Marquesan queen.

NUKUHIVA MAN, *left*, was sketched by Krusenstern party, holding a long club, its handle decorated with enemy's hair.

DR. SHAPIRO first visited the Marquesas in 1929. He returned in 1956 to pursue archeological research. He is Chairman of THE AMERICAN MUSEUM'S Department of Anthropology.

out of touch with the rest of the world. They were unfamiliar with alcohol. They had no immunity to such diseases as measles—which, among us, has become reduced to a rarely fatal disease of childhood. They were easy victims of tuberculosis, an affliction they had previously been spared. And, perhaps worst of all, the introduction of hitherto unknown venereal diseases had a devastating effect.

Such accompaniments of European contact are threat enough to the welfare of any people unprepared by selection and experience to deal with them. The Marquesans, moreover, were especially vulnerable. Their sex customs—which, by Western standards, might be described as uninhibited—served to spread the venereal diseases brought by the Europeans throughout the whole community.

WHILE the attitude of the Marquesans toward sex was far more liberal than is found in most societies, actually it was not so uncontrolled as is commonly believed. What misled the early visitors was the fact that, in Marquesan society, the youth of both sexes enjoyed a limited period of sexual freedom. Young girls (from approximately sixteen to eighteen years old) and young men (of a slightly older group) formed a kind of social class (known in Tahiti as a *taurearea*) that was rather like a club. Within this group, sexual experimentation was permitted, and even encouraged, in the expectation that the couples would eventually pair off in permanent union.

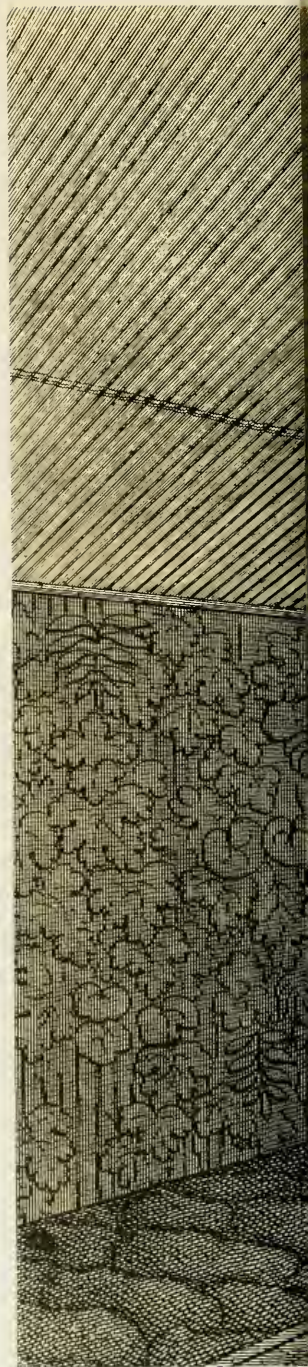
In a small community, where unexpected offspring were warmly welcomed as candidates for adoption, regardless of their legitimacy, such a system functioned quite well. Old maids and confirmed bachelors were virtually non-existent, and most marriages worked out happily—although Marquesan men, it must be reported, often did not object to their wives taking complementary husbands.

Under these circumstances, it is not

surprising that the young Marquesan girls received foreign visitors with the same ease they were accustomed to exhibit towards their customary male companions. Nor did the islands' many visitors spurn such attentions. The spread of venereal disease cut the birth rate, and this—combined with an increased death rate from the measles, tuberculosis and other newly-introduced diseases—brought about a steady and calamitous decline in the islands' population.

IT is only within the last two generations—as a result of the work of resident French physicians and the use of antibiotics—that the downward trend has halted. Between my first visit to the Marquesans (1929-30) and my latest (in the summer of 1956), the population has doubled itself. It now stands somewhere around 3,500. After such an interval, the most striking change for me was the sight of swarms of happy children in the various valleys. In appearance, they ranged from brown-skinned and black-haired to blue-eyed and tow-headed; all, regardless of racial heritage, shy with strangers at first, but laughing and merry when set at ease.

This wide variety of physical types among the Marquesans of today is another consequence of their recent history. In the heyday of whaling, the islands were frequently visited by American and English ships. The various racial strains represented in those whaling crews came to be rather thoroughly mixed throughout the native population. Since then, French *colons*, as well as beachcombers and casual visitors of various ancestries, have added their bit to the melange, and these genetic contributions became the more apparent as the native population, itself, dwindled. In the last half-century or so, Chinese traders have enriched the mixture. Thus, it is little wonder that old Stanislaus—one of the scions of an ancient chiefly family—told me rather wistfully, in 1956, that he could not name over half a dozen "pure" Marquesans. Yet, however mixed in origin, the islanders of today are sole heirs to an ancient tradition: the only descendants of an isolated Polynesian people whose origins and prehistory are still far from being understood.



PART II of "Les Iles Marquises" will appear in the May issue of NATURAL HISTORY. Subject: The Prehistory of Polynesia.



NUKUHIVA MATRON fondles a child while being tattooed by specialist, part of whose payment — in pork flesh — is being brought in by attendant. A palm-leaf mat covers stone floor.

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pieces of rootstocks show their tooth grooves wherever the feeders reach up from the surface of the ice or climb up on a lodge. But the muskrats are not the very best of climbers, and a hungry one that overextends itself on a steep surface may slip or tumble down.

"When the entire food supply of the muskrats becomes encased in ice—as is often true where nothing but count and other submerged water plants occur in a foot or two of water, and all of the freezes to the bottom—their situation becomes one of deadly crisis almost in a matter of hours. They cut out through the sides of lodges to travel over the ice going from one frozen lodge to another, gnawing at the fish frozen in the plunging holes or upon the vegetation making up the lodges. They fight with and eat upon the bodies of their fellow muskrats or



BUFFLEHEAD is one spring visitor

leave the marsh to wander over the countryside—tails, eyes, and feet freezing, always vulnerable to whatever predators prey upon muskrats that are trying to live at a hopeless disadvantage.

"Here is a beaten group trying to weather a cold snap. They huddle, half-dozen of them, in the eaten-out and reworked shell of a small lodge. Some openings to the outside are plugged with mud, fragments of waterlily rootstocks and miscellaneous debris, even with frozen bodies of bullheads. Other openings are partly plugged; others are not plugged at all, and inside the muskrat sits with upper parts frosting and lower parts wet. The inside ice-glaze has bullhead bodies in it but the muskrats are no longer eating bullheads. They are no longer doing anything except sitting or rearranging themselves. A wet tail sticks out of an opening and freezes to the ice outside. I have stroked the back of such animals with a hatchet handle and they just turned to look at me, without otherwise moving.

"Next morning, the whole top of the lodge shell is open, empty of muskrats and powdered by a trace of snow. A sink-killed muskrat lies smeared with blood on the ice, and a drag trail repre-

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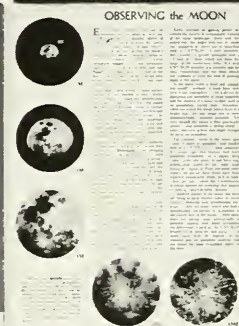
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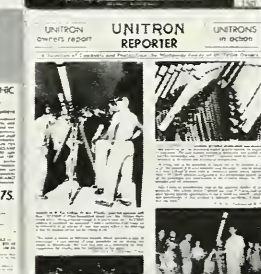
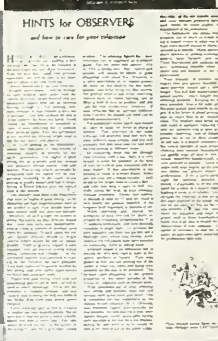
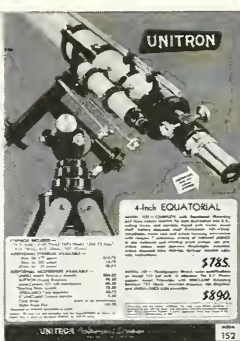
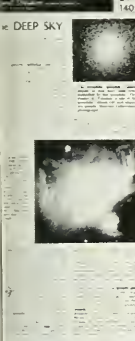
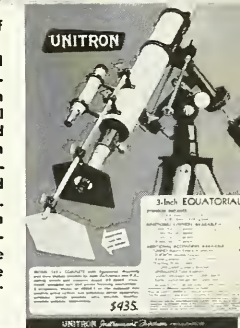
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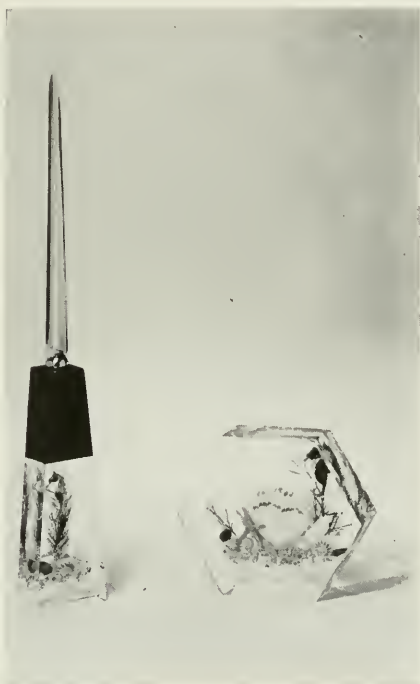
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sents another victim. A third muskrat lies on the ice without a wound on it but with lungs congested from pneumonia. The trail of a live muskrat can barely be distinguished; after tracking around the wreckage of the lodge, the animal headed for shore, where it worked the rushy and weedy fringes before crawling under a boat. The muskrat tail tip is still frozen to the ice beside the lodge, but the rest of the animal is gone. Fox tracks center about this spot, and they lead off in a straight line toward shore. A crow alights by the mink-killed muskrat; after a little pecking, it walks over to feed on a big bullhead that somehow got on the ice away from the lodge. The mink returns to its remaining victim of the night, but the blood-saturated underfur is now frozen too solidly to the ice for the mink to wrench it free. The mink finally drags away the muskrat with the pneumonic lungs, following the same drag trail it had made earlier."

After relating the detailed life of the seasons Errington makes his plea concerning "marshes and man and harmonious use." His point of view embraces a very wide range, yet loses none of its detail. In a discussion of drainage, for example, he regrets its "saddening" overall effect—for "the little potholes and sloughs and outlying marshes have an importance to the waterfowl breeding grounds . . . that is far out of proportion to their acreages and to the volumes of water impounded in them." It seems difficult to dispute the points this conservationist makes, based as they are on so much knowledge and compassion—for man, as well as for beast. Their justification is the entire gamut of life and death in the natural marshes, the process of nature itself.



THIS MARSH SCENE and others, all by H. Albert Hochbaum, are from *Of Men and Marshes*.

Errington's final chapter concerns precisely this process. The author points out that, because of man's "dominance and his faculties for upsetting so much of the rest of life," there is a tendency to exclude him from "what we think of as 'natural' relationships of living things." Errington would like to see restored a more just sense of man's place within these relationships, through a heightened awareness of the rest of nature. Those who read this book will be grateful to him for having recalled some primal truths.

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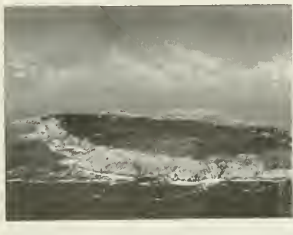
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THE WARBLED OF NORTH AMERICA, edited by Ludlow Griscom and Alexander Sprunt, Jr., illustrated by John Henry Dick. Devin Adair, \$15.00; 356 pp.

A SPLENDID contribution to ornithological literature. These bright and beautiful little birds at last receive, from the expert illustrator and the distinguished ornithologists who collaborated on the text, the study they deserve. The entire warbler family of North America is included, from its northern ranges, Alaska and Newfoundland, to the southern limits in Argentina and the West Indies. Description and interpretation are thorough, and will, incidentally, help to make warblers (a puzzling and complex group for most watchers) a little easier to identify.

A PADDLING OF DUCKS, by Dillon Ripley, and illustrated by Francis Lee Jaques. Harcourt, Brace & Co., \$6.00; 256 pp.

THERE is a splendid variety of ducks, and geese to read about in this book, together with evocations of the many parts of the world from which they come, although the center of interest is the pond in Connecticut near which the author, a Yale zoologist, lives. This intrepid man has been collecting and observing these waterfowl for many years; his book is written with poise and authority; and the pleasure he has found in his hobby is infectious.

Botany

TREES, by William M. Harlow. Dover Publications, \$1.35; 288 pp., illus.

THIS paperback edition makes a handy field guide to the trees of the eastern and central United States and Canada. Compiled by the well-known dendrologist, William Harlow, it includes a detailed descriptive text for each tree, illustrations, and a number of remarks about the uses or character of the principal species.

Meteorology

1001 QUESTIONS ANSWERED ABOUT THE WEATHER, by Frank Fortester. Dodd, Mead, \$6.00; 419 pp., illus.

HERE we have the weather from soup to nuts. You can find out, in this encyclopedic work, why your nose runs in cold weather, and how weather nearly ruined Alexander the Great, as well as what a parhellic circle is and where to go and what to do if you want to be a

meteorologist. There are very few common questions which are not answered here, reliably and succinctly. It is only regrettable that the question and answer format of this series did not allow a more serious treatment.

Anthropology

MAN: HIS FIRST MILLION YEARS, by Ashley Montague. *World Publishing Co.*, \$3.75; 249 pp., illus.

THERE are times when Dr. Montague's ability to inform and explain seems altogether too easy for him—many aspects of man's cultural history are treated here with more adroitness than substance. Otherwise, this is an interesting book and, for the "plain reader," a readable introduction to what the science of anthropology has so far discovered.

THE LIVING PAST, by Ivar Lissner. *Putnam*, \$5.95; 444 pp., illus.

THE author of this volume—which is very popular in Europe—does not think much of our own age, and endeavors to console himself—and us—by uncovering the excitements of the past. We are hopped, skipped and jumped through numerous civilizations, often described somewhat patly and inconclusively. Dr. Lissner is at his best when reconstructing the colorful aspects of his subject—the sights and sounds of the city of Rome, the tragic story of Hannibal, or the enchanted and enchanting story of the great Chinese poet, Li Po.

A MANUAL FOR NEANDERTHALS, by H. Mewhinney. *University of Texas Press*, \$3.50; 122 pp., illus.

MR. MEWHINNEY, a many-sided columnist for the *Houston Post*, has written an articulate and intriguing account of a craft that, today, seems remote indeed. But he succeeds not only in explaining the nearly-lost art of making flint artifacts, but in making such work sound like a very interesting thing to try one's hand at in A.D. 1958.

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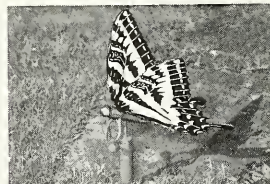
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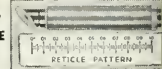
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New Fossil Find

These insects have been preserved in Mexican amber for thirty million years

Photographs by HAL ROTH



ENCASED IN AMBER thirty million years ago, stingless bee has been perfectly preserved. Fossil insects are being studied by entomologist Hurd, *left*, and his colleagues.



THE INSECTS, formally known as the Class Insecta, one of the six surviving classes of the Phylum Arthropoda, are divided into two subclasses: the wingless insects (called Apterygota) and the winged ones (Pterygota). The latter includes about ninety-eight per cent of all living species of insects.

Unfortunately, our knowledge of the evolutionary progress of this vast host of creatures is limited, for few fossils are known. The reconstruction

of insect evolution, therefore, is in great part hypothetical. Even so, it has been possible to learn a good deal from what we have. For example, the earliest fossil insects known are some wingless types from Middle Devonian rocks (dating back about three hundred million years). The fossil record also includes a dragonfly from the Pennsylvanian epoch, two hundred and twenty million years ago, with a wingspread of two and a half feet.

We know, by contrast, cockroaches



AMBER CHUNKS, cut and polished, are immersed in heavy oil for microscope study.



MICROSCOPE FIELD shows how stingless bees look within their amber encasement.

have changed hardly at all in the two hundred and twenty million years that have elapsed since the deposition of the Pennsylvania strata in which their fossils are found. Then, as now, cockroaches seem to have been fond of the accumulations of plant debris—from the decay of which the coal of these deposits was formed. Ancestors of the flies have also been found, whose four wings of equal size, while veined in a way similar to that of the two-winged fly of today, nevertheless relate them closely to butterflies and moths. These four-winged flies antedate the oldest true flies, which begin to be found in Upper Triassic strata (a hundred and seventy million years old), by about forty million years.

In view of an insect's fragility, it is remarkable that so many Paleozoic insects have been found. The most abundant insect remains, however, do not date back to Paleozoic times, but only to the geologically recent Cenozoic,—and, within that era, for the most part from the Oligocene and Miocene epochs, a mere fifteen to thirty million years ago. Geologically, then, these insects are recent; yet they are among the most beautiful of all fossils, for they have been preserved in fragments of amber.

THE best known of the amber-rich areas of the world is the Baltic, and principally the Samland peninsula in East Prussia—where the amber, as it formed from the sap of ancient conifers, encased many insects. There are other amber-rich areas, however, of which one, recently studied, lies in the state of Chiapas, far in the south of Mexico, along the Guatemalan border.

The Chiapas deposits have been known to man since pre-Mayan times, but only recently have entomologists and paleontologists been able to study the fossil insects they contained. Although mentioned in a technical publication in 1905, the amber remained largely unexamined until 1952, when the Associates in Tropical Biogeography of the University of California sent their first expedition to the south of Mexico. Since that time, three workers from the University of California's Berkeley campus—J. Wyatt Durham, Paul D. Hurd, Jr., and Ray F. Smith—have studied the continuing finds from these rich deposits.

The fossil insects of Chiapas originated, of course, in the same way as those from the Baltic. They were

trapped by droplets of tree gum, which, falling to the ground, were eventually washed to the sea, and there gradually covered by sedimentary deposits. Geologic upheavals have subsequently exposed these strata.

The fossil resin has been used by the Indians as jewelry. For the paleontologist, who wants to study the amber's content, the problem is more complex. The amber, often very brittle, must first be freed from its matrix of shell and rock. Then, part of the amber is cut away and the exposed face polished. The specimen, then immersed in heavy oil (of about the same refractive index as the amber). Optically, the amber then seems to disappear, and the entombed insect appears free, its original colors undimmed. Each specimen is studied under low magnification.

OF COURSE, study would be immensely simplified if the amber could be merely dissolved. But, when the insect was first trapped in gum, there was nothing to stop the decay of its internal organs—only the exterior was preserved, although this remained even to the most minute hairs. If the amber is dissolved—or accidentally broken—the insect crumbles away.

The Chiapas finds are still being studied, but already they have shed some light on the recent evolution of insects. It has been found, for example, that a stingless bee, trapped in amber in the Oligocene thirty million years ago, resembles its present-day descendants in all but the smallest details. Stingless worker bees, then, now, had pollen baskets on their hind legs—suggesting that the caste system was already established in Oligocene times and that thirty million years ago these insects were grouped together in societies much like those of today.

As another example, one sort of long-legged fly (of the family Dolichopodidae) has been found in the Chiapas amber. Today, this insect no longer lives in Central America but is found in the United States. It appears possible, therefore, that the fly's present range is similar in climate to that of Central America of thirty million years ago.

The work of recovery is continuing in Chiapas and analysis is in progress in Berkeley. The photographs on these pages, however, constitute a sort of preliminary report, and also suggest the interest and beauty of these find-



FUNGUS GNAT is a member of Order Diptera, as are flies. Immature stages develop in fungi or decaying vegetable matter.



LONG-LEGGED FLY is now no longer found in Central America but in the U.S., suggesting climatic change of former home.



DELICATE MEMBRANES of the book louse's wings shimmer as if in sunlight, belying this insect's unpleasant name. Actually,

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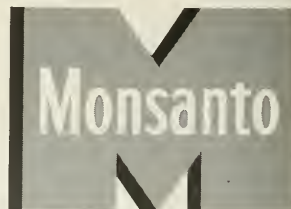
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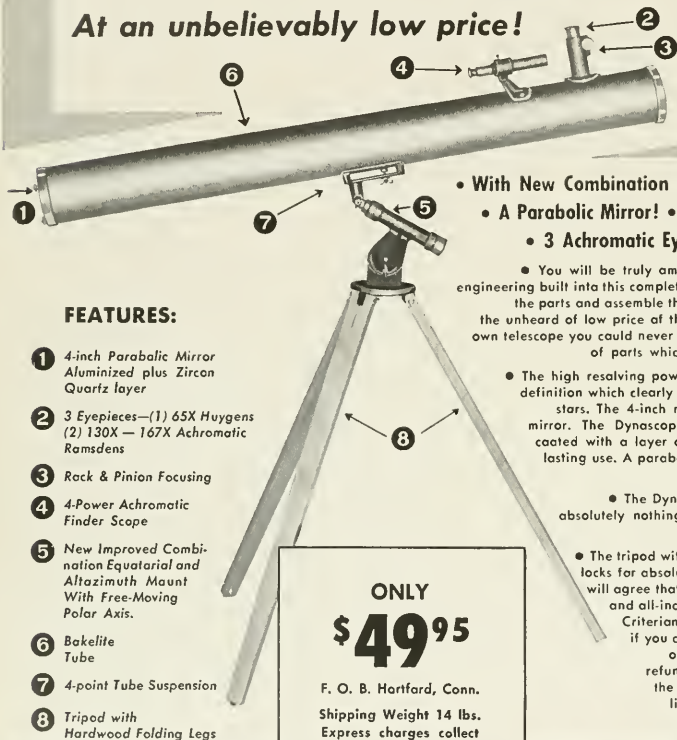
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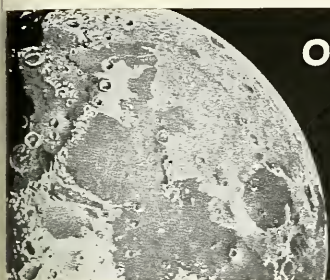
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ARRANGED ABOVE, in this photograph made for NATURAL HISTORY by LEE BOLTIN, are two study skins of *Tyto alba*, known commonly as the Barn Owl. The lower of the two is a nestling, still wearing its downy plumage; the upper is an adult bird.

Above these, from left to right, are portions of a study skeleton of the same species—a skull (comparison with the adult head, below, shows the extent to which the Barn Owl's plumage is responsible for the shape of its head); the two bony, sclerotic rings of the eyes (the rigid fixing of which forces an owl to turn its whole head in shifting viewpoint); and, finally, a lower limb, with its four keen, raptorial talons (by means of which *Tyto alba* seizes and kills its prey). For a translation of these various anatomical endowments into action, turn to the article on p. 238.

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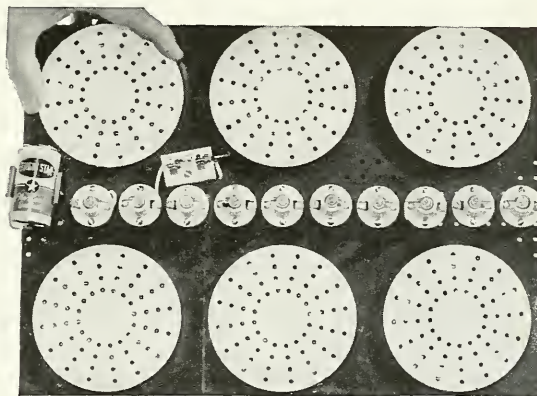
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Reviews

THE LOVE OF NATURE • HISTORY OF ASTRONOMY • PLANTS IN THE HOUSE



A PIONEER of the romantics, Alexander Wilson (above, 1809) still kept his powder dry.

NATURE AND THE AMERICAN, by Hans Huth. *University of California Press*, \$7.50; 250 pp., illus.

MAN'S LOVE OF NATURE is now taken for granted." Mr. Huth's book opens with this sentence, and attempts to show how our country has arrived at this amiable attitude. A careful scholar and an ardent conservationist, the author has set out to write nothing less than a social and philosophical history of conservation in the United States. Unfortunately, the confusion implicit in his first sentence dog him throughout his entire book.

A more exact statement would seem to be that man's love of nature, far from being natural, is an acquired taste, as sophisticated in its way as a taste for truffles or Palestrina's music. The average small child views nature with what can only be called destructive self-interest, until he learns better. Just so his forefathers, until they learned better, regarded nature with an attitude that combined resentment, superstitious fear and opportunism in about equal parts.

The story that Mr. Huth has to tell could probably be paralleled in any newly-settled country of the world, but nowhere else is it so neat and complete. Within the span of 400 years, our segment of the North American continent has been changed from virgin wilderness to an area of high economic development in agriculture, industry and other forms of humanized land use. As in other newly-settled countries, nature has done considerably better by man than man has done by nature; but here, thanks in great part to the efforts of devoted conservationists like Mr. Huth, the balance is slowly and painfully being restored.

Almost to a man, our northern settlers faced nature as an enemy and saw no virtue in her. In all its aspects, the wilderness was a formidable adversary to the would-be farmer, armed only with ax, firebrand, plow and musket. So a seventeenth-century traveler could describe the Connecticut Valley as "daunting and terrible," and Father Hennepin reporting the first view of Niagara wrote: "The Waters which fall from this vast height, do foam and boyl after the most hideous manner imaginable, making an outrageous Noise, more terrible than that of Thunder . . . dismal roaring may be heard above Fifteen Leagues off." To be sure, a far-seeing planner like William Penn could demand that settlers leave an acre of trees for each five acres put to the ax; but, in the main, the colonists saw only a howling wilderness to be exploited and subdued.

This attitude was as much of the age as of the country. Even in Europe, most men lived close enough to the soil to prefer the snug farm and the well-tilled field to any undomesticated landscape.

The next hundred years, however, introduced three movements that wrought profound change. One was the rise of science. The systematic study of nature became a passion with men of inquisitive intellect both in Europe and America. The second was the rationalist philosophy, which saw the magnificence of nature as exemplification and proof of the magnificence of God. The third was the growing romantic movement, which regarded nature as an ordered simplicity in contrast with the strife of civilization. All of these movements had their adherents and echoes in America, and in this country all three flowed together to form the unique and influential doctrine of transcendentalism. Transcendentalism, with its mystical base in nature and its emphasis on social reform, laid the groundwork for the conservation movement, which has been gathering slow momentum over the last century. Now, every schoolchild, farmer and hunter has been exposed to its basic principles.

This, in skeleton form, is the burden of Mr. Huth's book. As a social history of conservation it does not succeed: partly, perhaps, because it is too early to write such a history; partly, certainly, because the author is far too interested in evoking in words and pictures American attitudes toward nature in the days before conservation was even a word.

And it is precisely here that *Nature and the American* succeeds brilliantly. As Curator of Research of the Chicago Art Institute, Mr. Huth is excellently situated to collect out-of-the-way pictures and half-forgotten facts and to display them with an antiquarian's relish.

His plates are a nostalgic gallery of nineteenth-century American landscapes which tell fully as much about American attitudes toward nature as the rest of the book put together—as, for example, when W. H. Jackson's straightforward pioneer photographs of the Rockies contrast with the Golden West phoniness of Albert Bierstadt's expensive painting of Lake Tahoe. Here are the travelers, the vacationers and the buffalo hunters in illy cars. Here is Emerson on his philosophers' camping trip in the Adirondacks—without Longfellow, who refused to come when he heard that the League of Concord planned to carry a rifle. Here is a whole panorama of an uncrowded, unmotorized America.

Mr. Huth's clippings and quotations are almost as evocative. He brings back the life of the memorable day in 1821 when Misses Austin from Boston became the first ladies to climb Mt. Washington and, perhaps, to feel, with another traveler, "... the sensations which affect the corporeal faculties, as one views these stupendous creations of Omnipotence... too sublime to be described." Here, too, is the story of the first press



BY MID-CENTURY, holiday communing with nature had become a vogue.

junket in history, an "Artists' Excursion" run by the Baltimore & Ohio Railroad—on a special train with sofas, a bar and a darkroom.

But this reviewer's favorite vignette is of the inaugural train of the Erie Railroad, steaming majestically west with Daniel Webster thrown in a rocking chair mounted on a flatcar so he "might better enjoy the scenery."

Reviewed by:
CHRISTOPHER GEROLD,
NEW YORK CITY, N. Y.

THE DISCOVERY OF THE UNIVERSE, by Gérard de Vaucouleurs. *Macmillan, \$6.00; 328 pp., illus.*

IN a burgeoning scientific field, such as modern astronomy, much skill is required to write a history that covers the past as well as the most recent operations, and also knocks on the door of the future. Gérard de Vaucouleurs has pretty well accomplished such a feat in this enlargement and translation of his 1951 French history of astronomy. The book, with its selected analytic bibliography, should serve well for a college course in the history of astronomy—still better, perhaps, as a reference book in the history of science and for the general reader of matters scientific.

A reader concerned with the history of personalities will be disappointed if he turns to this volume for small talk about astronomers. Deliberately, the author has written about astronomy—not astronomers. Even so, it is a bit disturbing to find Aristarchus, Ptolemy, Copernicus, Galileo, Kepler, Tycho and Newton disposed of in about two pages each. The fact is, however, that in major discoveries and in basic processes, the astronomy of the twentieth century looms large compared with that of all time before, and DeVaucouleurs has therefore given fullest attention to the past half-century. To the original French edition he has added accounts of the new work on the scale of the universe and on the marvels of postwar radioastronomy. Fortunately, he has been cautious in presenting these latest discoveries and deductions.

The reviewer is not much annoyed by the author's intimation that he first proposed the "supergalaxy" hypothesis in 1953, when, in the galaxy maps at Harvard in 1932 and in the early studies of galaxy distribution at Harvard and in Sweden, the preliminary evidence on supergalaxies had already been presented—is not annoyed because none of the evidence is convincing; the supergalaxy is probably non-existent.

(continued on page 272)



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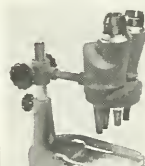
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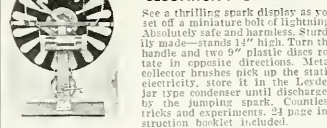
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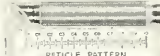
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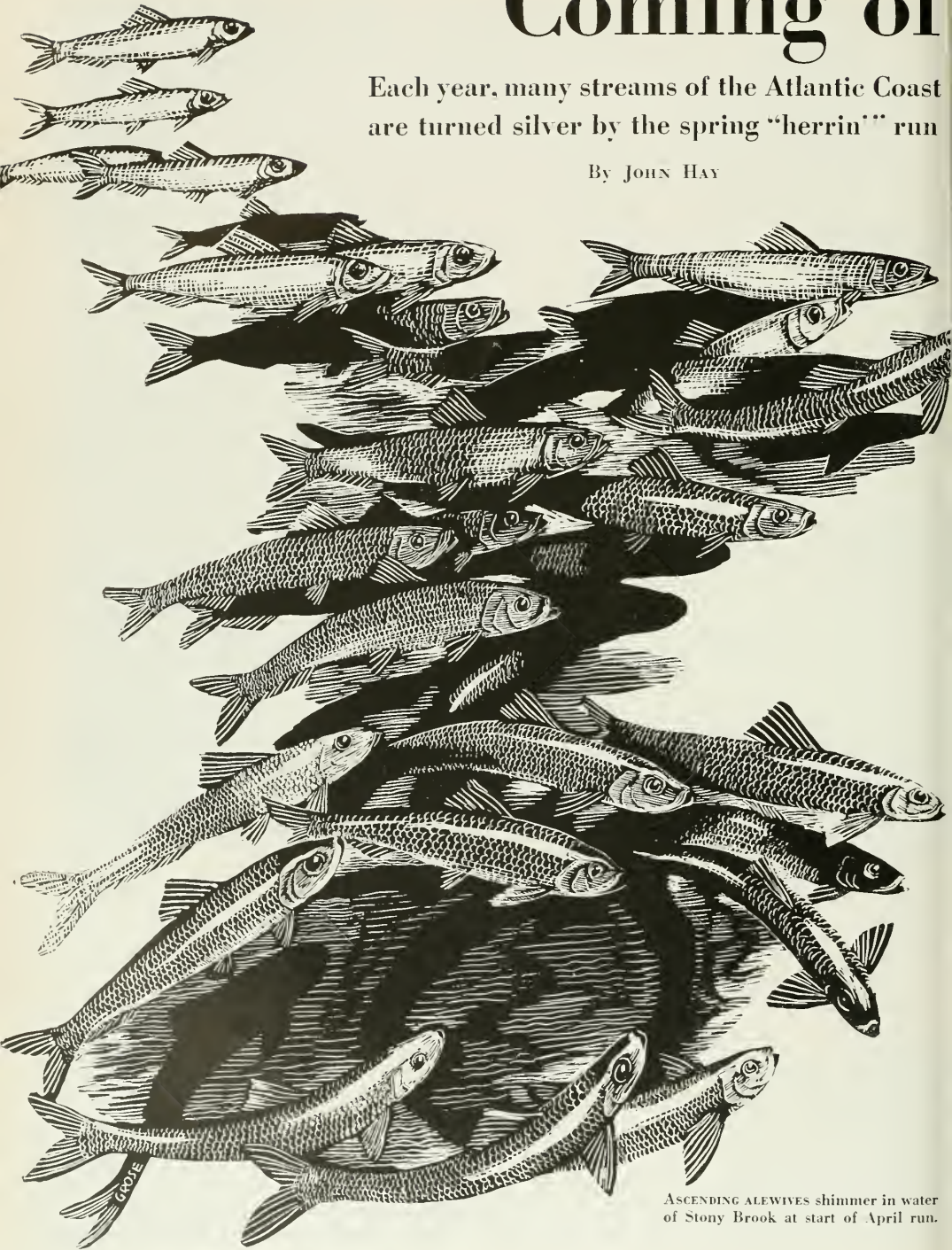


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Coming of

Each year, many streams of the Atlantic Coast
are turned silver by the spring "herrin'" run

By JOHN HAY



ASCENDING ALEWIVES shimmer in water
of Stony Brook at start of April run.

the Alewives

THE HERRING are running!" That cry has few remaining echoes on our Atlantic coast, but there was a time when it brought out men, women and children in the growing springtime to see a new flood of life crowding inland rivers and streams. This abundance of migrant fish meant food and revenue returning once more to the New Englander's backyard.

"Herrin'" is what the Cape Codders call them, though they have their alewives committees like other parts of New England; and alewife was the original name of this fish, stemming, in all probability, from English dialect. In any case it should be differentiated from its cousin the sea herring, which spawns only in salt water.

The alewife has also been called "sawbelly," "wall-eyed herring," "big-eyed herring" and "spring herring." In Canada it is the "gaspereau" or "kyak." The scientific name is *Pomolobus pseudoharengus*.

Early colonial fishing laws give evidence of their major importance in

the seafaring economies. The alewives, trapped or netted during their spawning migration from salt water to inland lakes and ponds, were smoked and salted, to be eaten locally or sent out as ship's provender on many voyages. A considerable trade also developed with the West Indies. Innumerable barrels of alewives, pickled in brine, were shipped to the Caribbean: some still are, from at least one area in Maine. And the alewife fry, hatched in the ponds and returning to the sea during the summer and fall, were as important as the incoming adults of spring, so far as local prosperity was concerned. The outbound fingerlings attracted numbers of striped bass, pollack and bluefish to offshore waters.

It is quite likely that the alewives were in prodigal abundance in the years before men began to catch up with them. Here is what *A History of Barnstable County*, published in 1890, has to say: "Early in the last century the supply of herring so far exceeded



TRIO OF PONDS, above, provide spawning ground near Brewster, Cape Cod.

the demand for fish food that the surplus was used to fertilize the field . . . the growing custom of using them in each hill of planted corn was checked in 1718, the town fathers (of Bourne) ordering that none should be taken in future to 'fish' corn."

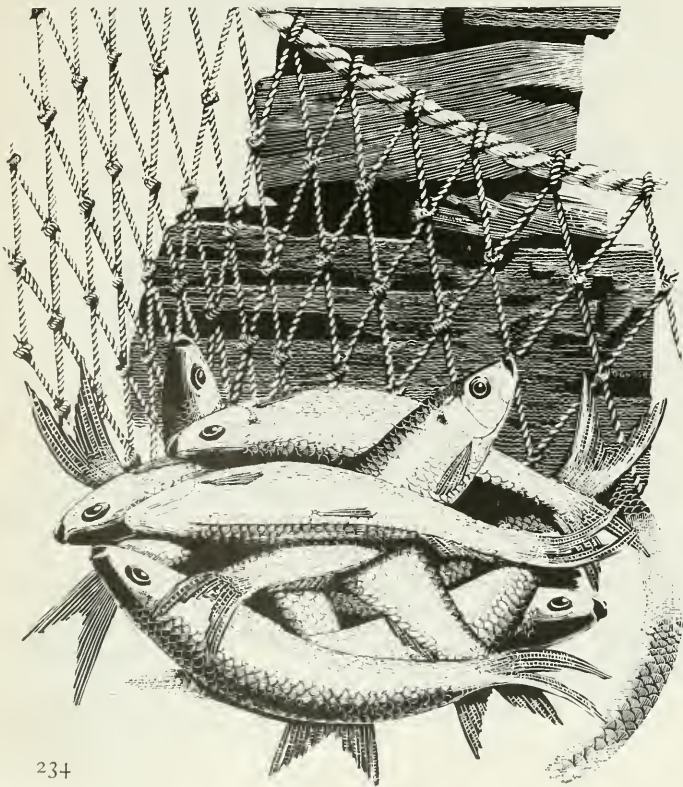
Apparently the alewives have greatly declined in numbers since then—as



GULLS WHEEL above the stream, where it meanders across tidal flats to bay.



NEAR OLD MILL ON Stony Brook, *above*, is the seining pool from which concessionaire nets alewives during spring season, *below*, for use as lobster bait.



a result, among other things, of the drying up of streams, the pollution of rivers, and the over-fishing of local runs. But they still come in heavily along our coasts, all the way from Nova Scotia to Florida, and it is hard to tell in some areas whether they are much less in numbers, or we and our demands are much more.

Where there are good-sized runs, New England towns still appoint alewives committees, whose members are re-elected annually at Town Meeting. It is their job to keep the runs free from obstruction—so that the fish can proceed to their spawning grounds, and also into the nets of the concessionaire. In Brewster, the Cape Cod town where I live, rights are sold annually to the highest bidder for the privilege of fishing the stream in season, five days a week. On the other two days, the fish are allowed to go ahead and propagate their kind.

"The herring are running!" would sound no less exciting now than it did a hundred years ago, although it would attract considerably less attention, provided anyone were eccentric

enough to get out in the street and yell it. Today's spring, too, is no less full of kaleidoscopic discoveries, as the air clears and warms and the wheels of the world seem to turn more brightly. What a live, high morning it is, still, when you wake to a gabbling of gulls in the distance and know that the fish have finally arrived! There are cool sweeps of breeze, broad runs of blue in sky and sea, past the gray and white houses of the Cape, when these silver hordes start to crowd the inland veins in their bold, annual reminder of perpetuity.

IF you go to the Herring Run in my town, perhaps toward the middle of April or later, you can watch the netting operation. On Stony Brook Road, a truck full of barrels is drawn up beside the seining pool, where the fish are cut off from further progress upstream by a small wire gate. The fishing crew is hauling in a purse net, with the aid of a winch mounted on the bank. The net is loaded with fish—enough to fill four or five barrels. The victims are flipping and flashing violently, making a loud, high sound in the morning air, a beautiful iridescence in their white-silver sides. The whole dripping net is heavy and alive with their shivering, thrashing and dying, many heads butting through the meshes in a frantic, vibrating despair. And to what end? These alewives will be—let us face it—lobster bait, worth six dollars a barrel.

This seining pool in Stony Brook is part of a little migratory route by which the alewives of Brewster travel inland, up from Cape Cod Bay to the fresh-water ponds where they spawn—provided they run the gauntlet successfully. At the Herring Run, the waters of Stony Brook pour down from an outlet north of these ponds. There are three of them, all interconnected: Walker's, Upper Mill and Lower Mill. The flow of Stony Brook then descends over a one-and-a-half mile stretch, first through the fishway (a series of concrete ladders and resting pools, built through rocks and high land), then through a valley of abandoned cranberry bogs, bounded by low hills; finally, Stony Brook elbows through tidal marshes to Paine's Creek, its mouth on Cape Cod Bay.

THERE are a number of mysteries about the alewives—their directional ability; where they go as they

are growing up in the sea; why the fry leave the ponds when they do. But one of my first interests, when I started to explore their migration, was to see them in the act of spawning. I asked the local alewife warden about this. An old Cape Codder, he usually, on his good days, could be counted on to give me some colorful information.

"What about the school I saw yesterday, running along the shore of Upper Mill Pond?"

"Well, they were kind of getting acquainted, you know. Just cuddling together! You know how it is."

He described the act of spawning for me: "...a kind of swish dance..." giving a hula-hula motion with his hands. The alewives would idle up to the shallow edges of the ponds, he said, rocking as you would rock a baby, and then the females shoot out the spawn, their fins lifting up with the effort. The pond suckers, he told me, would swim up to grab the eggs almost as they left the alewives' bellies.

One afternoon in May, I started out from the Herring Run to walk to the ponds above and try to see this decorative performance for myself. The concessionaire was still at work with his truck, barrels and net, but he was going to quit soon and deal in some red fish at Gloucester. The red fish, he said, made tougher, better bait for lobsters anyway. While he had been in Brewster, he had netted forty barrels a day on the average, sometimes as many as eighty, but he had not yet reached the four hundred mark. One barrel, by the way, might contain four hundred fish—so that anywhere from 160,000 to 200,000 alewives might be pulled out of Stony Brook in a season. The necessary minimum of fish that are allowed to go through the gate and up to the ponds during the weekend have a heavy job of it to assure the return of their race!

It was a warm day, bringing a new lassitude on the air and the sweet smell of lilacs. The gulls were gone that had flocked in, quarreling and screaming when the run was heaviest—hovering and rising over the waters and their hordes of fish, bold enough sometimes to perch on the bridge over the run, looking very large, with their pale yellow eyes glaring as naked as stone. In place of the gulls, there were a few dove-gray, black and white night herons—"Quawks," or "Quoks," a name true to the sound they make. These were perched on the outer



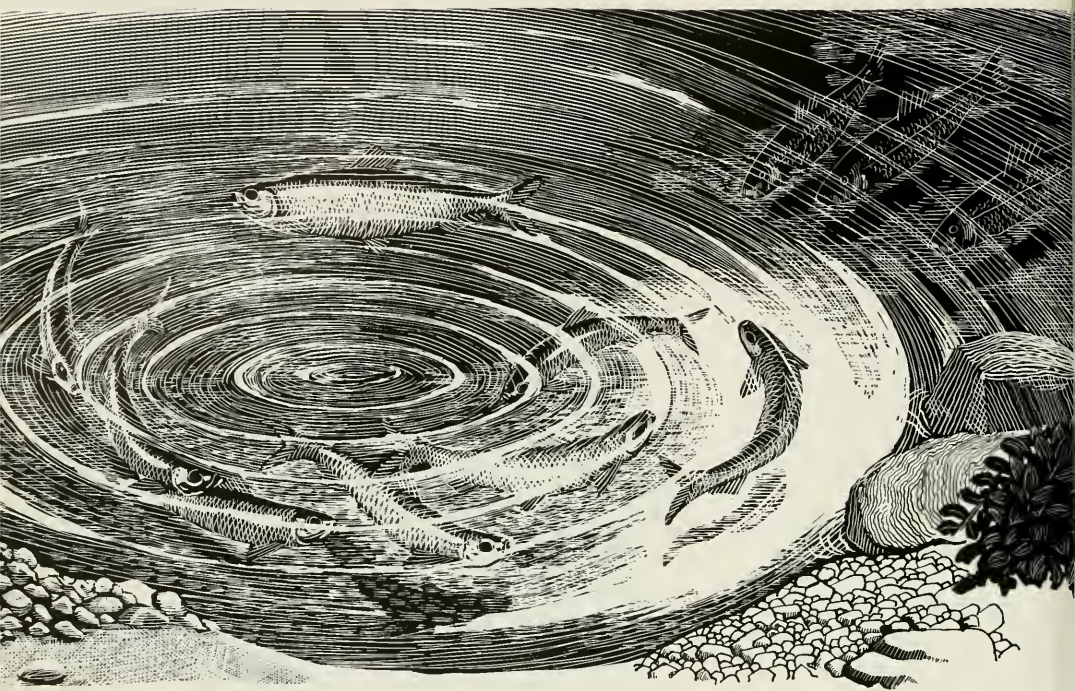
ALEWIVES' ENEMIES include the night herons, or "Quoks," *above*, and gulls. Hungriest of latter would sit on rail of bridge, *below*, watching for a fish.

branches of overhanging trees, like heavy sculptured ornaments, or standing in the water with their spearhead bills ready-poised.

I have heard it said, incidentally, that the herons keep the gulls away, but I have never witnessed any aggressive action between the two races. On the whole, they seem to respect each other's territory and keep their distance from each other. Yet, I have seen quawks and gulls together waiting for alewife fry on the tidal flats beyond Paine's Creek.

IN Stony Brook, there were still some fish ascending; but many others, perhaps more, were going back. It is a little hard to tell the difference at first, since both face up against the current, but the returning alewives gradually drop back downstream and many have on them the characteristic white marks of freshwater infection. The strain of spawning and using up their store of fat makes them thin, slow and weary. They have lost a good deal of their





START OF FINAL RUN to spawning grounds in inland ponds is frequently preceded by a period of swimming in circles in pool at foot of fish ladders. Groups of alewives form

up during circling and, when leading fish make a dash up ladders, others follow. Females' eggs are still unripe at this time, but quickly become ready in ponds' warm water.

fight, although not to the extent of preventing the return journey.

Although this was a "spring fever" day, it did not mean that the greatness of events was over—only the first, vast toppling of a wave, only the initial, violent forwardness, with its illimitable sounds and changes. There was a steadier greenness on the trees, and blossoms on the high lilacs. The Run's waters went on with a constant "wail" and "wah," if without the turbulence of a few weeks earlier. I left the Run and walked up into the warm pine woods to try and find the culminative point of the migration.

A light wind was running straight down the long surfaces of Upper Mill Pond when I reached it, and little waves scudded ahead. I walked on the north side, where sandy banks descended to the shore, shaded by pitch pines and covered with viburnum bushes and bearberry, a pink-blossomed ground cover locally known as "hog cranberry." There were stretches of amber sand, small stones, or gravel,

along the pond's edge. A fat sucker jumped for a fly and crashed heavily back into the water.

As I walked and watched along the Pond's shore, I saw one group of alewives, and then another, running by, looking light-colored and bright in the sunny water. These groups seemed to be made up of a female escorted by several males. (The female alewife is larger than the male.) When running upstream, the female's eggs are unripe, but they ripen soon after she reaches the ponds, providing the water is warm enough—between 55° and 60° F. As to the act of spawning, the female, depending on her size, deposits anywhere between 60,000 and 100,000 eggs—each some 0.05 inches in diameter—in shallow places. Because the eggs are sticky, they adhere to gravel, sticks, stones, or whatever they settle on. The males, who have been closely following the female, immediately cover the eggs with milt, thrashing and scattering it with their tails. The eggs, in turn, will hatch out after about six days' time at 60° F.

To clothe these cold facts with motion, what I saw was this: I saw the alewives run and circle, chase and weave offshore, sometimes slowing up in deeper holes along the bottom, or behind rock-protected water, and then come in close, with a quick impulse. One group raced to the pond's gravelly, shallow edge, not much more than ankle deep in water, with a sinewy, rippling motion together. Then—in the shadows under an overhanging shrub—there was a flipping, whirling and thrashing, a breaking of water. One fish, perhaps a female, slapped up against the side of a rock with a rising, shuddering motion of its body, as though shaking everything out of it, while the others simultaneously writhed, coiled and shimmered through. Then it seemed to me there were a few seconds in which the fish slowly reassembled their senses to go elsewhere. The word "deposit" is scarcely active enough.

Now it may seem incongruous to apply our word "love" to the actions of cold-blooded fish. A few species of

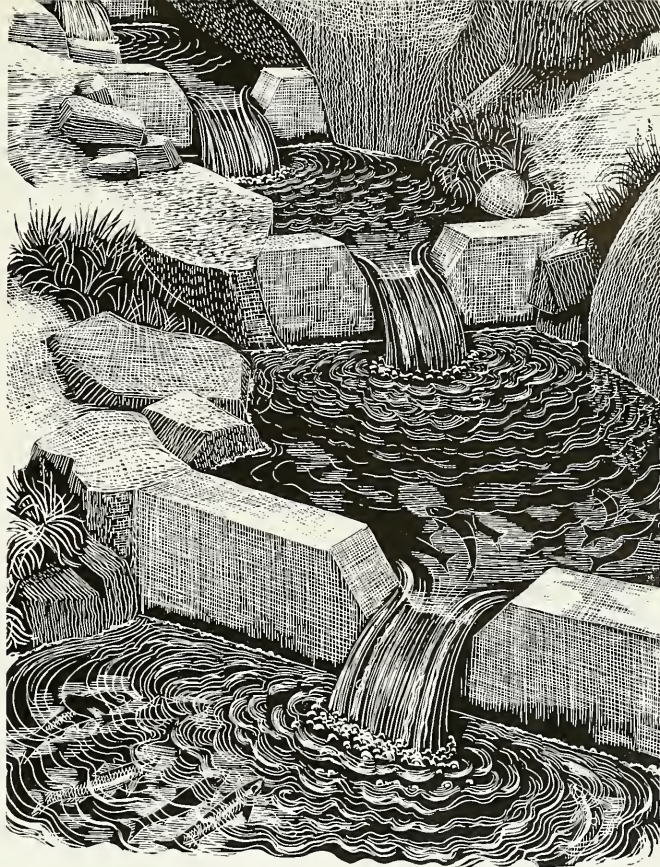
These and other observations of the alewife, by JOHN HAY, will appear in book form this fall—illustrated, as is the extract here, by DAVID GROSE, a Cape Cod artist-neighbor.

fish may show varying degrees of attachment between mates; others are more or less protective toward their young. The alewives, of course, leave their young to shift for themselves. But love—or perhaps I should say loving—does not, in our human sense, seem quite appropriate. All the same, this culminative act of the alewives has its universal connections. Theirs is certainly an imperative dance; a great rhythm, with grace in its preparation and power in its fulfillment. Is it “blind,” or has it all the light? The alewives’ life risk ends and starts again in a beauty of motion, a coming together of body and energy. Love? Yes, why not use the word—even though we have to omit the valentines.

SOMETIMES, that spring, it was the war cry of herring gulls, in small flocks, settling on the shore waters or rising up, that told me where the alewives were, but most of the time I found them in accustomed places such as this stretch of shore on Upper Mill Pond. Sometimes I could hear them splashing before I saw them. They seemed to be more inclined to spawn when the water was not too rough. On the other hand, I found them spawning when the ponds were so choppy that the small waves pushed them about as the fish coiled and thrashed at the shallow edge.

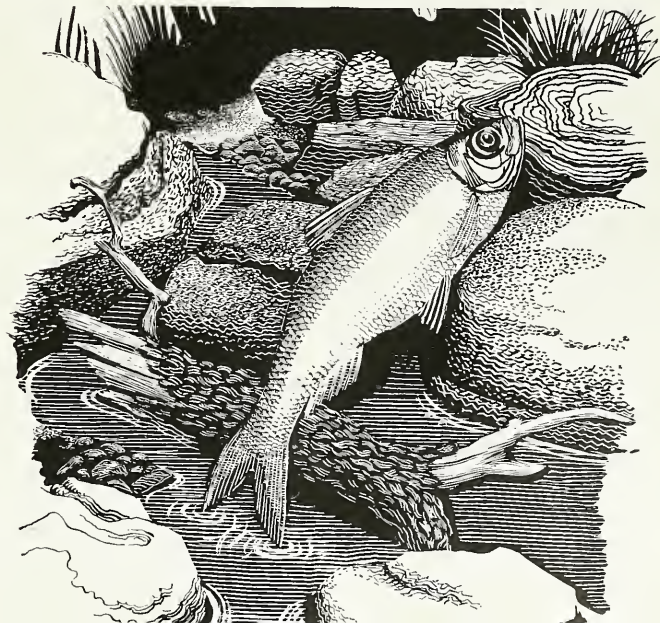
Once, on the south side of Upper Mill, I noticed the pond suckers before I saw the alewives. There were twenty or more suckers, lined up as if they were waiting for chow, with their large, fleshy mouths giving the bottom a slow going over. When groups of alewives ran in and characteristically heaved, flipped and writhed at the edge, the big suckers would move up closer. They were so oblivious to anything but their guttony that I could tap them on the head with a stick.

An overabundance of suckers in any one place seemed to discourage the alewives a little and make them move on to another place. But, on the whole, the alewives were so intent on their dance that they hardly noticed anything else. They had to force and fulfill themselves; then, stunned, go on. Their eggs were expendable.



FISH LADDERS, *above*, have been built in Stony Brook to aid alewives in run.

DESPITE HELP, not all the fish reach destination. Some, *below*, die on way.





PART I

Tyto alba

Foremost among nocturnal hunters, the Barn Owl
can be found in almost every part of the world.

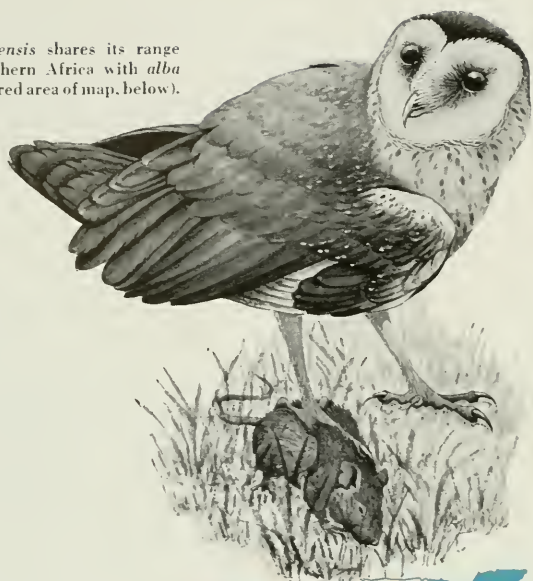


By E. THOMAS GILLIARD

NUMBER ONE hunter of houses, the Barn Owl, *Tyto alba*, is an eighteen-inch, pale yellow buff bird, with white underparts, a heart-shaped face and small, bulging black eyes. A nocturnal hunter and devotee of dark places (hollow trees, caves, old wells, dove-cots, barns, belfries and—particularly—the upper stories and attics of abandoned houses), the Barn Owl—

with its young—produces almost every haunting sound known to the literature of the supernatural. As if its repertory of hisses, rattles, growls, coughs, raucous chuckles, cries and screams were not sufficient, *Tyto alba*, in silent flight, can also provide the superstitious with that pallid apparition which, in occult fiction, suddenly swoops through the gloom of a dark

T. capensis shares its range in southern Africa with *alba* (hachured area of map, below).



garret, waving its veils as soundlessly as a wisp of smoke.

But *Tyto alba* is much more than an avian impersonator of ghosts. It is the widest-ranging of all nocturnal birds. Of the nine species of *Tyto* that comprise the bulk of the Barn Owl family—the Tytonidae—*alba* alone has managed to reach and populate most of the world's major land areas (see maps). Among all the land birds, only the Duck Hawk, *Falco peregrinus*—also a carnivore, with special feeding habits—enjoys so wide a range. But the hawk is diurnal; *T. alba* has achieved its globe-circling position while living as a nocturnal hunter.

THE BARN OWL has probably been greatly aided in its wide diffusion by the possession of a hunting mechanism unknown in any other carnivorous bird. This is an ability to




T. soumagnei is confined to Madagascar. Owls' size is in proportion to extent of range.

T. alba and its cousins: the distribution of nine of the Family Tytonidae

Distribution of *T. alba*, the most widespread of the family, is shown as solid tone, below.

Illustrations by
GUY TUDOR



locate its prey by hearing alone and to make accurate, flying attacks even in absolute darkness. Now, absolute darkness is uncommon in nature. At last year's convention of the American Ornithologists' Union, Roger Payne and William H. Drury, Jr., reported that they had achieved this unnatural darkness in a sealed room and that a Barn Owl, even under these exaggerated conditions, was successful in catching living prey. Payne and Drury will relate the details of their experiment in the next part of this series (NATURAL HISTORY, June, 1953).

It seems probable that the success of the Barn Owl as a nocturnal hunter

is also aided in some measure by the silence of its flight—so silent that human ears, at least, can scarcely detect it. All of *T. alba*'s plumage is very soft, and its flight feathers have "furry" edges that virtually eliminate sound. This specialization of plumage, which the Barn Owl shares with most other owls, may well increase the element of surprise in its strikes.

Almost everywhere throughout its vast range, *T. alba* is cohabitant with man, even in the midst of the largest cities. One pair once took up prolonged residence in the Smithsonian Institution at Washington; many Barn Owls have been found in New York City. This association with mankind may well be connected with the owl's predilection for mice and rats as prey—animals which man almost inevitably includes in his entourage.

WHEN the diurnal birds of prey retire from their hunting and the long shadows of twilight fall—over the city parks, farm meadows, fields and marshes and forests—*T. alba* shuffles up to the entrance of its dwelling and takes wing, sounding a note like the chuckle of a squirrel. Fanning out low over the ground, *alba* hunts

the small mammals that search for food in the dusk. In a single night, one Barn Owl may capture as much small prey as would a dozen cats.

Now, each Barn Owl nestling can eat its own weight in food in a night and remains a dependent for as long as eight weeks. Considering that there are usually three or four young—as well as unhatched eggs—in each Barn Owl nest, the size of the nightly adult haul becomes not so much remarkable as mandatory. One observer has seen a Barn Owl bring sixteen mice, three gophers, a rat and a squirrel to its ravenous nestlings during a single twenty-five minute period.

Another biological mechanism, not too widely encountered among birds, may help the Barn Owl raise its nestlings. This is what is known as “asynchronous hatching.” In its reproductive cycle, *T. alba* usually lays five to seven eggs, at two-to-three-day intervals, but begins incubating soon after the first egg is laid. The *alba* young thus hatch at staggered intervals, so that robust owlets and unhatched eggs are to be found in the same nest. Among the herons, as NATURAL HISTORY readers have seen (January, 1958), this asynchronous mechanism is no guarantee of survival. With *T. alba*, it at least minimizes the adults' need to provide for the survival of large youngsters simultaneously.

OWLS regurgitate pellets that contain the indigestible parts of their prey—skulls, fur and the like. As a boy, I once collected nearly a bushel basket of such pellets from a tree house at the edge of a Maryland forest—representing the kills of one pair of Barn Owls for less than a year. Unfortunately, my basket of grimy treasure was mistaken for rubbish and destroyed before analysis could be made of the hundreds of small mammal skulls it contained. But such surveys have been accomplished the world over. Recently, a pellet analysis in Poland, involving 15,587 vertebrates, showed 95.5 per cent small mammals, 4.2 per cent birds, and the remaining .3 per cent amphibians. In the New World, the Barn Owl's kill seems to be composed almost entirely of those species of rodents that, because of their nocturnal habits and abundance, are chiefly responsible for agricultural losses. But the Barn Owl is not reluctant to tackle larger prey, including

the so-called Jackass Hare, known to the sourdoughs of the Old West as the “narrow-gauge mule.”

HOW HAS *T. alba* made almost all the world its range? Two factors seem primarily responsible. First, the Barn Owl occupies a feeding niche not equally available to any other bird and, probably, not even to the other species of the Tytonidae. Seeking out and killing its prey, silently, in the deepest darkness, *T. alba* exploits a unique ability to use an otherwise untouched larder. This capacity, combined with *alba*'s mechanism of dispersal, described below, seems to have opened the world to Barn Owls.

Recent European banding records, involving more than 1,400 Barn Owls, have shown that the offspring disperse at random in all directions, exhibiting no tendency either to linger near or to return to their birthplace. Instead, the Barn Owls of each new generation seem to settle in whatever area they happen to reach during their first

T. longimembris is found in many areas of mainland Asia and the Pacific (tone on map).

winter. Once paired, the adult Barn Owls thereafter keep close to their nesting and roosting territory. Pairs have been observed to stay together for years—perhaps they do so for life.

Thus far, we have seen two factors that probably account, in large part, for *T. alba*'s remarkable, world-wide range. Is there still a third factor? The records of the past are faulty, and may never be fully reconstructed; yet, it is within the range of speculation to imagine the ancient human

dispersals—as old as the Neolithic—through which man, with his food-grains and his entourage of animal associates, domestic and wild, has moved outward to the far corners of the world. Along the way, man has repeatedly constructed environments—complete with abundant rodent life—which must represent something close to the optimum for *T. alba*. Perhaps this, too, has been a factor in establishing the global range of the ghostly, nocturnal hunter, the Barn Owl.

MR. GILLIARD is Associate Curator of Birds at THE AMERICAN MUSEUM and a regular contributor. Mr. TUDOR, a gifted newcomer to ornithological art, here makes his first appearance within NATURAL HISTORY.



Three Tytonidae (from left: *inexpectata*, *rosenbergii* and *aurantia*) dwell in islands.



T. tenebricosa extends over all New Guinea, plus eastern Australia (vertical hachure).

T. novaehollandiae overlaps extent of *longimembris* and *tenebricosa* (horizontal grid).

Barn Owl's Precocial Young



EUROPEAN NATURALISTS, whose work in banding the local Barn Owl populations, *left*, has established much information on the spread of newly-mated pairs, often document their work with excellent photographs, such as these. Typical Barn Owl's nest, *top*, was found in the steeple of a Swiss church. One of the eight eggs has already hatched. *Below*, the voracity of nestlings' appetites may be measured by the number of mice which the parent birds have brought to this nest. Finally, *right*, this portrait of a trio of maturing owlets demonstrates the staggered time of hatching.








FOUR-PEAKED MOSQUE TOWER dominates Ghardaïa, largest of the seven cities of the Mزاب Oasis. Mزابites, who are

Berbers, leave their home area in youth, to run shops in Algerian cities, making occasional trips back to Oasis

SOUTH ACROSS THE SAHARA

A new book, "Yallah," is an epic record of one man's journeys through desert Africa

By CARLETON S. COON



BETWEEN 1949 and 1953, a gifted Swiss photographer, Peter Haeberlin, made four trips through the Sahara. From north to south, his journeys took him from Algiers to Timbuktu. Being an artist and not a writer, Haeberlin—who died in 1953—has left only his pictures, which are superb. Twenty of them—taken from the book *Yallah*, published by McDowell-Obolensky—are reproduced on these pages.

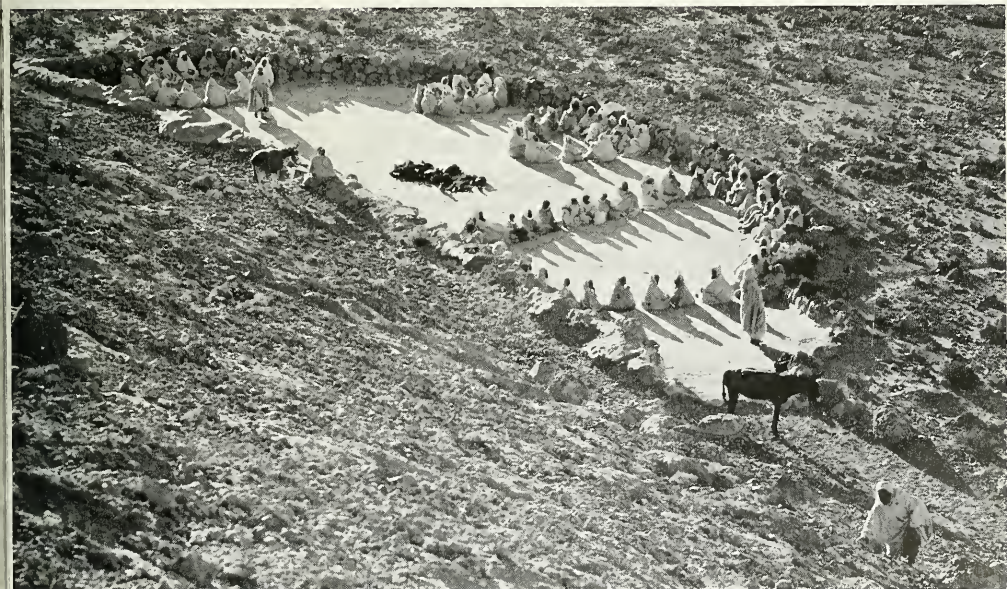
Yallah means, literally, "O God!" but its common significance, the sense in which it is used as the theme of Peter Haeberlin's journey, is "Let's go!" Motion is essential for any group of organisms—like camels or men, whose bodies consist largely of water—when they are crossing the dry expanse of a desert. Haeberlin stopped for water—and pictures—among five principal groups of people: the Mzabites, the Shaamba, the Tuareg, the Hausa and the Fula, plus other tribes of the region of Lake Chad.

The Sahara is the world's greatest



STRONG GREEN TEA, usually with mint and sugar, is a North African staple.

and hottest desert. It contains flinty plains, granite mountains rising to 10,000 feet, and patches of treacherous sand. At strategic points are oases with palm trees and water—and, between the oases, dodging the sand, stretch the caravan routes. Probably these routes were first traced by donkeys and men and, later, by camels. Today, they are marked by tire-tracks, and more of these will soon be made—along pipelines leading from oil wells to the sea. For, like the Arabian desert, the Sahara has been found to contain petroleum-bearing formations.



WHITE-ROBED TOWN ELDERS gather at Chardaïa cemetery. Graveyard meetings, particularly at night, are standard

procedure for Mzabites, who belong to puritanical Abadi sect of the Khawarij (or "outsiders") branch of Islam.



MID-DESERT COMMUNITY of In Salah, composed of twelve oasis villages, is center of the Tidikelt region. Here, in

the 1890's, coastal residents came to trade for ivory, ostrich plumes, rhino horns, gold dust, skins and slaves.



OUTSIDE THE WALLS of El Golea, one of the Shaamba serving women winnows

grain. Her masters, Arab nomads, live in the desert, come to town in summer,

THE MZABITES are Berbers, who inhabit the seven towns of the oasis of Ghardaïa in the northern Sahara. In religion, they are Abadi Muslims—members of a superstrict sect of the branch of Islam known as the “Khawarij,” or “Those who have gone outside.” As the oasis scarcely can support its population, Mzabite men go to Algeria as youths, leaving their wives behind. In the cities of Algeria, most of the tobacco shops, corner groceries and newsstands are run by Mzabites. After decades of frugal living, the Mzabite sells his shop to a kinsman and goes home.

Beyond Mzab lies the extensive country of the Shaamba, a confederation of tribes of nomadic Arabs, tent-dwellers who live on their flocks of camels and on the dates produced by their serfs in various oases. El Golea (The Castle) is considered their capital, but they come to it—and to other oases—only in the season of date-picking (August or September) and stay three or four months. The Shaamba are divided into nobles and commoners, and the nobles include both warriors and holy men. The sedentary people who live under Shaamba



It is still a favorite trading center for the Tuareg, who live farther inland. Miles of gently-sloping tunnels, fed

by wells, bring water to village gardens. "Dikes" of palm branches, *foreground*, guard against the drifting sands.

suzerainty include a few Arab and Berber cultivators and a majority of Negroes, known as "Harratin."

BYOND the Shaamba country, Hachberlin entered the domain of the Tuareg, who own the mountains of Hoggar and Aïr, as well as the empty stretches in between. Although similar to the Arab Shaamba in many ways—riding camels, living off pastoral products and the toil of agricultural serfs—the Tuareg could hardly be more different in social attitudes. They are Berbers, not Arabs. Their ancestors came down from the more fertile north a good two thousand years ago, after the camel had been introduced into Africa from Persia. While the Shaamba veil their women, it is the Tuareg men who go veiled, and the women barefaced. Unlike Arab women, the Tuareg ladies own much of the property, choose their own husbands and know how to read and write. Their writing is a primitive square-character script—derived from the ancient Libyan, which, in turn, came from the Phoenician. It is used mostly in writing love poems, a favorite Tuareg pastime.



SERVING WOMAN, at In Salah, spins thread for locally-famous wool robes.

Most of the nomads' servants (called "Harratin") are Negroes, from south.



NEAR HOGGAR MOUNTAINS, this Tuareg tribesman pauses to smoke. His camel

is one of the *mehari*'s, famous breed of racing dromedary beloved by Tuareg.



UNVEILED WOMEN of Tuareg drink tea amid mountain boulders. Two men, with veils, appear to be Negro slaves. The

bleak landscape, *right*, seen from an outcropping of weathered granite, is typical of Hoggar mountains' terrain.

Well known as an anthropologist, Dr. COON has, as his first love, the indigenous cultures of northern Africa.





HAVING crossed the Sahara, Haeblerin reached the Sudan near Zinder, and traveled east to the shores of Lake Chad. This body of water, 6,300

square miles in area and less than twenty-four feet deep at its deepest point, has no outlet: it is the center of an enormous drainage area. Most of its water comes from the forests and savannas to the south, but despite this exotic source of supply, the lake is gradually drying up. This is the southern limit of the desert. Not only is vegetation more abundant, but the rainfall cycle is different. In North Africa and the Sahara, variable amounts of rain fall, but in the winter. In the Sudan, the wet period is the summer. The moisture ameliorates the heat, and limits the seasonal variation. The heat equator lies farther north.

Here the country is no longer empty. The grassy plain is dotted with flat-topped acacia trees, and an occasional thick-trunked baobab. Village after village is to be seen; their people, nearly all black. Some are standard Negroes, thick-lipped and muscular; others are of the lean grasslands- and desert-build, with thinner faces and, often, aquiline noses. The variety of tribes is enormous, the cultural complexity great. In religion, this is a meeting ground. Some of the people are pagan, others Muslim. One can see women who veil their faces and expose their breasts. In the midst of this ethnic medley, two peoples are



WOMAN OF SUDAN, at southern edge of desert, models a cooking pot of clay, left; simultaneously tends infant son.

SALT CAKES are made by evaporation from brackish water of a well, above, in country at edge of the Air plateau.



HEAVY ANKLETS are a mark of women of the Fula, *right*, a pastoral group that conquered the Sudan in the 1800's.



SHADED MARKET of this Sudan village is occupied by Hausa women, offering

fruit to bypassers. The Negroid Hausa once ruled seven-state confederation.





BORORO HERDER, *left*, belongs to the Fula tribal group. He wears a Tuareg-style sword, sheath of Hausa leather.

outstanding, the Hausa and the Fula (or Peul). Both of them have ruled extensive empires, both are Muslim, and both live scattered throughout French and British territory.

THE Hausa, numbering about eight million, are mostly Negroid in appearance, and speak a language of the family called "Chad," remotely related to both Semitic and Berber. They are skillful farmers and stock-breeders and, in the towns, excellent artisans, specializing in leather work and the manufacture of cloth mats. In the Middle Ages, they attained political domination over the neighboring tribes and organized themselves into a confederation of seven separate states.



HUMPED CATTLE OF THE FULA display long, graceful horns. Related to the Watusi's sacred cattle in Ruanda-Urundi, and to Masai cattle, the breed may trace back to India.

HAUSA SCHOOLMASTER, below, writes erasable text, working with brush and ink on a wooden board. Both Hausa and Fula peoples are Muslim: text is probably from the Koran.

In the early part of the nineteenth century, the Hausa were conquered by the Fula, who today number about six million persons. Coming from the Senegal country to the west, the Fula infiltrated the Chad Basin and Nigeria, beginning with the thirteenth century, and took over power from the Hausa by 1810, when their leader was declared Caliph at Sokoto. They remained in power in the Sudan until the beginning of British and French colonial government. Like the Hausa, the Fula now live scattered among other populations. Some of the Fula are still pastoral, herding great flocks of long-horned cattle; others are semi-pastoral, and still others have become fully sedentary and agricultural people.





FREE-RUNNING WATER, after painful miles of desert, is welcome feature of Lake Chad neighborhood. Here, a herd

of Fula cattle—some of them packed as baggage animals—crosses a ford near the lake, as herders splash happily.



rather than black in skin color, narrow-faced and narrow-nosed, and often straight-haired. In the early days of colonial rule, the French army doctors rejected these warrior tribesmen for military service on the

ALTHOUGH their language is one of the Niger-Congo family, the physical type of these pastoralists is not Negroid. They are lean-bodied, brown

grounds that they weighed too little for their height. Instead, they recruited stockier Negroes, members of non-combattant agricultural tribes. However, the French soon corrected their mistake, and the Fula have made excellent soldiers ever since. The origin of these cattle people has long been a mystery, and one not likely to be solved in the immediate future. However, the Sahara has been growing progressively drier since historic times, and extensive rock-carvings, some showing long-horned cattle, have

been discovered in what is now the middle of this barren desert.

Africa is full of such mysteries—most of which will remain secret forever, with the encroachment of Western culture. So rare are first-class pieces of African sculpture today, for example, that an ivory mask from Benin recently sold for \$56,000. That Peter Haeberlin was able to preserve some of this Africa in his pictures is, indeed, wonderful for, in the world of the not-too-distant future, this Africa will no longer be found.



CHAD'S SHALLOW WATERS constitute a highway for local trade. Cargo raft, above, is being poled across the lake

by its crew, who have a three- or four-day journey ahead of them. Today, Lake Chad is gradually shrinking in size.



LAKESIDE VILLAGE, *below*, a seeming jumble of mud walls and straw thatch, is actually prosperous Chad trade town.



SCARIFICATION on cheek and temple of woman, *above*, is tribal custom among Negro, Arabic-speaking Shawa people.



A NOCTURNAL CRICKET'S DAYTIME SHELTER





This insect's fascinating work is shown in unique photographs

By ROSS E. HUTCHINS

DR. HUTCHINS, widely known as an insect photographer, teaches entomology at Mississippi State College.

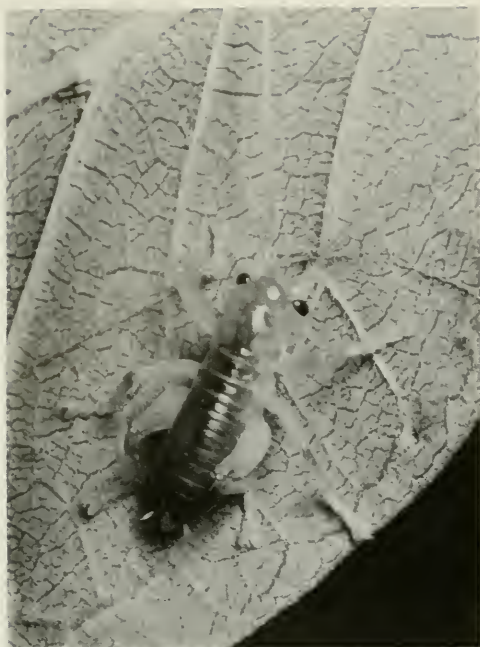
THE SMALL, WINGLESS INSECT known as the leaf-rolling cricket is a retiring creature. By night it ranges the gardens and forests of the central and south-eastern United States, in its quest for the tiny aphids that appear to constitute the bulk of its diet. But by day *Camptonotus carolinensis*—as it is scientifically named—is not to be seen, for it has taken shelter in a rolled-up leaf. It is scarcely surprising, then, that this pale and beautiful creature, so similar in appearance to a grasshopper, has largely eluded the attention of naturalists.

The existence of *carolinensis* was first recognized less than a hundred years ago, when Carl Gerstaecker first described it as a new species in a German journal. At that time, however, apparently nothing was known of the leaf-roller's remarkable behavior—it was merely a dried museum specimen from America, mounted on a pin. The little creature elicited some further comment, but it remained for an entomologist at the U.S. National Museum, A. N. Caudell, to do justice to *carolinensis* in a study published some forty years later. Caudell described a grasshopper-like cricket he had found near Washington, D. C., when, on opening a rolled-up papaw leaf, he had the surprise of seeing the insect leap out. Subsequently, others have studied the leaf-roller, but as one of them remarked, they have had "but little to add to Mr. Caudell's excellent account," and it is this we shall follow here.

The way in which *carolinensis* goes about its early-morning tent-making varies. It may, for example, fold an entire leaf together about the midrib, or roll just the tip of the leaf in a sort of flap. Or, as shown on the following pages, it may cut only one side of the leaf in the process of constructing its shelter. But the technique is basically the same, and the present photographs are probably the first ever taken of the entire, intricate process.

The first step in the shelter's construction is the cutting of slits along the leaf's margins. The direction of these cuts is variable, depending, apparently, upon the shape of the leaf and the particular preference of the cricket. When the cuts have been made, *carolinensis* places itself lengthwise on the leaf and, grasping the surface with its legs, slowly rolls the outer edge over. Then, when the two surfaces are quite close, the cricket begins to "sew" them together with strands of a silken fluid issuing from its mouth, weaving this thread from edge to edge of the rolled leaf. The damp strands contract as they dry, fastening the shelter's sides tightly together.

The cricket will usually assist this process by crawling out of its self-made shelter to press the edges closer until they meet. When the envelope is finally sealed, *carolinensis* re-enters the tent, weaves shut the open end, coils its long antennae lengthwise about its body, and settles down to pass the day until, that evening, it emerges to seek aphids.

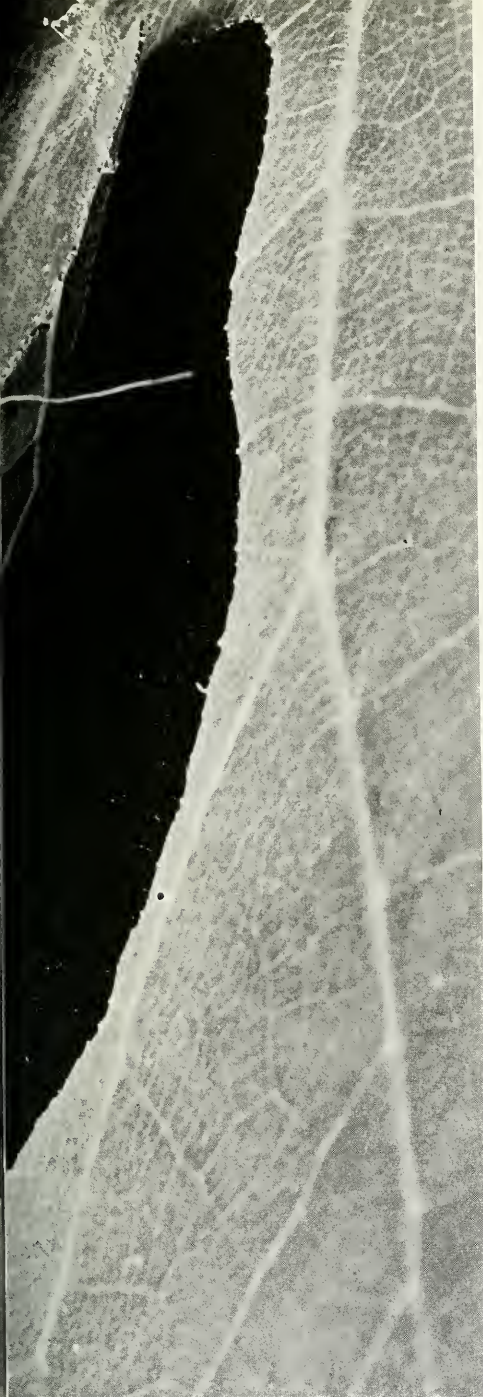


CONSTRUCTION OF LEAF "TENT" begins as cricket makes an incision in the leaf. Number and direction of cuts varies, according to shape of leaf and cricket's own preference.

IN SECOND STAGE, insect grasps leaf in legs, rolls cut and outer edges together. Enlarged third legs, like sharp mouth parts, put leaf-roller in same insect order as grasshopper.



CRICKET "SEWS" LEAF to complete shelter after edges have been pressed sufficiently close together, weaving strands of silken fluid from edge to edge. Among other insects in this



FLUID CONTRACTS as it dries, drawing leaf-edges still closer together. Cricket usually crawls out of shelter and presses sides together with legs to help speed tightening process.

FULLY ROLLED, this hop hornbeam leaf will provide shelter for cricket during the day. Insect begins building shortly before dawn, spends earlier part of night hunting aphids.



order, only the genus *Gryllacris* shows ability to secrete silk-making fluid, which issues from mouth in a single thread. Secreting gland is probably located beneath tongue.

LES ILES MARQUISES

Prehistory of Polynesia

By HARRY L. SHAPIRO

ABOARD "TE VEGA," the author, *below*,
(shorts) and Mr. Crane (aloha shirt)

survey Marquesan coast. Steep seaward
slopes of Ua Pou, *right*, typify group.



THE POLYNESIANS first became known to the Western World late in the sixteenth century, as a result of the Spanish trans-Pacific voyages that followed their conquests in Mexico and Peru. Ever since that time, but particularly after the mid-eighteenth century discoveries of Bougainville, Wallis and Cook, scholars have speculated about these Pacific islanders.

Their name was given to them by early European explorers who made a geographic distinction between Polynesia (Greek for "many islands"), Melanesia ("black islands") and Micronesia ("small islands").

The early scholars soon recognized that all the inhabitants of the Pacific islands lying east of a line connecting New Zealand, Tonga, Samoa and Hawaii were, basically, one people. Although the distances—north to south between Hawaii and New Zealand, west to east between Samoa and Easter Island—run into thousands of miles, the basic language spoken in all peripheral points, and in the inter-



mediate archipelagoes, is Polynesian. Dialectical differences, which sometimes make for a little difficulty in communication, are minor ones from a linguistic viewpoint, thus suggesting that they cannot be the result of any very ancient isolation of the speakers from one another after their dispersal among the distant islands.

Physically, also, these users of the Polynesian tongue impressed their discoverers by their distinct difference in appearance from the darker, frizzy-haired Melanesians, who are their neighbors to the west, and by their general resemblance to each other. Nothing that modern research has established contradicts this early observation, although regional variations of physique have been determined among the Polynesians

themselves, and some evidence of possible contact with the Melanesians has been suggested.

It was obvious—from their scattered geographical distribution in mid-ocean—that the Polynesians must have been emigrants from some original home on one of the Pacific's two bordering continental masses. The question was: from where?

The first writers who addressed themselves seriously to this question of Polynesian origins had little to go on, and mostly their hypotheses were finespun, relying on native myth and tradition, bits of cultural custom and on linguistic arguments. Where solid facts were scarce, imagination often enjoyed a free rein. As a result, the Polynesians have been "derived" from almost every great civilization of the eastern Mediterranean and the Middle East; variously, as transplanted Egyptians, Greeks, Arabs, Sumerians or others. Even the Vikings were not too remote to serve as a hypothetical hive from

which the Polynesian ancestors split off, crossing the Atlantic, and thence by diverse routes—one even through the jungles of South America—pushing to the shores of the Pacific, where they built fleets to carry them on to Polynesia.

Recently, Thor Heyerdahl has proposed an alternative hypothesis, which presents the American Indians as the ancestral Polynesians. Heyerdahl envisages at least two points of dispersion: one from the northern continent's Northwest Coast, the other from Peru. His hypothesis, however, rests on similarities that are either equivocal or accountable on other grounds, and the weight of modern scholarship remains very heavily in favor of an Asiatic origin for the Polynesians and their culture.

Some of the evidence strongly supporting this view may be summarized in the following manner. The Polynesian language is linked by old roots with the Austronesian group of languages of Southeastern Asia and,

In 1956, DR. SHAPIRO led an AMERICAN MUSEUM group that excavated in the Marquesas. Here, he relates this work to the general question of Polynesian origin and migration.



MARQUESANS of today lead peaceful lives, with copra as their major cash

crop. Coconut meat is stored in open, thatched sheds like this one, above.



YOUNG ISLANDERS, above, exhibit a variety of racial strains. Breadfruit,

laboriously pounded into thick paste, below, provides Marquesan staple, poi.



indeed, is one of the sub-divisions of a class known as Malayo-Polynesian. Polynesian culture—down to the detailed everyday processes of living and the homely tools employed—has its counterparts to the west, going back to the Asiatic mainland. The same origins are suggested by the decorative motifs and the rich oral tradition of the Polynesians. But from all this, it seems clear that the “set” of migration was from the Asiatic side of the Pacific, the “first home” of the Polynesians and their precise migration route to the mid-Pacific still remain in dispute.

NO people have been discovered in Asia who are *now* either physically or culturally sufficiently like the Polynesians to be claimed as close kin. We may *never* find such a population: much could have happened to any parental group in the long centuries since the ancestors of the present Polynesians began their wanderings, and comparable changes may have befallen the Polynesians themselves. In either event, time would have blurred the relationship. Nonetheless, two areas in Asia have been established as the Polynesians’ most likely homeland. One of these areas is India, which a number of scholars have inferred—from the interpretation of traditions and linguistic expressions—to be the starting point of the long migration to the Pacific. Some years ago, Edward Handy drew some striking parallels between the religious ideas of the Polynesians and those of India. The other favored point is southeast Asia—an area which, in recent years, has had the strong advocacy of Heine-Geldern, as well as a number of others. The highly distinctive adze-forms characteristic of Polynesia find their closest parallels in this Asian region. Heine-Geldern also sees in the highly stylized abstract designs found in the Marquesas so close a parallel to art styles of Chinese origin that, in his opinion, they could only have come from some region in Asia where such Chinese influences had been encountered and absorbed.

But to achieve any solid reconstruction of Polynesian history, some kind of reliable chronology is essential. The whole argument of Polynesian origins hinges, to a considerable degree, on the date of the Polynesians’ arrival in their present homes or, to put it the other way round, the date

when they left their original home. This date determines whether the ancestors of the Polynesians were (or were *not*) in a position to receive the influences that hypothetically appear to identify their geographical and cultural origin. Without such dating, for example, it remains a moot question whether the ancestral Polynesians left the Asiatic mainland before or after the age of metals began there. The historic Polynesians, themselves, did not use metals in producing their artifacts or ornaments for a simple reason: none was available in either their coral atolls or their volcanic islands. At least, they, themselves, discovered no deposits, although it is claimed they had a native word for iron.

TECHNOLOGICALLY, the historic Polynesians possessed a neolithic culture, using polished stone or shell for their hoe and adze blades. But unlike most fully-developed neolithic people, they were apparently unfamiliar with pottery and loom weaving; at least, this was true when they were discovered by European voyagers. It has often been said that the Polynesians, by then, had "lost" the once-known art of making pottery because of the lack of suitable clay on their islands. But I have myself found abundant clay in one of the Marquesan valleys, and have brought back a sample to America. This clay is being turned over to a ceramics expert, in order to determine its suitability for pottery-making. It still remains pos-

sible, however, that the ancestors of the Marquesans—having already "lost" the ceramic art—would not have recognized the value of clay when they encountered it in their new home.

Let me explain further the reason we want hard dates for Polynesia. If the Polynesians had, in fact, never reached a technological stage beyond the neolithic (and therefore are *not* a people who, for reasons suggested, relapsed from a metal-using culture back into the neolithic), then they *must* have left the Asiatic mainland or its immediate outlying parts before the use of metal had become common. But this hypothesis would carry the departure of their ancestors much further back in time than some scholars are now willing to believe.

The traditional date for this journey is generally set at around A.D. 500—largely on the basis of comparative study of the remarkable, oral genealogies found throughout Polynesia. Because these family lineages played a decisive role in establishing social status—as well as various rights, including those of property—they were carefully committed to memory by successive generations. For this reason, scholars have given them more weight than such oral tradition is usually awarded.

But, by A.D. 500, both bronze and iron were well known on the Asiatic mainland and on the principal nearby islands. This, and other discrepancies, have made it seem more probable to other scholars that the date of the Polynesians' ancestral depart-

ure will prove to be substantially earlier than A.D. 500.

In view of these considerations, it is not surprising that students of Polynesia have long felt the need for more precise chronological evidence than the study of tradition, myth and linguistics can supply.

THE MOST promising way of getting reliable dates for Polynesian prehistory lies in radiocarbon dating. Recently, a small series of such C_{14} dates have been determined for the Hawaiian Islands, New Zealand, Easter Island, Rapa and the Marquesas. The oldest thus far come from Hawaii, New Zealand and Easter (about A.D. 1000 for the first two and A.D. 850 for Easter). Since these islands are generally considered peripheral—settled after the more central ones were inhabited—still earlier dates may be expected from such islands as Tahiti, Samoa and Tonga. These sites, moreover, may not be the earliest in their respective islands. Until more are available, these dates can only be tentative.

In the islands to the west of Polynesia, for example, much more ancient C_{14} dates have already been established. In Fiji, one site has been placed at the beginning of the Christian era. In New Caledonia, human occupation goes back at least to 850 B.C. and in the Marianas, still farther to the west, even to about 1500 B.C.

Thus, archeological excavations—by recovering the actual relics of the past and by providing materials for



PRESENT-DAY CANOES in Polynesia, although built from planks rather than hollowed logs, still show variations

in means of attaching outrigger float. This striped one has "indirect" system: uprights between float and booms.



FLOOR OF CAVE SITE, on west side of Nukuhiva, was laid out in squares, excavated level by level. Quantities of

charcoal, for C_{14} analysis, were recovered from hearths. Mass of fine, organic dust forced diggers to wear masks.

dating—offer the best hope of reconstructing the prehistory of the Polynesians. Yet archeology has come only lately to Polynesia. Less than a generation ago, there was scarcely an example of a real “dig” anywhere in this vast region. Some few instances of fortuitous excavation were known, and a number of caves had been explored but not systematically excavated. Since then, active work has been started in New Zealand and Hawaii, with considerable success, but many other important archipelagoes are still untouched. Surface structures, such as those in the Marquesas, had been described and measured but the abundant record of man’s occupation, buried in the ground, had remained undisturbed.

IT was in the hope of making some archeological contribution to a better knowledge of Polynesian prehistory that The American Museum of Natural History undertook an expedition to the Marquesas in the summer of 1956. I have already given a brief account (NATURAL HISTORY, April, 1958) of what is known, historically, about the isolated Polynesian population that inhabited—and, in some remnants, still inhabits—that remote archipelago. Until that summer, however, no one, to my knowledge, had attempted any investigation of Marquesan prehistory.

At that time, Cornelius Crane, a part-time resident of Tahiti, a sailor who loves the Pacific and has a profound interest in its history, arranged to charter a splendid two-masted schooner—“Te Vega”—the use of which provided the Museum party with a freedom of movement otherwise impossible to achieve. Since our expedition was limited in time, my assistant, Robert Suggs, departed for the islands ahead of our main party, to make a preliminary reconnaissance and thus save all our expeditionary time for the actual work of excavation. He had five or six weeks to track down whatever leads he could discover from the natives familiar with every corner of their islands. When the “Te Vega” arrived at Hiva Oa, the principal island of the southern Marquesas, Bob was waiting for us with enough information to determine our work for the next five weeks. After a quick look at some of the outstanding structures on Hiva Oa and a short visit to the neighboring and now uninhabited Eiao, we

proceeded for Bay Marquiesienne—a depopulated area that lies on the west side of Nukuhiva.

HERE, one cave, near the beach and easily accessible, yielded evidence of occupation. Two others, just as promising, lay farther up the valley, opening onto the margin of a mountain stream. The setting of this deserted valley is idyllic. The richly-clothed valley sides slope sharply down to a clean, cool stream that flattens and widens out as it approaches the pebbly beach. The bay, itself, is flanked by headlands that jut out into the illimitable Pacific—now hazy in the distance, now sparkling with light and touched here and there by white sea foam from tossing waves. Nothing could have seemed more peaceful and we settled in for a delightful week or so.

Our first morning of work began shortly after daybreak and these first cool hours seemed to bear out our expectations fully. We had not reckoned, however, with the *nono* fly—a minute, insidious bane that renders life almost unbearable. As soon as the warmth of the day had wakened the *nono*’s to activity, their energy was incessant. Clouds of them hung about our faces, lodged under our collar bands, crawled up under tightly bound wrists and ankles to reach the tender skin. Relative to their size, the distances they crawled must have equaled miles, but nothing stopped them. They even explored our mouths, whenever opened, and we found them in our noses and around our eyes. Their mere presence would have been trouble enough—and so it was to some few lucky ones. But to the rest of us, not endowed with some natural immunity, their little bites, not felt when made, brought an excruciating delayed reaction. By the time we had returned to the ship, sighing with relief for a respite, we found ourselves covered with a rash of red pinpoints, each a deposit of agony and a focus of itching that called for violent scratching.

Our caves, however, proved rich in artifacts and even the *nono*’s and the fine, organic dust—accumulated during ages of decay and dryness—could not discourage our eagerness. We wound cloths round our necks, covered our faces with gauze masks and continued our excavations.

The deposits were three feet at their deepest, largely of organic dust.

The people who had lived here were mainly maritime in their culture. We found a rich assortment of fishhooks—most cut out of pearl shell, but some of bone. The hooks varied in size and in shape, no doubt for catching different sorts of fish. Crustacea of diverse kinds were also abundant, as well as fish skeletons, and the hollow, delicate bones of birds: all serving to indicate the variety of these prehistoric Marquesans’ diet. A few stone tools, of the usual forms, were discovered but they were not as abundant as the fishhooks. Luckily, the hearths contained quantities of charcoal which was carefully collected for future radiocarbon analysis, to give us C_{14} dates for our site. Although it was unlikely that we would have hit, on our first try, one of the earliest occupied sites in the Marquesas, the dating will nonetheless provide something specific in an area where no precontact dates are now known with any degree of certainty.

OUR next job took us farther along the west coast of Nukuhiva, to a bay called Hatuatua. Here, Bob had discovered a site made to order—a sand dune, twenty to thirty feet high, that fringed the concave beach line. From the distance, as we first approached, this dune looked like countless others. On the sea side, however, the tidal wave of 1946 had sliced the dune down its entire length—as if with a gigantic knife—exposing a wall studded with bleached bones—human, fish and bird—shells and various other indications of



AUTHOR TAKES TURN screening excavated debris from one of cave squares.

man's former presence on this coast.

We planned our campaign mainly to test the extent of this site, to sample its content and to gather more charcoal or carbon material for dating purposes. Hatuatua is a small and relatively dry valley, compared to such large rainy valleys as Taiohae or Taipivae, and only two or three families are now resident there. Our survey showed the extent of the prehistoric community to be rather greater than the area's present occupancy would suggest. But the ancient community had obviously been a maritime one—dependent on the sea's bounty rather than the land—and this may well account for its size.

OUR test digging, incomplete as it was, led us to conclude that virtually the entire dune had been occupied, a stretch of a quarter- to a half-mile. One end of the dune was covered by dwelling sites. The other end may also have been used for the same purpose but, in our limited time, we could not explore it thoroughly. In any event, much of this part had been carried away by the same tidal wave that had so conveniently exposed the dune as an archeological storehouse.

The middle of the dune, we discovered, had been put to a macabre use. Here, we found charred and split human bones in considerable disarray—evidence that the victims of cannibalism had been roasted and their fragments tossed to one side. Cannibalism, as already noted, was

practiced in the Marquesas at the time of contact, but it has never been clear whether the ancient practice was sporadic or common. The abundance of the fragmented and charred bones we found speaks for an ancient habitual resort to the eating of human flesh. That these feasts were held in a specific place and, moreover, as we shall see, associated with ceremonial burials, suggests that the custom may have had ritualistic, as well as gustatory, significance.

For, in this same area, we discovered a number of burials. Some were what are known as secondary interments—bundles of long bones, the lashings of which had long since rotted away, but still neatly held together by the pressure of the sand in which they were placed. This secondary burial implies an exposure of the body to the elements before the bones are clean and ready for final disposal. Such practices are well known in Polynesia, as well as in other parts of the world.

Besides these, we also found articulated skeletons, which had obviously been buried without any preliminary exposure. And one of these was the skeleton of a mature woman who must have been of some distinction. She had been placed to rest upon the huge scapula of a whale. This bone platform, in turn, was supported by a circle of six skulls, surrounding a mass of bones. The honored lady was decorated with shell ornaments and a bone ear plug. As

AT DUNE SITE, sliced open by tidal wave, many bones—including cranium,

below—had been exposed. Local inhabitants, right, watch diggers at work.



possible further evidence that this central area of the dune was hallowed ground, we found a small monolith still standing. In view of our skeletal finds, this could well have been the sort of stone that Polynesians frequently set up in their *marae's*—the sacred places where rites and ceremonies were observed.

One curiosity is that, based on field identifications not yet checked in the laboratory, all the skulls we found were female only. Although some of the long bones were obviously male, no male skulls were found. If our first observations are borne out by closer study, this will demand explanation. I have noticed that most, if not all, of the skulls found in Marquesan tree burials



still another form of disposing of the dead) are male. Perhaps these observations will prove to link in a pattern of some kind.

Of particular interest was the discovery of both dog and pig skeletons. The dog is supposed not to have reached the Marquesas until historic times. And the finding of the pig under datable circumstances may furnish us with information on the time of distribution of this widely-spread oceanic animal.

The dwelling sites, in turn, provided us a rich array of cultural debris, generally similar to what we had already obtained from the caves. Obviously, the living conditions were the same for both beach and cave communities. Whether they were con-

temporary will not be known until our charcoal samples have been processed. And, of course, much other analytical work will need to be done before all the archeological evidence accumulated in our summer's work can be properly evaluated and its meaning for Marquesan, and Polynesian, prehistory be inferred.

WE had not been long at the Hatuatua dune when we discovered a series of pictographs carved into the bedrock at the washed-away end of the dune. Some of these were representations of animal forms we could not identify with certainty; others were what we took to be whales. We would not have been especially excited by these picto-

graphs—such are found all through the islands and are virtually impossible to date—except for one circumstance. As we traced out some of the designs, we discovered that they disappeared under an indurated concrete-like layer three or four inches thick. Breaking up this overlay, we found a continuation of the designs. Obviously, the pictographs were cut before the concreted layer was deposited and, therefore, had to be older than the overlay's formation. Under some conditions, the process of concretion may be fairly rapid. But, even if the age of this example proves not very great, we will at least be in possession of a time estimate of some sort—something that is sadly lacking for most pictographs.



GREAT STONE, eight feet in height and width, *above*, is part of ancient

wall. Terrace of neatly-dressed stone, *below*, shows Marquesan masons' skill.



SQUARE CUTOUT in stone, *below*, at edge of an abandoned house platform, allowed insertion of a wooden upright to support roof. Masons worked stone with stone tools only.



MATCHING QUOINS cut in these corner blocks of another platform are a further evidence of early Marquesans' skill in working stone. Machete is to indicate size of blocks.



AFTER five weeks of concentrate digging, we had for our labor thirteen crates of artifacts and relics in bone, shell and stone. To the uninitiated eye, all this would look like the sorriest collection of refuse imaginable. To us, these crates represent a treasure trove of information. We will be busy for a long time still—identifying, sorting, comparing and interpreting our finds. Moreover, our summer's haul in 1956 was rich enough to warrant our continuation of the work. Bob Sugg is back in the Marquesas now, following up that summer's leads and exploring still further the past of these remote and fascinating islands. Whether this, and similar work elsewhere in the Pacific, is finally analyzed, we should be much closer to the still missing answers regarding the ancestral origins of the Polynesians.



BLOWERING TIKI, half hidden by jungle growth, is one of a few still remaining out of thousands that formerly

embellished the *marae's*—or sacred places—of ancient Marquesans. Figures range from miniatures to life-size.

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Reviews (continued from page 229)

However, the reviewer is annoyed by the author's unquestioning presentation of Zwicky's early deduction that there are hardly more than two supernovae per millennium in the average galaxy. These explosive stars are very important in considerations of stellar evolution for, in exploding and suddenly attaining a brightness equaling a million ordinary stars, they scatter into space dust and gas from which new stars may form. They are not nearly so rare as Zwicky suggested. In the interval from A.D. 1054 to A.D. 1604, three were recorded in our own galaxy, and the record must be very incomplete. Cosmic smog may hide many such outbursts, and the sky watches, especially in the rich southern skies, are very sketchy. In each of at least three external galaxies, we have already found in our records (of a few brief decades) two or more of these great explosions. A better estimate of their frequency would be that of at least one supernova every twenty-five years, on the average. The evidence for this revised and important estimate is published in standard journals, but nevertheless the old surmise keeps cropping up.

De Vaucouleurs presents the modern theories of stellar evolution in a cautious but sufficiently detailed manner, and the same is true for modern cosmology, photometry and stellar spectroscopy. It is a good book. And although the field is now occupied by several recent histories of astronomy, the work under review should find a welcome—largely because it is up-to-date and has the enthusiasm characteristic of an author who is, himself, making some of the history.

Reviewed by
DR. HARLOW SHAPLEY,
HARVARD UNIVERSITY.

EXOTICA—Pictorial Cyclopaedia of Indoor Plants. by Alfred Byrd Graf. Roehrs, Rutherford, N. J., \$17.50; 644 pp., illus.

IN America today, the "window gardeners"—a label applied to people who grow plants anywhere indoors, from attic to basement—are legion. Windows with good light-exposure are the easy and obvious places to select but, with artificial light, it is both possible and practical to carry on gardening successfully in places with no sunlight at all. Magazines for the specialist, with national circulation, indicate substantial indoor cultivation of African violets, begonias, cacti and succulents—and some of this culture is on a commercial basis. Surrounding this hard core of experienced and realistic indoor gardeners is a broad fringe of willing beginners—one-potters or two-potters—who have made a "go" of it with philodendron, an ivy or

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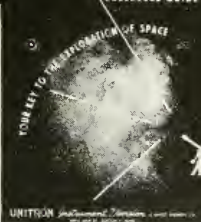
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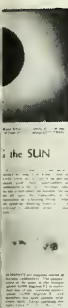
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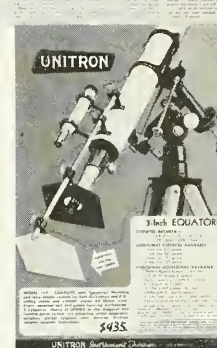
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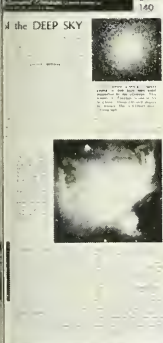
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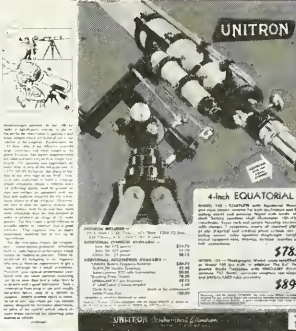
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some other common house plant, and are ready to broaden their activity. For this group, Alfred Graf's *Exotica* will open up a fascinating vista.

Graf's subject matter conforms closely to his title: this is to say that the plants he describes and illustrates are introductions from foreign lands, a great many of them not hardy if grown outdoors in a temperate climate. In brief, they are window-garden and greenhouse plants in the United States.

It has been this reviewer's good fortune not only to have seen many of these exotic plants in their native environment, but to have collected living plant material on several expeditions, and to have grown, under glass, extensive series of cacti, succulents, begonias, foliage plants and orchids. In light of this experience, I believe that Graf's book should be invaluable not only in identifying the plants a grower already has but in pointing his way toward future accessions. The popular interest in indoor plants has brought with it a very considerable commercial trade. Nowadays, many retail stores (including those once labeled "Five-and-Ten's") have plant counters that offer a wide field of exploration to the window gardener. Many unusual and intriguing house plants may be discovered on a tour of these outlets. And, after the grower has, as it were, wet his feet in these shallows of the pool of plant wealth, he is likely to strike out for the depths—the large nurseries that specialize in house plants. *Exotica* will be a much-used Baedeker on the trips to the retail stores: it will assume the stature of a passport to the nurseries.

Graf, himself a commercial nurseryman, has sought and found co-operation from recognized authorities in many botanical fields. His own experience, traveling round the world in search of plants, and his knowledge of the conditions under which such plants grow,

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stands unique. The major portion of his work (over 400 pages) is devoted to a well-organized series of encyclopedic illustrations, headed by a "Finding List to Families and Groups" and an illustrated key to these categories. From page 51 through page 497 there appears a solid rank of photographs—each figure with its proper botanical name—an array the like of which is to be found in no other single publication. If a group justifies illustration other than with half-tone, line or even color may be introduced (as with the striking Bromeliads). To cite a few examples of the coverage in this the greater part of *Exotica*, the philodendron is a common house plant but there are 225 separate photographs of the great variety of plants within this genus; 61 figures are given to the ivies; 29 pages to begonias.

Exotica is subtitled "A Pictorial Cyclopaedia of Indoor Plants," but it covers more than pictorial presentation alone. There are sections on plants in the home, decorating with plants and plant arrangements, methods of propagation and insect enemies. A long list of the common names of house plants is not only helpful but whimsical and revealing: some common names are obviously descriptive and fitting; others have no easily-associated feature and it is convenient to have such a list for reference. An index to genera lists the most prominent or well-known species and these are figured. A key to the care of indoor plants discusses temperature, location, light, humidity and soil. There are discussions of plant geography and regional floras. In all, this is a substantial, well-built volume, with lavish illustration, that should become one of the most useful and admired references in a plant lover's library.

Reviewed by:

DR. HAROLD E. ANTHONY,
THE AMERICAN MUSEUM.

This list details the photographer, artist, or other source of illustrations, by page.

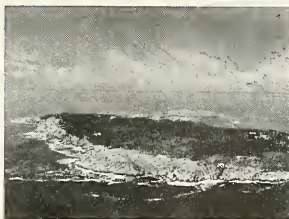
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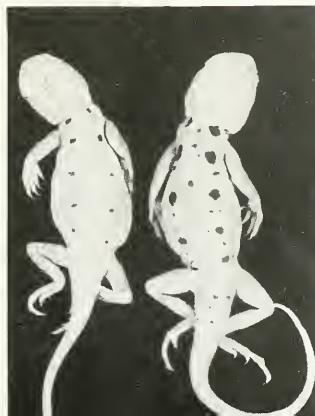
exclude sand. *Below* are two museum specimens: holotype male, *right*, and the allotype female, with smaller spots.

AUSTRALIAN ENIGMA: WHITE DRAGON LIZARD

By F. J. MITCHELL and H. A. LINDSAY

THE LARGEST of a series of huge, salt-laden depressions in the arid central region of South Australia, Lake Eyre—with an area of about 4,000 square miles and an estimated watershed of 450,000 square miles—is the focal point of the Great Australian Inland drainage system. The so-called “lake” is surrounded by desert country that receives an average annual rainfall of less than five inches.

In past pluvial periods, Lake Eyre really was a lake—fed by large river systems flowing south out of Queensland and the Northern Territory, as well as from the east and north within



South Australia. But the gradual desiccation of the Australian inland in post-Tertiary times has dried up these rivers. In the modern period, occasional floodwater, coming down these former river beds, has nearly always evaporated or been lost by seepage before reaching the lake. Huge sand ridges have built up across the lake mouths of most of these former rivers and, until 1950, it was considered doubtful whether water would ever again reach the basin.

The scientific study of Lake Eyre really began in 1929, when the late C. T. Madigan, of the University of



SCIENTISTS TRUDGE across the sand and salt toward horizon of Lake Eyre basin.

Australian Museum, found that the new lake was contracting rapidly under a fierce sun: the evaporation was at the rate of eighty inches per year, and the remaining water was too saline to support life. Salt crusts were re-forming on the mud deltas left by the receding water: the little black ants and their lizard predators had already begun to repopulate the drying surface of the rapidly shrinking lake.

The ability of the Eyre lizard to readjust itself to changing living conditions may be judged by comparing the coloring of specimens formerly taken well out on the lake by Madigan with those collected along the shoreline by the recent expeditions. Shoreline specimens had changed from their usual pale gray to a speckled pattern, in keeping—one might say—with the mottled sand bordering the lake.

Most soft-bodied lizards possess an ability to vary body coloring to some extent. It is interesting to note the efficiency with which fundamentally similar mechanisms have developed in unrelated groups of lizards—like the chameleons, or the anoles from the iguanid family—for this seeming purpose of bringing their color tone into sympathy with their surroundings.

Actually, color-change mechanisms can vary considerably, but in this case it appears to be a simple migration of pigment cells toward or away from the surface of the skin: this movement depending *not* on the color of the surroundings, but on the stimulus of light and heat as they are reflected by these surroundings. The epidermis of the Eyre lizard contains a number of darker pigment cells, but the majority of these cells are normally depressed out of sight by the high temperatures and intense glare characteristic of the lake's barren salt wastes. When forced ashore by the floodwaters, the Eyre lizard had some vegetation for cover on the gray shore sands and mudflats. The lower intensity of the reflected light in this altered environment allowed some of these darker cells to migrate nearer to the surface of the skin, thus bringing the over-all color tone nearer to that of *Tympanocryptis*' altered surroundings.

WHEN *T. maculosa* was first discovered, it was thought to be a variation of another species of the genus *Tympanocryptis*—*T. lineata*—although *maculosa*'s very pale coloring and smooth scalation were duly noted. Subsequently, however, a series of six

pores on either side of the thigh were noticed. It was these femoral pores which, in the senior author's opinion, gave *maculosa* the right to be classed as a separate species, since the average number of such pores on a given individual may, in general, be taken as a reliable guide for the identification of lizards in the family Agamidae.

MUCH REMAINS to be learned about the origin and true relationships of Australia's Dragon Lizards (Agamidae), however. Their generic or group classification is founded on variable external characters which are usually difficult to define and often show strong convergent tendencies from one species group to the next. Thus some species may possess some of the characters of one genus and some of another, making them difficult to classify with certainty. Before the generic classification can be stabilized, the internal anatomy—and the bone structure in particular—will have to be carefully examined for more clear-cut and stable differences—differences less subjected to the selective forces which are continually bringing about changes in the form of these lizards' outer integument.

Such is the problem which we face in trying to decide the origin and true relationships of *maculosa*. The genus *Tympanocryptis*, with which *maculosa* is now associated, is supposedly separable from all allied genera by the concealment of the tympanic membrane and the presence of only two or, alternately, four preanal pores. As already mentioned, *maculosa* has no preanal pores, but possesses a series of femoral pores! Furthermore, recent work on an allied genus, *Amphibolurus*—by the senior author—resulted in the discovery of an apparently undescribed species in which the juveniles have the naked eardrum covered by a thin translucent layer of skin which develops easily discernible scales as the lizard grows larger. Thus we have an intermediary stage in the development of the only other character which defines *Tympanocryptis*. It may be that *maculosa* will ultimately prove to have been derived from *Amphibolurus* stock and to have developed its hidden ear independently. But—whatever its derivation—*maculosa* is a remarkable instance of an animal equipped with very precise specializations, adapting it to life under the most extreme conditions, yet flexible enough to adapt to sudden alterations in environment.



LIZARD FORAGES beside an anthill, *above*, for formicine ants that comprise most of its diet in this barren region.

Changed coloring of normally pale lizard is shown below: after rains, light gray has given way to a mottled pattern.





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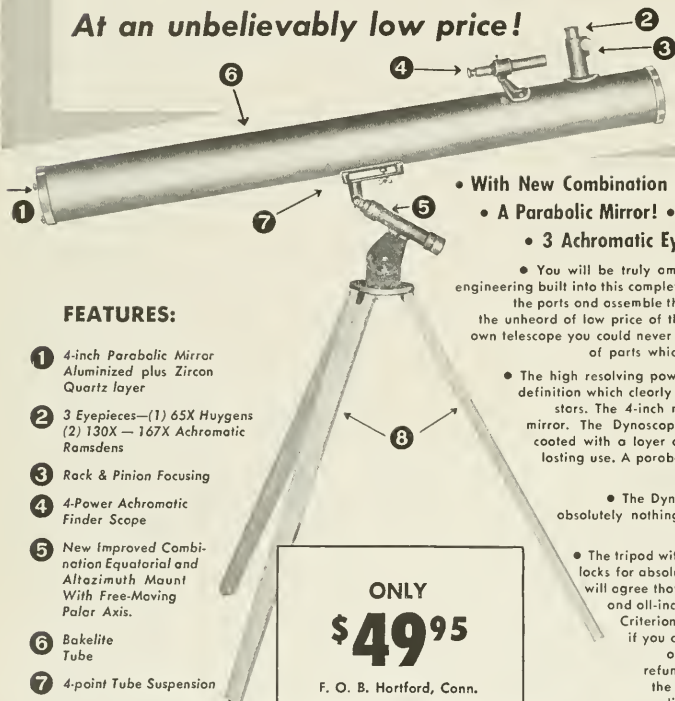
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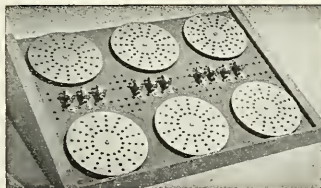
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THE TWO HUNTERS, above, standing in still wary triumph over their quarry, are practitioners of a dying craft that is as old as man's own history. The game they can kill—together with the berries, roots and nuts that they and their wives can gather—provides their only form of sustenance in the barren desert of the Kalahari Basin. Thus, these hunters are not to be confused with today's sport-men, nor should those who view the modern hunter as a sort of ogre extend their condemnation to include the Bushmen, here, or the dwindling numbers of other hunting peoples who still survive.

The unique story of the Bushmen—gathered in a series of expeditions to the Kalahari by Harvard's Peabody Museum—will appear in serial form in NATURAL HISTORY. Part I begins on page 291.

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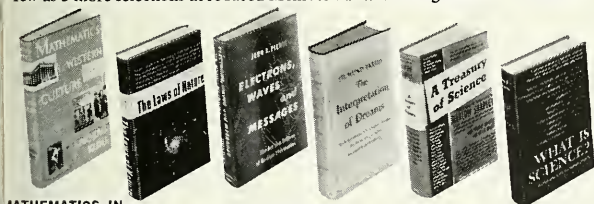
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Reviews

A SELECTION OF SUMMER READING FOR YOUNG PEOPLE

THE SEASON of summer vacation is upon the young people, and, with it, comes the prospect of long, leisure hours. As is the custom of *NATURAL HISTORY*, Senior, at this time, we turn to *JUNIOR NATURAL HISTORY* for summer-reading suggestions for children. Herewith, then, *JUNIOR*'s list of books in the field of science that are deserving of chronicle on their own account and that may also, happily, lead the young ones away from the television corner into the light of day.

GENERAL

With so much activity at the top and bottom of our globe we found *The Arctic Tundra*, by Della Goetz (Morrow), of particular interest. It tells of weather conditions, plant and animal life; of Eskimo, Lapp and other ethnic groups living there. \$2.50, 64 pp., well illustrated; ages 9-14.

For those interested in discoveries closer to home, *Science in Your Own Backyard*, by Elizabeth K. Cooper (Harcourt, Brace), is the answer. Many simple yet fascinating experiments are suggested for easy doing. \$3.00, 192 pp., indexed, line drawings; ages 8-14.

The First Days of the World, by Gerald Ames and Rose Wyler (Harper), is among the few children's books that try to convey solid scientific information—and succeed in the attempt. It describes the origin of the earth from elemental gases, the development of the first living cells in the earth's original atmosphere, and the evolution of higher organisms, animals and plants. \$2.95, 48 pp., excellently illustrated; ages 9-12.

A companion book, *The First People of the World*, by the same authors and publishers, maintains the same level of interest. It recounts the descent of man and his cultural change from hunter to farmer, along with his increasing mastery of tool-making. It has the identical price, illustrator and number of pages as the previous book.

ZOOLOGY: PAST AND PRESENT

Coming from the past to the present, we meet some animals living today in *All About Strange Beasts Of The Present*,



EARLY HUNTERS, far left, spear game at water hole: Weisgard drawing from Ames and Wyler's *First People in the World*.

CRAYFISH AND CLAMS, above, are bottom residents: illustration by Lubell, from Millicent Selsam's *See Through the Lake*.

Islandin Time

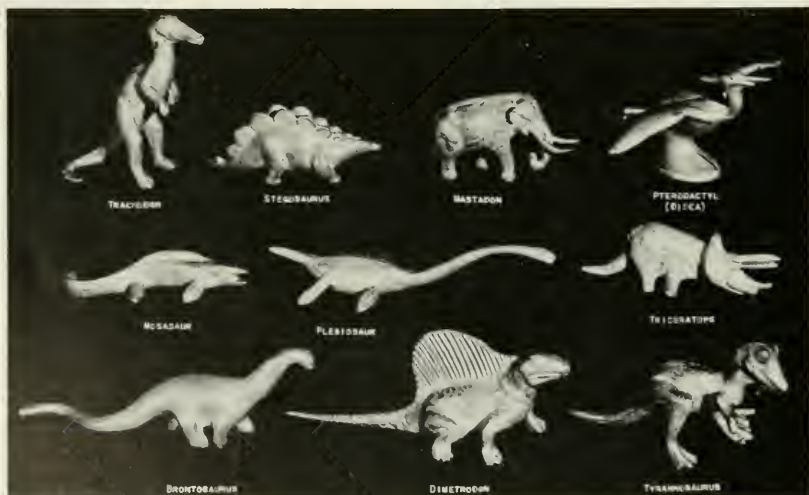
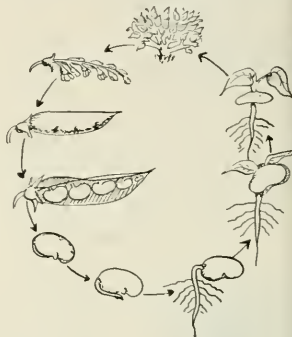
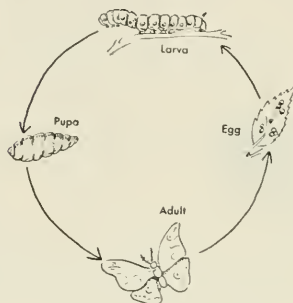


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PECK ORDER OF FOWL, shown in sequence fashion above, is another illustration by William Berry, from Vinson Brown's volume, *How to Understand Animal Talk*.

PAIR OF SKETCHES, below, show cycle of insect, from egg to adult, left, and a bean's growth, from seed to pod, right. From *Science in Your Own Back Yard*.



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an adventure into the various levels of a lake and tells of its very special community of living things. \$2.50. pp. unnumbered, many illustrations, ages 8–11.

Ponds are interesting also when we read *Pets From The Pond*, by Margaret Waring Buck (ABINGDON). Information on how to house and care for such creatures as turtles, salamanders, water insects, snails and frogs found in a pond are clearly given, as is information on their life cycles. \$3.00, 71 pp., indexed, ages 8 and up.

BIRDS

Rare is the word for a whooping crane, so it was with real interest that we read *Old Bill, The Whooping Crane*, by Joseph Wharton Lippincott (J. B. LIPPINCOTT). Here is an authentic and complete little book on these wonderful birds. \$3.00, 176 pp., line drawings and photographs; ages 12 and up.

Ostriches, by Herbert S. Zim (MORROW), will answer many questions provoked by visits to a zoo that contains ostriches. \$2.50, 64 pp., illustrated with many line drawings; ages 8–12.

BOTANY

How Does A Garden Grow, by Ann Towson Brown (DUTTON), is a guide to successful gardening for the beginner. The book begins with a planned garden on paper, goes from indoor planting to outdoors and the care needed. Graphic, step-by-step photographs accompany the text and make an excellent book; one to be added to every young reader's bookshelf. \$2.50, 48 pp., ages 10–14.

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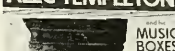
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MAN AS A HUNTER

By JOHN MARSHALL



Hunting is mankind's oldest—and least rewarding—way of life. Among its last practitioners are the Kalahari Bushmen

PART I

A PEOPLE, small of stature, few in numbers, calling themselves “!Kung,” but who are called “Bushmen” by others, live today in a tremendous depression, half-a-continent wide and sunken in the southern African plateau—by name, the Kalahari Desert Basin. They live on the huge floor of this Basin, near one of its imperceptible sides. It is an open land—large to the point of vagueness, under a limitless sky. There is a word used frequently by the other inhabitants of this Basin—mostly black-skinned peoples—to define the different cultural groups now living there. The word is “nation.” One speaks of the Herero nation, the Chuana nations, the Okavango nations. To follow this usage, one would speak of the !Kung nation of *Nyae Nyae*—one among several Bushmen nations. [The prefix, (!), indicates one of the so-

called “clicks” that mark the speech of the Bushmen. Distinction is made between four classes of “click”: the dental (/), lateral (/ /), palatal (≠), and alveolar (!)—Ed.]

But “nation” is a new word, recently arisen in the vocabulary of a country whose people are struggling to define themselves in present times. The !Kung, who know who they are, do not yet need it. For, besides !Kung, which they use rarely, they call themselves *Dzu/oassi*. *Dzu/oassi* can be interpreted as “the people” in opposition to “the animals,” for example, or as “the perfect people,” or, indeed, as “the only people.”

Unlike other nations, the Bushmen practice no agriculture, domesticate no animals. They are hunting and gathering peoples. But all the nations—Bushmen, Bantu and white alike—who live in the Kalahari Basin must



!KUNG BAND'S CAMP, left, is set up in shelter of overhanging trees. The thousand !Kung in this area are divided into twenty-eight such nomadic bands.

WORLDLY GOODS of a !Kung family are arrayed, above, preparatory to moving camp. The number of belongings cannot exceed family's carrying capacity.



TREES AND SHRUBS of campsite provide convenient racks for family possessions, and even partial support for the

sketchy *skerms* (screens) built in the dry winter, *above*, little more than bunches of grass caught on a few sticks.



COLLECTION OF FOOD, in contrast to hunting, is women's work among the !Kung. Almost every day, they leave camp

to gather *veldkos* (roots, berries, nuts and the smallest animals) in the wild bush. The basic tool is the digging

face its exigencies, for this sand-filled depression is distantly rimmed by mountains, and the mountains catch most of the clouds that might otherwise bring rain. The rain that does fall is sucked into the sand, so that there is little surface water and much of the Kalahari Basin is true desert.

ALTHOUGH true desert, the Kalahari is not a bare place: the face of the sand is hidden. Much of the desert is clothed with stalwart, similar bushes, most of them thorned. In places, dry forests grow slowly: the trees stand apart and the air between them is strangely still on days of wind. Grass covers the sand: in sweeps on the dry plains, in glens in the bush; grass grows on dunes gathered long ago by patient wind, and in the silent valleys, called *omuramba's*. In a younger, greener time that has come and gone since man first lived in southern

Africa, these valleys once flowed—draining water from the high edges into the Basin. Now the sand has wandered into these valleys also.

There are four seasons in the Kalahari, two are brief. Winter begins in May and lasts through September. It is a healthful season. Of the foods available to gatherers in winter, roots are the most abundant. The earth is dry: the days are warm and clear, but cold in the shade; the nights are chill. Temperatures sink to 20° F. and below when the night wind turns, blowing from the antarctic south. On some hazeless nights, when the empty air seems insufficient protection from the cold of space, the morning ground will be wet with heavy dew. However, the smoke from a thousand African veld fires often thickens the skies of noon, reddens the setting sun and keeps the nights warmer and the earth dry.

At the end of September, clouds be-



FOR RAINY SEASON, the open-fronted grass shelters are more substantial.



stick, fashioned by the man of the family from a tree-branch. Children soon learn, by watching, to identify more

than a hundred edible wild plants. *Above*, four women, one with a young child, set off across the veld for food.



!KUNG MOTHER, collecting near camp, cradles a suckling daughter in a fold

of her skin *kaross*, while her toddler son carries along a stick of his own.



MOST roots are dug up for food, but the ones held out, *above*, are valued

gin to tower in the afternoons. They wear over the desert from the east and are usually gone by morning. But should they encounter the right conditions, the local rains that fall from these clouds—the “little rains”—bring the spring of the year. This is the sudden season of thunderstorms. The storms are like gods walking in the desert, each attending to a narrow path with violence and rain. In the quiet, after their passing, many plants bloom—small flowers and edible greens.

SPRING is also the season of heat. Myriads of flies, the year's crop, now hatch. The heat increases toward



for their bark. When it is powdered and rubbed on, it turns the skin red.

LITTLE ESCAPES the women's eyes in their intense search for food, *below*.

Even small animals—like turtles and grasshoppers—are carefully gathered.

summer and, although clouds continue to form early in the afternoon, often no rain falls. November and December pass in heat and privation for the people. Temperatures rise above 100° F. not long after the brief dawn, as the sun mounts, close and huge, bringing the heat of day. Many of the blooms of the "little rains" wither in November, as do many young greens. The roots have sent their substance into vines; now the loose skins of the roots lie collapsed around inedible fiber. Spring means blooming of plants, but spring is ardent and quickly over: many of the desert's flowers have only a few days in which to flourish.





HUNTER'S LIFE is not all hunger and privation. *Above*, a young !Kung belle amuses herself with stringed instrument.



BUT AGE COMES SOON: bracelets, beads and pendants that adorn this mature !Kung matron contrast with seamed face.



DESPITE DESERT RIGORS, the children's lives are relaxed ones, largely lacking in formal instruction and without



organized pressure on the young to assume an adult role. Here, a gathering of children from one !Kung camp enjoy

themselves in the shade of a tree—one swinging, others scampering, “follow-the-leader” fashion, in the branches.



LATE in December or early in January the rains of summer—the “big rains”—begin. This is the season of water. Water collects in the hollows of the land; it seeps into the pans, changing them into shallow lakes; it melts the baked clay in the *omuramba* bottoms, and turns the Kalahari green.

This is the season when two nuts, the *tsi* and the *mangetti*—the most important and abundant of the wild desert foods—begin to mature. By March, the *mangetti* forests sound with the falling nuts. Beside the summer storms—when water piles up uselessly on the reverberating earth—days on end are cloudy and, sometimes, a fine mist falls over parts of the northern Kalahari through the day and into the night. Now, the people eat many fruits. In the deeps of green thickets, ponderous flowers droop on slender vines. Spring and summer, the times of bounty, are also the seasons of disease.

By the end of April, the afternoon skies begin to clear, the air dries, the wind seeks. It is autumn. In April, the *tsi* nuts ripen and the pods split, turning out their brown wealth. The many desert roots cease their activity and become firm and full, safe in



WATER IS KEY to life in the Kalahari: in all the !Kung territory, there are

only ten permanent waterholes. Above, a man fills his ostrich-egg “bottle.”



THE SUMMER RAINS, from January to April, bring water to the desert pans

for a time and allow the !Kung luxury, left. For the rest of the year, above,

they fill their eggshells from permanent waterholes, dig for water roots.



FEWNESS OF NUMBERS in desert's vast expanse may help account for character-

istic !Kung habit of huddling together in company, as in case of this group

of children, above. Items of personal adornment—eggshell disks, often in



HUDDLING HABIT is noticeable again in this gathering of women and chil-

dren at a !Kung *werft*. Well-ornamented child, foreground, is still at breast.

themselves for the winter and in a state most suitable for food. The desert pales. Day and night, water evaporates from the pans; first becoming a film, then less than a film, with only the damp clay glistening. One noon, the clay begins to wrinkle in the sun. By June, the earth is dry: the land is fast and quietly held by winter.

Such would be a perfect round of seasons. In the periods of drought that have come every few years in the recent past, however, there have been no such perfect seasons and all living things have, of necessity, fastened tenaciously to the drying earth and held on. Even in normal years, the weather is unbalanced: large areas of the Kalahari may be flooded, while others receive a sprinkling of rain in what amounts to drought conditions. In this land, and through these seasons, the !Kung nation lives.

THE AREA in which the !Kung now live is called *Nyae Nyae*. How long they have lived there is not



strings with seed beads, and hoops of traded wire—show parental affection.

known. At one time, Bushmen lived throughout Africa from as far north as Angola and Tanganyika to, southward, the Cape of Good Hope. This was a time when few peoples shared that part of the continent. In southern Africa, beside the many Bushmen nations, there were Hottentots and pre-Bantu Negroes—some of whom were hunters and some of whom practiced agriculture. In the distances between the nations grew years of peace.

About five centuries ago, larger, stronger, Bantu-speaking peoples, who had cattle to pasture, entered southern Africa from the north. They came in two prongs, like the horns of a bull, prodding down the eastern and western highlands. In search of grazing land, these Bantus were themselves driven south by defeat in wars then current on the plains of East Africa. The established peoples of the south—the Bushmen, the Hottentots and pre-Bantus—were dislocated by this push and began to move, themselves. This flux has yet to come completely to rest.



YOUNG COUPLE stands, shyly smiling, at outskirts of *werft*. Marriage among

the 'Kung, as in the case here, often occurs before the girls reach puberty.



SKIN KAROSS, being stitched, *above*, is the !Kung's most important garment,

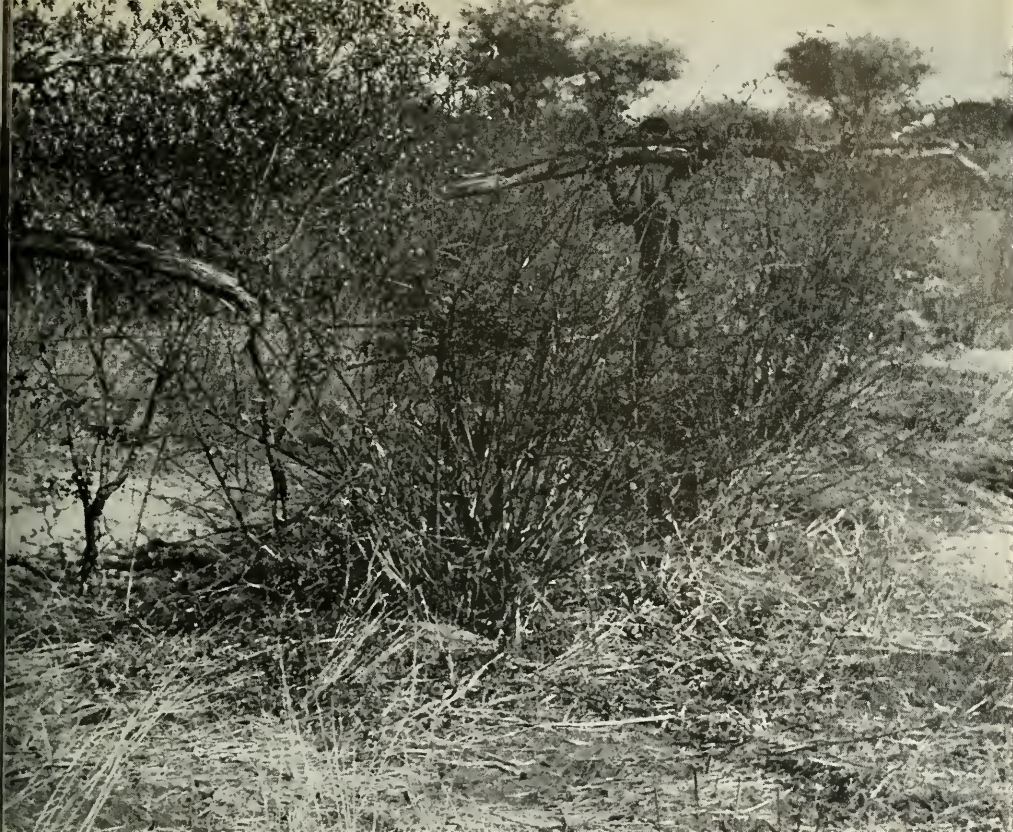
while nuts from the *tsi* and *mangetti* trees (in pot, *below*) are chief food.



FIREWOOD FOR CAMP is another prize to be sought from the veld. Here, two

In such disturbed times, the Bushmen fare ill. They are not, and probably were not ever, a warlike people. Their society is not constructed for war, their culture dampens war. Yet, now, wars and battles began to scatter across the land, as groups of people—large and small, Bantu armies, itinerant raiders, the remnants of tiny nations and the dispossessed—marched and wandered in their search of conquest or safe distant places.

Some Bushmen nations were driven into pockets in the hills, where they died slowly. Some stayed on their land and were decimated and made slaves. Some resisted and, as one who spoke of his people told me: "We were soldiers in those days." Their armies changed into marauder bands that sometimes fought and often ran. Of these, the Heikum were an example—an embittered, scattered nation of travelers on the then uncertain grasslands of South West Africa. When, at



fine logs are being carried back to the *werft* for fuel. Besides fires for

cooking, the !Kung need them at night for warmth, since temperatures after

sunset often fall well below freezing. Each family shelter has its own fire.

last, white and black met,—raiding one another for cattle across the Fish River—and the time of the Zulu and the Voortrekker was near, the classic period of the Bushmen was over.

THE AREA called *Nyae Nyae* lies on the border between South West Africa and Bechuanaland. It covers about 10,000 square miles, between 18°55' and 21°0' South latitude and 19°50' to 21°25' East longitude. In the center of this area is a ring of *kalk* pans. *Nyae Nyae* is actually the name the !Kung gave to this ring of pans, although I have applied it to the whole area occupied by the !Kung nation.

There is game round these pans and, in small groups, everywhere in *Nyae Nyae*. Wild roots grow in the bush that shrouds much of the territory. There is *tsi* in the south, while *mangetti* forests crowd along the crests of white sand dunes in the south and east, and spread over the north. Their

nuts drop abundantly to the ground every year. There are ten permanent waterholes—some clustered around the ring of the pans, the others set like infrequent jewels in a low limestone ridge along the eastern border. During the rains, small pans and hollows hold embroidered pools. Hollow trees also catch water and keep it until it turns brown, while several kinds of water roots can be counted on all year.

Until recently, few came and none but Bushmen stayed for long in *Nyae Nyae*, for there is not enough water to attract pastoral peoples, and the soils are not the best for crops. The !Kung say: "We have always been here, drinking the *Nyae Nyae* waters." Perhaps this "always" began at about the time when the western Bantu horn was moving southward through Ovamboland. All one can say for sure is that they came, possibly seeking sanctuary in the empty spaces of the Kalahari, found, in *Nyae Nyae*, a quiet

place, and stayed. In *Nyae Nyae*, the !Kung have since lived on unchanged—replacing only their bone arrow-points with metal ones, made from the nails and wire that filtered into the desert after the Europeans' entry into South West Africa.

The !Kung nation cannot so live for much longer. Already their last lands are being occupied by the Herero nation—Bantu-speakers—who say: "The Bushmen are like our children. We feel obligated to care for them." It seems likely that, in a few years, these lands will be farmed by white people. Then, if the past of other Bushmen is any omen, some !Kung will become farm laborers, some will contract syphilis, some will die and some will breed. Few will marry.

SO MUCH for the little history and the brief geography. How do the !Kung live in *Nyae Nyae*? Human ecology is the study of the relation-



YOUNG MOTHER bows her head as ornament for ear lobe is twisted to shape.

ship between man and his natural environment. In such a relationship, two directions of cause and effect are implied. These two directions may be understood by two terms—adaption and control. Adaption means the effect wrought by the environment upon the body or the culture of man. Control is the effect wrought upon the environment by man, his body and his culture. In the one case, man conforms to the environment. In the other, man conforms the environment to his needs.

THERE IS no ecological situation where either adaptation or control prevails to the exclusion of the other, for the fact of man's presence changes an environment, and the most effective technology, the most developed society, are—in part—responses to an environment. Every ecological relationship is a welter of compromise. Yet, there are extremes. If we take Western technological culture as one extreme—with control prevailing and America the exponent—the !Kung might be considered the opposite extreme, for the !Kung control their environment scarcely at all.

To the !Kung, in their environment, there are available a certain number of natural resources, in a certain geographical pattern. There are also available a certain number of !Kung. They have a culture. Living within their culture, they are able to exploit their environment. The first aspect of this ecological relationship is the fairly obvious relationship between !Kung technology and environment.

With considerable empirical knowledge, the !Kung have arrived at workable solutions to the problems of subsistence. By means of their technology, they have managed to satisfy their basic needs and their many wants of life (at least, they satisfied them until they were exposed to the wealth of white men). The fact that their population is limited because of their technology is one result of this adaptation—of which infanticide is an occasional expression. That they live to all intents and purposes from day to day—having no real measure of surplus in the form of stored crops and

beasts ready to slaughter—is another indication that the !Kung have largely adapted to their environment. But the contrasting fact that the !Kung live in *Nyae Nyae* as easily as they do also indicates some measure of environmental control.

THE more complex aspects of the !Kung ecological relationship exist in areas other than their simple technology. That the !Kung are able to exploit their environment with a certain degree of efficiency is due in some measure to the structure of their society. Thus, the second aspect of the



WOMEN OF WERT gather children and possessions in preparation for march

to a new campsite. A band can travel about ten miles a day, gathering food

ecological relationship is this one: the relationship between a certain number of natural resources, arranged in a certain environment, and a society that has developed in the presence of these resources and whose members are dependent on them.

Of course, their society did not come into being because the !Kung needed it to exploit their environment, nor is that society shaped only in accordance with environmental dictates. Indeed, some elements of !Kung society seem to exist in spite of the environment. There is reason to believe that their society has not basically

changed through periods when there was more water, more game, and probably more *veldkos*—the wild vegetable products of the land, gathered by the women of the bands—in South Africa, although this point might be debated on grounds that the !Kung depended more on hunting in previous periods. But it is that aspect of !Kung social structure, the functioning of which clearly seems to facilitate exploitation of their environment by means of their technology, that we shall discuss. These manifestations appear primarily adaptive in nature, although control is also discernible.



as it goes. The !Kung move in annual patterns: staying near waterholes in

dry winter, visiting *mangetti* forests in moist summer, and *tsi* areas in fall.



DELOUSING is a courtesy among kinsmen: the salty-tasting lice are eaten.

There are about 1,000 !Kung—gathered into 28 bands—who build their ephemeral camps, or *werft*s, separately in an area of 10,000 square miles. The houses in the *werft*'s are of grass, pressed over a framework of sticks, making small quarter-shells, with their backs to the prevailing wind. Cossamer things, made of the same grass that sways and crowds against their doors, they are positioned in a loose pattern according to their occupants' kinship, and all are held—finally—by the headman, who builds his shelter under the tallest tree.

From a little distance, when the sound of voices is lost on the wind, one would not know a *werft* was near. The people never return to the same *werft*—preferring to build anew and saying it would not be safe from the spirits of the dead, or sanitary, to do so. Perhaps, also, they find it sad to see the little houses toppling, day by day, into the grass of the new year.

AS A STARTING POINT, labor among the !Kung is divided between two basic subsistence activities—hunting game and gathering *veldkos*. Men hunt, because their bodies are better suited to the chase. Women gather, because they could not leave their children for the long periods of hunting that men both enjoy and endure.

Women's work—the technology of gathering—is simple and adaptable: the tools are easily acquired, the methods quickly learned. The constant necessity to provide and the almost daily edge of effort slowly bends the

JOHN MARSHALL is one of a family that has been studying the Bushmen for nearly a decade, in expeditions to South West Africa by the Peabody Museum, Harvard University.

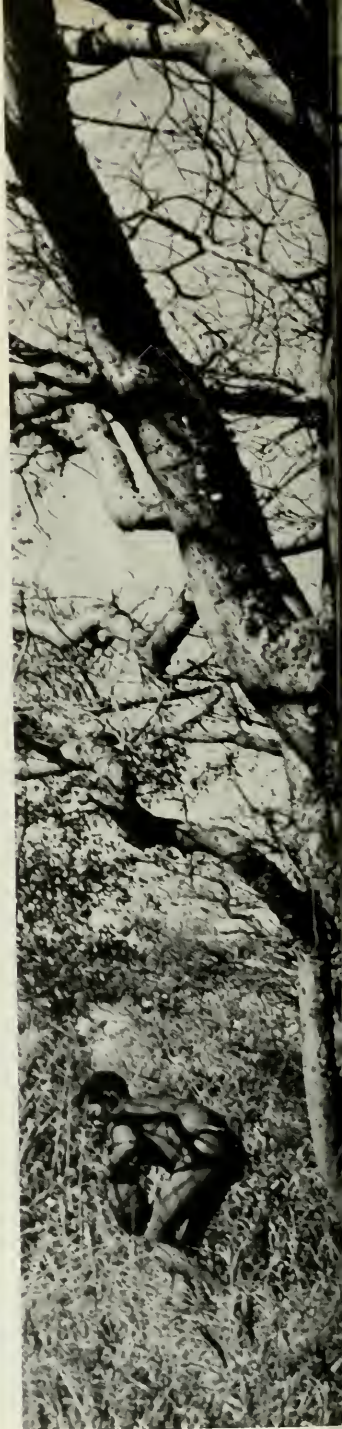
!Kung women, who are slender-armed and do this monotonous work to the end of their lives. All roots—a major food—are gathered in identical fashion. The implement for this is a digging stick—made usually by a woman's husband from any of a number of hardwoods: the bark is peeled from a branch, a point is whittled sharp. Women, squatting, dig narrow holes in the earth with these sticks, and tug until the root they have reached comes free. Berries are picked—high ones jostled down with sticks and sought for carefully among the grass stems. Nuts are collected on the ground.

SMALL ANIMALS, such as tortoises and even grasshoppers, are sometimes captured by the women and brought home in the evening—such small creatures are also considered *veldkos*. The women, too, will kill snakes, even puff adders. When they see a puff adder, they gather around it in a little crowd, their high laughter tinkling while they drop large, heavy things on its flat head.

Averaged over a year, women gather on four or five days of each week—the number of days depending

on the season. In the long days of wilting between the October spring and the January summer, food is scarce and the women may go out every day into the failing veld, leaving their *werft* early in the morning and returning late in the afternoon. All that a woman gathers belongs to her alone, and of course is shared with her family. She feeds her husband, her children and often a visitor or two, at her own hearth. No formal instruction is practiced among the !Kung, with the possible exception of certain kinds of religious teaching and what might be called an occasional hunting school. Learning to gather comes from the children's observation of the more experienced women. Girls soon learn to recognize more than a hundred kinds of edible plants that grow in *Nyae Nyae*, as well as the seasons and places in which these plants grow. They learn to see tiny, shriveled root vines coiled around thorns in the thickets and, in the process, develop fine powers of observation. Possibly complementary to this lack of formal instruction, no formal pressure is exerted on young people to take up adult roles. Girls, if they wish, accompany their mothers on gathering trips. If they do not, they rarely feel guilty. A girl usually begins to feel responsible soon after she marries, which is often before puberty. But only when she has children of her own does a woman see the world through the eyes of a provider.

"Man as a Hunter" will continue in the August-September issue.



!KUNG WOMAN, left, has gathered tsi nuts enough for several days' eating.



WITH THE SUMMER RAINS, the nuts of the *mangetti* forests—related to the

almond—begin to mature. The 'Kung arrive as soon as possible to start

collecting, pay later visits as well. In winter, *above*, they search again.

Sky Reporter



THE SOUTH PORTION OF THE NIGHT SKY is shown, *above*, as it will look to an

observer in the U.S. at about 9:00 P.M., during the last seven months of 1958.

Constellations lying along the zone of the zodiac have been named. The three

A selective celestial calendar

JULY

July 5. At 3 P.M. (EDT), the earth is at *aphelion*, its farthest point from the sun this year, some 94.6 million miles away (see p. 314).

July 22. In the evening twilight, the waxing moon and giant Jupiter will be seen in company, low in the western sky.

July 26. Just after sunset, Mercury may be seen close to the horizon, almost due west.

AUGUST

August 7. This evening, Mars—like a bright orange star—appears in the constellation of Aries, just south of the moon.

August 11–13. Peak of the Perseid meteor shower: an average of fifty an hour, especially after midnight, will enter the earth's atmosphere.

August 26. A fine chance to locate Uranus with binoculars: it lies less than a quarter of the moon's diameter distant from Venus in the east.

SEPTEMBER

September 9. About one hour before sunrise, Mercury may be observed rising, slightly north of east.

September 23. At 8:10 P.M. (EDT), the sun stands directly over the equator at a point some 1,000 miles south of Dakar, French West Africa, on its journey into the southern sky, marking the start of *Autumn*.

DR. FRANKLIN, of THE AMERICAN MUSEUM-HAYDEN PLANETARIUM, regularly prepares this list of events.

ROLL-AROUND" MAP

The night sky of June and July is presented on these pages in a chart especially designed for easy use by the amateur

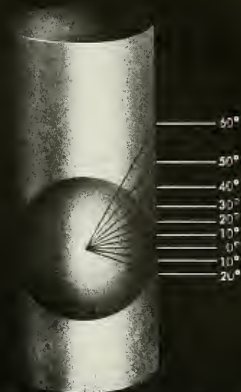
These pages are readily removed for outdoor use.



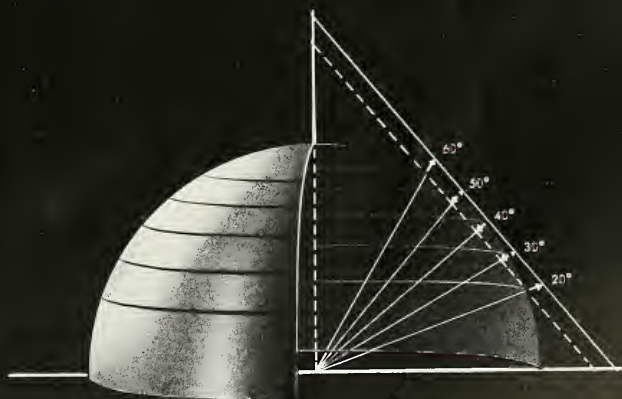
CELESTIAL SPHERE, an imaginary construction astronomers use for determining the positions of stars in the sky, presents cartographers with the same, fundamentally insoluble problem—in plotting spherical points on a flat surface without distortion—that is faced in making maps of the earth. On this page are examples of the main cartographic techniques, and evidence of the distortion that accompanies various projections. The "roll-around" map on the next pages, designed by Henry M. Neely, combines three projections.



GREAT SQUARE OF PEGASUS, plotted in three different evening positions, demonstrates distortion at all but center of polar projections. Eastern horizon is at left; above circle at center is directly overhead. Great Square, and three stars that form a line leading from Pegasus through Andromeda to Perseus, are plotted in correct positions of altitude and azimuth. As they first clear the northeastern horizon, characteristic shape is almost unrecognizable to any but experts: polar projection shows square only near center.



CYLINDRICAL PROJECTION is "true" only at equator—where the imaginary cylinder is tangent to the sphere. However, distortions are not excessive in the lower latitudes (to 25° north and south). As a result, cylindrical projections are often used for equatorial regions. However, as the higher latitudes are plotted, the spacing between parallels and, worse, the nonconvergence of the meridians, cause severe distortion and exaggerated size of the areas depicted. Classic example is appearance of Greenland on a Mercator projection.



CONIC PROJECTION brings virtues of the cylindrical projection to higher latitudes, by dint of placing point of tangency at midpoint of mapped area (solid line). Lambert's "conformal" projection, a modification of the simple conic, imagines that the cone's plane passes beneath the surface to be mapped (dashed line); thus, two points of tangency are achieved and small distortion is averaged over a larger area. Most maps of large areas either combine different conic projections ("polyconic") or utilize Lambert's system.

A SUMMER STAR GUIDE

By Henry M. Neely

THIS MAP shows the entire horizon, and the user is thus free to face in any direction outdoors. To match the map with the horizon visible before him, he should rotate it until the printed compass direction (on the map's circumference) that matches the direction of his view lies at the "bottom" of the map. The stars lying along the selected "horizon" on the map will now be those he sees nearest the horizon he faces. As printed here, for example, the south horizon lies at the bottom. Facing south, the observer should easily locate the constellation Scorpius.





TIMETABLE

TO USE any map that shows stars in relation to the horizon, one must use a timetable, since the stars rise and set about four minutes earlier each succeeding night. Thus, a star that is on the horizon at 10:00 P.M. on the first of any month will, by month's end, be in that same position at 9:00 P.M. For this map, the following table of equivalent times may be used (DAYLIGHT SAVING):

JUNE

First week	12:30 to 1:30 A.M.
Second week	midnight to 1:00 A.M.
Third week	11:30 P.M. to 12:30 A.M.
Fourth week	11:00 P.M. to midnight

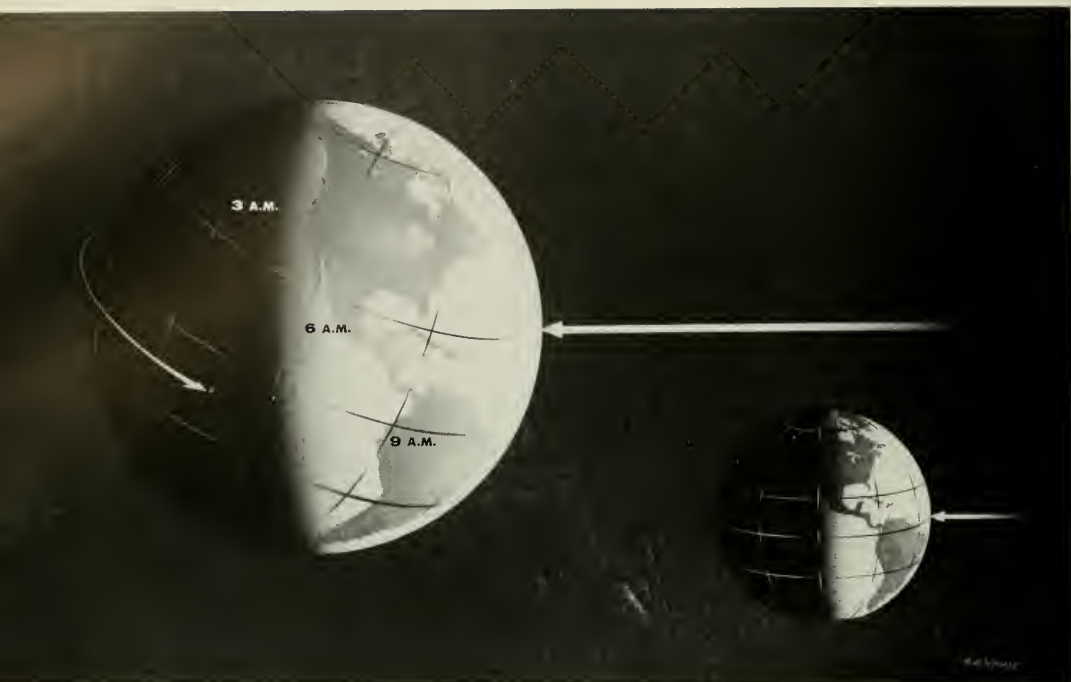
JULY

First week	10:30 to 11:30 P.M.
Second week	10:00 to 11:00 P.M.
Third week	9:30 to 10:30 P.M.
Fourth week	9:00 to 10:00 P.M.
Fifth week	8:30 to 9:30 P.M.

SCALE OF MAGNITUDES

THE MAGNITUDES of the stars, as shown on this map, are what the astronomers call "apparent visual magnitudes." This system dates back to the early days of observation, when all stars were arranged in six groups. As finer measurements became possible, a reorganization took place, so that, while most stars remained in these six groups, "negative" categories were added for the brightest ones. Thus, Sirius, brightest of all stars in apparent visual magnitude, has a value of -1.56 . The planets of our own system, from time to time, shine with reflected light of even greater "negative" value than this: Jupiter, near the southwest horizon, left, is now valued at -2 . For comparison, the moon has an apparent visual magnitude of -12 and the sun, -27 .

☉ -2 and above	★ 2.5 to 2.9
☉ -1.9 to -0.1	★ 3.0 to 3.4
☉ 0.0 to 0.9	★ 3.5 to 3.9
☉ 1.0 to 1.5	★ 4.0 to 4.3
☉ 1.6 to 1.9	★ 4.4 to 4.6
☉ 2.0 to 2.4	★ 4.7 and below



EARTH AT SUMMER SOLSTICE, *left*, is shown in contrast to an imaginary planet, *right*, with untilted axis. The increase in length of days during this season may be judged by comparing 9 A.M. sunrise in

Tierra Del Fuego to 3 A.M. sunrise in Alaska. Sun's direct rays, parallel to the ecliptic (straight arrows), now hit Tropic of Cancer, rather than the equator, as in the case of the perpendicular planet.



PARADOXICALLY, the heat of summer in our Northern Hemisphere is coincident with the time that the earth, in its annual revolution around the sun, attains the greatest distance from that prime source of energy. This seeming paradox derives from the tilt of the earth's axis (see above).

The directness of the summer sun's rays and the longer daylight hours, together, more than outweigh the effect of distance.

AMONG THE PLANETS, for June and July, Jupiter and Saturn may be readily located in late evening hours, to the southwest and south, respectively (see pp. 312-13). A brilliant sight just before dawn is Venus, *left*, rising above the eastern horizon and shifting eastward among the constellations. The best time for observing this spectacle is about 4:30 A.M. (*Daylight Time*) during June, and a few minutes later during July.

MR. NEELY, editor of SKY REPORTER since its start in 1917, has been active in popular astronomy for fifty years.



bright stars at center—Deneb, Altair and Vega—form the so-called “summer

triangle” (see p. 312-13). From left to right, the other bright stars to

be noted are Fomalhaut (left of “triangle”), Antares, Arcturus and Spica.

for the second half of 1958

By K. L. Franklin

OCTOBER

October 5. Mercury is once again at *superior conjunction*, 130 million miles away, on the opposite side of the sun, passing from the morning to the evening sky.

October 12. The year's only total eclipse of the sun occurs today; however, it will be visible only in the South Pacific.

October 26. Daylight Savings Time ends in many areas. Remember to set your clocks *back* one hour.

NOVEMBER

November 8. On this day, the red planet, Mars, is in its position closest to the earth for 1958—some 45.4 million miles away.

November 11. Venus is now at *superior conjunction*, 159 million miles distant from the earth, on the opposite side of the sun.

November 16. Mars has reached the point of *opposition* (exactly opposite the sun in the sky). Thus, it stands directly south near midnight.

DECEMBER

December 9. Mercury, at *inferior conjunction*, is 63 million miles from the earth (see October 5).

December 12-14. The Geminid meteor shower, with a peak on Dec. 13, may best be seen during early morning hours (about forty meteors per hour).

December 22. At 3:40 A.M. (EST), the sun reaches its most southerly point over the earth for 1958, standing overhead near Farafangana, Madagascar. The first day of *Winter*.

MARKSMAN OF THE DARKNESS

Experiment shows how *Tyto alba*
can locate its quarry in the night

By ROGER S. PAYNE

and WILLIAM H. DRURY, JR.



BARN OWL SCREAMS when held in hand, showing size of strong beak. Feathers forming facial disk are evident.

ANY BIRD THAT SINGS, if we stop to think about it, should be able to hear its song. Biologists have shown that this is true: not only can a bird hear its own song, but the tones that it hears best are those near the middle range of all the various notes it utters. This seems to be a general avian rule—but, like most rules, it has exceptions, and a notable exception is found in the case of owls. J. Schwartzkopff has shown that the Long-eared Owl (*Asio otus*), for example, can hear about the same tones that humans do: it is, however, most sensitive to tones high above the middle range of its own voice—even above the normal middle tone of most small songbirds' songs.

Why do owls have this strange specialization to best hear notes that are so much higher than their own calls? It seems that there must be some reason, important in the lives of owls, which has made it necessary for them to hear high-pitched sounds.

We know, for example, that mice (which are important prey for many owls) squeak at about the same pitch at which owls hear best. Although mice probably do not squeak often enough to allow hunting owls to track them all down this way, they do make rustling and crackling sounds as they move through ground litter, and some of the component frequen-

cies of these sounds are high-pitched. Can it be that owls, hunting in darkness, use their ears to locate mice? When the light is poor, even the best eyes would have difficulty seeing a mouse moving about in the leaves or grass. But what about the ears?

If we examine an owl's ears, we find them quite different from the ears of other birds—for instance, a sparrow's—and with many modifications for sensitive hearing. Starting at the outside of a bird's head and working inward to the middle and inner ear, we find that the structure of these three parts differs from the parallel three-part mammalian structure. In birds, the outer ear is a chamber that ends flush with the surface of the head, without any external, sound-concentrating device, such as the funnel-like external ear of mammals. In the middle ear of birds we do not find three bones (hammer, anvil and stirrup); instead, there is one large bone called the columella. Finally, in place of the spiral, snail-shell-like cochlea of mammals' inner ears, the birds' cochlea is almost straight. Now, how do owl's ears differ from this general avian design?

First, an owl's head is large and wide, so that its ears are set fairly far apart. In the case of the larger owls, this separation means that the time difference between the arrival of

sound at one ear, and then the other, of an owl would be greater than in the case of a songbird—perhaps great enough to provide a clue concerning the sound's direction. Second, the ears of many owls are asymmetrical. In some, the size of the opening differs between right and left ears. In others, the external ear cavity is divided into two compartments; one a blind alley, the other going to the eardrum. The blind alley is a different compartment on each side of the head. Owls which have no visible structural differences between their ears, may possibly use flaps of skin in front of their ears to change the effective sound path to each ear and make reception different for the two ears. It seems from theory (which we will not discuss here) that such differential reception is necessary in determining distance to a sound source. The Barn Owl (*Tyto alba*) has symmetrical ears, but the highly-developed flaps of skin in front of the ears are asymmetrically placed. They are shown on page 319.

Still a third contrast is found in the owl's eardrum. It is very large—proportionally, far larger than in other birds. With a larger area of sensitive surface exposed to sound waves, a larger amount of the waves' mechanical force is available to owls than to most other birds. This means,



BARN OWL STRIKES. All photographs were taken by David G. Allen in re-enactment at Cornell of original experiments.

Windows were boarded to exclude the light and owl struck by ear as prey moved, rustling dry leaves strewn on floor.



OWL'S HEAD is seen in three states, above: feathered, plucked to reveal

other things being equal, that an owl can hear a less intense sound than other birds can. As we look at the middle ear, we find that, while in most birds the columella is attached to the center of the eardrum, in owls, it is attached off-center. The center of the eardrum moves farther than the edge, because the edge of the eardrum is attached to the skull and the eardrum bulges inward when a sound wave strikes it. If we consider just one radius of the eardrum, we see that it is acting as a lever with fulcrum at the outside edge of the eardrum. The force that the moving eardrum can exert upon an off-center columella is multiplied, just as force is multiplied as we move closer to the fulcrum of a lever. Thus, although the columella moves a shorter distance as a result of this off-center attachment, force is gained, and the owl has achieved what is probably another advantage over other birds in hearing soft sounds.

The columella, itself, fits into the cochlea at a spot called the "oval window," acting somewhat as a piston on the liquid inside. The motion of this liquid disturbs the nerve end-

hidden skin-flap, and bare skull. Below, ear is seen from two views: left, out-

ings in the cochlea. The nerve endings transform mechanical impulses into electrical ones that travel to the bird's brain. Because the cochlea is a blind alley, the liquid inside it has no place to flow; but when the columella pushes on the liquid, this pressure must be relieved. The "round window," a hole in the cochlea, covered by a thin membrane, provides for this. As force is applied, the round-window membrane swells out. Within limits, the larger the round window, the less will be the resistance to liquid being moved by the columella. By now, it should not be surprising that, in owls, this round window is proportionally larger than it is in other birds.

In all birds, the eardrum is many times larger in area than the footplate of the columella (the end of the



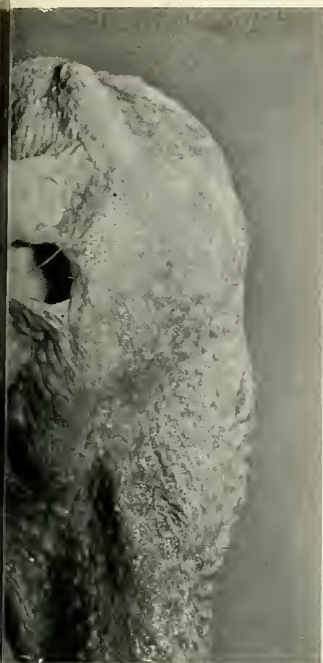
side and right, inside the skull. The drawing shows enlarged eardrum (ex-

columella that inserts in the oval window). This disproportion in size multiplies pressure on the liquid of the cochlea, and the amount of multiplication is determined by the ratio between the area of the eardrum and the area of the footplate. As pressure is multiplied, sensitivity to slight sounds is increased. An example of the owl's advantage here is the following: in the house sparrow (*Passer domesticus*), this ratio is about twenty-two to one; in the Long-eared Owl, it is forty to one.

Finally, a widely accepted theory (not yet proven experimentally) holds that the length of the cochlea is directly related to the ability of the ear to analyze complex sounds. Whether or not this theoretical function of cochlea length is correct, the fact remains that owls have longer cochleas than would be expected in birds of their size.

We are faced here with a great deal of evidence, all telling us that owls must have extremely exceptional hearing. The next question seems to be: "Why?" In September, 1956, while Payne was at the Louise Ayer Hatheway School of Conservation

MR. PAYNE, now engaged in graduate work at Cornell, and DR. DEURY, Director of the Massachusetts Audubon Society's Louise Ayer Hatheway School of Conservation Education, were both trained in zoology at Harvard. MR. PAYNE is continuing the research here described at Cornell.



posing wide surface to sound waves). off-center columella that fits into



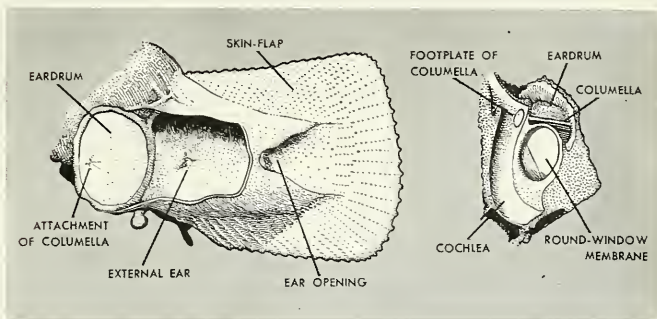
cochlea at the "oval window"—against which columella moves like a piston—

and "round window," affording relief for fluid thus compressed in cochlea.

Education, in Massachusetts, the authors decided that it would be worthwhile to look into this question. The late James L. Peters, of Harvard's Museum of Comparative Zoology, had suggested to Drury in 1947 that the reason for specialized ear structure in owls be investigated. A Barn Owl (*Tyto alba*) was donated to us by Dr. Winthrop W. Harrington of Lexington, Massachusetts, who had raised it from the age of a few days. This exceptionally tame bird was known, with apologies to A. A. Milne, by the name of "WOL."

WOL had the instincts to hunt and pounce, but being hand-raised, he did not know *what* to hunt, or pounce upon. He would peer at a picture on a newspaper page, and glide down and strike it with his talons. He seemed to be striking at any small object that differed from its background. This well-developed hunting activity, before he "knew" what to hunt, was an interesting aspect of animal behavior in itself. We set out to show him prey.

"WOL's House," as it was called, was in a kennel where the late Mrs. Hatheway, who left her estate and a



generous endowment to the Massachusetts Audubon Society, had formerly bred and trained Welsh terriers. It was a room about twenty-five feet by twenty feet, empty except for a seven-foot-high perch, a bathing trough and a table in one corner, where we fed WOL when experiments were not going on.

The first time WOL saw a living mouse he flew down onto the floor near it. The mouse ran. WOL finally caught it, but only after a long chase—half-flying and half-running over the floor. The same pattern of chasing the mouse persisted for the next several

trials until, one day, he flew from his perch and struck a mouse directly. This, a more normal hunting method, stayed with him, for he struck the mice directly thereafter.

Having satisfied ourselves that WOL was capable of catching mice in true owl fashion, we set up the equipment for our hearing experiments. We spread dry oak leaves on the floor. This meant that anything moving through the leaves on the floor could be heard. We boarded up the windows, with painstaking precautions, to make sure that the room was light-tight. We checked ourselves



GRASPING ITS PREY. Barn Owl keeps wings and tail raised to spill the sup-

porting air and maintain balance, as talons are used to secure bird's catch.

by exposing hypersensitive film for an hour when the lights were turned out: the film was developed and showed no trace of exposure. We thus felt safe in assuming that, no matter what animal we were working with, there was no light for it to see by.

The preliminary to our next experiment was to make sure that WOL was "at home" in his quarters. It was very important for him to know the whole room "by heart," so that he would later fly round in the dark. We gave him about five weeks to "memorize" his surroundings. During this time, we left a small night light on in the room, turning it off occasionally. During the last week before we started our experiments, and off and on during them, WOL was left in complete darkness.

OUR first experiment was to release a wild-caught Deer Mouse (*Peromyscus leucopus*) on the leaf-strewn floor of the room, with the lights off. The mouse moved about, "exploring" the room and rustling in the leaves. When the mouse stopped and was silent, we heard WOL leave his perch, fly down and strike in the leaves. Quickly we turned on the

lights and found WOL, standing motionless, holding the mouse in his talons. We tried this seventeen times. When the mouse stopped (and, in our experience, *only* when it stopped) WOL flew. In all but four of these trials (which involved misses by no more than two inches), WOL successfully struck the mouse.

With no light available, WOL obviously was not using his eyes to find the mouse. This left four other possibilities. I: He could be using his ears, and homing on the sounds the mouse made. II: He could be homing on the odor of the mouse. III: He could be making his own sounds, using the echoes to guide him (echolocation), as some bats are known to do. IV: He could be "seeing" the mouse by means of radiation in wave lengths invisible to us—in other words, the infrared heat waves given off by the mouse. Although evidence suggests that owls are insensitive to infrared radiation, we could not ignore the possibility.

To test the heat, odor and homing-on-sound hypotheses, we proposed to see whether WOL could find an object that had no smell and gave off no heat greater than the heat of

the leaves on the floor, but which made a sound like a mouse rustling through the leaves.

A crumpled wad of paper (mouse-size), dragged through the leaves on a thread, seemed just right. We turned out the lights and dragged the paper wad through the leaves. We heard WOL leave his perch and strike. We snapped the lights on: he held the wad of paper in his talons.

Since the paper wad had neither smell nor heat (above the heat of its surroundings), we interpreted this to mean that he could only have been using his ears to direct him to our fake mouse. Fortunately, since W. E. Curtis (1952) had shown that Barn Owls have no ability to echolocate, we could discount this possibility.

Theory suggests that an owl would



need both ears to determine distance to a sound source, but we wanted to make sure. We plugged one of WOL's ears with cotton, turned out the lights and released a mouse. We heard WOL leave his perch and strike in the leaves. We turned on the lights and saw both animals standing motionless, WOL about eighteen inches short of the mouse, but on the right line from his perch. We removed the plug and tried him again. This time, WOL caught it. We repeated this experiment with the cotton plug in WOL's other ear, with the same result.

WITH this array of evidence before us, we now felt sure that WOL was using his hearing to guide him to the mice in the darkened room. L. R. Dice was the first worker to find

that Barn Owls (and Long-eared and Barred Owls, as well) could catch mice in total darkness. Dice's primary interest, in his experiments, was to determine the value of protective coloration in mice. To do this, he released two Deer Mice (*Peromyscus maniculatus*) of different color strains on the floor of a room in dim light: one mouse matching the color of the background, and the other contrasting to it. Dice then released an owl and recorded which mouse the owl caught. After many such trials—using four species of owls, including a Barn Owl—protective coloration was definitely shown to possess advantages for survival in mice.

Now, Dice used these species of owls as the predators in his experiments because he had previously

found out just how much light these owls needed to see a mouse. Thus, when he adjusted the light in his coloration experiments, he knew whether or not the owl could see the mouse. Since he was interested in a selection of prey based on visual cues, Dice tried to minimize the effect of what he correctly assumed to be the owls' ability to catch mice by hearing alone. In order to do this, he made what he called a mouse "jungle"—a lattice of sticks screwed together and held above the floor by uprights. The "jungle," he hoped, would keep the owls from catching the mice in total darkness, because the owls would not "dare" strike at them through this obstacle.

Dice says that his "jungle" was also probably a closer approximation

WINGS ARE LOWERED, as owl grips mouse. To test theories of prey-detection through odor or heat, authors also used

crumpled paper wad, dragged by thread, instead of mouse. Owl caught this, too, proving sound to be determining clue.





PROPPING BODY WITH WINGS, owl holds mouse in talons, bends to kill it with bill. Propping, like holding wings

aloft, is necessary for balance—not, as had previously been thought, to catch the prey by enfolding in wings.



DEAD PREY IN BILL, motionless owl hunches forward some thirty seconds.

of natural conditions, where mice are moving about under shrubs and herbs, than a bare floor would be: a closer approximation of nature, because when he had observed his owls catching mice on the bare floor, they had used their wings to enfold the mouse and pull it within reach of their talons. He assumed that the owls could not do this under natural conditions because the presence of shrubs and herbs on the ground would prevent such behavior.

Our observations showed that WOL, striking his prey on the leaf-littered floor, held his wings over his back after he first struck. Only after he had caught and started to shift the mouse in his talons, did he lower his wings to the floor on both sides and “enfold” his prey. It appeared that WOL used his wings and tail as props when his talons were otherwise occupied and *not* to draw his prey within reach. WOL did this

“enfolding” even when he struck a mouse near his feeding table, where table legs were in the way and his feathers disarranged in the process.

The consistency of WOL’s enfolding action led us to believe that such behavior occurs in nature, regardless of obstructions, and that the real effect of Dice’s “jungle” had been to give painful consequences to the owls’ more “natural” hunting method—by hearing—when they came up against the unnaturally rigid stick-lattice in total darkness.

In earlier experiments, testing the vision of owls under various levels of illumination, Dice had used dead mice as bait. They made no sound. He kept reducing the amount of light until the owls could no longer pounce on the dead mice. Then, by measuring that level of illumination, Dice knew how much light the owls needed to seize a mouse. He then measured the amount of light available to night-

hunting owls in nature and came to the conclusion that there must be many nights in which owls cannot see well enough to catch their prey.

Though R. J. Pumphrey has estimated that an owl can probably see about as well by starlight as men can see by the full moon, we must remember that clouds effect such available light, as do shadows cast by vegetation. Dice measured this light reduction. He found that, under heavy clouds, the reduction may be as great as one-tenth to one-sixteenth of the light from a clear sky, while under trees and shrubs it may fall to between a fiftieth and a 200th of the original light. These reductions may be multiplied in such conditions as forest shadow on a cloudy night, when available light may be no more than a 500th to a 3200th of the normal intensity in the open on a clear night.

WHAT does all this mean in the lives of owls? It means, first of all, that an owl, hunting by vision, goes hungry on cloudy, moonless nights, if he hunts his prey in the woods. Is it not possible that, under such circumstances, the owl will use his remarkable hearing to lead him to a mouse? It has often been suggested that owls do use their ears to locate the general position of their prey, and then switch over to their eyes for the final strike. But WOL's ability to locate mice by hearing alone leads us to suggest just the reverse.

In our hypothesis, the owl's eyes would be used to avoid obstacles, such as branches and twigs, while its ears would lead it to the final strike. Field observation supports this. Watch an owl hunting through the woods: he flies down from a branch, swoops low, and then rises to a perch. This pattern is repeated over and over again. Is he not perhaps getting close to the ground while he flies, in order to see branches as silhouettes against the relatively bright sky? On dark nights, he needs all the information his eyes can provide in order to avoid collisions with branches, while his hearing is valueless for this purpose. We do not mean to exclude the eyes completely from the owl's final "run in." Probably, in nature, owls use either ears or eyes, or both, according to the opportunity afforded. But from our work with WOL it seems clear that hearing, alone, will permit an owl to strike accurately on the darkest night.



RAID COMPLETED, owl turns to fly back to perch. Although owl usually

holds prey in bill during flight, in present instance he holds it in talons.

RECOLLECTIONS OF
YOUNGER DAYS, BY THE
OLDER DARWIN

Chronicle Of A MISSPENT YOUTH

Looking back at his school days,
Darwin felt he had learned little
then and, that little, on his own

By CHARLES DARWIN



LAMARCKIAN VIEW OF EVOLUTION is praised to Darwin by Dr. Grant. Darwin was then a medical student in Edinburgh.

AS I was doing no good at school, my father wisely took me away at a rather earlier age than usual, and sent me (October, 1825) to Edinburgh University with my brother, where I stayed for two years or sessions. My brother was completing his medical studies, though I do not believe he ever really intended to practise, and I was sent there to commence them.

The instruction at Edinburgh was altogether by lectures, and these were intolerably dull, with the exception of those on chemistry by Hope; but to my mind there are no advantages and many disadvantages in lectures compared with reading. Dr. Duncan's lectures on *Materia Medica* at eight o'clock on a winter's morning are something fearful to remember. Dr. Munro made his lectures on human anatomy as dull as he was himself, and the subject disgusted me. I also attended on two occasions the operating theatre in the hospital at Edinburgh, and saw two very bad operations, one on a child, but I rushed away before they were completed. Nor did I ever attend again, for hardly any inducement would have been strong enough to make me do so; this being before the blessed days of chloroform.

My brother stayed only one year at the University, so that during the second year I was left to my own resources; and this was an advantage, for I became well acquainted with several young men fond of natural science. One of these was Ainsworth, who afterwards published his travels in Assyria; he was a Wernerian geologist, and knew a little about many subjects. Dr. Coldstream was a very different young man, prim, formal, highly religious, and most kind-hearted; he afterwards published some good zoological articles. A third young man was Hardie, who would, I think, have made a good botanist, but died early



"AT THAT TIME I should have thought myself mad to give up the first days of partridge-shooting for geology or

any other science," wrote Darwin, who left a geology trip in Wales to return to Shropshire for the hunting season.

in India. Lastly, Dr. Grant, my senior by several years. He had published some first-rate zoological papers, but after coming to London as Professor in University College, he did nothing more in science, a fact which has always been inexplicable to me. I knew him well; he was dry and formal in manner, with much enthusiasm beneath this outer crust. He, one day, when we were walking together, burst forth in high admiration of Lamarck and his views on evolution. I listened in silent astonishment, and as far as I can judge, without any effect on my mind. I had previously read the *Zoonomia* of my grandfather, in which similar views are maintained, but without producing any effect on me. Nevertheless, it is probable that the hearing such views maintained may have favoured my upholding them under a different form in my *Origin of Species*.

Dr. Grant took me occasionally to the meetings of the Wernerian Society, where various papers on natural history were read, discussed, and afterwards published in the "Transactions." I heard Audubon deliver there some interesting discourses on the habits of N. American birds, sneering somewhat unjustly at Waterton. By the way, a negro lived in Edinburgh, who had travelled with Waterton, and gained his livelihood by stuffing birds, which he did excellently: he gave me lessons and I used to sit with him, for he was a very pleasant and intelligent man.

DURING my second year at Edinburgh I attended Jameson's lectures on Geology and Zoology, but they were incredibly dull. The sole effect they produced on me was the determination never as long as I lived to read a book on Geology, or in any way to study the science. Yet I feel sure that I was prepared for a philosophical treatment of

the subject; for an old Mr. Cotton, in Shropshire, who knew a good deal about rocks, had pointed out to me two or three years previously a well-known large erratic boulder in the town of Shrewsbury, called the "bell-stone"; he told me that there was no rock of the same kind nearer than Cumberland or Scotland, and he solemnly assured me that the world would come to an end before any one would be able to explain how this stone came where it now lay. This produced a deep impression on me, and I meditated over this wonderful stone. So that I felt the keenest delight when I first read of icebergs transporting boulders, and I gloried in the progress of Geology.

After having spent two sessions in Edinburgh, my father perceived, or he heard from my sisters, that I did not like the thought of being a physician, so he proposed that I should become a clergyman. He was very properly vehement against my turning into an idle sporting man, which then seemed my probable destination.

As [this] was decided, it was necessary that I should go to one of the English universities and take a degree; but as I had never opened a classical book since leaving school, I found to my dismay, that in the two intervening years, I had actually forgotten, incredible as it may appear, almost everything which I had learnt, even to some few of the Greek letters. I did not therefore proceed to Cambridge at the usual time in October, but worked with a private tutor in Shrewsbury, and went to Cambridge after the Christmas vacation, early in 1823. I soon recovered my school standard of knowledge, and could translate easy Greek books, such as Homer and the Greek Testament.

During the three years which I spent at Cambridge my time was wasted, as far as the academical studies were

concerned, as completely as at Edinburgh and at school. With respect to Classics I did nothing except attend a few compulsory college lectures, and the attendance was almost nominal. In my second year I had to work for a month or two to pass the Little-Go, which I did easily. Again, in my last year I worked with some earnestness for my final degree of B.A., and brushed up my Classics, together with a little Algebra and Euclid, which latter gave me much pleasure, as it did at school. . . . In order to pass the B.A. examination, it was also necessary to get up Paley's *Evidences of Christianity*, and his *Moral Philosophy*. This was done in a thorough manner, and I am convinced that I could have written out the whole of the *Evidences* with perfect correctness, but not of course in the clear language of Paley. The logic of this book and, as I may add, of his *Natural Theology*, gave me as much delight as did Euclid. The careful study of these works, without attempting to learn any part by rote, was the only part of the academical course which, as I then felt, and as I still believe, was of the least use to me in the education of my mind. I did not at that time trouble myself about Paley's premises: and taking these on trust, I was charmed and convinced by the long line of argumentation. By answering well the examination questions in Paley, by doing Euclid well, and by not failing miserably in Classics, I gained a good place among the *hoi polloi* who do not go in for honours; but I cannot remember how high I stood, and my memory fluctuates between the fifth, tenth, and twelfth on the list.

Public lectures on several branches were given in the University, attendance being quite voluntary; but I was

so sickened with lectures at Edinburgh that I did not even attend Sedgwick's eloquent and interesting lectures. Had I done so I should probably have become a geologist earlier than I did. I attended, however, Henslow's lectures on Botany, and liked them much for their extreme clearness, and the admirable illustrations; but I did not study botany. Henslow used to take his pupils, including several of the older members of the University, on field excursions, on foot or in coaches, to distant places, or in a barge down the river, and lectured on the rarer plants and animals which were observed. These excursions were delightful.

Although, as we shall presently see, there were some redeeming features in my life at Cambridge, my time was sadly wasted there, and worse than wasted. . . .

BUT no pursuit at Cambridge was followed with nearly so much eagerness or gave me so much pleasure as collecting beetles. It was the mere passion for collecting, for I did not dissect them, and rarely compared their external characters with published descriptions, but got them named anyhow. I will give a proof of my zeal: one day, on tearing off some old bark, I saw two rare beetles, and seized one in each hand; then I saw a third and new kind, which I could not bear to lose, so that I popped the one which I held in my right hand into my mouth. Alas! it ejected some intensely acrid fluid, which burnt my tongue so that I spat the beetle out, which was lost, as was the third one.

I was very successful in collecting, and invented two new methods; I employed a labourer to scrape, during the winter, moss off old trees and place it in a large bag, and likewise to collect the rubbish at the bottom of the barges in which reeds are brought from the fens, and thus I got some very rare species. No poet ever felt more delighted at seeing his first poem published than I did at seeing, in Stephens' *Illustrations of British Insects*, the magic words, "captured by C. Darwin, Esq." I was introduced to entomology by my second cousin, W. Darwin Fox, a clever and most pleasant man, who was then at Christ's College, and with whom I became extremely intimate. Afterwards I became well acquainted, and went out collecting, with Albert Way of Trinity, who in after years became a well-known archaeologist; also with H. Thompson, of the same College, afterwards a leading agriculturist, chairman of a great railway, and Member of Parliament. It seems that a taste for collecting beetles indicates future success in life!

I am surprised what an indelible impression many of the beetles which I caught at Cambridge have left on my mind. I can remember the exact appearance of certain posts, old trees and banks where I made a good capture. The pretty *Panagæus crux-major* was a treasure in those days, and here at Down I saw a beetle running across a walk and on picking it up instantly perceived that it differed slightly from *P. crux-major*, and it turned out to be *P. quadripunctatus*, which is only a variety or closely allied species, differing from it very slightly in outline. I had never seen in those old days *Licinus* alive, which to an uneducated eye hardly differs from many of the black Carabidous beetles; but my sons found here a specimen, and I instantly recognised that it was new to me; yet I had not looked at a British beetle for the last twenty years.

I have not yet mentioned a circumstance which influenced my whole career more than any other. This was my friendship with Professor Henslow. . . . I cannot resist mentioning a trifling incident, which showed his kind



DARWIN LEARNS to stuff birds in Edinburgh—one of the extracurricular studies that formed his actual education.



ENTHUSIASTIC DARWIN, beetle in each hand, popped one into mouth to seize a third from tree, ended losing both.

consideration. Whilst examining some pollen-grains on a damp surface, I saw the tubes exerted, and instantly rushed off to communicate my surprising discovery to him. Now I do not suppose any other professor of botany could have helped laughing at my coming in such a hurry to make such a communication. But he agreed how interesting the phenomenon was, and explained its meaning, but made me clearly understand how well it was known; so I left him not in the least mortified, but pleased at having discovered myself a remarkable fact, but determined not to hurry again to communicate my discoveries.

Henslow then persuaded me to begin the study of geology. Therefore on my return to Shropshire I examined sections, and coloured a map of parts round Shrewsbury. Professor Sedgwick intended to visit North Wales in the beginning of August [1831] to pursue his famous geological investigations amongst the older rocks, and Henslow asked him to allow me to accompany him. Accordingly he came and slept at my father's house.

A SHORT conversation with [Sedgwick] during this evening produced a strong impression on my mind. Whilst examining an old gravel-pit near Shrewsbury, a labourer told me that he had found in it a large worn tropical *Volute* shell, such as may be seen on chimney-pieces of cottages; and as he would not sell the shell, I was convinced that he had really found it in the pit. I told Sedgwick of the fact, and he at once said (no doubt truly) that it must have been thrown away by some one into the pit; but then added, if really embedded there it would be the greatest misfortune to geology, as it would overthrow all that we know about the superficial deposits of the Midland Counties. These gravel-beds belong in fact to the glacial period, and in after years I found in them broken arctic shells. But I was

then utterly astonished at Sedgwick not being delighted at so wonderful a fact as a tropical shell being found near the surface in the middle of England. Nothing before had ever made me realise, though I had read various scientific books, that science consists in grouping facts so that general laws or conclusions may be drawn from them.

Next morning we started for Llangollen, Conway, Bangor, and Capel Curig. This tour was of decided use in teaching me a little how to make out the geology of a country. Sedgwick often sent me on a line parallel to his, telling me to bring back specimens of the rocks and to mark the stratification on a map. I have little doubt that he did this for my good, as I was too ignorant to have aided him. On this tour I had a striking instance how easy it is to overlook phenomena, however conspicuous, before they have been observed by any one. We spent many hours in Cwm Idwal, examining all the rocks with extreme care, as Sedgwick was anxious to find fossils in them; but neither of us saw a trace of the wonderful glacial phenomena all around us; we did not notice the plainly scored rocks, the perched boulders, the lateral and terminal moraines. Yet these phenomena are so conspicuous that . . . a house burnt down by fire did not tell its story more plainly than did this valley. If it had still been filled by a glacier, the phenomena would have been less distinct than they now are.

At Capel Curig I left Sedgwick and went in a straight line by compass and map across the mountains to Barmouth, never following any track unless it coincided with my course. I thus came on some strange wild places, and enjoyed much this manner of travelling. I visited Barmouth to see some Cambridge friends who were reading there, and thence returned to Shrewsbury and to Maer for shoot-



COLLECTING ROCK SPECIMENS in North Wales, Darwin got first geological field experience on a tour with Sedgwick.

ing; for at that time I should have thought myself mad to give up the first days of partridge-shooting for geology or any other science.

On returning home from my short geological tour in North Wales, I found a letter from Henslow, informing me that Captain Fitz-Roy was willing to give up part of his own cabin to any young man who would volunteer to go with him without pay as naturalist to the voyage of the "Beagle"... I was eager to accept the offer, but my father strongly objected, adding the words, fortunate for me. "If you can find any man of commonsense who advises you to go I will give my consent." So I wrote that evening and refused the offer. On the next morning I went to Maer to be ready for September 1st, and whilst out shooting, my uncle sent for me, offering to drive me over to Shrewsbury and talk with my father, as my uncle thought it would be wise in me to accept the offer. My father always maintained that [my uncle] was one of the most sensible men in the world, and he at once consented in the kindest manner. I had been rather extravagant at Cambridge, and to console my father, said that, "I should be deuced clever to spend more than my allowance whilst on board the 'Beagle'." He answered with a smile, "They tell me you are very clever."

Next day I started for Cambridge to see Henslow, and thence to London to see Fitz-Roy, and all was soon arranged. Afterwards, on becoming very intimate with Fitz-Roy, I heard that I had run a very narrow risk of being rejected on account of the shape of my nose! He was an ardent disciple of Lavater and was convinced that he could judge a man's character by the outline of his

features; and he doubted whether any one with my nose could possess sufficient energy and determination for the voyage. But I think he was afterwards well satisfied that my nose had spoken falsely.

The voyage of the "Beagle" has been by far the most important event in my life, and has determined my whole career; yet it depended on so small a circumstance as my uncle offering to drive me thirty miles to Shrewsbury, which few uncles would have done, and on such a trifle as the shape of my nose. I have always felt that I owe to the voyage the first real training or education of my mind; I was led to attend closely to several branches of natural history, and thus my powers of observation were improved. Investigating the geology of all the places visited was far more important, as reasoning here comes into play.

To return to the voyage. On September 11th [1831], I paid a flying visit with Fitz-Roy to the "Beagle" at Plymouth. Then to Shrewsbury to wish my father and sisters a long farewell. On October 24th I took up my residence at Plymouth, and remained there until December 27th, when the "Beagle" finally left the shores of England for her circumnavigation of the world. We made two earlier attempts to sail, but were driven back each time by heavy gales. These two months at Plymouth were the most miserable which I ever spent, though I exerted myself in various ways. I was out of spirits at the thought of leaving all my family and friends for so long a time, and the weather seemed to me inexpressibly gloomy. I was also troubled with palpitation and pain about the heart, and like many a young ignorant man, especially one with a smattering of medical knowledge, was convinced that I had heart disease. I did not consult any doctor, as I fully expected to hear the verdict that I was not fit for the voyage, and I was resolved to go at all hazards.

Looking backwards, I can now perceive how my love for science gradually preponderated over every other taste. During the first two years of the five-year voyage my old passion for shooting survived in nearly full force, and I shot myself all the birds and animals for my collection; but gradually I gave up my gun more and more, and finally altogether, to my servant, as shooting interfered with my work, more especially with making out the geological structure of a country. I discovered, though unconsciously and insensibly, that the pleasure of observing and reasoning was a much higher one than that of skill and sport. That my mind became developed through my pursuits during the voyage is rendered probable by a remark made by my father, who was the most acute observer whom I ever saw, of a sceptical disposition, and far from being a believer in phrenology; for on first seeing me after the voyage, he turned round to my sisters, and exclaimed, "Why, the shape of his head is quite altered."

These excerpts are from an autobiography CHARLES DARWIN wrote for his children, at the age of sixty-seven, first published in the U.S. by Appleton. It is the first of several articles related to Darwin's life and work to appear in NATURAL HISTORY during the hundredth anniversary of the publication of *The Origin of Species*.



GEOLOGICAL ANOMALY, a tropical shell found in England, taught Darwin value of grouping data into coherent whole.



DARWIN VISITS THE "BEAGLE" at Plymouth in September, 1831. The vessel, kept in port by heavy seas, finally left

on December 27. The voyage was "by far the most important event in my life," Darwin wrote to his children in 1876.



ART OF ABORIGINAL AMERICA

At the Brussels Fair, a U.S. show presents a rich, native tradition

Photographs by CHARLES UHT

EUROPEAN VISITORS to the Brussels World's Fair—and many Americans who usually look upon Europe as the source of all their continent's culture—may be surprised by one of the exhibits in the United States Pavilion. Organized by the Museum of Primitive Art in New York—and drawing upon the collections of ten other museums, two private persons and the U.S. government—the exhibit consists of thirty-five works that give a cross section of the aboriginal cultures of North America. Three great geographical areas are thoroughly represented. The high cultures of the Pacific Northwest were, with respect to their technology, no more advanced than other Indian societies; but an extremely favorable environment allowed them, upon contact with Europeans, to acquire material wealth unequalled by other North American Indians. The tribes of the Southwest are also well represented, as are the mounted hunters of the Central Plains, whose special culture largely developed after their European contact, when the horse—extinct in the New World since the Pleistocene—was reintroduced. But other cultures further to the East have not been neglected—a death mask from Tennessee (see next page) is not only one of the earliest works in the Brussels exhibit (photo below) but one of the best-known from the whole of American prehistory.



Leather mask, *left*—a katchina, or ancestral spirit—is the work of New Mexican Zuni. Katchinas gave names to entire clans.

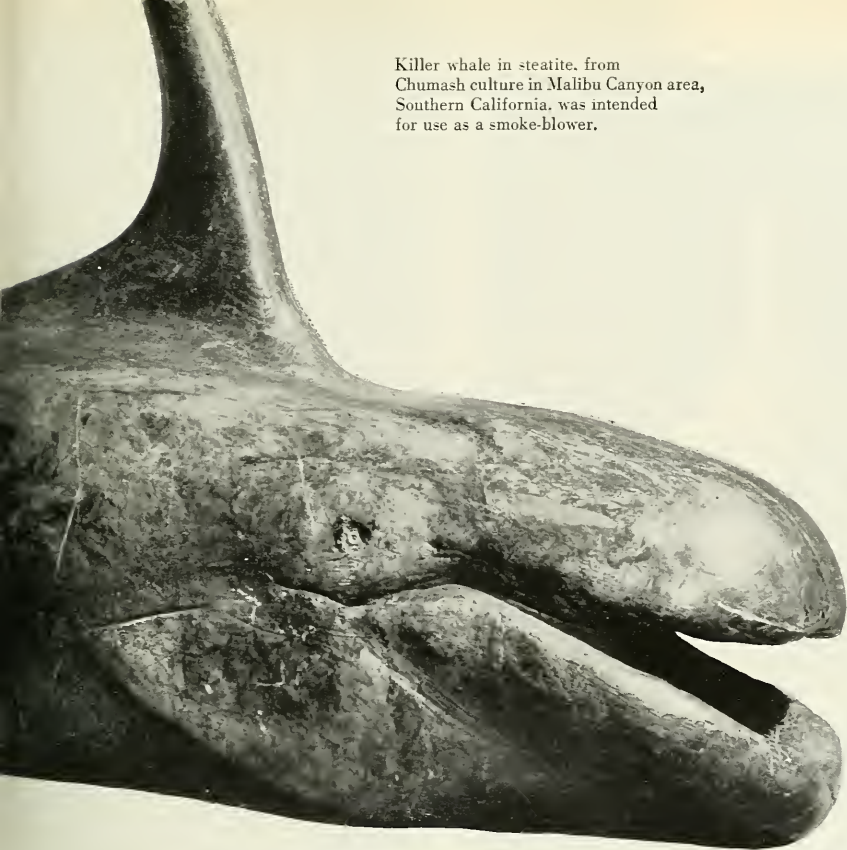


Walrus ivory was used by Eskimos for this figure of a pregnant woman, a monumental piece although it stands less than four inches high.



Funerary mask from eastern Tennessee, in shell, is from culture typified by log-vaulted, earthen burial mounds. It dates from A.D. 1000-1500.





Killer whale in steatite, from Chumash culture in Malibu Canyon area, Southern California, was intended for use as a smoke-blower.

Kwakiutl Indians from Gwa Island, British Columbia, fashioned striking bird mask, over three-feet long, from painted wood.



Mask of the man in the moon, also made of painted wood, is an example of intricacy of much Eskimo work. This piece is from southwest Alaska.



Wood figure of Zuni war god,
perhaps of twentieth
century, indicates great
persistence of original cultures.



Hide-painting figures buffalo hunt and hunting rites. It was produced by a Central Plains culture, Arapaho or Sioux.

So-called "birdstones," loaned by Museum of Primitive Art in New York, were found in the northern Mississippi valley.





Northwest Coast "copper" was used in potlatch ceremonies—ritual expressions of prestige typical of area's wealthy tribes.

Mask of a dead man. Tlingit work from British Columbia. is in painted wood, has eyes of metal, painted leather headdress.



Letters



Hummingbird Feeders

SIRS:

Among the many interesting features of *NATURAL HISTORY* for May, 1957, I saw an illustration of a hummingbird-feeder developed by personnel at the American Museum's Southwestern Research Station. I should like to learn more about hummingbird-feeders: design, food composition, bird attractants, preferred location, protection from ants, etc. I should appreciate any information you can provide.

CLAUDE E. ZOELL

University of California
La Jolla, California

THE DEPARTMENT OF BIRDS replies:

Neither the Department of Birds nor the staff at the Southwestern Research Station claims to have made a scientific study of the operation of hummingbird-feeders. The feeders were installed at the Research Station primarily to attract numbers of hummingbirds to the environs of the laboratory for all to observe and admire. No particular effort has been made, however, to pursue the potentialities that these feeders hold for studying the biology of hummingbirds. Such a project would be extremely interesting and worthwhile—an excellent example of how the amateur naturalist can make a substantial contribution to science.

We visualize two features as essential for a successful hummingbird-feeder: a supply of sweetened water and a self-operating dispenser.

For sweetened water, we use a simple solution of table sugar in water, roughly in a ratio of 1:1 or 1:2. Honey has been successfully substituted. The success of such homemade "nectar" in hummingbird feeding has led to a popular miscon-

ception that the diet of these birds is principally, if not entirely, nectar. Such is not the case. There is good evidence that insects and tiny spiders, especially those varieties to be found on flowers and foliage, make up an important part of the normal diet. Aviculturists have long been aware that a restricted diet of sweetened water will not maintain captive hummingbirds in good health. We do not mention this to discourage the continued use of sugar water, but to indicate something of the biology of these birds. What a hummingbird takes from a feeder is only a supplement to its natural diet; we know of no evidence that the health of free-living hummingbirds has been impaired by the use of feeders. There may well be a "preferred" formula for nectar, however. An interested amateur could readily determine this by designing a "choice" experiment and recording the "preferences" shown for each solution over a period of time.

The simplest dispenser need be nothing more than a pop bottle (or other narrow-mouthed container), with a stopper penetrated by a short piece of small-bore glass tubing that will restrict flow through capillary action. The bottle is filled, inverted, and the tube adjusted to a position where it can be reached conveniently by a hummingbird in flight. The dispenser at right in the photograph, constructed by Dr. James Tanner of the University of Tennessee, is such a model.

A more elaborate dispenser, designed by Dr. Van Riper of the Denver Museum of Natural History, has also proved very effective at the Station (*at left, in photograph*). In this model, the sugar solution flows into a plastic cup. A lid, bearing a number of tiny holes, covers this reservoir and helps both to prevent wasps and

other insects from monopolizing the feeder and to reduce the loss of fluid through dripping (two factors that are sometimes troublesome with the simple hummingbird-feeder).

The perch on the Van Riper model is a welcome addition for an observer who is interested in photography but cannot afford the expensive equipment required to "stop" a hummingbird in flight. Birds that visited the Van Riper feeder at the Research Station regularly rested on the perch while drinking, and could be readily photographed. With the simple model, the birds feed in flight.

The "attractiveness" of the feeder can often be enhanced by the use of bright colors about the dispenser, simulating the brightly-colored petals of the flowers the bird normally visits. In the simpler model, this was accomplished by leading the feeding tube through a piece of bright-red cardboard; the lid of the Van Riper feeder is also bright red. Here again, a variety of experiments suggest themselves: what portions of the color spectrum are most attractive to hummingbirds? Once the birds have become conditioned to visiting feeders in a given area, is there any evidence that feeders with color are "preferred" to undecorated ones? Rather simple, but carefully-controlled, backyard experiments could provide answers to these questions.

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288-9—William D. Berry, (top), Elizabeth K. Cooper (bottom), courtesy Harcourt, Brace & Company.

291-309—Peabody Museum, Harvard University.

310-15—drawings by Helmut Wimmer,

AMNH; star map by Henry M. Neely.

316-23—David C. Allen; except p. 319 (right), by Lee Boltin and drawing on p. 319 by Dr. William C. Dilger.

324-29—Enid Kotschnig.

330-337—Charles Uht; except p. 331 (bottom), Wide World; and p. 333 (bottom), University of California.

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year's growth is seen
in sequoia's section.
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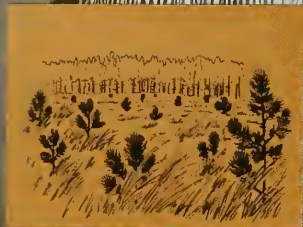


TREES' TALES

The American Museum opens new
exhibit: North American Forests

TEN YEARS IN PREPARATION, the Hall of North American Forests has opened at THE AMERICAN MUSEUM. The exhibit's theme is the diversity of forest life, shown by means of twelve separate life-sized displays of North American forest types. But a tree's history is not easily read from its bark or leaves. It is best seen in the rings that not only mark each tree's annual growth, but record the hazards of growth, as well. This story, told in one of the new Hall's exhibits, is presented on these pages.

EFFECT OF COMPETITION on tree's growth is seen from cross section of loblolly pine. Germinating with hundreds of others in abandoned field, it grew at an average rate for seventeen years. Then, neighboring pines began to rob it of light at the top, water and minerals at roots. After sixty-four years of slower growth in the crowded stand, the pine was released from this competition by the felling of many of its neighbors. Thereafter, the tree grew rapidly.

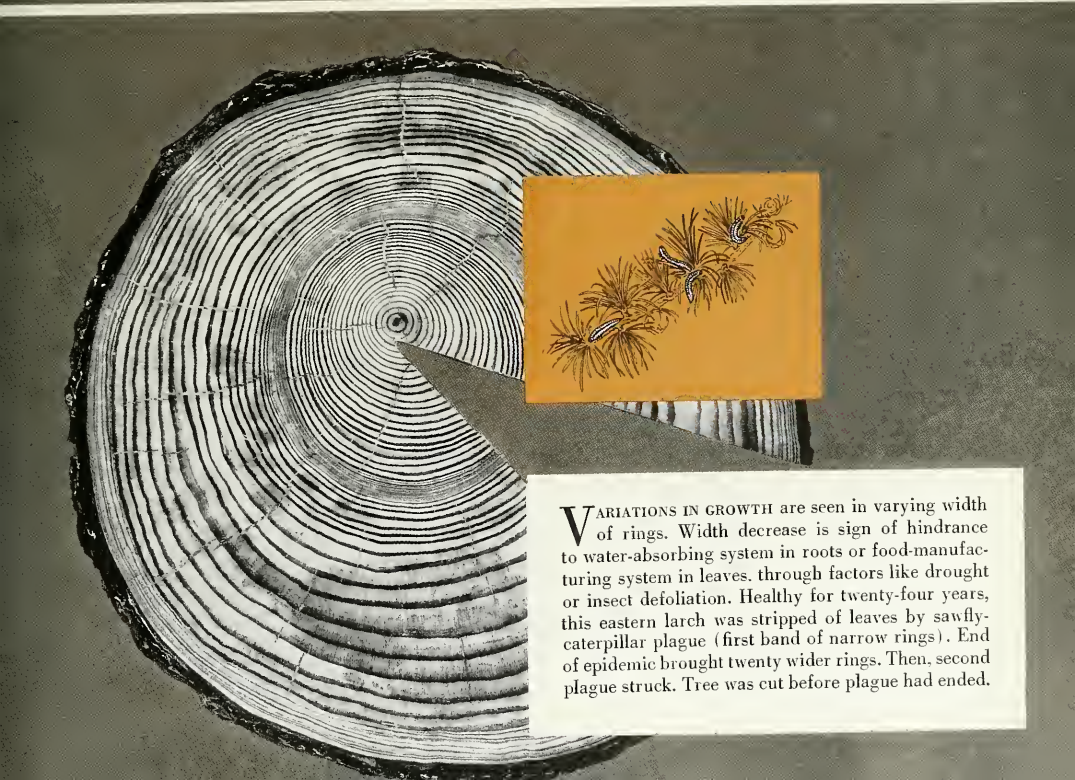


ANNUAL RINGS can also record such events as landslides, windstorms and other disturbances that tip trees — for growth-rings of leaning trees are abnormally wide to one side. Here, a red spruce shows two such upheavals. The first, occurring at age twenty-four (recorded by normally-shaped rings in center), tipped tree toward upper right. The second, six years later, pushed it in opposite direction, and spruce kept leaning that way forty-three years more.





CHRONICLE OF FIRES is written in yearly rings of this ponderosa pine, which received a total of nine scars from fires during its 103-year life. Four scars cluster together at center of the cross section, one is isolated by sound wood to the left of center, still four others are visible on left side. Open wound along bottom of section is called a "cat face." Intervals between fires may be calculated by counting rings that have grown over charred wood.



VARIATIONS IN GROWTH are seen in varying width of rings. Width decrease is sign of hindrance to water-absorbing system in roots or food-manufacturing system in leaves, through factors like drought or insect defoliation. Healthy for twenty-four years, this eastern larch was stripped of leaves by sawfly-caterpillar plague (first band of narrow rings). End of epidemic brought twenty wider rings. Then, second plague struck. Tree was cut before plague had ended.



WORLD'S OLDEST KNOWN TREE, bristlecone pine, *above*, proves extreme slowness of growth in hostile conditions of an extreme environment. Pine is thought to have germinated about 2550 B.C.—although date must

be inferred from width of later growth-rings (less than a hundredth of an inch annually), since growth center, at left of cross section, has been eroded away. In rocky soil on the slopes of White Mountains, in

eastern California, pine endured blizzards, short growing seasons, cold. Section also reveals scars made by debris-laden winds. At time of cutting, tree's growth was limited to C-shaped portion seen at upper right.





See Theodore Roosevelt National Memorial Park, in North Dakota's beautiful Badlands.

T.R.—the cowboy who rode herd on our natural glories

Most Americans think of Teddy Roosevelt as part bull moose and part steam-engine. But mostly, T.R. was the Fourth of July rared back and walking on its hind legs. *He was a man on fire for his country*, and it was the natural glories of this land that lit the fuse.

They've made a wonderful park of his Elkhorn Ranch and the Badlands where he worked as a cowboy and found health and strength. Here, you can see the open range that made him first appreciate his country's greatness. You can ride the trails that gave his imagination new directions. You can climb the ridges that lifted his eyes, and gave him the power to lead his Rough Riders up San Juan Hill in '98.

This is the centennial of T.R.'s birth; if he were around today, he'd be "dee-lighted" that the conservation policies he fostered have been so wisely continued. He knew America would always need breathing space, open waters and green, growing forest — the heart lifting glories of Nature that men must have to grow strong and great.

★ ★ ★

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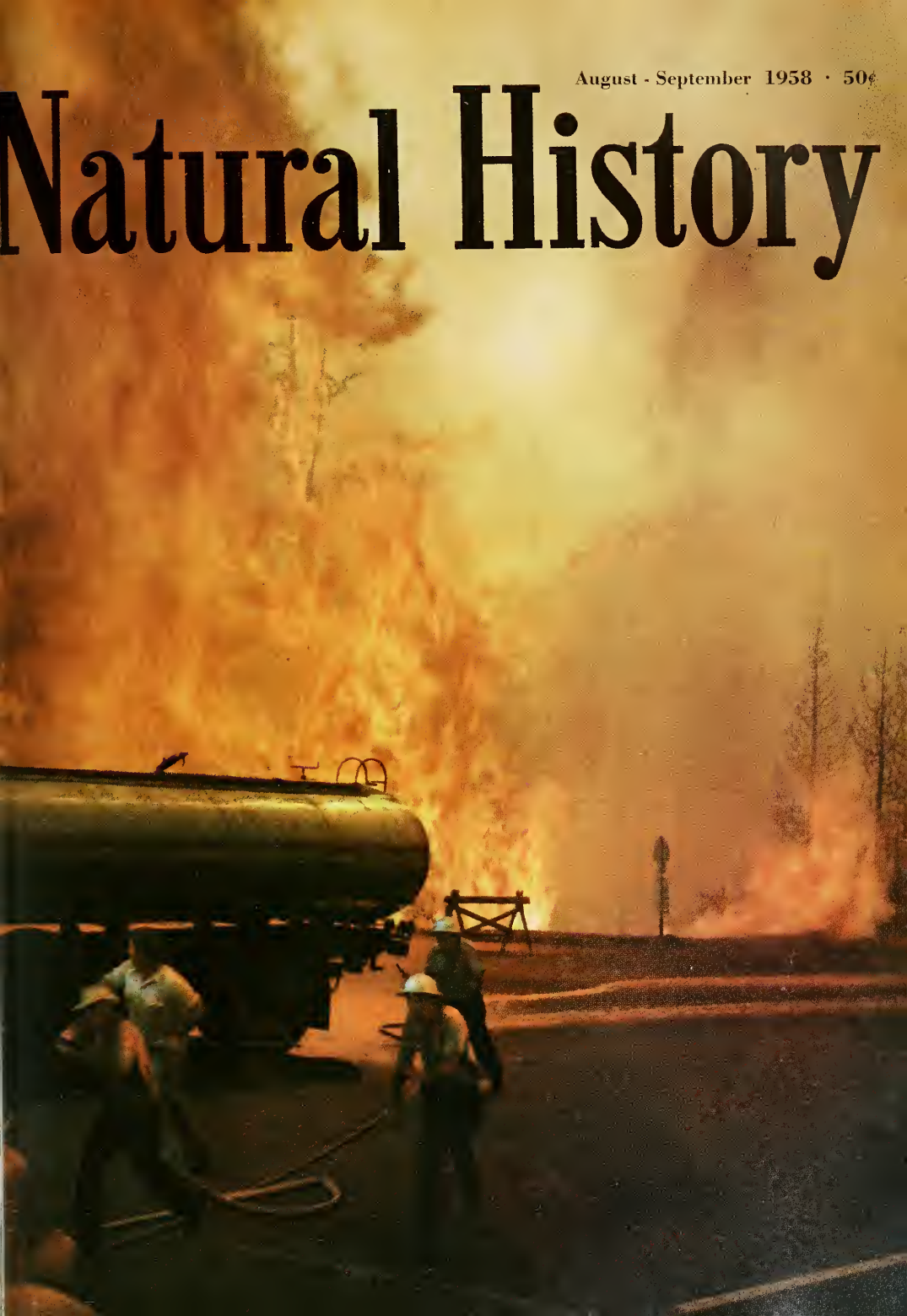
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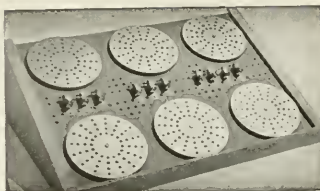
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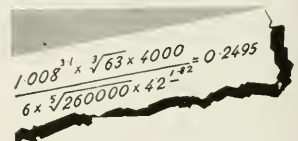
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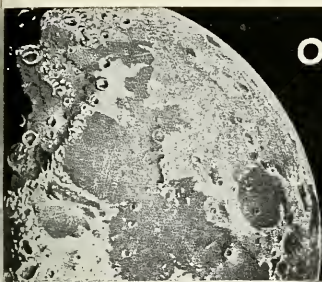
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THE FIRE SCENE, above, is at the junction of state highways 180 and 65 near Happy Gap, California, on the Sunday before Labor Day, 1955. Crews had just enough time to wet down their equipment as the McGee fire—so called because it is thought to have started near the McGee ranch by Kings Canyon National Park—pushed by an updraft, swept up a steep slope and past the men, who were left unharmed. Before the blaze was trapped and stifled some two weeks later, over 17,000 acres of timber had been lost, for a total damage of close to a million dollars.

After this episode of destruction had ended, however, a new phase began. Aided by forestry programs, new growth is rising where the old timber stood. The first stages of this process, as well as the McGee fire, are shown on p. 356 ff.

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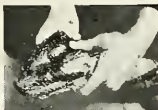
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Reviews

THE NATURE OF EXTINCTION

Reviewed by DEAN AMADON

EXTINCT AND VANISHING BIRDS OF THE WORLD, by James C. Greenway, Jr. *American Committee for International Wildlife Preservation, Special Publication No. 13, 1953; \$5.00, 518 pp., illus.*

AS REGARDS THE EXTINCTION OF BIRDS, North America has the worst record of any continent on earth. The Passenger Pigeon, the Carolina Parakeet, the Labrador Duck, the Eskimo Curlew and the Great Auk are gone, while several others—the California Condor, the Ivory-billed Woodpecker and the Whooping Crane—are seriously threatened. Yet, with the exception of two or three in Australia, not a single species of bird

on any other continent has become extinct. One wonders why?

The answer is not entirely clear. Certainly, the almost barbaric destruction of Passenger Pigeons by sporting and market hunters swept them from America. The social nesting habits of this species may have prevented the scattered stragglers from reproducing, as—instead—they wandered about in search of great nesting throngs that no longer existed. In other cases, destruction of the habitat has been the cause of extinction. Drainage of marshes, as much as shooting, has driven the few remaining Whooping Cranes to the remotest northern limits of their range—the wilderness

DR. AMADON, who is Lamont Curator of Birds at THE AMERICAN MUSEUM, grew familiar with the processes of insular extinction in the course of work with the land birds of Hawaii.

of Canada's Wood Buffalo Park—to nest. Or, rather, to attempt to nest, for in this submarginal habitat an inclement season may prevent reproduction.

Greenway, of the Museum of Comparative Zoology at Harvard, has documented these and other case histories in the present volume, and the gifted artist, D. M. Reid-Henry, has depicted the rare creatures discussed by Mr. Greenway, some of which are now known only from a few specimens in museums and from early accounts. Lord Walter Rothschild formed a great collection of such obliterated species and, in 1907, published a folio volume, "Extinct Birds." Before the appearance of Greenway's work, Rothschild's was the standard reference on the subject.

Yet, as Greenway's geographical summary makes evident, the continental losses are less, in numbers of species, than the insular ones. By far the majority of the one hundred or so species of extinct birds formerly lived on isolated, small islands: the Dodo on Mauritius, the Cuban Macaw in the West Indies, the Golden Pheasant, now gone along with King Kamehameha of Hawaii, whose feathered robes its plumage adorned. Indeed, nearly half of the original twenty-five or thirty species of Hawaiian land birds are extinct and others are threatened. Consideration of these cases makes it clearer why extinction occurs.

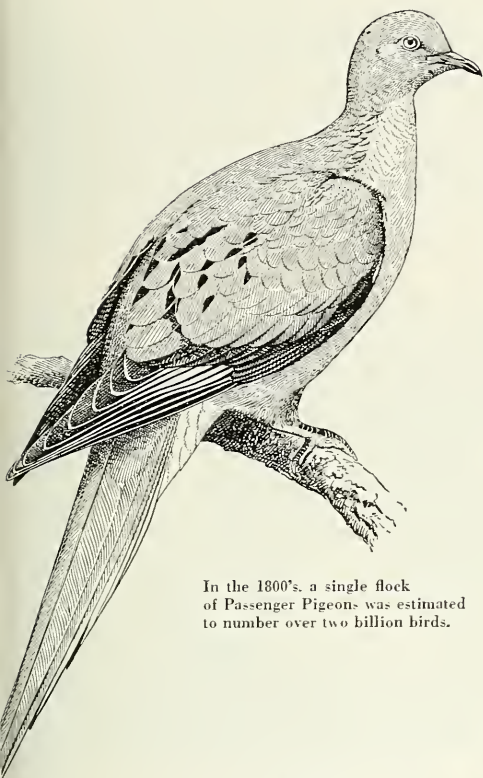
What are the factors affecting the status of species in general? All species face stresses of two kinds: those imposed by the physical environment—heat and cold, floods and droughts; and those resulting from interactions with other species. Some of the latter are direct and dramatic—the ravages of enemies or parasites. Others are more subtle—the disappearance of the eastern chestnut, in the U.S., probably resulted in the extermination of specialized insects dependent upon this tree, and certainly adversely affected birds and mammals that fed upon beech mast.

Viewed thus, the extinction of certain



Emu of Kangaroo Island, in Bass Strait, had vanished by 1836. Only one specimen exists, in Paris.

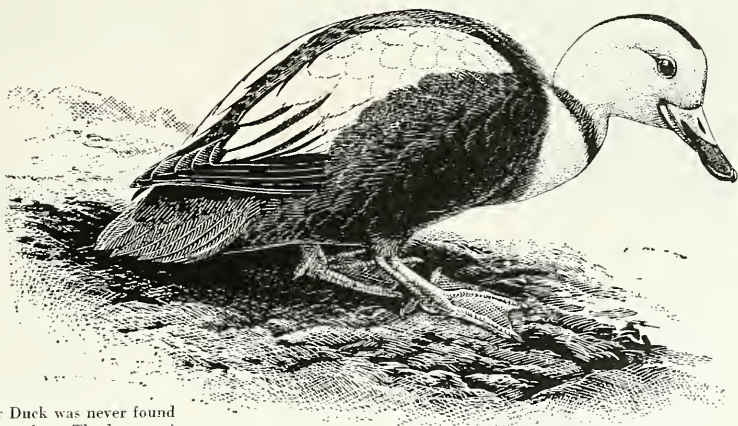
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species is as inevitable as the evolution of others. Tennyson, grieving for a friend, wrote that Nature is: "So careless of the single life; so careful of the type..." But the poet was only partly correct. Nature seems to be no more concerned with the species than with the individual, although the former may persist for millennia and the latter only for a few hours or years. Yet it is incorrect, geneticists believe, to conclude that species, like individuals, necessarily pass through a cycle of youth, maturity and senescence. Some species do become so specialized, so closely dependent upon a limited or unusual environment, that they are in a vulnerable position. Others, remaining more adaptable and generalized, persist indefinitely.

WHAT, then, are the factors that make island birds so vulnerable to extinction? The following may be cited:

I. *Small size of range.* The Australian Emu is much persecuted, but it inhabits most of that continent and remains fairly plentiful in some areas. The Dwarf Emu of Kangaroo Island, however, could not flee beyond the confines of its home. It quickly became extinct; the sole remaining mounted specimen reposes in the Paris Museum.

II. *Environmental limitations.* Many insular environments are so limited, both physically and biologically, as to impair in time the adaptability and variability of the local species. Then, when aggressive, adaptable continental species reach the island—either under their own power or by human introduction—the hitherto isolated island species are immediately threatened (as were such isolated human populations as the Eskimo and the Polynesian when they were at last exposed to the diseases of civilization).

The ancestor of the Dodo doubtless was able to fly and reached Mauritius in that way. There, it found no predators, and waxed fat and clumsy. By the time man arrived, along with his dogs and pigs, the Dodo had evolved into a flightless, goose-sized creature utterly unable to cope with these new enemies.

It should be noted that, in the ebb and flow of evolutionary power-politics, islands may also become refuges where backward species can survive so long as advanced competitors, which have evolved elsewhere, do not reach them. The marsupial fauna of Australia is an example frequently cited.

III. *The deleterious genetic effects of small populations.* In small populations—and many island populations will perforce be small—harmful mutations are more apt to become widespread, and beneficial mutations are less likely to become established by selection. A



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species may survive a temporary period of drastic reduction in numbers, as did the American Buffalo. But if it remains at low ebb for a long time—as may prove to be the case with such species as the Whooping Crane—the entire population may in time become debilitated. Reproduction will be even further curtailed, and extinction inevitable.

ALTHOUGH extinction is thus often an inevitable part of evolution, one need not conclude that naturalists and conservationists should give up their efforts to preserve the many surviving species—not only animals, but plants as well—that are increasingly threatened today. The majestic California Condor, in the North America of 15,000 or 20,000 years ago, fed on the remains of mastodons and giant ground sloths, sharing its repast with Sabre-toothed Tigers and Dire Wolves. Of these Pleistocene giants in North America, it alone survives, although now reduced to a remnant of sixty or so individuals. Yet, given proper protection and management, there is no reason why it should not delight the eye for several more millennia.

How can such rare birds be preserved from extinction? Greenway shows that, although the answer varies from species to species, certain general principles are apparent. Killing must be reduced to the minimum. The Mallard can stand a great deal of hunting; the Redhead much less. The Labrador Duck couldn't stand any hunting at all, and had become extinct by 1875.

Even more important is the preservation of environment—important because it contributes to the welfare of other wildlife as well, and can be correlated with broader programs of conservation. And the programs must be based upon sound and thorough ecological studies, such as have been conducted in this country, under the sponsorship of the National Audubon Society, by Robert P. Allen, Karl Koford and James T. Tanner on the Roseate Spoonbill, Whooping Crane, Ivory-billed Woodpecker and California Condor.

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ing threatened species by rearing them in captivity. This last resort is perhaps only feasible for prolific species that breed more or less readily in captivity and can then be successfully released in numbers into a wild or semiwild environment. The Golden Pheasant and the Mandarin Duck are examples. The possibility of really helping the Whooping Crane, still less the California Condor, by such means is more dubious. The Passenger Pigeon bred in captivity, but the caged population nonetheless died out. The last individual succumbed in 1914, some fifteen years after the final record of a wild bird.

In summary, this history of extinct birds, as Greenway graphically shows us, attains its significance when the melancholy story of the past, abetted by recent research in genetics and management, is projected into effective programs for preserving the rare species both in the U. S. and elsewhere that are threatened with extinction today.



Feet down for a landing, this one of the sixty or so surviving California Condors was photographed in 1952.

This list details the photographer, artist, or other source of illustrations, by page.

- | | |
|---|---|
| COVER—George Ballis. | 372-3—Asher E. Treat. |
| 348-9—drawings by D. M. Reid-Henry, courtesy of American Committee for International Wildlife Preservation. | 374-5—star map by Henry M. Neely; illustrations by Helmut Wimmer, AMNH. |
| 355—Carl B. Kafard, National Audubon Society. | 376-95—Peabody Museum, Harvard University. |
| 356-65—George Ballis. | 396-403—Garry Salsman and Andy Harrold; diagram by Robert Gartland, AMNH. |
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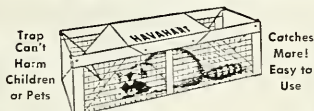
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THE MCGEE FIRE: HOLOCAUST IN CALIFORNIA

This forest disaster left scars that will need a century to heal; but the story it tells is of growth as well as destruction

By GEORGE BALLIS

THE MONTH OF SEPTEMBER, three years ago, will long be remembered in California as a forester's nightmare. Searing, crackling heat conspired with electrical storms, winds and human carelessness to touch off 436 separate fires in the eighteen days from August 27 through September 13. Over 307,000 acres of timber and brush were devoured by flames—the equivalent of a two-mile-wide swath nearly 200 miles long. Timber damage, alone, totaled \$100 million; property damage, another \$3.8 million. Eight persons were killed; state and federal agencies spent over \$3.5 million fighting the blazes. On one day—September 10—over fourteen thousand men were on the fire lines. That September made 1955 the most disastrous year for forest fires of any of the previous thirty years.

Each summer, cattlemen in the Sierra foothills burn off large acreages of brush in an effort to enlarge their animals' range. These are co-operative projects, and ranchers in each area organize "burning committees" for this special purpose.

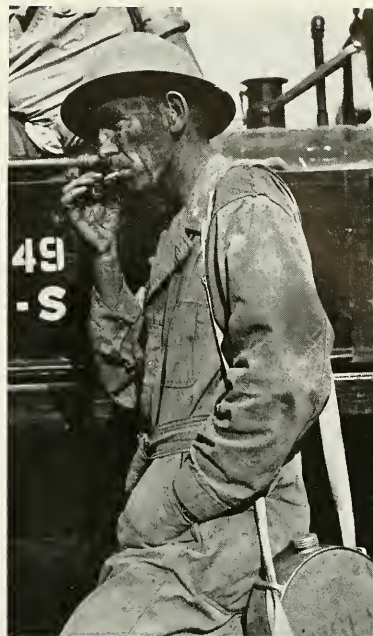
One particular "burn" had been conducted about ten days before Labor Day, close by the McGee ranch,

which is in the vicinity of Kings Canyon National Park, some seventy miles west of Fresno. On the Friday afternoon before the holiday, the controlled brush-burn having been completed, the local burning committee ceased its work.

By nightfall, the same day, a new fire—possibly an escape from this burn—had skipped out of a wide valley in the Sierra Nevada, and was running wild. What follows is an account of that fire and its aftermath.

THE hastily-summoned fire fighters found much against them. Unusual night breezes sucked the flames over a nearby ridge and pushed them into vast stands of valuable timber. With at least two other giant forest fires raging in the state and many people away for the long holiday weekend, men and equipment were almost impossible to find. Undermanned, overpowered and unlucky, the desperate fire crews waged a losing rear-

A free-lance writer and photographer, working out of Fresno, MR. BALLIS spent five days on the McGee fire lines. His account was written with the help of the U.S. Forest Service.



COVERED WITH SOOT, crewman takes a break after week of frantic efforts.

guard action against what was first known as "the McGee fire," and, finally, "the McGee."

In most places, the McGee moved slowly, but relentlessly, through brush and timber. It hopped and skipped from tree to snag to brush to grass. It sneaked over narrow fire lines. Occasionally, a dead-dry tree "blew up," literally exploding into flames, but the fire, in general, was not spectacular. Rather, it was more like a stolid steam-roller of flame, methodically bent on destroying the entire Sierra.

Once in a while, the McGee put on a grand display. Late Sunday afternoon, as one example, the usual up-canyon draft pushed the fire up a slope and managed to blow it over the junctions of Highways 180 and 65. Flames swept round the fire fighters, their water trucks and fire trucks. The men had just enough time to wet down their equipment: neither trucks nor fire fighters were harmed, but the McGee roared on beyond them—uncontrolled. Again, on Labor Day, the afternoon updraft grabbed the McGee, bounced it over a narrow fire break and—in thirty-eight minutes—heaved it three miles through Cherry Gap. A giant smoke pall rose over the Sierras.



GENERAL STAFF meets to chart plans. Map of fire area is tacked up on tree.



CREW REFILLS fire truck at creek in Labor Day effort to stem the flames.



BULLDOZER WORKS vainly to clear fire break as flames move north. McGee was finally halted at Kings River Canyon.

THROUGH the following ten days, the McGee led a devastating and exhausting chase. It burned within a quarter-mile of the famous General Grant Grove of "big trees"—one of the priceless relics of Kings Canyon National Park—and seared through many fine stands of second-growth pines, firs and redwoods. Over 1,300 men—crack Indian crews, specially-trained convicts, loggers, Forest Service personnel, students and migrant fruit-pickers—were hurled against the flames. Supported by a twenty-four-hour-a-day field kitchen, as well as supply and first-aid centers, these fire fighters were directed by a general staff that pored over detailed, up-to-the-minute maps of the fire area and planned the defensive strategy. But it was not until two weeks after its start that the McGee was finally trapped—in the depths of the Kings River Canyon, behind a forty-five-mile-long fire break. Here, a light rain helped snuff it out.

Mopping-up operations took several weeks more, and rangers kept a close watch all the next summer for possible flare-ups from embers that might have been nurtured in dead logs through the winter. A fifty-year-old pile of sawdust at Abbott Mill, as an example, smoldered for almost a year after the McGee was dead.

When it was all over, the McGee had burned off 17,580 acres (12,180 of them in Sequoia National Forest). Of these, 10,160 acres were high-grade commercial forest lands: the McGee had destroyed about 120 million board feet of commercial timber (enough to build twenty-four thousand average

homes). Fire suppression had cost the State of California \$47,000; the National Park Service, \$31,381; and the U.S. Forest Service, \$775,900—a total of more than \$850,000.

NOW, for the part of the McGee story less generally known. The U.S. Forest Service, as soon as the flames had cooled down, let contracts to salvage the area's marketable timber before decay and insects could take their inevitable toll. Much of the area of the McGee burn had been logged of its natural stand of pine, fir and sequoia between 1890 and 1910, while under private ownership. During the fifty years that followed, a vigorous stand of young conifers had become established. Protection from fire had allowed growth to proceed at an accelerated pace, promising early maturity of the well-stocked, well-regulated forest. Salvage work brought out some 35 million board feet of timber from the burnt-over area, and the Forest Service realized nearly \$400,000 on this salvage. A quarter of this sum was set aside for replanting and, at the same time, reseedling was started in areas not likely to develop natural reproduction of conifers.

Other postburn aspects were less encouraging. The soil of the burnt-over area, largely weathered granite, is subject to severe erosion. Following the fire, uncountable tons of precious topsoil were lost in the runoff. In addition, many trees not killed outright by the flames had been severely weakened by the heat. In the ensuing years, these trees have been killed by the attacks



PARTICULARLY DANGEROUS HAZARD, snag is cleared away to slow flames' progress through tinder-like undergrowth.



NEAR ORIGIN OF BLAZE and early in its course, crewman works on Sunday morning. Flames raged northwest from

Kings Canyon, meeting with little initial opposition from fire fighters, busy at other fires or away for holiday weekend.



CRUCIAL SPURT occurred on Sunday afternoon, when blaze blew over a highway within the conflagration area. Crews

had just time enough to wet down equipment and were left unharmed as the flames swept over them and across the road.



GRIM AFTERMATH of the McGee is seen above, at the same site as in the photo opposite. The front of flames moved so

quickly, however, that much marketable timber remained within stricken fire area—some 35 million board feet in all.



BEFORE AND AFTER fire's passage, Cherry Gap wears an entirely different



aspect. Blown by updraft, fire raced three miles in thirty-eight minutes.

of western pine beetle and mountain pine beetle. The beetle population built up alarmingly during this time: by the late summer of 1957, it had reached epidemic proportions. Infestations spread three to eight miles beyond the burn—into virgin timber. A \$30,000 beetle-control project by the Forest Service and the National Park Service was undertaken to slow these attacks. Infested trees were cut and removed to sawmills in the San Joaquin Valley—where the beetles were drowned in the log ponds or burned with the slabs. Nearly four million board feet of timber were removed by lumber operators in the control project, and an additional two million board feet felled and treated with insecticide where logging was not practical. Additional control work will probably be required in the course of this year.

NORMALLY, areas as completely burned as the McGee take many decades—even centuries—to revert back to coniferous cover. Following a burn, annual and perennial weeds become established—from seed remaining in the soil or from seed blown into the area. These constitute the bulk of new growth in the first postfire year. During the first and second years, sprouts develop from the burned stumps of manzanitas, oaks, chamiso and other sprouting plants. *Ceanothus* plants (particularly whitethorn and deer brush) and *Ribes* plants (currants, gooseberries, etc.) become established from seed which has been dormant for many years in the forest floor. Within five to ten years, the burn becomes an impenetrable field of

brush, intermingled with standing snags and a mass of fallen, rotten logs. For as long as twenty years, following a fire, these old burns—with their great potentials as fuel and the attendant difficulty in fire-line-building—remain the bane of fire fighters.

As the dead trees begin to decay and the dense brush develops, seeding-in of pine and fir from the exterior edges of the fire area takes place. These little seedlings have a hard fight for survival—often they do not grow to more than three or four feet in twenty years. But, as the quick-growing brush ages, it loses its vigor. The seeded-in conifers increase their rate of growth and, with time, their roots win the fight for water and minerals, and their tips



break through the brush cover into the sunlight. Then they have the opportunity to grow much more rapidly: within a few years, they will overtop the brush, which eventually dies. At any time before this dead brush decomposes, however, another surface fire can wipe out all progress and force the slow cycle to start over again.

The recapture of a burned area by conifers—as the remaining timber at the fire's edge seeds into the burned areas—may thus be a long, slow procedure. Occasionally, two to four hundred years are needed to bring the cycle round to the point of a fully-stocked, mature forest. In nature, a short cut is only rarely provided. It may be that a fire comes during one of



RAVAGES OF FIRE are also gauged in these two views of same locale. While



some trees were not completely burned, only stumps, ironically, seem the same.

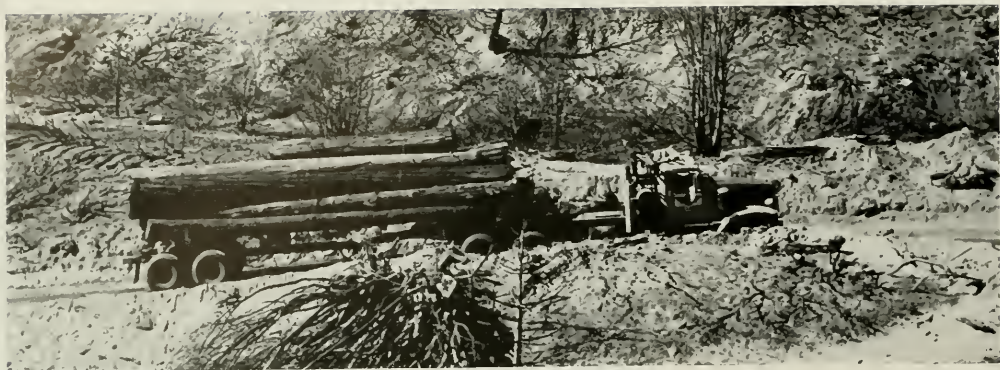


the forest's good seed years. If that happens, and the seed is mature at the time of the burn—early September, usually—the ripe seed (of the thick-coned trees) is usually undamaged, even though a crown fire may kill the seed tree. After burning, the cones open, the seeds fall into the ashes and, the following spring, they germinate. A brand-new forest is then on the way. Such seedling trees can keep ahead of the brush and, within as short a time as seventy years, the cycle to maturity may be completed.

In California, such a good seed year occurs, on the average, only once in five years. The year 1955 was not one of these. On the McGee burn, in consequence, sequoias are the only conifers that are seeding-in naturally and in large numbers. But other short cuts can be provided by man: not unlike efficient squirrels, the U. S. Forest Service collects tree seed in the good years and stores it for the lean ones.

Each year, about five million trees are raised in the Forest Service's nursery at McCloud, California. These trees are grown primarily to replant burned areas. The deeper and more fertile forest soils are planted first, with about 630 trees per acre, equally spaced eight feet apart. These seedling trees are often planted in strips, cleared of competing vegetation by bulldozers, in order to shorten the time needed to return the area to its forested condi-

AMONG FIRST to re-form brush cover after fire are manzanita shoots, left.



SALVAGED LOGS are brought out of fire area after blaze. Government let

contracts to save marketable timber, realized nearly \$400,000 from salvage.



WINDING EGG GALLERIES of western pine beetle are seen on inner surface

of bark. Trees, weakened by heat, fell easy prey to epidemics of insect pests.



RESEEDED GROUND is inspected two years after fire. Planting is done in

strips previously cleared of competing growth. Right, strong Jeffery seedling.

tion. On the McGee burn, about 1,200 acres—or less than ten per cent—have been replanted to date. Such a percentage may seem small, but tree-planting costs an average \$50 an acre. It is a difficult, back-breaking job. Mechanical planting has not yet been perfected for the steep mountain slopes, so present work is all done by hand. Survival of the planted trees in the McGee area has, in general, been good. Some trees have died because of poor planting or insufficient moisture during the long, dry summers: rodents and deer also take their toll. Where the mortality rate proves too high, second or fill-in plantings are made.

Nearly three years have passed since the McGee roared over these central Sierra slopes. This is only a moment in the life span of a forest, and the burn is still ugly and desolate: vistas of blackened tree skeletons—patched with white now and then, where the dark bark has fallen off. Most oppressive are the views to be found where the hot explosions blew through—along Highway 180 at Cherry Gap, and again near the junction with Highway 65—where the saw timber has been removed and the slopes are littered with logging slash.

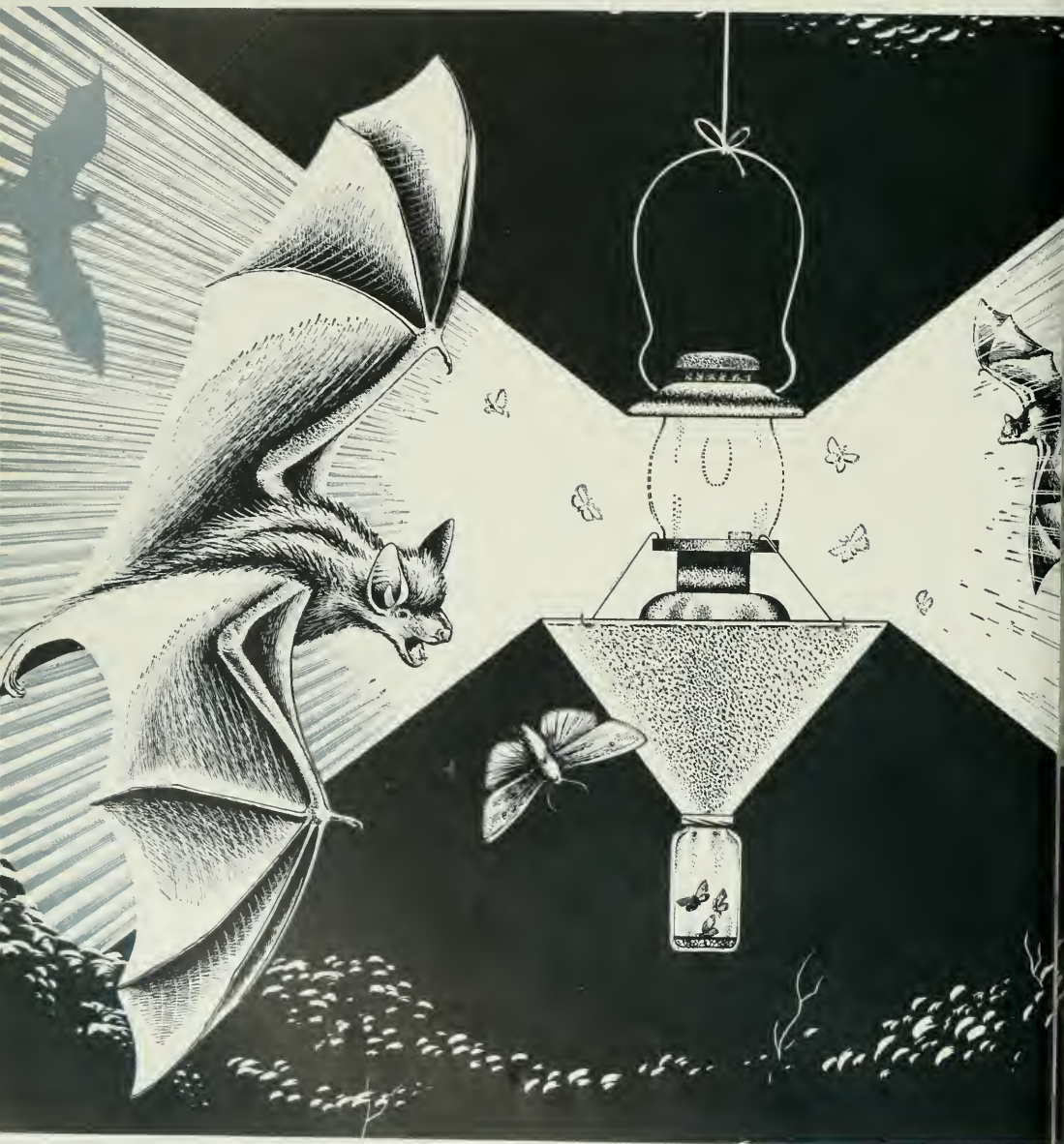
But a close inspection of the McGee is more heartening. The seedlings planted by the Forest Service—young, strong trees—are taking hold. Although many acres are not yet reseeded, either naturally or by the Forest Service, the natural reproduction of conifers—especially redwoods—has been a pleasant surprise. Perhaps if nature is kind, man is careful and the Forest Service is lucky in its appropriations, the McGee burn will look like a forest again in seventy years or so.



INSECTIVOROUS BATS, attracted by the moths around collector's lamp, *below*, utter their ultrasonic cries. Certain moths—possessing tympanic organs, or “ears”—are apparently able to avoid the bats’ swoops. Common among these, paradoxically, is the army worm moth—which is infested by a parasitic mite that destroys one of the moth’s ears.

A Case of

This common moth’s “hearing” is



Peculiar Parasitism

often impaired by mites, but their damage is confined to one ear only

By ASHER E. TREAT

IN COUNTRY PLACES where artificial illumination is not widespread, almost any summer night it is easy to attract moths with a collector's light. Bats learn to visit such lights, in search of the many flying insects. As they sweep the air, the bats utter their ultrasonic (and, to us, inaudible) cries—by the echoes of which they not only avoid collision with other bats or with objects such as trees and houses, but also seem able to locate at least the larger insects on which they feed. Very often, at the approach of a bat, one may see a moth swerve sharply from its previous flight path—as though the moth had detected danger and was responding by some sort of "evasive action."

This "evasive" behavior is observed only among those species of moths that possess tympanic organs, or "ears." It has been shown in the laboratory that these tympanic organs are actually capable of being stimulated by the bats' ultrasonic cries. It is therefore commonly inferred that what we shall call the "ears" of these insects, whatever other function they may have, are of adaptive value in escaping such predators. The additional laboratory-established fact that flight movements of such moths may be induced, inhibited or altered by artificial ultrasonic stimulation, appears to support this inference.

Among the "ear"-equipped moths, the army worm moth (*Pseudaletia unipuncta*) is a common species. Even in normal years, its number in light-traps often exceeds those of any other species. It seems astonishing indeed that this very group of moths is often host to a group of parasitic mites that infest the moths' ears, and destroy tympanic membranes! Even more astonishing is the fact that these mites occupy only *one* of the moth's two ears, while the moth's other ear is left unoccupied and undamaged.

These mites are of the species *Myrmonyssus phalaenodectes*. They are only one of a number of primitive

arachnids that are parasitic on insects. Among other insect-inhabiting mites, it is usual to find the animals distributed equally, and with great precision, on the two sides of the host's body. But *Myrmonyssus*—the only one that destroys the auditory organ in the course of its occupation—has colonies that are strictly unilateral. One might be tempted to say the *Myrmonyssus* "knew" that their own survival was linked with the life-expectancy of their host, and even that they went to some pains to avoid the total destruction of the unwitting moth's valuable auditory sense.

Since we are unwilling to grant such intellectual powers to a creature only a quarter of a pinhead in size, we must suppose, instead, that selective pressures have somehow established in the mites' inheritance a tendency to congregate in only *one* of the moth's ears, regardless of how many parasites are present. But it will not aid our understanding glibly to dismiss this inherited behavior as "instinctive." What are the sensory cues and the motor responses by which this behavior comes about? How have these responses been evolved?

The study of animal behavior is full of such questions, few of which can be answered in full. In most instances, the experimental approach to such problems, in itself, requires removing the animal from its natural surroundings and placing it under more or less controlled artificial conditions. In the case of the moth ear mites, fortunately, we are afforded an unusual (although by no means unique) opportunity to observe an animal, throughout its life cycle, in a natural environment of its own choosing. To be sure, the fact of such observation presupposes some modification of the natural environment, but less, perhaps, than is necessary in most such studies. For example, one must illuminate the moth in order to see the mites. In species that have eyes, this might be expected to alter normal behavior. But the moth ear mite is eyeless, and is apparently unaffected by light so long as it is protected from excessive heat.

WE MAY start the life cycle of the moth ear mite at that stage in which a single, gravid female is about to begin egg-laying. Engorged with the juices of her host, she is at



GRAVID FEMALE *Myrmonyssus*, above, is ready to deposit her egg—visible

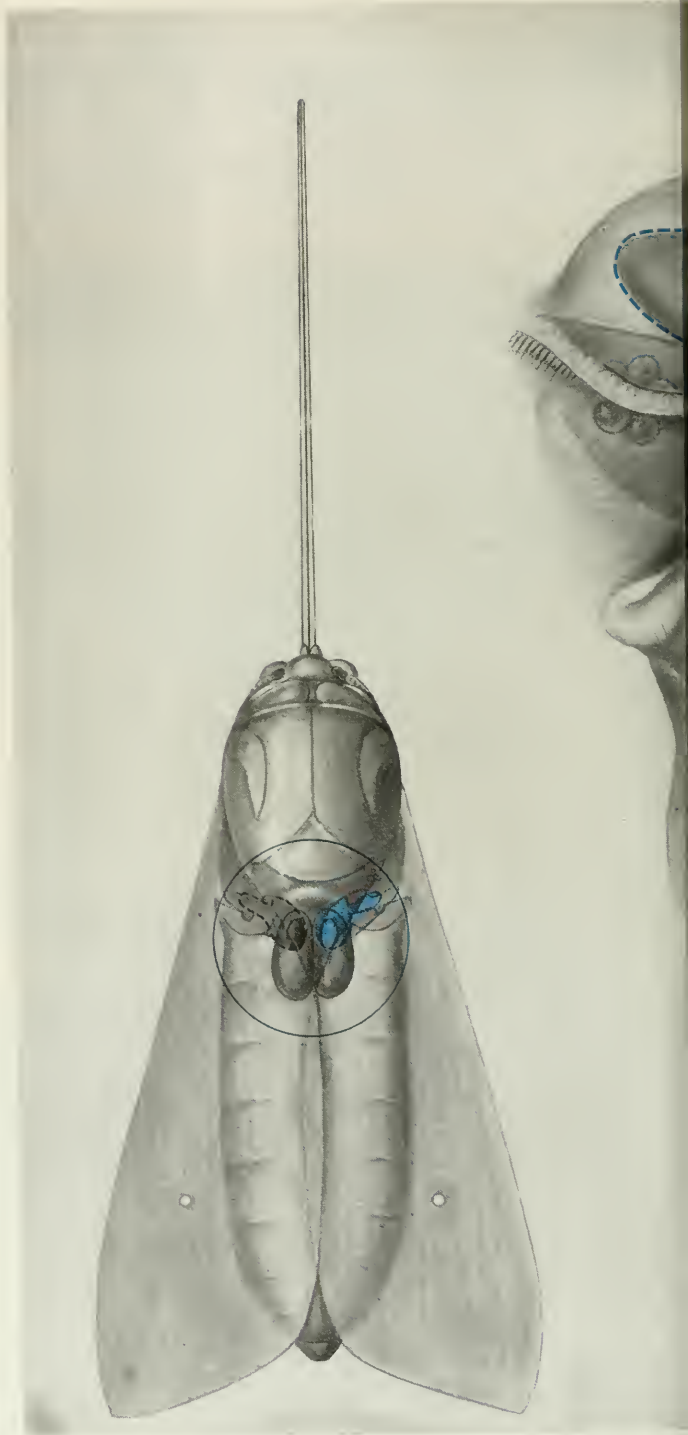
as a faint oval at rear of the mite's half-millimeter-long, translucent body.

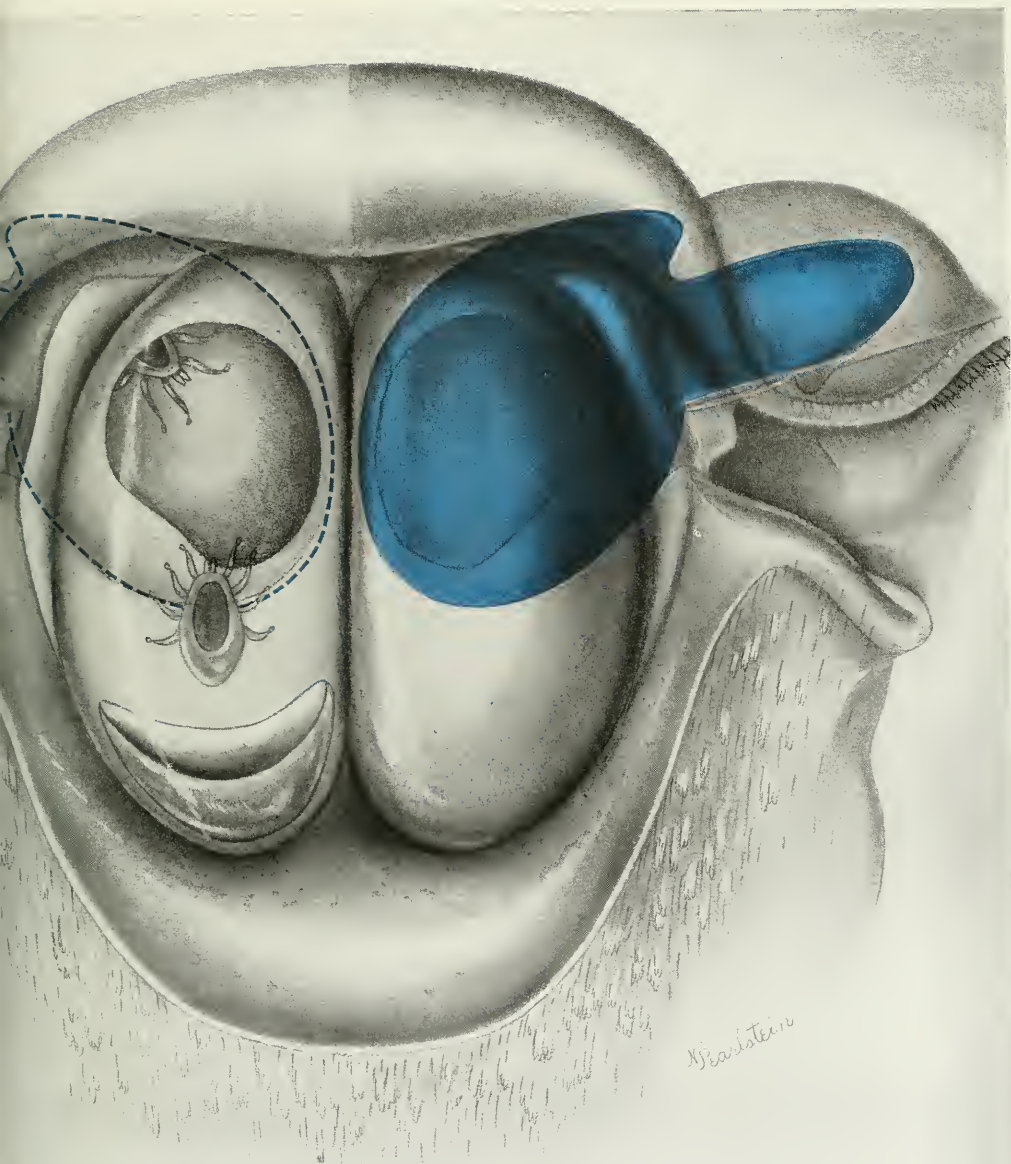
rest in the "inner room" of her "three-room apartment" (illustration opposite). This room is the tympanic air sac—a thin-walled enlargement of the moth's tracheal system, in the dorsal portion of the thorax, just beneath the base of the moth's hind wing. She has previously forced her way into this "inner room" by puncturing the tympanic membrane, or eardrum, that separates the air sac from the moth's external tympanic recess. This external recess—"the porch of the ear," a depression that opens to the exterior and is bordered by long hairs and scales—is situated above the base of the moth's hind leg: in our analogy, it is the "outer room."

THE "upper," or third, room open to the gravid mite is a transparent, eggshell-shaped structure known as the countertympanic cavity. This upper room lies just beneath the upper surface of the moth's first abdominal segment and has an external opening above the "roof" of the external tympanic recess. Inwardly, this cavity faces the air sac, but is normally separated from it by a circular membrane. When the mite has perforated this membrane, as well as the true eardrum, she can move about "indoors," as freely as her bulk will permit, from one to another of the three chambers. The nervous portion of the moth's ear—once draped across the air sac, with its outer end attached to the eardrum—has been destroyed by the mite's previous movements. The moth is thus deaf in one ear.

Before laying her first egg, the gravid female mite prepares a site to receive it. Most often, this is a soft white area of the hind wing's lower articular membrane known as the conjunctiva, that is most readily available from the outer room. The gravid mite attacks the soft cuticle of the conjunctiva with her mouthparts—pinching, kneading and scarifying it at the chosen site. The spot prepared, she withdraws to a deeper part of the ear and rests for a few minutes. Then she returns to the roughened place and, after some straining movements, produces a large, pearly egg, almost half her own body size, from the genital aperture that is located in the middle of her ventral surface.

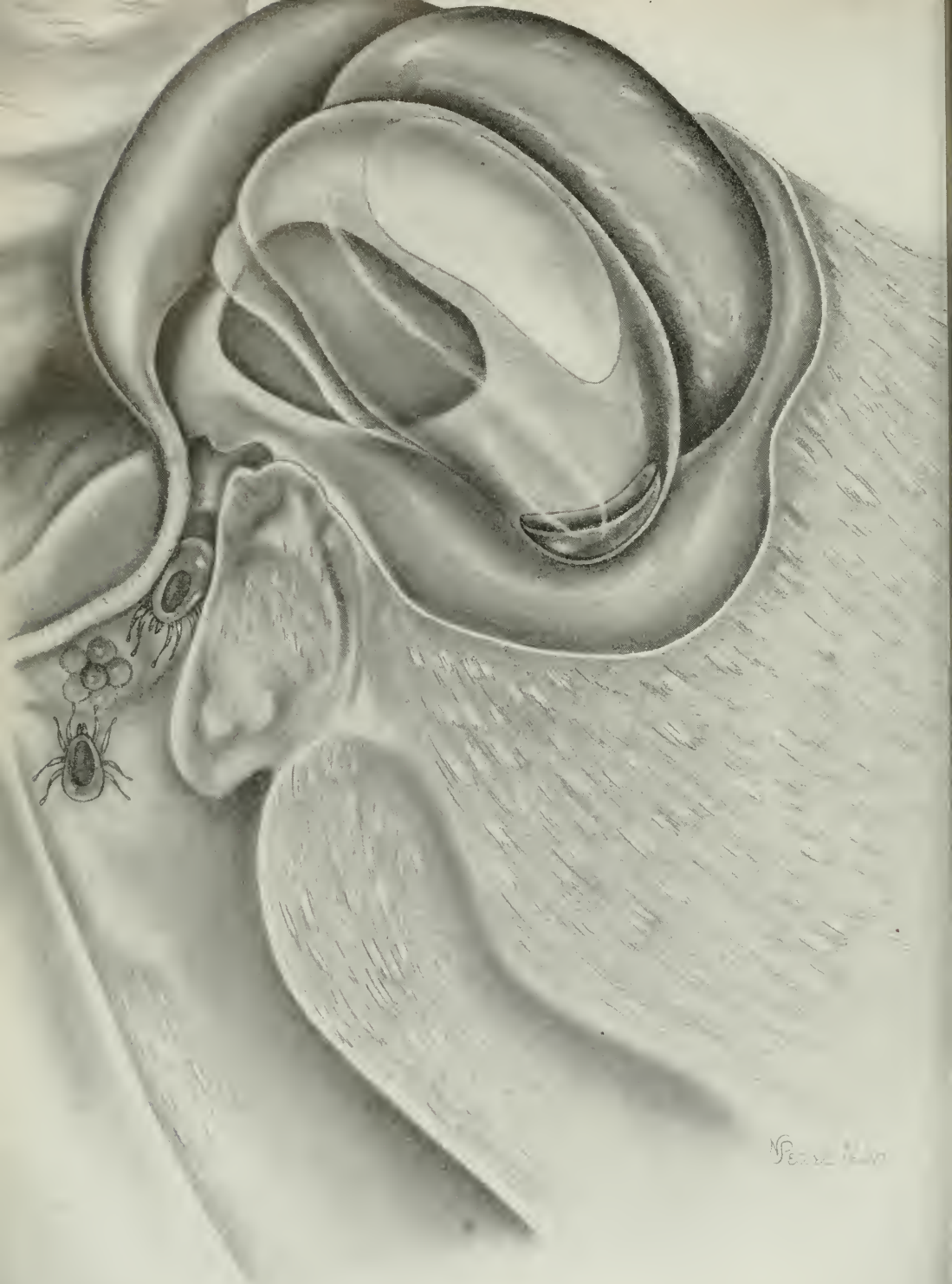
Quickly, she passes the egg forward beneath her body, and deposits it on the prepared site with her forelegs and palpi. She rocks it back and forth,





ARMY WORM MOTH'S TYMPANIC ORGANS are found beneath the wings, at juncture of thorax and abdomen (tint, *left*). In cutaway view, *above*, "inner rooms"—tympanic air sacs—have been outlined in color. Oval "upper rooms"—pair of countertympanic cavities—lie above these air sacs. On inhabited side, *left*, cluster of mites' eggs marks "outer room"—the external tym-

panic recess. Entrance to interior chambers on this side has been achieved by destruction of both tympanic and countertympanic membranes, but colony has left opposite "ear" untouched. Mites visible, *left to right*, are protonymph, in air sac; immature female, entering cavity; and male, within cavity, resting just forward of a plug of mites' consolidated fecal matter.



Ferris

PROFESSOR TREAT, a native of Wisconsin who now teaches biology at CCNY, first encountered *Myrmonysus* in 1952 while doing research on the tympanic organs of Lepidoptera.

stroking it with her mouthparts as though smearing it with some secretion. This she may actually do, for the egg adheres to the conjunctiva as though cemented in place.

If the weather is warm, the female mite may lay another egg about two hours later, then another and another at about the same interval until, at last, ninety or more have been deposited. Each time the procedure is much the same. A spot is prepared and then revisited for oviposition. As a rule, the eggs are placed side by side, so as to form a neat pavement upon the conjunctiva. As available space becomes limited, the eggs will be laid elsewhere—in the air sac (near the entrance to the countertympanic cavity), or around the periphery of the external tympanic recess.

From time to time, the egg-layer pauses to take nourishment from any point where the host's membranes are soft enough to permit her mouthparts to penetrate. The moth shows no sign of distress during the process. At this, as at other times, the moth tolerates its mites with no apparent recognition of their presence. By the same token, the mite appears undisturbed by the occasional strong vibrations of the moth's thorax caused by the activation (under restraint, of course, during observation) of the moth's flight muscles. In the visual blur created by such movements, the mite may be seen doing precisely what she was doing before the vibration commenced and what she will continue to do when the moth ceases its wing action.

THE mite defecates only at one of two places in its "apartment"—so situated as to produce minimal fouling of the area. One of these spots is the extreme posterior end of the countertympanic cavity, where a waxy plug of brownish yellow fecal matter gradually accumulates. The other is the ventral periphery of the "porch of the ear." Here, the shrinking fecal droplets adhere to the moth's hairs and gradually produce a mat, or thatch,

which eventually covers the tympanic recess and conceals it from external view, unless removed by the observer or detached accidentally by wing or leg movements of the moth.

If, while this first female mite is producing her eggs, another female of the same species should enter the tympanic area, a sort of contest develops between the two. The invading female persistently approaches the inner room's doorway—the perforated frame of the eardrum—while the occupant female just as persistently blocks the newcomer's entry. No matter from which direction the intruder advances, the firstcomer is there, blocking the entrance with her own body, fending with her mouthparts, and often exhibiting a peculiar side-to-side jostling movement that seems effective in excluding the intruder. Such a contest may go on for an hour or more but, at length, the blocking actions become feebler, and the newcomer gains access to the inner parts of the ear.

It seems inevitable that this should be the eventual outcome, for—as we have noted—the external orifice of the countertympanic cavity (just above the porch roof) offers an alternate route for the intruder, and both routes cannot be defended simultaneously. That such defensive actions actually represent some sort of rudimentary territoriality is further suggested by the fact that the behavior may be induced in a brood female by artificial stimulation with any foreign object, such as a fine bristle. Yet this blocking behavior seems limited chiefly to the earlier stages of egg-laying and to situations in which the egg clutch has been started by a single female, rather than by several simultaneously. Later, many gravid females may assemble in the ear and contribute continuously to the egg mass without exhibiting any mutual hostility. Even more noteworthy is the persistence of new arrivals in seeking entrance to the occupied ear chambers. In every instance, the newcomer would have but a short way to travel to find an unoccupied ear in which to found its own colony. Yet this does not happen.

In mid-summer, when the mites are most abundant, the moth ear will com-

monly harbor compound colonies—consisting of two to ten gravid females and their offspring. The mites become so closely packed that movement is difficult. Even though all three chambers of the chosen ear may be filled to overflowing, the ear of the opposite side remains deserted. Experimentally, bilateral colonies have been established—by transferring some females to the moth's opposite ear, or by placing females simultaneously in both ears of a previously mite-free moth. But in more than a thousand natural infestations, only two have been found in which both ears were occupied.

TO return to our life cycle, the eggs—once deposited—receive no special care or attention. During mid-summer, they hatch in about two days. From each egg there emerges, rear end first, a tiny, transparent, larval mite with three pairs of legs. Slowly, clumsily, guided by cues still unknown, the larvae make their way from the porch into the tympanic air sac. There they feed, penetrating the moth's delicate tracheal epithelium, until ready for their first molt—which transforms them into protonymphs, with four pairs of legs and a pair of external breathing pores. Soon the second molt occurs and they emerge as deutonymphs—much like the protonymphs in appearance, but larger.

As the young mites develop, their feeding punctures blacken the walls of the air sac with the coagulated haemolymph of the host. Occasionally, a mold may invade a colony, destroy many of the mites, and even penetrate the damaged flight muscles adjacent to the tympanic air sac. Otherwise, injury to the host does not seem severe.

A few of the deutonymphs transform into males—small but stout, thick-legged mites, with mouthparts specialized for the transfer of sperm packets to the females. These males typically assemble in the upper room, the countertympanic cavity, and thither the potential female deutonymphs also make their way. Some minutes before the final transformation of the female deutonymph, the male has already embraced her. As the nymph's cuticle is shed, the female emerges rearward and the male shifts his position to her ventral side. By the time her forelegs are withdrawn from the old skin, he has transferred his sperm packet and impregnation has been accomplished.

PERSPECTIVE VIEW of mites' domain, left, shows first settler in position at ruptured eardrum, thereby blocking passage of new arrival into tympanic air sac. After an hour, newcomer will win entry. In mid-summer, females and offspring may overflow the inhabited ear. But only twice, in over thousand cases studied, was other ear occupied.

THE young, impregnated females may linger for a time about the moth's general tympanic area, but before long they leave the parent colony and push their way forward among the hairs of the host to the neck and collar region. Here, well concealed in the moth's hairy vestiture, they feed intermittently, but not to a level of full engorgement that would hamper their movements. As more and more females assemble in this region, the host may fairly swarm with mites. Both sides of the moth's head, neck and shoulders are occupied, but its one functional ear is still left untenanted.

At intervals—perhaps especially when the moth is nocturnally active in feeding—the young female mites congregate on the ventral side of the moth's head and neck, especially between the palpi. If we uncoil the moth's proboscis at such times, a number of the mites may be seen at its base, always with one leader facing forward and waving its forelegs much as an insect does its antennae. If, at this stage, a foreign object (such as a fine needle) is presented, the leading mite and a few followers may abandon their host and board the object. If

what is presented is a fresh flower, such as a milkweed blossom, a dozen or more of the mites may scramble on to it. Such mites, known as "wanderers," represent the infective stage of the parasite.

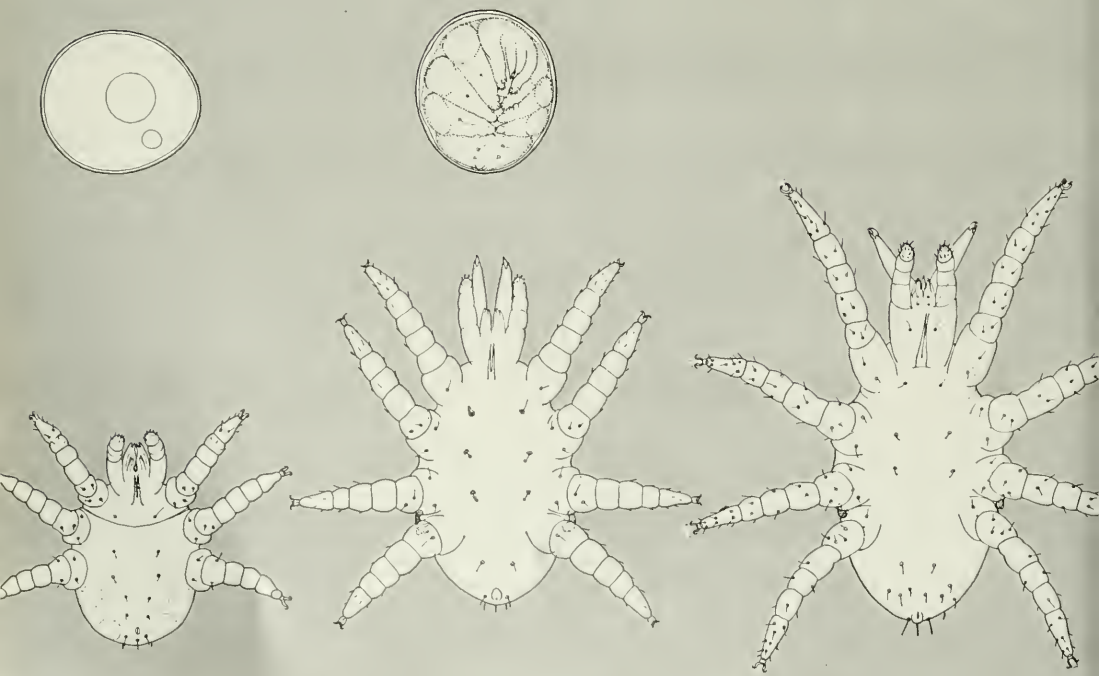
The evidence so far available suggests that the transfer of mites from moth to moth, via the flowers upon which these insects feed, is the usual means of the parasites' dispersal. If allowed to feed upon a flower containing wanderers, a mite-free moth of the genus *Leucania* (or of the closely related genera *Aletia* and *Pseudaletia*) is almost certain to become infested. Noctuid moths of other species are attacked more rarely.

Once aboard a new host, a wanderer mite does not go immediately to the ear. Even if placed in an ear, the wanderer will not always remain there. Instead, its first destination is the collar region on the top of the moth's prothorax. Although it is impossible to say with certainty how the wanderer is guided to this region, a reasonable surmise is that it is oriented by the direction or "lay" of the moth's hairs and scales. At any rate, the wanderer's path lies deep among the bases of these structures and, in its progress toward

the moth's collar region, and after its arrival, the mite moves hesitantly, with repeated sharp jerks which seem to adjust its position with reference to the hairs that surround it.

After an hour or more of rest and desultory feeding in the collar area, the wanderer shows a sudden increase in its activity. Coming to the midline at the forward border of the moth's thoracic disc, the mite parts the moth's long hairs, as one might push a way through a forest of tall reeds. Proceeding in this manner, the mite moves quickly to the rear along the midline, leaving behind a furrow of parted hairs, until it reaches a point just midway between the moth's two ears. There, if the wanderer is the first mite to arrive, it hesitates for several minutes, probing this way and that until, at last, it creeps one way or the other and enters the corresponding ear.

The wanderer remains in this ear for only a few minutes, however, and then returns again to the midpoint—the "crossroads," where its first "choice" of ears was made. Again there is a period of probing, after which the mite returns to the ear first visited. During the next hour or more this retracing of steps from ear to



"crossroads" and back is repeated eight or ten times—always with the same result. The opposite ear is not visited. At last, the mite—having "enlarged" its home by destroying the two membranes—settles down to the business of egg-laying, and the cycle is complete. The actual act of piercing the membranes, which must take place at this time, has never been observed. In warm weather only eight to ten days have elapsed from egg to fertile adult.

IF several mites board the same moth—all at once or in succession—the procedure of each is like that already described and, until each has reached the "crossroads," there is no indication that its behavior has been influenced by the preceding wanderers. At the crossroads, however, these latecomers seem to find a clue of some sort which guides them to the occupied ear. Is this a trail, left by the first arrival as she re-treads her path to the crossroads and back? If so, why does she resist latecomers when they try to enter?

Many questions here remain unanswered, but on some points the picture is clear. For example, we know that no mite is congenitally right- or left-

handed. A mite removed from the right ear of one host may go to the left ear of another even when both ears of the new host are unoccupied. Right-ear and left-ear mite colonies, moreover, are of nearly equal occurrence both in the case of experiments, and in natural infestations.

Although the mites regularly spare one ear of their hosts, their motives are surely not altruistic. It is unthinkable that a hundred mites could be nourished to maturity within eight or ten days without some injury to the host. Discernible damage to the flight muscles is relatively slight, yet the moth must be in some degree less competent than its uninfested fellows in motor, as well as in sensory, capacities. Nevertheless, under laboratory conditions, infested moths live about as long as uninfested ones and show no obvious impairment in feeding, movement, or reproductive capacity. Evidently these parasitic mites have "learned" to get along while doing

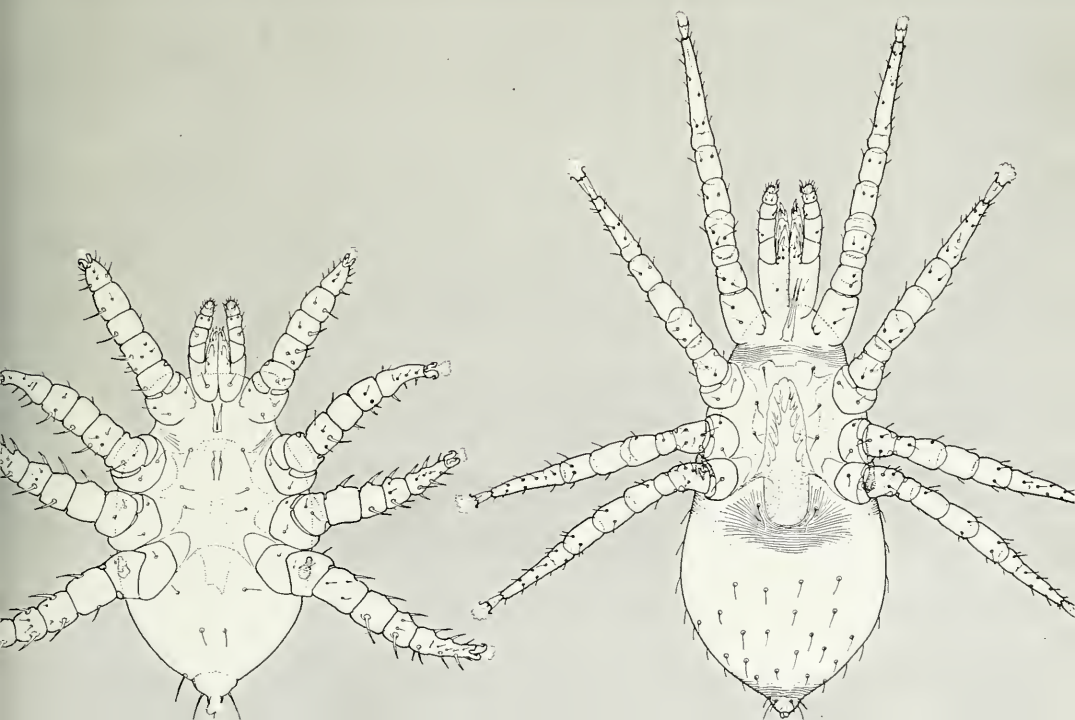
a minimum of damage to their hosts.

What is the basic cause of unilaterality? It is unlikely that the attraction of the latecomers to the occupied ear is the result of the activities of the first mite within the ear itself. Neither experimental perforation of the membranes nor the placing of mites' fecal matter—abundant under natural circumstances—in one ear of an uninfested moth will result in that ear being occupied by transplanted mites in preference to the other.

Yet, whatever the sign that is followed, it must be clear and unmistakable, for mistakes virtually never occur. This sign remains unknown at the present, but it seems probable that, when we know what it is that governs the reactions of latecomers at the "crossroads" we shall have the answer. Moreover, that answer should tell us the precise stage of behavior at which the evolutionary influences that have led to this remarkable condition of unilaterality have become effective.

MITES' DEVELOPMENT includes stages shown here. At top, *left*, are egg and embryo. Next, in ventral aspect, *left to right*: a mite larva; a protonymph; a deutonymph; thick-legged male; and,

finally, engorged female. The females, impregnated at once, gather at host's head, whence some transfer to flowers when the moth feeds. Uninfested moths may then acquire mites when they feed.



SKY REPORTER

By HENRY M. NEELY



SEPTEMBER brings us the Harvest Moon, as that full moon nearest the autumnal equinox is called. This year, the equinox falls on September 23: the moon will be full at 5:43 P.M. (EDT) on September 27. But what is the Harvest Moon? The phrase dates back to early England, and derives from the fact that, in the harvest season, when farmers may need to continue their work past sunset, there occur several successive nights with bright moonlight through all the hours of darkness.

As the illustration, *above*, shows, the light of the full moon, while far from dazzling, is some nine times greater than the illumination of the "half-moons" we see at the first and third quarters. Actually, an area of the day sky, equal in diameter to the full moon, gives twice as much light as the full moon, itself. But these consecutive nights of autumn moonlight helped the reapers get their crops in before the frost.

How do these full nights of bright moonlight come about? The answer lies, primarily, in the angle that the moon's orbit makes with our horizon (illustration, *below*). On an *average*, in the mid-latitudes of the U.S., the moon rises some fifty minutes later each night (it is convenient to remember that a full moon always rises about sunset). But the angle of the moon's orbit varies, in relation to our horizon, from an almost vertical intersection to an almost horizontal one. The variations in this angle, in turn, bring changes in the time it takes for the earth's rotation to expose the moon to view on each consecutive night. An added factor, of less importance, is the rate at which the moon crosses our field of view: when closest to the earth (perigee), it travels the fastest and, when farthest away (apogee), the slowest.

In the example, *below*, the dotted line represents the moon's orbit in March of this year, near the time of perigee. Then, the combination of angle and speed made moonrise come an hour and fourteen minutes later each night. The dashed line shows the moon's orbit on the September, 1953, dates shown, as it approaches apogee (September 29). On each successive date, moonrise will be only half an hour later than the day before.



AUGUST TIMETABLE

First week	1:30 to 2:30 A.M.
Second week	1:00 to 2:00 A.M.
Third week	12:30 to 1:30 A.M.
Last week	midnight to 1:00 A.M.



SEPTEMBER TIMETABLE

First week	11:30 p.m. to 12:30 a.m.
Second week	11:00 p.m. to midnight
Third week	10:30 to 11:30 p.m.
Last week	10:00 to 11:00 p.m.

HUNTSMEN OF NYAE NYAE

The !Kung still practice man's oldest craft

By JOHN MARSHALL

HUNTING is the work of men. !Kung hunters range the land, seeking the agile game. The men walk rapidly, never lowering their eyes, making sure of the awkward ground with their dextrous feet. They glance swiftly over the distances of the country and, with their good vision and knowledge of what to look for, see any moving thing. As girls learn gathering, boys learn most of hunting on their own. They hunt little birds in the grass around the *uerft* houses. They impale beetles with tiny arrows shot from toy bows. Tracking, which is the most difficult part

of hunting, is learned last of all. Hunters must be able to recognize the spoor of one wounded wildebeest out of a herd of fifty, and follow that track across desert ground which is almost as hard as stone.

The usual techniques of hunting are well adapted to the Kalahari terrain and, except on rare occasions, do not change—no matter what the animal may be. The !Kung hunt an eland and a duiker in the same manner: the idea is to get to the animal just as quickly as possible. The hunters feel that the longer they creep and wait, the more time the



CHIEF WEAPONS OF !Kung are bow and poisoned arrows (in quiver, above).

At end of chase, with quarry stricken, spears may be used on big game, right.



animal will have to decide what to do. I have seen a man, using this principle, run crouched across a perfectly open flat, with grass no higher than his knees, and come within twenty yards of a wildebeest who was watching him all the time. Of course the men use cover when they can, but they use it quickly and deftly, keeping on their feet and running bent and bunched so that their arms will not wave and attract unnecessary attention. Although their arrows are true and straight, they are unfeathered and therefore not very accurate. At fifty yards, a !Kung hunter can only feel sure of hitting a kudu somewhere.

Among the less frequently used techniques of hunting are trapping, the use of blinds built near the pans (manned at night during the rains) and a technique of running down fat elands in the dry season when, what

MR. MARSHALL has participated in all six expeditions to the Kalahari by Harvard's Peabody Museum. Two of the expeditions were in association with the Smithsonian Institution.

with the heat and exertion, the portly animals suffer a kind of stroke and have to take to the shade to recover. There, puffing and dizzy, the exhausted elands can be butchered by the deep-breathing hunters.

The trap is a spring-pole snare, of which exists a small version for birds and a larger version for small bucks. Such trapping is usually practiced only by young boys, and even they seem to do it rarely, so that what could amount to an important food source is neglected by the !Kung. The men would rather be gone after the big game, absorbed in the heat and chance of hunting.

than to be squatting around the edges of the pans, making little guises with sticks and string into which guinea fowl invariably fall.

The technology of hunting is the most complex in !Kung culture, and the most involved aspect of that technology is their amazing poison. Without it, the little unfeathered arrows, driven by a light bow, would be useless against big game. With the poison, a !Kung hunter could kill an elephant although, perhaps fortunately, for both, the two seldom encounter one another.

THERE are four kinds of poison—a root (which is rarely used), two grubs and the pod of a tree. One of the two kinds of grub is the larva of an unidentified beetle that lives in a bush; the other is the larva of a beetle that lives in certain Murula trees, identified as *Diamphidia sim-*



HUNTER'S BOOTY, in addition to meat for the pot, includes much-needed raw

materials for !Kung economy. Skins of smaller animals are cut into the breech-

cloths worn by the men, and, above, are sometimes ingeniously peeled off,

plex. This identity, however, is complicated by the presence of still a third beetle, a parasitic one that apparently lives on the grubs of *Diamphidia simplex*, so that it is not now clear which is the poisonous grub. The Bushmen are aware of the parasite and feel that its grub does contain poison. They say it "runs around and runs away." They may be speaking of the beetle, for it is difficult to imagine a grub running, and the grub may be so similar to the young *Diamphidia* that the !Kung simply confuse the two. Lastly, still a fourth insect—smaller, and hairy—said to become easily inflamed, is occasionally encountered among the grubs. It is possible that this is the insect that has a poisonous larva: in any case, somewhere in the community is a poisonous grub, and how the Bushmen found it we have no idea.

Assuming *Diamphidia* to be the



BAGS FOR FOOD, above, like eggshells for water, give !Kung some freedom in

moving. Food may be brought to water or water carried far into the desert.



almost in one piece, and turned into bags, with the legs serving as straps.

poison-bearer, its cycle is somewhat as follows: the beetle lays its eggs in the *Murula* tree leaves. Hatching in the rains, the grubs migrate down the trunk, progressing through a number of growth stages. Finally, they make their cocoons under the ground near the tree. In these cocoons, they struggle through metamorphosis and emerge as small, bravely-colored beetles in the New Year's rains, providing the Bushmen have not already dug them up. The hunters know the particular trees frequented by the beetles and make expeditions to them at least twice a year to replenish their supply. Then the grubs are dug up, and used on the spot or kept in their cocoons, depending on the man's needs.

The poisoning of !Kung arrows is a long process, with a number of variations. The most common poison is a mixture of the grub and the previously mentioned tree-pod. The grubs are crushed and the pod is warmed until its contents melt slightly and can be crushed with the grubs. This mixture is thinned with the copious spit which results from chewing any of a variety of barks and is then smeared on the foreshaft of the arrow—but cleaned immaculately off

the point, for the slightest prick, the least bit of poison getting in such a wound, would cause death.

Depending on where the poisoned arrow hits, a small buck can die in a morning, a man in a few hours, a giraffe in four to five days. There is nothing that can be done for a man, short of amputating a limb or immediately excising the wound and cutting the nearby flesh to let the blood drain. Yet, the poison has no effect upon the game's meat. One can even eat the mixture with relative impunity: it must enter the bloodstream directly to be deadly.

As subsistence activities, the men's and women's roles—hunting and gathering—are of unequal weight. Almost eighty per cent of the people's food is *veldkos*, more abundant than game in *Nyae Nyae*, and far more easily acquired. If from one summer to the next, a man kills twelve antelope, he feels he has had a good year.

But, despite its relatively minor subsistence value, hunting is extremely important in !Kung culture. It has developed its body of technology, acquired a large tradition of beliefs, fostered a wealth of knowledge, and



MEAT FROM THE CHASE is shared by all among the band. An old woman, *below*, is skinning her portion of an ostrich.

LARGE HIDE IS STAKED OUT, *above*, to be cured. This may become a cloak (*kaross*), the most important !Kung garment.



become both the measure of a man's ability and a test of his readiness to marry. Part of the explanation may come from the passion in hunting. Like their fires, the tales of hunting burn brightly for the !Kung in the night, warming their memories. Of equal or greater significance is the !Kung craving for meat and undoubtedly for protein. Unlike the sharing of *veldkos*, limited to the nuclear family, a complex system of distribution insures that everyone in the *uerft* will get a share of all game killed. This is done, they say, simply to prevent jealousy and the inevitable renunciations that go with it. The !Kung declare "We are a jealous people" and they try to keep jealousy at a minimum, for they fear it.

Still another aspect of hunting—perhaps the most important in terms of subsistence—is the by-products it provides. Sinew is used for thongs

and bowstrings, horn makes spoons and small containers: most needed of all are the skins—converted into bags and nets for carrying, and into clothes. Men wear only a breech-clout. Women wear modesty aprons, often one in front and one behind, as well as a piece of soft skin, clasped between their buttocks and thighs, when menstruating. Both men and women wear *kaross*'s. The *kaross*, or skin cloak, is the most important garment and everyone tries to have one. If a man has only one *kaross*, and he is a good man, he will give it to his wife and do without—for, to a woman, a *kaross* is essential. In it, she is modest. In it, she carries the roots she has gathered in the day and the baby who must go where she goes. Her *kaross* is her warmth at night, her softness on the cold ground. It breaks the blind wind and roofs away the narrow rain.



IN ANNUAL CEREMONY, *above*, a girl is guided as she lifts a *tsi* nut from the fire. She is now free to eat *tsi* for a year.

FIRE IS MADE, *below*, with a drill. Upright stick is rolled between palms, one end socketed in another piece of wood.

TEN permanent waterholes, as we have seen, occur in two areas—around the ring of pans in the east center of *Nyae Nyae*, and along the eastern border. To the west, beyond the limit of the pans, there is no water in the long dry seasons. Around each permanent waterhole, the *veldkos* near enough to be gathered in a day are considered by the !Kung to be an integral part of that waterhole. This means that such a waterhole includes both the water itself and all the *veldkos* within a circle with a radius of some four miles. This area might be called a certain waterhole's "district," taking its name from the waterhole. When a man mentions a waterhole, he usually has such a district in mind.

Yet neither the *veldkos* in these districts nor the *veldkos* scattered between the districts, nor the game, which wanders, constitute the main





WOODEN WANDS ARE WHITTLED by pair of intent !Kung boys, in preparation for a children's game. Bounced off ground,

the sticks sail through the air for yards. Woodworking and exercise from the game help to prepare future hunters.



POISON IS SMEARED ON arrow's metal foreshaft, but carefully cleaned away

from point. Commonest poison is made of tree pods mashed with beetle grubs.

food resources of *Nyae Nyae*. Instead, these are the *mangetti* and *tsi* nuts. Both are found only far from permanent water. Distance becomes more significant when one thinks not only of miles—but of time, footsteps, heat and carrying capacity. From the nearest western water, it is about twenty miles to a *mangetti* forest. The distance between *tsi* and the closest water is about seven miles. The people calculate their marching ability at about ten miles a day, with women and children, although men can make forty if necessary. They gather food as they travel, for a day of traveling is just like any other day, with children and old people to be provided for.

IN order to exploit the environment successfully, with their limited technological equipment, the !Kung must move from place to place. The calendar of their movements is revealing. In winter, the people are forced to remain near the waterholes,



!KUNG ARROWS ARE SMALL and unfeathered, and the bow is light. But the powerful poison will kill a small buck in

half a day and a giraffe in less than a week. Hunters make their own points, *above*, and can recognize one another's.



HUNTER'S TRAINING starts as childhood play, *above*, and !Kung youths will use anthills as targets and even stalk

beetles as a game. Although their arrows are featherless, adult hunters, *right*, can hit their quarry at fifty yards.

gathering in districts and making occasional trips to places where enough water-roots can be dug to support them for several days. When the "little rains" of spring come to Nyae Nyae, the land usually relents somewhat. Some of the small western and northern pans fill, and a hollow *mangetti* tree may have collected some water. The people, who keep track of conditions throughout Nyae Nyae from the reports of hunters and visitors, try to get to the *mangetti* forests as soon as possible, and bring

back as many nuts as they can carry.

THE "big rains" open the land. People travel to distant places and remove to the *mangetti* forests until autumn, when the *tsi* ripens. Then they remain in the *tsi* areas till the *tsi* nuts are exhausted—which sometimes happens before the small annual waters have evaporated—and finally make their way back to their permanent waterholes.

In such a transient life, the importance of light belongings—and

of ostrich eggshells for carrying water and skin bags for food—is evident. With carrying bags and ostrich eggshells, the people can bring water to food and food to water. Partly because of their life of motion, the !Kung do not accumulate heavy wealth. Infanticide is uncommon among the !Kung, but one of the various reasons for the practice is that a woman may feel she cannot carry another child when the band moves. Then, the baby is born into a tiny grave near the *werft*, and the grave is closed.





!KUNG RITUAL LIFE is sparse, but one means of reaching out to the infinite

is a state of trance that may come in the course of dancing. The man being

supported, *above*, is in such a state. The !Kung believe that a man in trance

THAT the !Kung live in small bands, flexible in their composition and spread widely over their Kalahari world, is owing in good part to their environment and to the technological means by which they cope with it. But the effect of the environment, carrying through the technology, penetrates the structure of the bands themselves and influences the way in which the !Kung distribute themselves around their resources.

The headman of each band is considered to "own" a waterhole. What he is considered to "own" is both the water and the *veldkos* of the district. The ground itself is described as *chi dole*, worthless. Headmanship is hereditary, the headman being the oldest son of the previous headman although, if the male line is cut off for a generation, headmanship is passed through the eldest daughter to her eldest son. But head-

manship is different from leadership, which is not hereditary. Leadership depends heavily on a man's character, his hunting prowess, and especially his ability to focus people's opinions. Usually headman and leader are the same person but, should a headman be too young—perhaps still in his mother's womb—or very old, a band will have a separate leader.

Theoretically, the right to refuse water to members of another band



can take away a person's sickness and throw it back at the god who sent it.

belongs to the headman, although we never saw this done nor did we ever hear of such a thing. Neither leadership nor headmanship implies any overt coercive power over the other members of a band. Only as a sort of coagulation of group opinion can headman or leaders exert a control—which, even then, is not final. The leader, being the kind of person to whom others come when decisions must be made, is often an arbiter, in



When they gather, the men are most likely to discuss hunting—the great

exploits of memory, or plans for the future. For the chase is their passion.



ORACLE DISKS, bottom left, are made from eland hide, in sets of five. The

!Kung often use them to determine the direction of their next hunting foray.



YOUTH'S PLAY is not all purposive. Here, a young !Kung boy is happily engaged in nothing more important to his

future than giving his sister a sled ride on the trampled floor of his band's *verft*, using a scrap of hide, hitched



to a thong. When lived upon, the veld earth soon turns to dust, as seen here. In the rains of the coming year, the

rank veld grass will have grown again across the floor of the deserted *werft*—to toss in the passing, desert winds.



SEATED YOUTH, *above*, enjoys a smoke as his companions make characteristic

!Kung gesture—arm outstretched—to show they also wish a turn with the

pipe. Because the !Kung crave tobacco, but grow none, they must trade for it—

quarrels, a focal point in discussion of plans, a comfort to the bereaved and a strength for those in doubt.

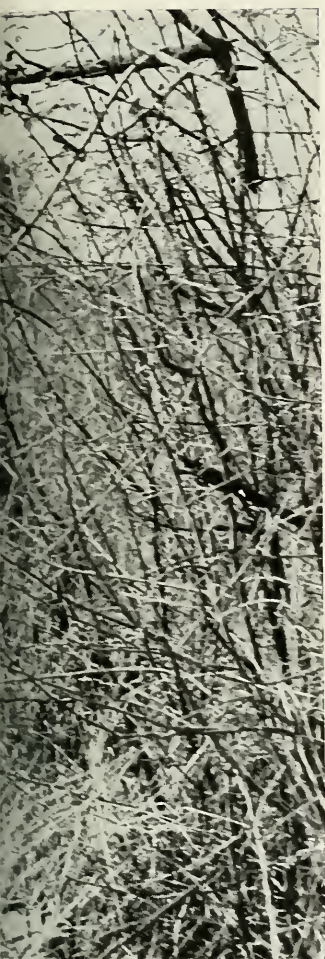
The functions of headman, as headman, are of a different nature. In order to take up residence with a band, a person must have certain ties of kin with members of the band. Such a person may live with his own parents or siblings, or with his wife's parents or siblings. It is a wide choice, providing for flexibility—but within limits. There are, of course, exceptions, and visitors from other bands are never denied, but possession of some kinship tie seems to be a general requirement for residence which,

if violated, would subject the violator to criticism by the band.

SHORT of fighting, all the !Kung can do to control the actions of individuals is to criticize. But this is apparently enough. A man, expelled from his band, *might* be able to survive alone in the desert—with luck, he might even manage for years. If he could persuade his family to come with him, they might survive together even more easily, for the family is the basic subsistence unit. But freshly gone, he would be an outlaw and, in time, become a stranger to his people. This would be an unthinkable

horror to a !Kung! The worst dream might be to see the fires flickering in the *uerft* at midnight and be unable to go to them. All the people we knew could tell us of only one time when such a departure from the group occurred; and the man had gone insane, had murdered and then run raving into the veld. There he had lived for a little while in a hole, then died.

It is in connection with the need to live widely spread over the land that the !Kung headman's functions are peculiar. There is one essential qualification to headmanship, in addition to heredity. A headman cannot leave his waterhole to join another



often disastrously—with the Bantu peoples on the borders of Nyae Nyae.

band and still remain a headman, for he, in his person, does not possess headmanship. It is only when a person is *born* headman, and in association with his waterhole, that he assumes the full authority of headmanship. We have seen that headmen were considered to “own” the water and *veldkos* of a district. I believe this association is another way of expressing what the !Kung mean by “own”: the headman is the symbol of a place.

In the same manner that a headman “owns” a district, he also “owns” other geographical features of the country. These include pans that fill during the rains, *veldkos*



BEFORE MARRIAGE, !Kung youths have few responsibilities. But the hunt is

in their blood and it is a proud boy who kills his first buck early in life.



!Kung parents cherish the children their harsh environment permits them

to raise. A mother, above, fits ornamental headband to her small daughter.



FATHERS TAKE PRIDE in their growing sons, to whom will pass both the task

of hunting for the band and the many skills and traditions of !Kung hunters.

areas, baobab trees, and—most important—*mangetti* trees that hold water in their trunks, and *tsi* areas. It is these “owned” features, and the direction from the waterhole in which they lie, that define a territory. Since, as we have seen, *mangetti*s and *tsi* are the most important !Kung resources, they are the main determinants of a direction.

But animals are *not* owned. Neatly bounded sections of the countryside are *not* owned. A territory, therefore, can best be defined as the combination of a permanent waterhole and a direction; the !Kung so define it by the word “side.” One headman’s territory is said to be on this “side.”

JUST as the Kalahari’s scant resources of food and water are distributed in accordance with a geographical pattern, the !Kung bands are distributed in accordance with both a geographical and a social pattern. Natural resources are the focal points in the geographical pattern of band distribution; headmen are the focal points in the social pattern. In a sense, headmen tie together the two patterns, the concept of headmanship being the embodiment of a certain quantity of resources in a person around whom a band can take shape and operate. Because of their kin ties with a headman, the people living round him, clustering their *skerms* around him and moving with him over his territory, feel right in being where they are.

The headman receives no special privileges. He is no more wealthy than other men. If he is a leader, he may assume responsibility and speak out. But, as headman, he need not speak, for headmanship is a silent office and while the headman lives by his waterhole or out somewhere on his territory with his band—he serves his whole purpose.

Most of the permanent waterholes have two !Kung bands associated with them, and the *tsi* areas are likewise shared by bands from the same and different waterholes. Such sharing may come about because two brothers (only one of whom may be the true headman) live together and feel they possess joint claims. It may come about through the passage of time, which confuses genealogies and lets claims, once tenuous, become firm through usage. The !Kung are a people of present tense, living—in their minds as well as with their



THE ROAD FROM YOUTH TO AGE is a short one among these desert dwellers, as witness the father and daughter here.

It is a sparse life, and the hunter who can count twelve antelope killed in a year feels he has had a good season.



HAPPY LIFE of children includes such moments as these: a laughing game of

"pull-away," above, and the endless elaborations of "cat's cradle," right.

bodies—from day to day. If the water-holes were not shared, some bands would be without permanent water.

Not all !Kung territories are of equal value in terms of food and water. Some people have *mangetti* nuts, some have *tsi*, and some have both. There is mild wealth, and gentle poverty in *Nyae Nyae*. Territories also change in value year by year. The rains may fail in some parts of *Nyae Nyae*, and fall in others. In normal years, *mangetti's* in the north may become available earlier in the season than those of the western forests. Because of the flexibility of band composition, the bands gathering *mangetti's* in such a favored area are enlarged by people who would otherwise have to wait.

This is usually a temporary situation, the newcomers having more the status of guests than members of the bands. Often, whole bands—headman and all—will visit kin in this manner. During years of dessication, the fact that a person has several choices of bands in which to live becomes vital to him—he can move from a hopeless place to perhaps a better one.

By such means, balance works out between the desert's resources and the numbers and distribution of !Kung who exploit them. No one district or *mangetti* forest could support more than a limited number of people. Only certain people possess the necessary kinship qualifications to join a band. The flexibility of their

composition enables bands to swell during lean years, while the concept of association, through a headman, to a district and a territory provides for the distribution of people throughout the barren land.

If a band were confined strictly to one territory, or could use the resources of another territory only over the bodies of the band that lived there, there would be many less *Nyae Nyae* !Kung—perhaps none at all.

The !Kung give various reasons for their preference of the territory they consider home. For some, it is where they were born. For others, it is where they spent their youth. And for some, it is where they are waiting in their old age. Hunters say they must know their territories—every pan and stretch of bush, every unusual tree—and they say that to amass such knowledge takes years. An old man we met while he was visiting for a few days from the west, said that the weather was more gentle in Debera, the place where he lived, and that, moreover, "there are no stones in Debera ground."

Early one autumn morning, blue and sweet, when dawn air was still fragile on our faces, a close !Kung friend stood beside me in Gautcha Territory, looking across a pan that still smiled with water despite the late season. It was the pan where he had come, as a young man, to live with his bride. We were quiet, waiting for the rising sun. "Gautcha is beautiful," he said.







SUNLIT WATERS of Wakulla Spring serve to silhouette the mouth of the great cave, at a depth of 130 feet, out of

which issues the Spring's flow of 183 million gallons a day. Using a system of ropes and pulleys, divers Jenkins,

THE WAKULLA CAVE

Amateur paleontologists investigate an underwater site in Florida

By STANLEY J. OLSEN



left, and Harrold are at work raising one of the cave's numerous fossil bones to the surface. Inverted bag above

the massive find (a mastodon leg bone) has been inflated for buoyancy with air from the divers' breathing apparatus.

THE IMMENSITY of the cosmos that astronomy and its allied sciences present to the general reader, together with the lure of the "unknown" hidden in outer space, has brought a host of new followers to its study. Yet, many unanswered questions still lie locked in the depths of our old familiar planet, Earth. Geology and paleontol-

ogy, earth-rooted as they are, are two fields that offer a comparable measure of "unknown" time to balance the "unknown" space that serves to attract the inquisitive student.

In this day, moreover, few places on the earth's surface are available to the daring soul who wishes to do original investigation in an area never

before visited by man. Yet, the student of the earth sciences need only turn to underwater exploration or to the dry caves of the "spelunker" in order to discover areas that remain as yet unprospected and uncharted.

Much of the earth's strata, and in particular that covered by water, has not been explored, sampled or mapped.

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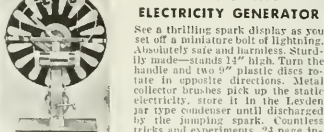
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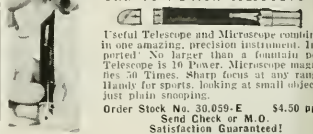


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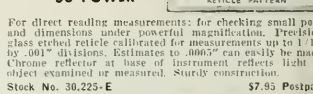
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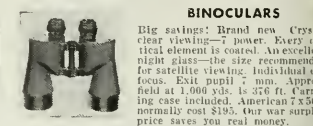
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the ceiling may be as low as a crowded five feet but rises in places to the proportions of an arena, with a height of over a hundred feet. The cavern at first extends in a southeast direction for a distance of some six hundred feet. There, it angles sharply toward the southwest, blotting out the feeble light that had linked the young divers with the outside world.

For its first two hundred feet the cave floor is sand, interrupted by an occasional limestone boulder from some ceiling breakdown of a forgotten age. From a depth of one hundred feet at the cavern's mouth, the bottom slopes sharply downward, reaching one hundred and eighty feet before it levels off and the sand floor gives way to limestone rubble. Soon, the cave continues to deepen.

Three hundred feet further, the depth reaches two hundred and twenty-

MR. OLSEN, a paleontologist with the Florida Geological Survey since 1956, spent the previous decade at the Harvard Museum of Comparative Zoology, collecting tertiary fossils.

five feet. Here, the wall of the cave on one side makes a sharp right angle, while the opposite side opens into a depression, its bottom two hundred and forty feet below surface. Dubbed "Grand Canyon" by the divers because of the layers of clay exposed in bands along its sides, this depression—with chunks of the layered clay in a tumble at its bottom—appears to be a sink hole in the cave floor.

Beyond "Grand Canyon" lies a glistening white sand bar which rises to a depth of two hundred and fifteen feet only to dip back to the natural cave floor. Eleven hundred feet inside

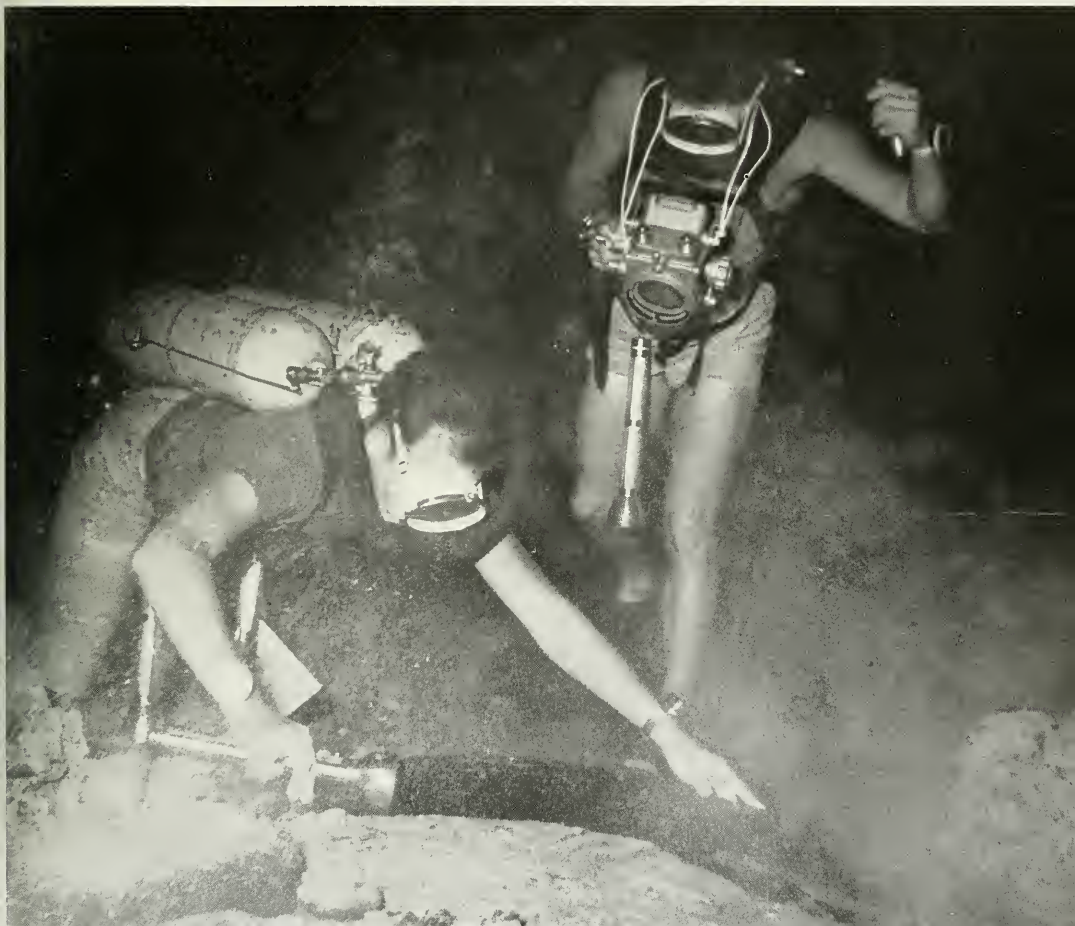
the cavern, at a depth of two hundred and fifty feet, the passage continues to slope down out of sight. Able to spend only scant moments here, the divers pointed their lights ahead into the utter darkness, only to see an ever-deepening, ever-widening cavern that beckoned them onward.

This, however, was the limit of the geographical reconnaissance—a limit imposed by physiology. At depths between two and three hundred feet, only fifteen minutes is safely allowable for aqualung-equipped divers. At these depths, co-ordination is seriously reduced by nitrogen narcosis.

So much for the geography of the Wakulla cavern. But that was only one part of the young divers' work. Their first paleontological discovery came in November, 1955, when they found a large bone lying amid the limestone rubble at the two-hundred-foot level.

PAIR OF DIVERS, more than 500 feet inside Wakulla cave at a depth of 220 feet, examine tusk partially embedded

in clay floor. Scene is illuminated by spotlight carried by third diver, who also used flash to take this picture.



It was subsequently identified as the limb bone of a mastodon. This first discovery was followed by others until, at a depth of two hundred and twenty feet, the floor was found to be literally strewn with the bones of mastodon, sloth and deer. A mastodon jaw was discovered, with the teeth still intact, embedded in a clay pocket.

How these remains reached the depths at which they were found is a question not yet answered. Water action will transport such objects a good distance, particularly when helped by a sloping floor, but at Wakulla the flow is in the opposite direction. Some objects can be easily rolled but not, for example, a crescent-shaped tusk weighing hundreds of pounds. Yet, surely Wakulla cavern has never been dry at this depth, and thus had not been visited by these animals at the time when they were alive.

Also among the finds were over six hundred bone spear points, similar in design to those found with Florida's prehistoric inhabitant, the Vero Man. But interpreting underwater finds in Florida is no easy occupation and the excitement of this juxtaposition of man and mastodon is quickly dampened by experience. In the Ichucknee River, one of Florida's most productive fossil localities, for example, it is possible to find the remains of mastodon and tapir in juxtaposition with pop bottles and beer cans. Until extinct animal bones are found with a spear point actually embedded in the bone—and preferably with *the bone growing around the point*—positive, contemporary association of the two cannot be claimed in the case of a stream deposit.

What, then, is the answer to the Wakulla Spring finds? At present, we can only speculate. Did these bones and artifacts find their way from some ancient surface into the depths of the spring by means of a sink hole or fissure through the ceiling of the cavern, now blocked and filled with rubble?

WHAT is it like to be down in such a cavern, out of touch with the sun and the world of air? Following is the log of a typical fifteen-minute descent to photograph and remove a recently discovered mastodon bone.

Donning their equipment, the divers step down a ladder from the diving pier into the air-clear water of the spring, and swim down to a limestone ledge thirty feet below the surface. Here, they pick up heavy weights and step off the ledge, descending effort-

lessly to the sloping sand bottom of the pool, one hundred feet down. Relinquishing their weights, they continue to swim down, aided by the fins, until they pierce the shadow of the ponderous, overhanging ledge which will intercept their exhaled air bubbles for the duration of the dive.

Gliding down an ever-darkening corridor past the one-hundred-and-fifty-foot level and on to the one-hundred-and-eighty-foot point, they turn on their flashlights and locate the white safety rope leading deeper into the cavern. The rope, running eleven hundred feet into the depths of this submarine river, is the established base line of the exploration.

SIX minutes have elapsed before they find themselves nearing the bone—embedded in the clay at a depth of two hundred and twenty feet. The photographer moves in first, careful not to stir up the bottom and destroy the visibility. One flash bulb, and then another, bursts the scene into brilliance for a moment; now the other divers can move in to do their work. The distance from the base line is measured, the orientation of the bone is noted and its condition is checked for the best method of removal without breakage. Only a few minutes of deep-dive time remain.

As the fifty-pound bone is freed of

its clay matrix, a pillowcase—lined with plastic—is produced. The open end of the sack is tied to the bone, and the sack filled with air from a diver's mouthpiece until the whole becomes neutrally buoyant. Then, it is an easy task for the divers to push the weightless discovery ahead of them as they make their way back out of the cave. Ascending, they find that the buoyant bone rises more rapidly as the air in the sack expands so that, periodically, air must be spilled out to control the specimen's rate of rise.

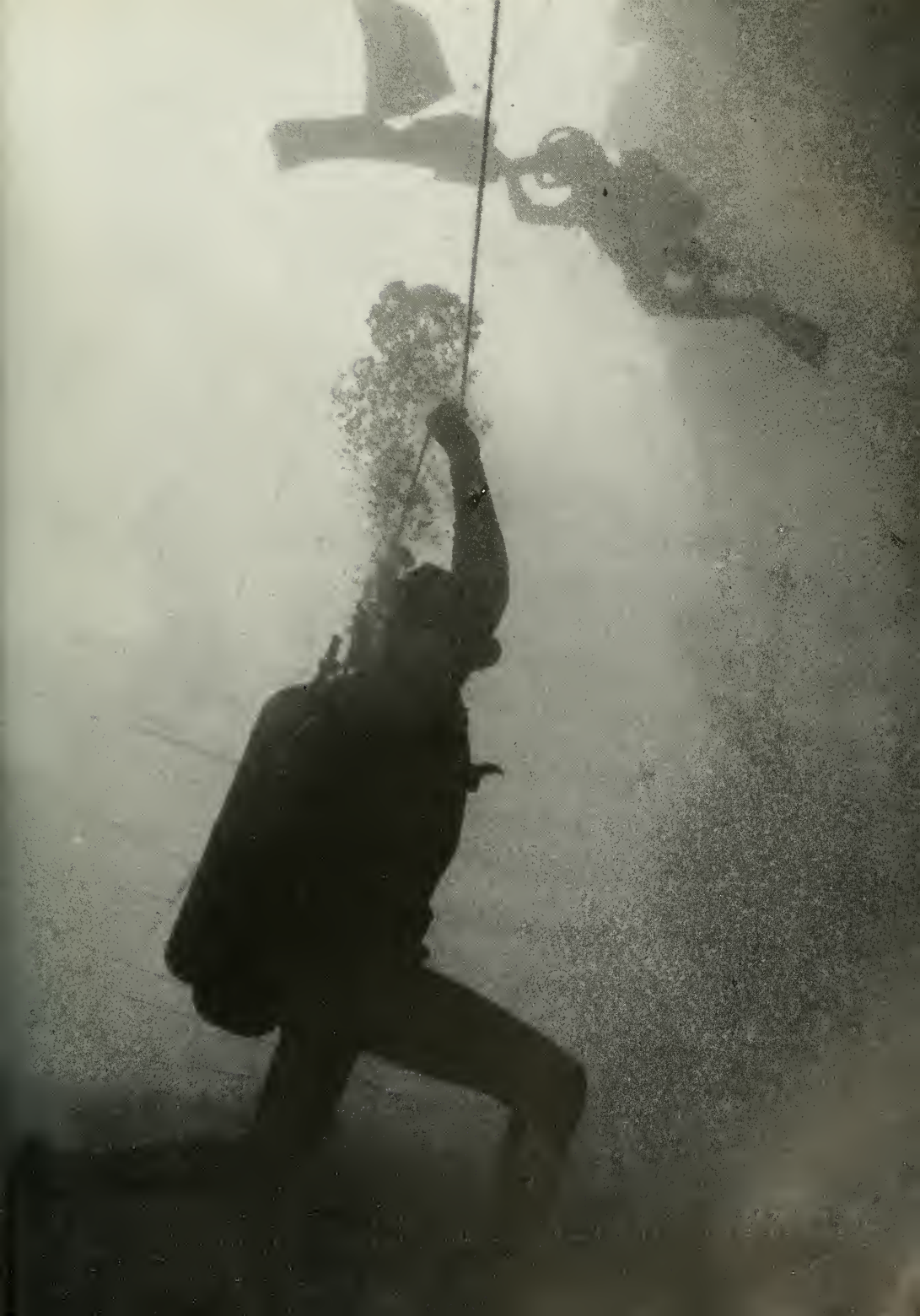
Now, with the fifteen minutes "run out," the team is clear of the cavern mouth. But the ascent is slow, and a thirty-six-minute decompression stop must be made at a depth of ten feet, to eliminate the danger of "bends." No one can too much emphasize the need for extreme caution in work of this kind. It is a tribute to the skill and planning and care of these six young divers, that in over a hundred descent to beyond the two-hundred-foot level there was not one mishap or accident.

Further exploration of greater depths is certain to come, as faster means of propulsion and safer mixtures of breathing gases are developed. For the challenge remains, and all of us want to know what lies at the end of those passages—as at Wakulla cavern—that disappear into the gloom beyond the range of our feeble lights.



TIME LIMIT NEAR, diver removes his mouthpiece, letting air fill the sack, above, that will buoy specimen on its

long journey to the surface, right. A few of the Wakulla cave finds prove to be too fragile to permit removal





TAKEN AT THE HEIGHT OF SUMMER, this photograph is one of a series of seasonal shots. Platt recommends that

the same scene be photographed at monthly intervals or at the peak of each season, to bring out site's full interest

SPIRALS AT CENTER are seen in macrophotographic shot of this daisy—which Platt took with close-up tube extension.

A Camera Looks At Plants



A veteran photographer comments on the secrets and pitfalls of his art

By RUTHERFORD PLATT

I HAVE SPENT twenty years pursuing the Plant Kingdom with a camera. I sincerely believe that photography of plant life offers a guarantee of exciting variety and sure rewards, including a satisfaction akin to that felt by a lover of poetry.

Opportunities for different kinds of plant photography follow each other through the seasons of the year. However, the very abundance of the subject matter calls for caution and discipline. There is a time of year and a certain day for each category, and the photographer must be on the alert. For example, if you are taking smooth, silvery bark—such as that of the beech—for pictorial effect rather than identification, your picture will be more interesting with

the play of leaf-shadows on the bark. White birch trunks make a prettier picture in summertime, against a background of dark blue water. Lichens, mosses and some ferns, in contrast, are more colorful and vivid in winter. So are winter buds.

Wildflowers of early spring are the most exciting and the hardest to photograph because they are the smallest, weakest, and quickest to fade. These include jack-in-the-pulpit, violet, spring beauty, bloodroot, trout lily, and hepatica. It is topnotch adventure to photograph them. You have to work fast, for the time between the thawing of the ground and the expansion of tree leaves is brief. Leaves on trees blot out the wildflowers with their shadows. This time

of special opportunity lasts for little more than two weeks in most places.

Late spring flowers are less of a challenge because they are easier to find and to take. Dogwood is the outstanding subject for the camera at this time. Its flower is big, with a definite geometric pattern. Moreover, the tree spreads its flowers in artistic horizontal planes. Try to find a way to point down on these spreading flowers to do them justice, or you will get the petals too much edgewise to show up well. The neat dogwood tree is easier to isolate than most trees, but close-up clusters of the flowers also make marvelous photographs. Fruit trees are in bloom at this time—apple, cherry, peach. Forsythia first, and later lilac, are



UNFOLDING MILKWEED FLORET is shown in macrophotographic sequence, above.



Platt uses a 35 mm camera in his macro work, regulating size by means of ex-



tension tubes. The pictures here were taken at life-size before enlargement.

shrubs you may also want to photograph in late spring.

Look in the open woods where there are patches of sunlight or along the edges of woods. Here are Dutchman's breeches, rue anemone, wild columbine and geraniums. On the floor of the woods—partridge berry, bunchberry and Canada mayflower are in their prime. Early buttercups and mustards turn fields to dazzling yellow. I have taken several color shots of these bright yellow spring fields. However, when pointing to them with pride later, I was told that the gorgeous displays of mustard are an insult to the farmer, for they betoken neglect of his fields! The wise photographer will not show his mustard pictures to the farmer.

FLOWERS of early summer get a running start in late spring. This is the time to go after wild roses, especially in the northern states and along the seashore. The light is fine and the flower photographer has no alibi. He might as well go fishing if he cannot get superb pictures of wild roses. I am inclined to think the same way about daisies, black-eyed Susans, evening primrose, and milkweed. They are all big enough for every lens, they come in early summer when the weather is good,

Well-known as a plant photographer and author, Mr. PLATT was among the collaborators on the book *Hunting with the Camera* (HARPER, 1957), on which the present article is based.

and there are plenty to choose from.

In late summer and fall, white and yellow sweet clovers are three to five feet tall. Goldenrod is in its prime. The light purple clouds of flowers that bank the roadsides and edges of fields are wild bergamot, one of the most common and hauntingly beautiful. In a damp place you will find, come September, the famous joe-pye weed. I have never found who Joe Pye was—perhaps a farmer who stood in front of this great flower with a shotgun to keep it from being mowed down. It towers six to eight feet, but do not look up to it when you shoot, in hope of glorifying this flower against blue sky. The misty mauve of the giant flower-head blends with a blue or white overcast. For a joe-pye to show up well you must maneuver to have dark shadows behind it.

Somewhere, a photographer is going to take his camera out in the late fall—after the aster, thistles, and goldenrods have vanished and the days are short. He will catch sight of a shrub reflecting the rays of the low sun with a lovely golden gauze.

That flowering shrub will be witch hazel, the most unorthodox of all our wildflowers. Because it is solitary and out of season, it is conspicuous. Witch hazel delights the eye and the spirit—but somehow it does not delight the camera. If you can take a picture of this one and have it look anything like what you see, you are lucky indeed. Anybody with close-up equipment can get the interesting right-angle design of this flower, but taking it on the bush, in the wild, is a real challenge. The yellow of very narrow petals is lost in the play of light and shade that surrounds it.

You have to get close to take a portrait of a flower, even the biggest, and that tends to magnify its least movement. This is one of the greatest problems in wildflower photography. The first disillusionment is that flowers seem never to be still. They quiver, sway, describe circles, nod, swing, and bounce up and down. However, it is my impression that there comes a time when a flower is perfectly still. That is just *before* you set up your tripod or point the camera in its direction. The moment you start to focus on the flower, it becomes the plaything of every zephyr. On a fine fair day in summer, there are apt to be fleecy clouds in the sky. When a shadow passes over the



OPENED BLOOM completes the sequence. Lighting on flower was provided by

pair of microscope lamps, with condensers to narrow beam to dime-size.

flower the air is slightly cooler: when the sun shines on it again, it is suddenly warmer. This sets up local drafts. For the same reason, the edge of woods—where many flowers are found—always has a play of air currents due to the mottled patches of sunlight and shade. If you set up your camera when the flower is under the shadow of clouds or vice versa, the condition is reversed and at that moment the flower begins to jiggle and shake. This is one of the myriad ways in which the photographer's patience will be tried.

At last, the time comes to peer closely at the flower and choose the proper moment to snap. You lean forward tensely and unconsciously change your stance. Naturally, your foot touches a stick or weed stalk or grass that acts as a trigger to the intertwining "jungle" of surrounding growth and you are amazed to see the flower move. It dodges and shies away, even leaving the field of the

ground glass entirely. So you must learn not to stir your foot, and also to keep your elbows close-hauled.

The second greatest problem for getting definition and clarity into photographs of plants concerns the skill with which all plants camouflage their leaves and flowers on the negative. This is due to the contrast of brilliance in terms of what you see. For example, a common combination is yellow against green—a vivid picture as you see it. But yellow photographs dark, not light. Therefore countless flowers that you admire against green leaves or grass may be scarcely visible on the negative. One answer is to shoot from a low angle so as to silhouette the yellow flower against sky, not against green. Another way is to maneuver so that shadows under a tree are behind the flower. A yellow filter (I use a K₂) helps to build up the contrast under both methods. In fact, when taking black-and-white pictures outdoors I almost never take the filter off. It

not only lightens yellow, but serves to darken the blue of the sky.

Blue flowers offer opposite difficulties, for they photograph much lighter than the eye sees them. For this reason, the beautiful sky-blue chicory taken against the blue sky almost vanishes in a black-and-white negative. Little blue flowers on a stone wall are scarcely distinguishable from reflections from the stones and leaves of grass. The yellow filter, which darkens blue, turns the blue flowers unnaturally dark. Thus, for blue flowers it is better to maneuver for a green background and no filter. This gives contrast, because green becomes darker and blue lighter on a black-and-white negative, and thus approximates what the eye sees.

By the same token, to bring out the details of a white and yellow flower—such as a daisy, blackberry or apple blossom—it is better to shun the filter. The yellow filter, by lightening the yellow center, will weaken contrast with the white petals.

AUTHENTICITY of wildflower pictures taken outdoors in their natural habitat does not necessarily depend on leaving the surroundings untouched. You are taking a picture of a plant, not of the debris which nature has left around it, or of capricious plants in the environment. So, to do good work, you may have to clear away some of the jungle of twigs, grass, and weeds that will make confusion on the negative. If it is a small flower and you are photographing the entire plant, the ground *must* be simplified, grass pulled away, stones that reflect light removed—often, just plain dark earth is best.

Once, I had before my lens a fine combination of a wide-open wild iris and beside it on the same stalk, a handsome burgeoning bud. A flower and a bud together, as they appear in nature, make a better picture than does a solitary bloom. Therefore, I fussed with this opportunity, taking plenty of time to check stop, exposure, and background—I know of no satisfaction in photography greater than to have the opportunity for unhurried study of the subject and to strive for greater perfection. Before I had ended this self-indulgence and was set to take the great picture, I rubbed my eyes with disbelief: the two irises were in full bloom. The bud had popped open.

The phrase "time lapse" is bor-



CRUCIAL MOMENT in life cycle is caught, *above*, as cinnamon fern throws

off spores, by which plants not having flowers or seeds reproduce themselves.



MAGIC INSTANT is caught as milkweed pod, *left*, splits open, releasing seed to be borne aloft, *right*, by the air-

rowed from movie photography, but the still-picture photographer of plant life can use the same idea with telling effect. The time interval is longer, and the result is a series of photographs that can be exhibited side by side, or projected one after the other.

An interesting project is to stake out a spot that has year-round identification—such as a road, stream, mountains, or tree trunks. Then take a picture from exactly the same spot at intervals: for example, once a month, or just four times a year at the height of each season.

I have photographs that portray a little pond with three birches, and it is exciting to compare the various seasons. I also have a sequence of a landscape where a brook tumbles out of the woods. In winter, it is utterly different from midsummer. Plants are always changing: leaves expand and fall, flowers open and then fall off when the fruit appears. You do not have to leave all this excitement to the motion pictures.

The recording of friendly life in beautiful color and design is a reassuring occupation in our tense and worried world. There are many exciting by-products of discovery. A spider catches a grasshopper before your eyes. You find a black-eyed Susan, with deep red rays. A bright bee plunges into a fringed gentian.

A final word of advice: always take the picture when you see it. You may never have the chance again.



filled "cotton" balloon. Photograph on opposite page is one indication of the rewards awaiting the patient photographer.





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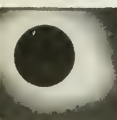
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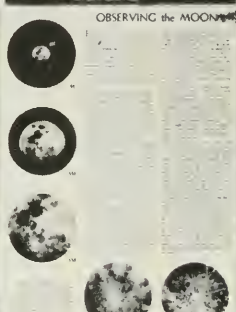


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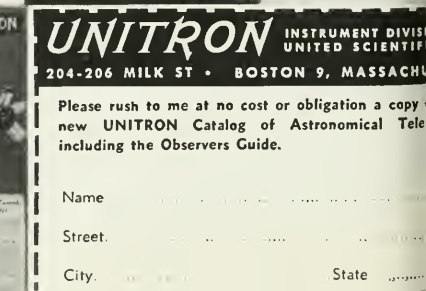


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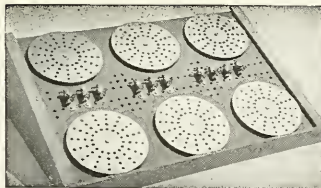
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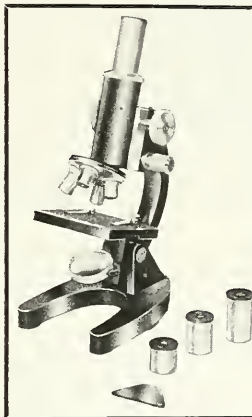
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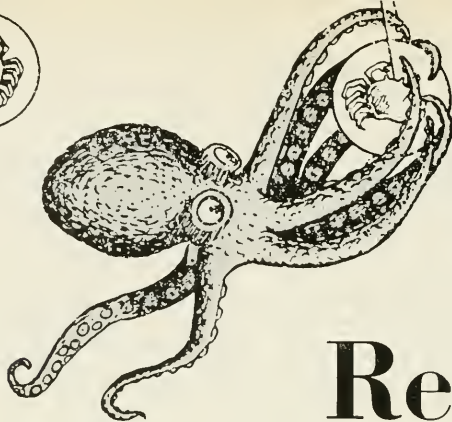
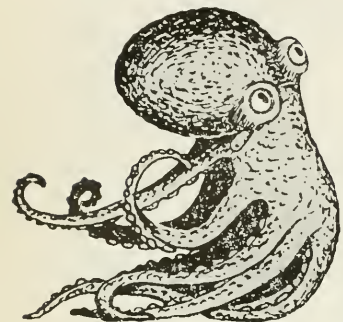
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OCTOPUS can learn to distinguish between a painful and a harmless object. Here, octopus seizes crab (attached to a white plate) and gets an electric shock.



Reviews

MAN'S VIEW OF THE ANIMALS

Reviewed by JAMES W. ATZ

ANIMAL BEHAVIOR, by John Paul Scott. *The University of Chicago Press, \$5.00; 252 pp., illustrated.*

SINCE TIME IMMEMORIAL, men have observed the behavior of animals and have drawn conclusions as to the meaning of what they saw and heard. We all do the same thing today, and the unfortunate truth is that the vast majority of our modern inferences are not one jot more scientific or reliable than those of our ancestors. To be sure, we no longer believe in dryads, propitiate the spirits of volcanoes or invoke the demons of the elements; animism is out of fashion as far as the inorganic world or the Plant Kingdom are concerned. But for animals, the anthropomorphic approach is still the predominant one. The reason for this, of course, is our recognition of similarities between ourselves and other animals. Because we see animals doing many of the things that we do, we assume they must be experiencing mental processes like our own. We also realize that, in order to survive, animals must be successful in some of the same kinds of activities as ourselves—for instance, in procuring food or escaping from powerful enemies. And we assume that, if the ends are the same, the means—in this case, the driving force or motivation within ourselves and within other creatures—must also be the same. Although a moment's reflection reveals the extreme fallibility of such trains of thought, their appeal is so irresistible that—in one guise or another—they continue to plague not only laymen and popular writers on animal behavior, but serious students of the subject as well.

From its beginnings, the scientific study of animal behavior has suffered a disadvantage unequalled in the more esoteric sciences. Besides establishing their own body of facts and principles, behaviorists at the same time have had to clear away a tremendous undergrowth of preconception and prejudice. Moreover, the roots of these hardy weeds remain alive, and constant pruning is necessary to keep them from running wild. In this field, familiarity has bred not contempt but confusion.

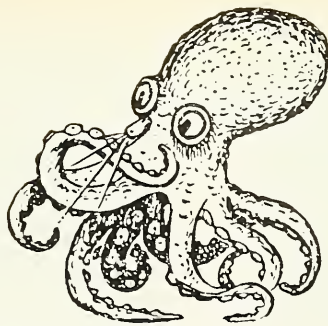
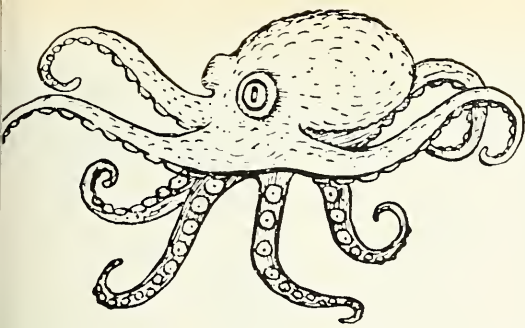
Other, more or less related pitfalls of scientific methodology have also beset animal behaviorists. Some, like preformation and the false dichotomy between heredity and environment, arise because any real understanding of behavior requires a knowledge of its development. Others, like the vitalist- (or teleologist-) mechanist controversy, and the problem of the relation of function to structure (in this instance, the nervous system), are common to all biological subjects, but are especially acute in psychology, whether it be the psychology of animals or men. Anecdotalism has been a particular curse of the literature on animal behavior; much information on animals under natural conditions has of necessity been fragmentary, but caution has frequently been thrown to the winds in interpretations based on brief and unverifiable observations, often reported by untrained observers.

The situation is aggravated by the fact that comparative psychology, of which the study of animal behavior forms a considerable part, embraces several other scientific disciplines. The student of animal behavior must be trained in both zoology and psychology.

Zoologists, naïve in the ways of psychology, and psychologists, ignorant of animals' ways of life, have contributed more than their share of errors and confusion to the field.

THESE difficulties are reflected in the protean condition of the field today. Not only are there apparently irreconcilable differences on several fundamental issues currently under debate, but these differences involve the entire approach of the antagonists to their subject, rather than only the interpretation of certain data. It is precisely the controversial aspect of the science of animal behavior that Dr. Scott, who directs behavioral studies at the Jackson Memorial Laboratory, Bar Harbor, ignores in his book. Perhaps Scott believes that such matters are best omitted from an introductory volume, but his book is also meant to serve as a text, and no serious-minded student can afford not to be informed about the fundamental differences of opinion and approach that characterize this subject. To potential researchers, methodology—with all its logical ramifications—is fully as important as subject matter. In addition, considering the prevalence of misinformation in the field, it is regrettable that Scott did not take fuller advantage of this opportunity to expose the commoner fallacies about animal behavior, by demonstrating their basic illogic or pointing out the most telling scientific evidence against them.

A graduate of Cornell, Mr. Atz is Associate Curator of the Aquarium of the New York Zoological Society.



Animal Behavior is, nevertheless, an important book. It is the best introductory volume to the subject thus far available, and both student and layman will find it worthwhile reading. It is a simple, straightforward account, and anyone with a high school course in biology behind him or an interest in natural history should find it stimulating.

Scott's unifying concept is that the behavior of animals plays a vital role in adapting them to their environment, with all its changing conditions. On this central theme he bases his analysis of the many different kinds and aspects of the behavior of organisms. Although this is a perfectly adequate approach, it may be asked whether the reader is not entitled to at least a brief description of the several other, equally valid, ways of considering the subject. Scott first discusses adaptation and his application of the stimulus-response theory to this aspect of behavior. He then describes nine general types of adaptive behavior: ingestive, shelter-seeking, agonistic (contesting), sexual, epimeletic (care-giving), et-epimeletic (care soliciting), eliminative, allelomimetic (mimetic and contagious) and investigative. In subsequent chapters, these are discussed in more detail and in reference to such topics as learning, intelligence, social behavior, hormones and behavior, and the language of animals. A relatively great amount of space is devoted to a consideration of the relation of heredity to behavior, and the book ends with discussions of behavior and environment, and behavior and evolution.

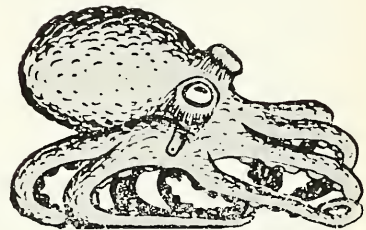
As long as Scott sticks to adaptation as his frame of reference, the organization he has chosen for his book serves him adequately. When, however, he groups together completely unrelated animals, with regard to such characteristics as his nine general types of behavior, or with regard to topics like intelligence or learning, he runs into hidden difficulties. Scott is not unaware of these. "What words," he asks, "can we use to say that two animals as un-

like as elephants and spiders are doing similar things?" For example, how can we compare learning in an elephant with that in a spider? We know that both organisms exhibit behavior that can be modified by experience—that is, we say they both can *learn*. But is the process at all similar in the two? Certainly not so far as the structure of their nervous systems and sense organs is concerned. Certainly not so far as variability of response to a situation is concerned, or the carrying over of responses originally acquired in one situation to other situations. Significant differences between learning in spiders and elephants—and the emphasis here is on the word *significant*—are difficult enough to uncover, while similarities of any consequence turn out to be so rare that we might wonder whether the same term ought to be applied to both processes. One needs only to pose the question: "Which is more intelligent, the elephant or the spider?" to make its fatuousness apparent. Scott, of course, avoids ratiocinative crudities like this, just as he avoids the commonplace but gross error of anthropomorphism—which, incidentally, differs from the spider versus elephant inquiry only in that one of the two very unlike animals being compared is Man, usually in the person of the comparer himself. Nevertheless, the structure of Scott's book tends to encourage the recognition of insignificant, even spurious, similarities between the behavior of widely divergent animals.

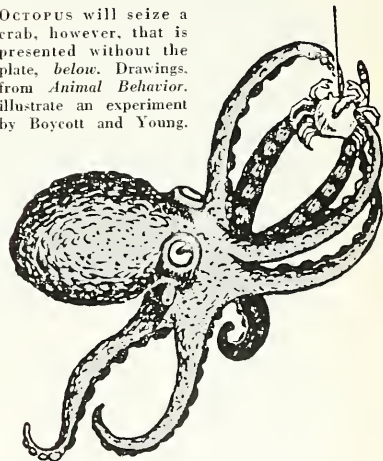
In a few instances, Scott may even be deemed guilty of fostering confusion. Most notably, he heads one of his chapters "Communication: The Language of Animals." Now it is true that one definition of "language" is: "Any means, vocal or other, of expressing or communicating feeling or thought." On this basis, the behavior of many mammals other than man can be considered to involve "language." The tendency, however, is at once to identify with the better-known definition: "The faculty

(continued on page 463)

TURNING PALE, left, the shocked octopus retreats and blows water over its tentacles. The next time crab on plate is offered, below, the octopus avoids contact.



OCTOPUS will seize a crab, however, that is presented without the plate, below. Drawings from *Animal Behavior* illustrate an experiment by Boycott and Young.



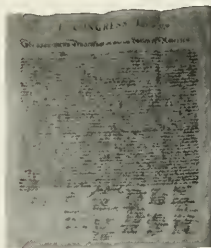


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THE REDIRECTED CAREER OF A NATURALIST

In public life, Theodore Roosevelt fought for his private passion

By ALDEN STEVENS

ONE HUNDRED YEARS AGO, on October 27, 1858, a son was born to Martha and Theodore Roosevelt in New York City. He grew to be a scrawny child—studious and a little lonely. He had asthma and his eyes were bad. "He looked so pindlin' we thought we couldn't raise him," said Bill Sewall, a large, powerful Maine guide who was to become a close companion and friend in later years.

Before he was nine, this boy knew with certainty that he wanted to be a naturalist. By the end of college, this early goal had been set aside. Yet, paradoxically, had young Theodore Roosevelt succeeded in his childhood plans, he could neither have contributed to science what in later years he did contribute, nor could he have made come true the dream of conservation which stands today as perhaps his greatest achievement.

At seven, Theodore Roosevelt was a serious student of animal life. By nine, he had founded—in his room—what he called The Roosevelt Museum of Natural History. His father, two years later, was among the founders of a larger institution with similar purposes—The American Museum of Natural History. The elder Theodore undoubtedly inspired and encouraged his boy's interest in nature, partly because the child was not very strong. At fourteen, the weakness of his eyes was discovered, and his father got him spectacles and his first shotgun; he was already receiving lessons in taxidermy under the great John G. Bell, an associate of Audubon.

THAT same year, 1872, the family took him on an energetic and extended tour through Europe and to Egypt. Here, he collected and subsequently mounted considerably more than a hundred bird specimens. No young naturalist ever got off to so promising a start; no boy his age was ever surer of what he wanted to do.

Roosevelt entered Harvard just too late to be taught by Louis Agassiz and Asa Gray, but he did have splendid teachers: Shaler, Davis, Mark Goodale and Faxon. However, as he remarked later, Harvard at that time was too interested in working with dead tissue, with microscope and dissecting tools, and the activities of the field naturalist were regarded as comparatively unimportant. Perhaps this attitude on the part of his teachers swayed young Roosevelt from his former goal. Later, he wrote, "the tendency was to treat as not serious, as unscientific, any kind of work that was not carried out with laborious minuteness in the laboratory."

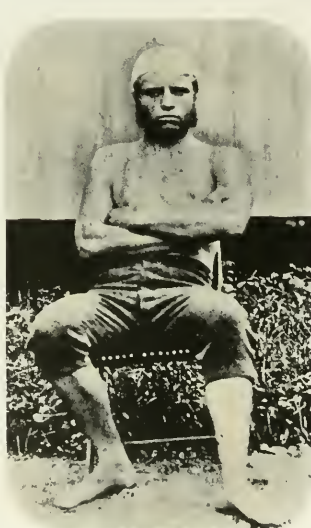
Soon after graduation, in 1880, he broke up his bird collection—giving the bulk of it to the Smithsonian Institution and about twenty specimens to The American Museum

of Natural History, where several of his mountings are still displayed.

Instead of pursuing nature, Theodore now studied law under his uncle, Robert Barnhill Roosevelt and, as an outlet for his energies, wrote a history: *The Naval War of 1812*. Apparently, he was through with natural history forever for he next entered politics, and was elected to the New York State Assembly in 1882. The next year, partly for sheer pleasure and partly to help his asthmatic, run-down physical condition, he decided to go off and hunt buffalo.

In the wilds of Dakota Territory, he got his buffalo and also found himself back with his first love—nature. He invested in a cattle enterprise—which, in the end, cost him fifty thousand dollars, but paid him back in pleasure. He got a buckskin suit and wandered all over this wild country; he wrote three books about his experiences—*Hunting Trips of a Ranchman*, *Ranch Life and the Hunting Trail*, and *The Wilderness Hunter*.

Roosevelt's studies had given him an enormous respect for C. Hart Merriam, then head of the U. S. Biological Survey. He rated Merriam with Agassiz and Jordan. But the knowledge of coyotes gained on his ranchlands led him into a heated discussion when Merriam revised the coyotes into eleven distinct species. Roosevelt, having watched coyotes in the field and having thrilled to their high-pitched wail, could not believe they were so different, and said so. He thus enrolled himself in the ranks of the "lumpers" (those who regard minor differences in animals insufficient to separate them into different species), as opposed to the "splitters," like Merriam, who hold that slight differences are of substantial significance. He later debated Merriam at Washington's Cosmos Club (Roosevelt was then Assistant Secretary of the Navy) and surprised that august institution's



THOUGH SICKLY in childhood, Teddy boxed in college years.



WHILE PRESIDENT, Roosevelt toured the wonders of the West. At Glacier Point, overlooking the beauties

of Yosemite Valley, he posed for this portrait with another conservation crusader, naturalist John Muir.

gathering of biologists and naturalists with his knowledge of wildlife.

THROUGHOUT his distinguished political career, Roosevelt never failed to keep up with the literature of natural history. He apparently read everything, and maintained a voluminous correspondence with workers in the field. His letters to Frank M. Chapman of The American Museum of Natural History show a broad and deep knowledge of animals and a great appreciation of them. Birds were a particular delight to him, and many of his letters to Chapman describe their colors and songs ecstatically. Said Chapman later: "The growing demands of official life on Colonel Roosevelt's time and thoughts never drove the bird from his heart. Rather did he become increasingly dependent on the friendship of nature for relief from the cares of office."

While in the White House, Roosevelt spent hours watching birds and listening to them and took long walks in Rock Creek Park. He often invited foreign diplomats to join him and, flattered, they were usually eager to do so. But, by the time they had followed at his breathless pace for an hour or so, many were exhausted—and viewed the President with a new respect and admiration. The walks in the Park thus served a political as well as a scientific purpose.

Roosevelt's interest in conservation started in a small way, but grew rapidly. He had begun it as Governor of New York, by strengthening the Fisheries, Forestry and Game Commission, tightening regulations, controlling stream pollution and recommending that the Catskills and Adiron-

Roosevelt's vivid personality was one

THE years that T. R. spent as a cattle proprietor and sportsman in Dakota were adventurous ones. The picture, *below*, appears in his autobiography with the caption "Sheriff Duty." Another view of the same scene is found in William Sewall's account of these years, captioned: "Roosevelt guarding Finnegan and company." As is evident, *right*, still another picture from these years—T. R. with his Maine friends, Dow, *left*, and Sewall, *right*—was made at the same spot (note identical tree at right of each picture).



dacks be set aside as park areas. But it was as President that he became truly the father of American Conservation. The surface had hardly been scratched up to his inauguration; by the time Roosevelt left the White House it was a powerful and permanent policy. He began with reclamation. His first (1901) message to Congress stated: "The western half of the United States would sustain a population greater than that of our whole country today if the waters that now run to waste were saved and used for irrigation. Great storage works are necessary. . . . Their construction has been conclusively shown to be an undertaking too vast for private enterprise." The Reclamation Service (later the Bureau of Reclamation) was founded; by 1904, sixteen reclamation projects were well started. By the time Roosevelt left office, in 1909, the 25,000-odd western acres which had previously been under irrigation had grown to more than a million. Today, over five million acres are supplied with water by the fifty-eight projects of the Bureau of Reclamation. Once the advantages of irrigation had been demonstrated, many

other agencies took up the work. Now, not only irrigation, but flood control, hydroelectric power and even recreation are well served by the principles that Roosevelt laid down more than half a century ago.

IN his autobiography, Roosevelt remarked that the pioneer American "had but one thought about a tree, and that was to cut it down." By 1900, almost half the original timber—which once covered almost fifty per cent of the nation's land surface—had fallen before this primitive urge. And more was going every year.

Ten years before Roosevelt took office, an Act of Congress allowed the President to establish Forest Reserves: fifty million acres had been so set aside. But forest administration was weak and divided, and government powers quite inadequate. Practical forestry existed only in a few isolated places, and the public was far from ready to accept it. Powerful lumber interests fought government interference with money and influence. When America's pioneer forester, Gifford Pinchot, took over the Forestry Division in 1898, he was anything but en-



TEDDY'S RANCH was managed by two friends of Maine days.

What inspired myths. Is this an example?

The "Finnegan and company" affair—Teddy's chase and capture of a trio of tramps that had stolen his boat—seems an improbable occasion for snapshots. Nor does the fresh-killed antelope by Teddy's feet fit the record of six days on short rations after the capture. Yet both these pictures evidently were taken at the same place. Can the three men, *left*, be "Finnegan and company"? NATURAL HISTORY's readers are invited to offer alternative identities. The known facts: near the Little Missouri; around 1886.



enthusiastic about its prospects. At that time, Roosevelt was Governor of New York. Pinchot, as forester, was asked to inspect an area in the Adirondacks and called on the Governor in Albany on the way. He reported, in his *Breaking New Ground*: "T. R. and I did a little wrestling, at which he beat me; and some boxing, during which I had the honor of knocking the future President of the United States off his very solid pins."

Thus they were old friends and, when Roosevelt entered the White House, Pinchot had a solid and determined supporter: a survey of the forest lands of the entire nation was begun. From this survey came recommendations as to precisely which areas should be set aside by the President as "National Forests."

Just at this time, a group of senators—opposed to nationalization of forests—tacked a rider onto the Agricultural Appropriations Bill, forbidding the President to establish any more National Forests in the Northwest. The bill couldn't be vetoed without disastrous consequences, and the senators who had slipped in the rider thought they had dealt a death blow

to any such nonsense as the development of National Forests.

They were wrong. Roosevelt immediately called Pinchot, who gave him the forest survey's boundaries of appropriate areas in those states. The President immediately established these new forests—totaling sixteen million acres—and *afterwards* signed the bill, with its "trick" rider. It was an outstanding coup for conservation, and one which conservation's enemies had brought upon themselves.

Roosevelt doubled the number of National Parks (from five to ten) and, under a new act, set up sixteen National Monuments (similar to National Parks, except that Congressional action is not required for their establishment). He created fifty-one Federal Wildlife Refuges. He called the North American Conference on Conservation, and helped organize the National Conservation Commission. In seven and a half years, he made American Conservation a living thing, and by speeches and writings won acceptance—even enthusiasm—for it. It is doubtful whether anyone else in the world has ever executed so broad and varied a program.

ALL through his Presidency, Roosevelt never lost touch with the literature and study of natural history. He made frequent trips into the field. In 1903, he spent two weeks with John Burroughs in Yellowstone, watching bighorn sheep scramble without a misstep down a precipitous canyon wall, running to identify such birds as a pigmy owl and a Townsend's solitaire—tramping and touring, seeing everything. Burroughs later wrote: "I cannot now recall that I have ever met a man with a keener and a more comprehensive interest in the wildlife about us—an interest that is at once scientific and thoroughly human. . . . I was able to help him identify only one new bird. All the other birds he recognized as quickly as I did."

From Yellowstone he went to Yosemite for several days with John Muir. This, too, was a memorable trip for Roosevelt, although he was disappointed that Muir, with his great knowledge and understanding of mountains, big trees and glaciers, seemed to know little of wood mice and birds. Muir was as enthusiastic about the President as Burroughs had been; he, too, admired the sharp eye and the professional's careful, sure, observation technique.

That same year, Roosevelt joined John Burroughs in attacking Ernest Thompson Seton, William J. Long and Jack London for some fairly lurid, imaginative writing about animals. Burroughs published an article in the *Atlantic Monthly*—Roosevelt was delighted with it, and said so. He then politely suggested that, on one minor point, Burroughs might be mistaken. "I shall never cease to marvel at the variety of your interests and the ex-



AT REST in the West, Teddy sits, dog in lap, in Colorado.

tent of your knowledge," replied Burroughs. "You seem to be able to discipline and correct any one of us in his chosen field. My *Atlantic* paper had some hasty streaks in it."

WHEN his Presidency ended, Roosevelt promptly set out for Africa. This was partly—but only partly—a hunting trip. Knowing that the Smithsonian Institution was weak in its collection of African animal specimens, he suggested that, in exchange for such specimens, the Smithsonian both sponsor the expedition and send some taxidermists and field naturalists along with him.

"I am much more pleased at making the trip a scientific one with a real object than merely a holiday after big game," he noted with pride.

There can be no doubt that Roosevelt enjoyed practically every minute of the African expedition. His was the joy of the huntsman, but of a new kind of huntsman—one with the purpose of the collecting scientist. He brought back the largest collection of animals ever taken by a single party and made the Smithsonian's collection one of the finest in the world: five thousand mammals, forty-five hundred birds, twenty-three hundred amphibians and reptiles and thousands of fish, insects and plants, many of them new species.

Roosevelt summarized his experience in a delightful book, *African Game Trails*. He followed this work with another, in collaboration with the expedition's zoologist, Edmund Heller; a comprehensive volume—*Life Histories of African Game Animals*—that was a milestone in its field. The expedition was a solid scientific success that contributed greatly to knowledge of the then still little-known continent of Africa.

Roosevelt's other great expedition, to Brazil in 1913, was a different—and less happy—story. He was fifty-five years old. The year before, he had been shot by a would-be assassin; it was not a serious wound, but it was not so trivial as Roosevelt pretended. He had been defeated for the Presidency on the "Bull Moose" ticket, a bitter disappointment. While his enthusiasm for adventure was as high as ever, there can be no question that his health was far from robust, and he was a very tired man.

Preparations for the trip were left mostly to Frank Chapman of The American Museum, which assigned



Roosevelt saw the sights at Yellowstone with Burroughs.

two naturalists to the party: George Cherrie and Leo Miller. In Brazil, the Minister of Foreign Affairs casually mentioned an unexplored tributary of the Amazon—the "River of Doubt"—of which the headwaters alone were known. Roosevelt instantly said, "We will go down that unknown river!"

IT was a snap decision, and one that nearly cost him his life. Not only Chapman, but Henry Fairfield Osborn of The American Museum and many others of his friends protested, pointing out that he was making a voyage about which no one knew anything of the hazards, through perhaps the most unhealthy jungle in the world. Replied the old warrior: "I have already lived and enjoyed as much of my life as any other nine men I know; I have had my full share, and if it is necessary

ALDEN STEVENS, widely acquainted with our National Parks, frequently writes on the history of the American Scene. He prepared scripts for the CBS-AMNH program, "Adventure."

for me to leave my remains in South America, I am quite ready to do so."

The voyage down the river in dug-out canoes was a nightmare. Some of the canoes leaked, others were hard to handle. They lost three, together with food and supplies on which they had been counting. They faced a thousand miles of river, punctuated with waterfalls and rapids, murderous hordes of ants and flies, disease, unknown and unfriendly natives and innumerable other dangers.

At one point, Roosevelt plunged into the swirling rapids to prevent destruction of a capsized boat. His leg was dashed against a sharp rock and the wound became infected. A few days later, he realized he also had malaria. Dysentery added to the misery of the abscess on his leg and the malaria. His temperature rose to 105° and he was frequently delirious.

Cherrie and Roosevelt's second son, Kermit, nursed him through one desperate night. Toward dawn he spoke to them: "Boys, I realize that some of us are not going to finish this journey. I know that I am only a burden to the rest of you. Cherrie, I want you and Kermit to go on. I want you to get out. I will stop here."

Cherrie and Kermit flatly refused. If it meant their own deaths—and they knew it well might—they would never leave him behind. The devotion of these two men and his own feeling of responsibility stirred Roosevelt to the last ounce of determination of which he was capable: they had given him the strength to go on.

THE new strength came just in time. The next day Kermit had malaria; Cherrie had dysentery. One crewman killed another and ran off into the jungle. Portages followed one after another, and each was worse than the last. They were driven to eating monkeys and bloodthirsty piranha fish—bony, but nourishing.

No one was ever certain how they got through the last few days. But suddenly they reached the Amazon and men from rubber plantations were on the shore. They had come through. A few days paddling down



FOREST CONSERVATION work inspired this Darling cartoon.



PLANTING A REDWOOD at Campbell, California, in May, 1903, Roosevelt posed with the town's founder, Benjamin

Campbell (beside T. R.) and Union veterans. The tree still stands, but widening of the busy intersection may doom it.



THE FIRST OF ROOSEVELT'S GREAT EXPEDITIONS came in 1910, under the auspices of the Smithsonian Institution.

The party, which included Roosevelt's second son, Kermit, toured Africa in the grand manner (the photograph above).

the river and they caught a steamer that took them to Manaus.

The results were valuable from a scientific standpoint. Cherrie and Miller collected twenty-five hundred birds and five hundred mammals, as well as numbers of amphibians, reptiles, fish and insects. The American Museum had a new, significant collection, but at what a cost! Roosevelt's health was broken, he was never

quite the same again. His friends—Chapman, Osborn and all the others—had been quite right when they tried so strenuously to dissuade him from his perilous voyage down the River of Doubt (which was later renamed, in his honor, the Rio Roosevelt, or the Rio Teodoro).

IN his college youth, Roosevelt had deliberately decided *not* to devote

his life to natural history. Yet, the channeling of his tremendous energy into politics led Roosevelt to perform feats impossible for a studious naturalist. His tremendous prestige made possible both the African and Brazilian expeditions. His passion for nature made him the greatest conservationist the world had ever known. And his contribution went beyond even this. When he liked a piece of work in the

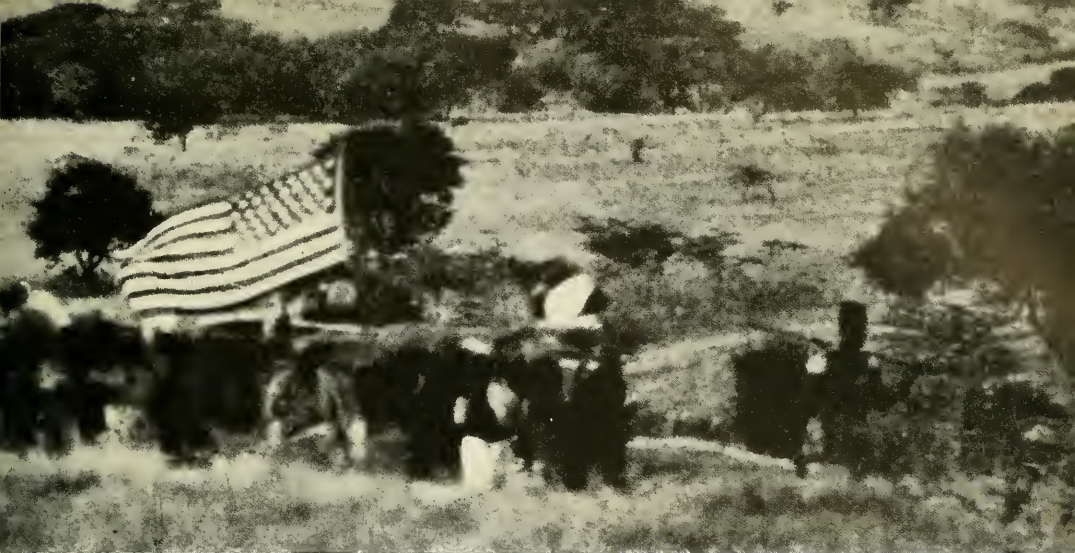


AFRICAN TRIO: Kermit, left, T. R. and Heller the zoologist.



EXPEDITION'S BAG included eleven elephants. The one shown above was

photographed by Kermit. Some are American Museum's Akeley Group.



shows the expedition's line of porters coming into camp on the East African veld). Within eleven months, the party

had set a new record for collecting—nearly ten thousand mammals and birds, thousands of other animals and plants.

field of natural history, he wrote enthusiastically to the writer, spurring him on and often inspiring the author to greater things.

Roosevelt's last letter was one he wrote to William Beebe, expressing great pleasure in a new monograph on pheasants that Beebe had just published. The letter was in Roosevelt's usual, helpful and friendly vein.

He died the next morning, January

6, 1919. Frank Chapman, shocked by grief, said, "He has been my inspiration for nearly twenty years." John Burroughs, at eighty-two, felt the loss heavily. "The old man's tears come easily," he said, "and I can hardly speak his name without tears. . . . I have known him since his ranch days . . . and to know him was to love him. . . . The world seems more bleak and cold since he is no longer in it."



IS SECOND EXPEDITION—down an unexplored Brazilian river in 1914—

nearly proved fatal to Roosevelt. He is seen, above, at the trip's start.



NATURALIST to the end, T. R. here holds Louisiana turtle eggs in 1915.



UNLIKE MOST BITING FLIES, both the sexes of the tsetse are blood-feeders. At start, proboscis swings down from between palps and rapidly penetrates the skin (cloth in lab photo, *above*).



AFTER TSETSE'S PROBING has caused a pool of blood to form in torn tissue, abdomen is quickly filled, *right*. If the host's blood harbors trypanosomes, tsetse will carry disease all its life.




THE DEADLY GLOSSINA

Blood-feeding carriers of disease, tsetse flies remain a problem in much of Africa

By

WILLIAM A. McDONALD

Photographs by WALTER PETANA



THE TWENTY-TWO known species of tsetse flies, belonging to the genus *Glossina*, are now all restricted to the African continent, but this was not always so: fossil remains found in the Miocene shales of Lake Florissant, Colorado, about twenty million years old, tell us that tsetse once inhabited the New World. No adequate explanation for their disappearance has been advanced, but it is possible that—with the gradual drying up of western North America since Pleistocene times and the consequent disappearance of large herds of game—tsetse could no longer exist. For, although some species of present-day tsetse in Africa can range through semiarid bush, while others must stay close to water and deep shade, all tsetse require a ready source of blood in wild game. A second and less plausible hypothesis holds that the North American game animals were unable to develop immunity to trypanosomiasis—the disease borne by present-day tsetse, more familiarly called “sleeping sickness”—and were thus killed off, leading to extinction of the disease-bearing fly.

Yet, some species of African tsetse



UNIQUE PHOTOGRAPHIC SEQUENCE starts with picture, *above*, in which

female tsetse deposits its developed larva, which has hatched from an egg

within tsetse's body and grown to its present size through nourishment from



1



special "uterine milk glands." Two to three larvae are produced each month.

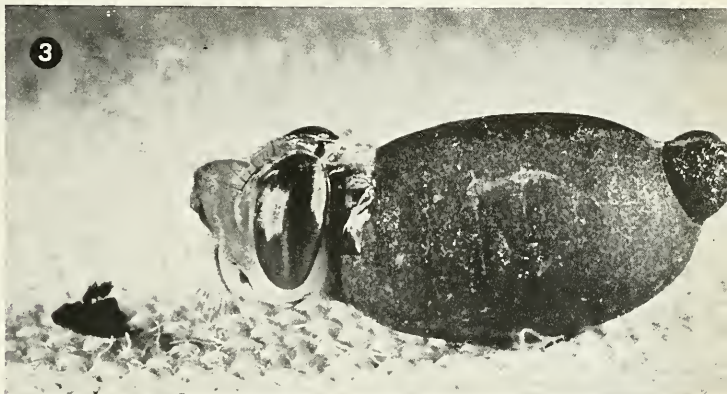
2



AFTER DEPOSIT, larva burrows into soil, hardens into a puparium, which

is ready to hatch in a month. Above, fly starts to emerge from tough shell.

3



BREAKOUT IS AIDED by balloon-like expansion of fly's forehead (ptilinum,

above and in No. 2), which withdraws again into the head as tsetse emerges.

5

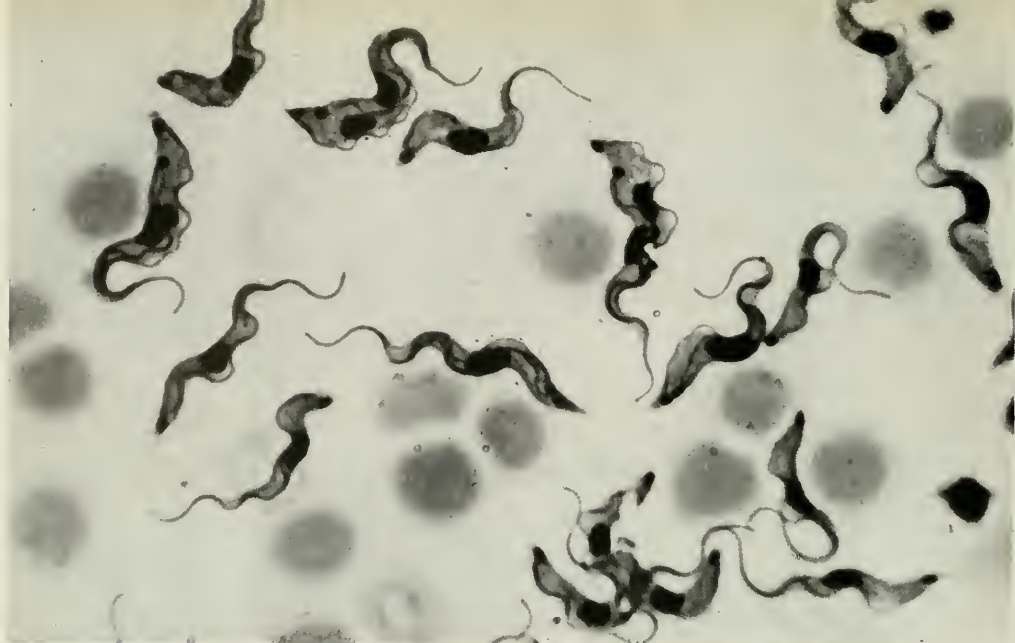


4



FORELEGS FREE, above, young tsetse is about to emerge. Then (No. 5, left)

it rests briefly as wings expand. The tsetse fly is harmless until infected.



FLAGELLATE PROTOZOANS, several species of trypanosomes are responsible for sleeping sickness. This is *T. vivax*,

one of the cattle-disease species, which is also found in South America and can be spread by various biting flies.

could probably now become established in parts of the American southeast, where both tropical climate and sufficient game exist, and very likely in some parts of Central and South America as well. Indeed, one species—*Glossina palpalis*—has been carried in airplanes from Africa to Brazil, but happily has not become established.

THE tsetse fly may be positively identified by one outstanding characteristic: it possesses plumelike hair on the arista of its antennae—and no other fly does. Two other marks are notable: a long proboscis (actually two palps with the true proboscis tucked between them) and a “scissors-like” crossing of its wings when at rest. Unlike most other biting flies, among which only the female bites, both sexes of the tsetse are blood-feeders. Indeed, animal blood is their only known source of food and drink. They seem to find the host through a combination of smell and reaction to moving objects. In preparation for feeding, the proboscis swings down from between the two palps, and tiny cutting teeth at its tip rapidly penetrate the skin. The fly then probes about, puncturing capillaries, until a pool of blood forms in the torn tissues. When actual feeding

starts, the fly’s abdomen is quite quickly filled with blood.

Among flies in general, the tsetse is unusual both in its life cycle and in the complicated disease-vector relationships that have developed between it and the several protozoan species of trypanosomes which it transmits. Unlike the great majority of flies—such as the blowfly and the common housefly, which lay egg masses—the female tsetse hatches a single egg within her body, nourishing the developing larva by special “uterine milk glands.” Once fertilized, a female tsetse may produce from two to three larvae per month for the rest of her life (which may exceed 200 days). When each larva has matured, it is deposited by the female on a shady patch of soil, into which the larva burrows within half an hour, whereupon it hardens into a puparium.

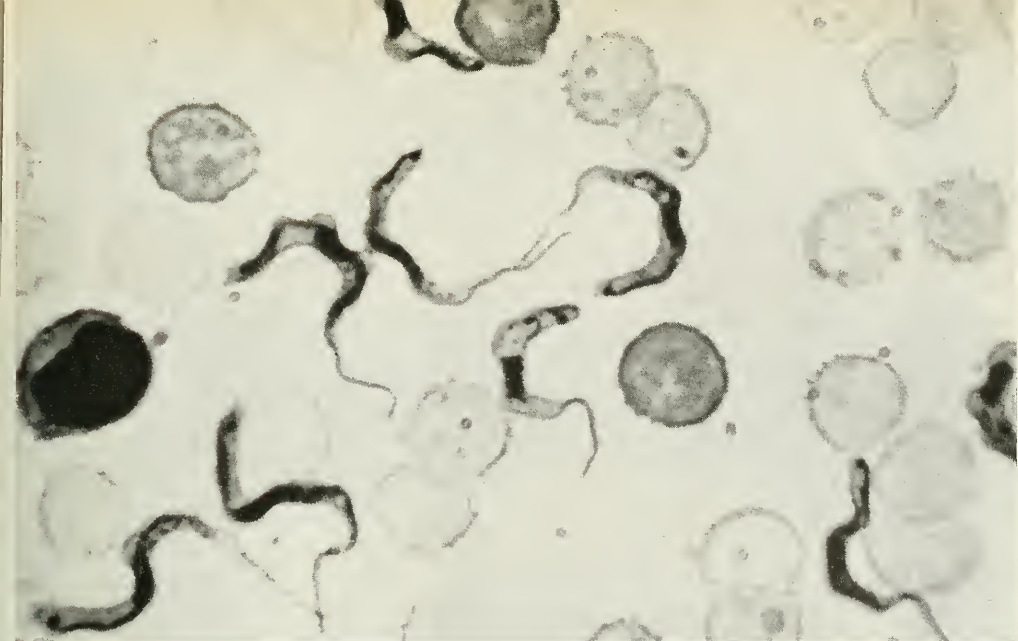
The puparium takes about a month to hatch, the newborn fly bursting out of its tough shell by means of the

ptilinum, a balloon-like expansion of the forehead which withdraws into the head as the newly-emerged fly quickly expands its wings and legs to become an adult tsetse (pp. 428, 429).

TURNING NOW to tsetse as vectors of sleeping sickness: the disease, in humans, is caused by two species of trypanosomes, *T. gambiense* and *T. rhodesiense*. The former, which causes Gambian sleeping sickness in West Africa, is vectored by two species of tsetse—*G. palpalis* and *G. tachinoides*—both of which are riverine species, confined to thickets along streams. It is this restricted habitat of the fly that sets the stage for village epidemics. In the dry season, both man and tsetse are closely confined to the water-hole and an extreme degree of “man-fly contact” results. On the other hand, this same habitat preference permits protection of humans: streamside thickets can be cleared where roads and paths cross the fly-infested streams, or around the village water-hole. In this way, man can be isolated from the fly, and the disease cycle may be broken.

T. rhodesiense, responsible for the more deadly Rhodesian sleeping sickness of East Africa, is carried primarily by a single tsetse species—*G.*

Mr. McDONALD took his master’s degree in entomology at the University of California and later worked at UCLA. He is presently engaged in tsetse fly research in West Africa.



ONE OF THE TWO SPECIES that causes the disease among humans, *T. gambiense*, is shown here. The two flies that

vector the Gambian sleeping sickness are confined to the thickets along streams, making control relatively simple.

morsitans—and, to a lesser extent, by several others. In contrast to the riverine situation in West Africa, these tsetse species range through the open bush and hence are far more difficult to combat. Control measures in East Africa consist mainly of selective game destruction and spraying with residual insecticides.

In their association with tsetse, the trypanosomes exhibit a variety of life cycles. Most complicated of all is that of the polymorphic trypanosomes, which include the two human pathogens, as well as one of the cattle varieties (*T. brucei*). The polymorphs, sucked up in the blood of a sick host, are carried almost entirely through the tsetse's intestine, where they develop into new forms. These new forms then travel back up the gut, out into the mouthparts, and back through the salivary ducts into the salivary glands. Here, in the salivary glands, the forms infective to man (or, in the case of *brucei*, to cattle) develop. Two to three weeks after the tsetse has been infected, it becomes infective, and remains so for the rest of its six months or more of life.

The two other cattle trypanosomes, *T. vivax* and *T. congolense*, have simpler cycles: they develop in the fly's

mouthparts or gut, and do not invade the salivary system. Indeed, *vivax* can be spread mechanically by horseflies, or biting stable flies (*Stomoxys*), being carried on the fly's proboscis as it moves from one animal to another; in South America, where the tsetse is not found, *vivax* is transmitted entirely by this method. An even simpler type of vector-pathogen relationship is shown by *T. grayi*, which parasitizes crocodiles. The crocodile is a favorite host of *G. palpalis*: the reptile's tough skin offers only illusory protection from fly bites since it usually sleeps with its mouth open. The trypanosomes pass directly through the tsetse's gut where they undergo development, and, when the infected fly's feces come in contact with the next crocodile's gums, the new host is infected.

The tsetse has long been regarded as one of the greatest deterrents to progress in many parts of Africa. Owing to the unrelenting vigil of the

Sleeping Sickness Service, the disease among humans is kept in check save in the remote bush, where epidemics may still occur. Drugs exist which will cure human sleeping sickness if it can be caught before it damages the nervous system. But the disease in cattle, nagana, carried by perhaps half-a-dozen species of tsetse, continues to cripple rural development in much of the continent—by prohibiting animal transport, and by denying the Africans both manure for their crops and meat to alleviate their widespread protein deficiency.

YET, as Africa continues to develop economically and culturally, more and more country must perforce be reclaimed from tsetse—for, when the human population of any area becomes great enough, the game must leave, and the tsetse which carry nagana cannot exist without game. This rollback will take many years, but someday we can hope to see the tsetse fly confined to the remote jungle, as man and his works continue to spread over this vast, fertile continent. When that time arrives, the tsetse fly will no longer rank with malaria and superstition—as it does today—prime among mankind's enemies to progress in modern Africa.

MR. PETANA, a colleague of MR. McDONALD in Africa, produced the photographs illustrating the article. Of Czech origin, he is well known in the U.K. as a photomicrographer.

IGY ECLIPSE

Although this solar eclipse will be seen only in the remote Pacific, its observation is a key event of the International Geophysical Year

By THOMAS D. NICHOLSON



#K.W.

ALTHOUGH the year 1958 contains only the minimum of two solar eclipses which must take place in any year and neither of the two is visible from any part of the United States, the year's second solar eclipse — visible in a wide area of the South Pacific on October 12 — must be considered one of the most important in many years. Coincidence of the event with intensive International Geophysical Year studies makes it one of the major scientific happenings of 1958.

At the most favorable location on October 12, the sun will be completely covered by the moon for five minutes and twelve seconds — a longer-than-average duration (the maximum possible is seven minutes, thirty-one seconds). The special interest of astronomers and other scientists in this eclipse stems from the fact that it occurs at a time when solar activity is near maximum. The current cycle of sunspot activity constitutes a peak for the entire two-hundred-year period during which systematic records have been kept. Indeed, the scheduling of the IGY from July, 1957, to December, 1958, was aimed at coinciding with an expected maximum of activity in the sun, and sunspot records to date show how well the plan has worked. Observations of solar and terrestrial phenomena during the October 12 eclipse were planned as an important part of the IGY program from its inception.

Solar eruptions, during periods of peak activity, are followed by many observable effects on the earth. Cosmic ray storms, auroral displays, bursts of radio noise from the sun, disturbances in the ionosphere, magnetic fluctuations and disrupted radio communications are frequent consequences of marked solar activity. It has been known for some time that the solar corona — the faintly glowing outer atmosphere of the sun, extend-

ing several millions of miles outward from the sun's apparent edge — also changes with the level of the sun's activity. Although techniques are now available for making limited observations at other times, the corona's fullest extent, its form and brightness, and the features of its radiation can best be observed only when the corona becomes visible during a total eclipse. During periods of sunspot maximum, the appearance of the corona close to the sun is nearly symmetrical, and it may have long, irregularly shaped extensions in almost any position. Near sunspot minimum, in contrast, the corona exhibits long streamers extending parallel to the solar equator, with short, brushlike extensions appearing near the poles.

The eclipse of January 25, 1952 — reputedly the most thoroughly observed eclipse in history, studied by many teams of astronomers in Africa and Asia — came near the last period of sunspot *minimum*. The eclipse of October 12 is expected to be a *maximum*-phase counterpart in the solar cycle. The record of the two should give astronomers valuable information on the changes that occur in physical conditions at and above the sun's surface in the cycle from minimum to maximum. This eclipse will also offer the opportunity to co-ordinate observations of a variety of terrestrial conditions, by the many widely scattered IGY stations, with observations of solar features that can be obtained only during an eclipse.

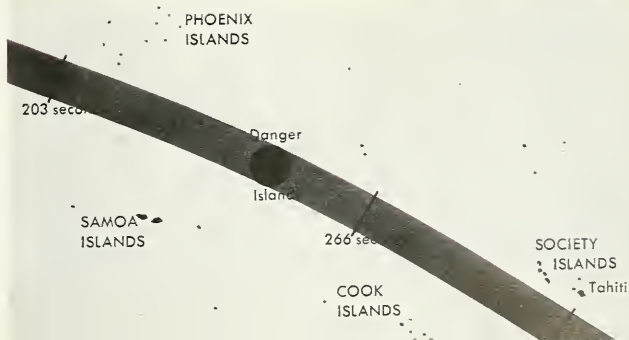
TO the scientific community's misfortune, the path of the October eclipse — geographically speaking — falls far from convenient and accessible places. An examination of the path that the moon's shadow will trace across the earth may even be deemed a demonstration of the perversity of

inanimate objects. The dark line (*below*) represents the path of totality, the only zone in which the sun will appear completely covered by the moon. This path, some 9,000 miles long and up to 124 miles wide, manages to dodge every major island in the vast area of the South Pacific. In South America, the only large land area intersected by the path of totality, the eclipse will coincide with sunset; both the lowness of the sun and the short period of totality will prohibit any observations of value.

Outside this narrow path of totality, of course, there is a vast area wherein the eclipse will be partial. In many areas, including parts of Australia and New Guinea, most of New Zealand, and most islands in the Central and South Pacific, it will be possible to observe the spectacle of the sun covered by the moon to varying degrees. The path of totality, however, will touch only eight tiny land areas — islands or island groups — from which useful observations are possible. Three of these, Atafu, Nukunono and Fakaofu, in the Union Group, are just north of the Samoa Islands. Three others are parts of the Cook Group: the Danger Islands, Nassau and Suvarrow. Two more, Scilly and Mopelia, are in the Societies, west of Tahiti. All are low atolls with few inhabitants and little or nothing in the way of facilities to assist visiting scientists. Vessels up to about 200 tons can pass the reef entrances at Suvarrow and Mopelia but, at the others, landings must be made by canoe.

In selecting a site for eclipse observations, astronomers are concerned with several factors: the length of totality, the chances of favorable weather, the site's accessibility, and its proximity to equipment and supplies. The longest possible period of totality is a prime consideration. In

PATH OF ECLIPSE extends from dawn in Australia to sunset in South America. *left*, Dark band covers the area in which eclipse is total; oval shows extent of penumbra at noon. The large shadow covers all of the earth's surface from which the eclipse, partial or total, may be seen in its entirety. To the west of this zone, the eclipse will have begun *before* sunrise; east of it, the eclipse will not end until *after* sunset. Map, *right*, shows path of totality at Danger Islands: times, in seconds, tell duration of totality.





BASIC FACTOR governing length of an eclipse is varied size of the moon's shadow, *above*. The maximum shadow

is at apogee (*left*, in inset): largest area of shadow touches the earth when the moon is nearest (at perigee, *top*).



FURTHER FACTOR in length of eclipse is rate of the shadow's travel, *above*. At equator, speed of earth's rotation

some cases, however, duration must be sacrificed because of other factors.

In one notable case—that of the June, 1955, eclipse, one of the longest on record—the greatest duration occurred in the Philippines where, for over seven minutes, the sun was completely covered by the moon. June is the season of the southwest monsoons, however, and weather over the Philippines was predicted to be extremely poor. Most astronomical parties, instead, established their camps along the east coast of Ceylon, where past weather records offered clear skies during that season, even though totality lasted only about four minutes. On the great day, June 20, dense morning clouds at Ceylon prevented observations of any value, while clear weather in many parts of the Philippines allowed a number of amateur astronomers to view a fine eclipse.

A COMPLEX variety of factors govern the length of an eclipse. The basic consideration is the size of the moon's shadow as it touches the earth. The moon's distance both from the sun and from the earth determine the size of this shadow. Our satellite, the moon, is farthest from the sun when the earth is at aphelion (about July 3); its shadow is then at its largest (illustration, *above*). When the moon is closest to the earth (at its perigee, which comes about once a month), the earth will intercept the moon's

shadow over the largest region. So, the longest eclipse will occur only when the moon is at perigee, about July 3.

But local factors on the earth also effect the length of time during which any eclipse can be observed. The moon's shadow strikes the earth most directly at that place on the earth's surface where the eclipse occurs at noon. At this point, then, the moon's shadow is larger than at any other, and the eclipse will be longer. But the latitude of this point also affects the duration. The moon revolves around the earth at a speed of some 2,100 miles per hour in an eastward direction and the moon's shadow also races across the earth at that same speed and in that direction. But the earth is simultaneously rotating eastward—in the direction of the shadow's movement—so that the earth's rotational speed serves to reduce the rate at which the moon's shadow crosses any one point on the earth's surface. Because the earth's rotation is most rapid at the equator (about 1,040 miles per hour) and decreases with latitude, the net speed at which the moon's shadow passes a point will be least nearest the equator. The slower the speed of the shadow, the longer will be the duration of the eclipse.

Still another effect reduces an eclipse's duration in areas removed from the noon point. Since the earth's surface is curved, it slopes away from the shadow and the shadow strikes it

more obliquely at greater distances from the noon point. Moreover, the shadow sweeps across the obliquely-oriented surface more rapidly than it would across a perpendicular one; thus, the earlier or later in the day that an eclipse takes place at a given point, the shorter will be the duration of the total phase.

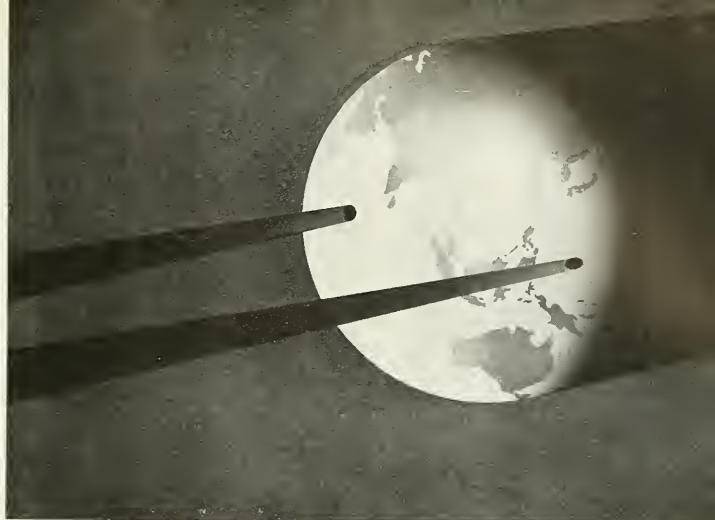
Finally, the observer's position within the shadow path also affects duration. The closer he is to the center line of the shadow path, the larger will be the width of the shadow crossing his position. The longest possible observation of an eclipse, therefore, would require an observer in the center of the path of totality, at noon at the equator, with the eclipse on or about the date of aphelion and the



CORONA, at time of minimum activity, shows a short, brushy pattern at poles.



reduces the shadow's rate of passage to 1,060 mph. At 45°, in contrast, moon's shadow passes at a rate of 1,365 mph.



THIRD FACTOR affecting duration of eclipse in shadow's angle at point of observation, above. Obliquity of morn-

ing or afternoon shadows gives them a speed over the earth's surface of up to 5,000 mph. Speed at noon is slower.

moon at perigee. The longest possible eclipse would last about seven minutes, thirty-one seconds; the longest one in the history of eclipse observations was that mentioned above, the Ceylon fiasco of June, 1955, lasting about seven minutes, eight seconds.

WITH this October's eclipse, astronomers have very little choice among possible observation sites. None of the handful of islands in the path of totality is at the center line of the eclipse path, and all are located where the eclipse occurs several hours before noon. All have about the same weather opportunities, and all are inaccessible, poorly-equipped and difficult to approach. The Danger Islands, closest to the center of the path of

totality, have been selected as the location to which both U.S. and many foreign observers have gone for their studies. The southernmost of the three islands in the group, Motu Koe, is the closest to the center of the eclipse path and has been selected as the observing site by American groups. The eclipse will come about 8:45 A.M., local time, when the sun will be halfway up the sky to the east. Totality, there, should last for about four minutes, two seconds, compared to four minutes, seven seconds at the center of the path in that position.

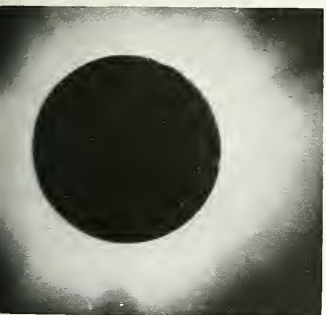
As with other U.S. programs for the IGY, transportation and logistic support for the observers are being supplied by the Department of Defense. The U.S. Navy has furnished a vessel, the LSD U.S.S. "Thomaston," both to transport scientists and equipment and to serve as a base of operations. The "Thomaston" has a helicopter flight deck and, following the suggestion made by H. von Klüber two years ago, transportation of men, equipment, and supplies to and from Motu Koe will be by helicopter. The ship also contains the launching facilities needed for rocket-firings planned during the eclipse.

Little is known about weather conditions at the site, except for general seasonal patterns. The Danger Islands lie in the region of prevailing southeast trade winds. Storms are relatively uncommon in October, temperatures

range from 70° to 90° Fahrenheit, and relative humidity should be about 80 per cent. Morning cloudiness has been estimated at between four-tenths and seven-tenths sky coverage. New Zealand weather authorities, to their best of knowledge, estimate that there is a 60 per cent probability of clear weather at the time of the eclipse.

THE eclipse at Motu Koe is far from unique as solar eclipses go. Coming, however, at a time when science is participating in the most ambitious study ever undertaken of the earth and the forces from space that affect it, the October eclipse is an event of great significance. American observing teams will be studying the sun and the earth's atmosphere by optical methods, by radio-sounding, and by high-altitude rockets; many of these programs are independent of weather and can proceed successfully even if the eclipse is not visible. But even one stray cloud, coming at the wrong time, will scarcely be welcome. Months of planning have been gambled on clear skies during the four minutes, two seconds when the moon will cover the sun over Motu Koe.

As an astronomer of THE AMERICAN MUSEUM-HAYDEN PLANETARIUM, Mr. NICHOLSON is a frequent contributor to NATURAL HISTORY. Most recently, he discussed the calendar.



CORONA, at time of sunspot maximum, has these long, irregular extensions.

SKY REPORTER

By HENRY M. NEELY



above) in the early morning hours—the best time to observe meteors—when they look for the celebrated October showers known as the Orionids.

These meteors are expected from October 14 to October 27, with a maximum display on October 20. They radiate from an area between the brilliant star Betelgeuse, in Orion, and fairly bright Alhena, in Gemini.

Observers this month will find these stars in the positions, above, from about 1:00 to 5:00 A.M. (Standard Time) from October 1 to 10; from 3:15 to 1:15 A.M., October 10 to 20; and 2:30 to 3:30 A.M., from October 20 to the end of the month.

THE DIAGRAM, below, shows the relative positions of the five major planets this month (distance and dimensions are *not* to scale). The observer is imagined to be in space, above and to one side of the sun.

Mercury and Venus are circling around the far side of the sun and, as viewed from the earth, are too close to the sun's glare to be seen well. This is also true of Jupiter. Far-distant Saturn is being left behind by the speeding earth and will have disappeared from our night sky next month.

Mars now becomes our nearest planetary neighbor. The earth is overtaking Mars as the two spin around the sun and will come between Mars and the sun (*opposition*) the middle of next month, November 16.



OCTOBER TIMETABLE (Note: Standard Time)

October 1	7:30 to 8:30 P.M.
October 10	7:00 to 8:00 P.M.
October 20	6:20 to 7:20 P.M.
October 30	5:40 to 6:40 P.M.

THIS "ROLL-AROUND" MAP shows the appearance of the entire sky during the hours noted. Its center is the zenith (the point in the sky directly overhead); its circumference covers the entire horizon. When facing in any direction, the user should "roll" the map around to bring that direction to the bottom. The stars can then be identified from the horizon up to the zenith. Here, the observer is facing south.



OUTDOORS, AT NIGHT experienced observers read star maps by use of a red light. A white light dulls night vision; after it is turned off, some time is required for the eyes to readjust to the dark sky. A red light minimizes this difficulty. To make a red light, one may insert a disk of red cellophane under a flashlight lens or use a red bulb. Another method is to give the lens a coat of red nail polish.



CROSSING DESERT AREA that bounds the Coto Doñana on west is biologist

Sir Julian Huxley, who was a member of the expedition. Wind-blown dunes

are advancing eastward at the rate of thirty feet yearly. This desolate region

SANCTUARY IN ANDALUCIA

A vast wilderness in southern Spain, the Coto Doñana is now a preserve where many rare birds may be found

By GUY MOUNTFORT

Photographs by ERIC HOSKING

THE COTO DOÑANA, Europe's finest wildlife sanctuary—isolated in the wilds of Andalucía, in southern Spain—has finally revealed its hidden treasures. After three expeditions by a total of twenty-one naturalists, this remote area has now been explored in detail. Among those taking part in the study were several internationally famous ornithologists—Field Marshal Viscount Alanbrooke and Sir Julian Huxley from Britain. Dr. Roger Tory Peterson and Reginald Denham from the United States. Professor François Bourlière and Robert Etchécopar from France and Don Mauricio González Díez and Don Antonio Valverde Gomez from Spain. Some six thousand photographs of



HIGH BLIND is built beside tree containing eagles' nest. Photography

on Coto was difficult, with temperature in shade frequently up to 96°F.

supports only lizards, snakes and the short-toed eagles which prey on them.

the birds, mammals, reptiles, amphibians, insects and plants, as well as fifty thousand feet of color film of the Coto's wildlife can now be analyzed and catalogued at leisure.

For 450 years, the Coto Doñana belonged to the Dukes of Medina Sidonia. The word *coto* means a hunting, or private, reserve; Doñana is a contraction of Doña Ana, the name of the wife of the original ducal owner. Today, the property is still privately owned by a syndicate of three Spanish gentlemen, who fortunately recognize its priceless value as a sanctuary for local wildlife and protect it vigilantly.

No roads lead to the Coto. To reach it, one must sail up the broad



POLES FOR BLIND, cut in a wooded part of the preserve, were dragged to

required location by mules. Most bird pictures were taken from these blinds.



AZURE-WINGED MAGPIE is seen, *above*, in first picture taken of member of a remnant population very rare in Europe.



ANOTHER "FIRST" for Mr. Hosking, expedition's photographer, is this shot of the blue-black, spotless starling.

Rio Guadalquivir and then ride on horseback across rough country for five hours. Its only inhabitants, the fast-riding *guarda's*, patrol the unfenced boundaries and give short shrift to poachers. During the hunting season, the owners permit the taking of a few red deer, wild boar and lynxes, as well as a carefully-controlled number of ducks and geese (from the enormous flocks which pour into the marshes from northern Europe in winter). But, for most of the year, the Coto is completely undisturbed. In consequence, it has become more abundantly populated with rare birds and other animals than any area of comparable size throughout Europe. More than one third of the bird species of the entire continent were found there by the expeditions, some of them represented in amazingly large numbers.

THE Coto Doñana is shaped like a narrow-based isosceles triangle, with its short northern boundary adjoining a sparsely-inhabited region known as the Coto del Rey. To the west is the Atlantic Ocean, behind a great sand barrier which stretches unblemished for forty miles between the mouths of the Río Tinto and the Río Guadalquivir. Wind-driven sand



SMALLEST OF HERONS found on the Coto is squacco, seen at rest, *right*.



SQUACCO IN DISPLAY makes sharp contrast to bird at rest. In breeding season, the scapular "cloak" at base of wings

is a pale amethyst, its breast golden buff and its bill bright blue, with emerald skin about the golden eyes.

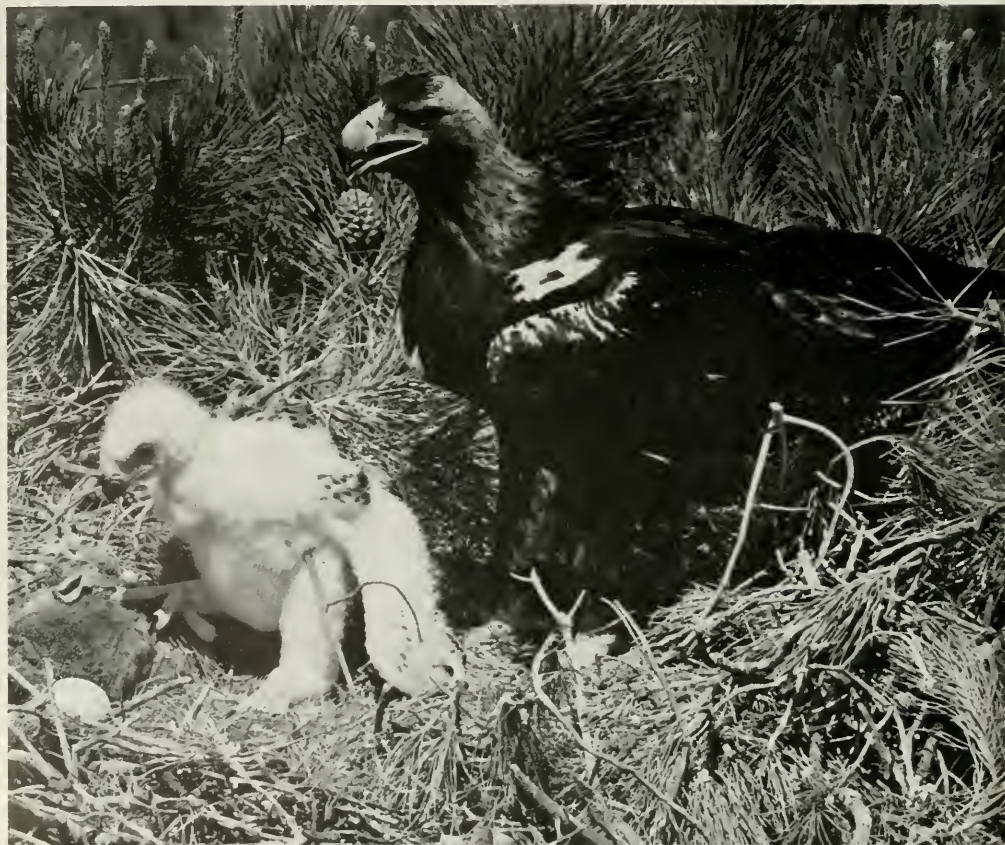


ANOTHER PHOTOGRAPHIC "FIRST" was the rare Spanish Imperial eagle, *above*.



PARENT BRINGS BACK HARE, *right*, as half-fledged nestling awaits meal.

EVEN AT FOUR WEEKS, the nestling had no hesitation in tackling hare, *below*.





PARENT STANDS BY as the eaglet starts to eat. Infertile egg lies beside here.



SIX PAIRS of Spanish Imperials were found nesting on Coto, despite

birds' small numbers. Perhaps no more than one hundred pairs in all survive.



MACABRE FEAST BEGINS as a griffon vulture approaches a deer's carcass. Strangely shy, vultures were difficult to

approach; pictures could be taken only from a blind. Behind the griffon is one of much smaller Egyptian vultures.

from the coast is advancing inland in unstabilized dunes at a rate of thirty feet per annum, burying the trees in its path. In one area, a great sand desert has been formed, resembling the Sahara in its fierce desolation. To the east lie the *marisma's*, among the largest marshes in Europe; through these wander the various channels of the Guadalquivir, effectively isolating the Coto from the chief local centers of human habitation. The *marisma's* are fringed with vast reed beds; farther out, the mud banks and islands are covered with stunted, salt-dependent plants, among which countless wading birds nest. Across the center of the Coto is a string of fresh-water lakes, with adjacent thickets of pistachio and tree heath growing to a height of ten feet. The flat, dry central plain is clothed with a low scrub of cistulike *Halimium halimifolium*, dotted here and there with gnarled old cork oaks and coppices of flat-topped stone pines. The only substantial building, the fifteenth-century Palacio, or hunting lodge, is on the edge of the *marisma's* and it was here that the expeditions made their headquarters.

IT is along the verdant borders of the *marisma's* that the great concentration of bird life is found. Here, also, the pressure of predation is most severe. Lynx, mongoose, polecat, genet, wild cat, fox, badger and other carnivorous hunters compete with five species of snakes and the fierce three-foot, ocellated lizard for mastery of the undergrowth, while more than a dozen species of birds of prey patrol watchfully overhead. In a drought year, such as 1957, when the *marisma's* dried out almost completely, the water-dependent birds—such as ducks, grebes, terns and waders—were obliged to concentrate in enormous numbers around the few remaining lagoons, where furred, feathered and reptilian predators caused severe losses. Breeding was virtually impossible and as many as four thousand mallard ducks and seventeen hundred black-tailed godwits were seen still in single compact flocks, although it was at the height of the nesting season.

One of the tasks of the expeditions was to study the breeding biology of the various herons and egrets of the Coto. During 1956, the largest

colony contained about seven thousand occupied nests of little egrets, cattle egrets, night herons and squacco herons. About one thousand non-breeding birds brought the total population of the colony to fifteen thousand birds. White storks, common herons, purple herons, spoonbills and bitterns were also found nesting in the region. Such a remarkable concentration of species with broadly similar feeding habits would obviously be impossible if there were active competition for the same basic food along the borders of the *marisma's*. A careful study showed, however, that both the foraging ranges and principal food of each species differed. Thus, the little egrets (the European equivalent of the American snowy egrets) foraged over a radius of fifteen miles from their nesting sites and sought particularly for fish such as *Gambusia*, *Mugil* and *Athernia*, whereas the smaller squacco herons ranged over only six miles and fed chiefly on aquatic insects. The cattle egrets, which are also largely insectivorous, took few fish but many small invertebrates. Night herons were shown to have a great

iking for toads, eels and fish along the banks of the Guadalquivir, and for the *Carassius* fish which were abundant only in the *marisma's*. During the expeditions, solid proof of a connection between the egret populations of Spain and those of the New World was established: a little egret nestling, ringed on the Coto Doñana in 1956, was recovered the following spring on the island of Trinidad. This record of a flight of four thousand miles (probably via West Africa and the Cape Verde Islands) across the southern Atlantic is one of the most remarkable yet obtained.

None of the heron or egret colonies suffered to any appreciable extent from predation by the many birds of prey, though wild boar often raided them at night and ate any eggs or young birds they could dislodge from the low nests. The chief predator was the jackdaw, which in recent years has effected a local population "explosion" and has become a serious problem during the breeding season. Thousands of these small crows were

found nesting in hollow trunks of cork oaks, in rabbit burrows and in the foundations of old nests of storks and eagles. Many nested in the midst of the heron and egret colonies and lived almost exclusively on the eggs of these birds. Being early breeders, they effectively pre-empted all the available nest holes which would otherwise have been used by such interesting and highly-colored migratory species as hoopoes and rollers, few of which now succeed in breeding on the Coto. Green woodpeckers also were seen to be repeatedly dispossessed of their nest holes by the abundant jackdaws.

UNTIL 1941, flamingos bred in the *marisma's* of the Coto in very large numbers. A flock of one thousand birds was present during each of the expedition years and some of these were found to be fully adult, though many were immature. The declining salinity of the water in those parts of the *marisma's* providing suitable nesting sites may be the

reason for this long cessation of breeding. For successful breeding, a flamingo's food should possess a high salinity. The *marisma's* of the Coto Doñana, therefore, seem to have become merely a summer feeding ground for non-breeding or immature birds bred in the great colonies of France's Camargue sanctuary at the mouth of the River Rhône.

No fewer than twenty-seven of Europe's thirty-eight species of birds of prey have now been seen in the Coto Doñana region. About a dozen still breed there. This is a record without equal elsewhere in Europe in any locality of similar size. Five species of eagles occur there: the golden and Bonelli's as visitors from the adjacent *sierra's*, and the Spanish Imperial, the short-toed and the booted nesting there regularly. Of these the most interesting is certainly the Spanish Imperial, one of the rarest and most magnificent birds on the European list—restricted to the south of the Iberian peninsula and a few localities north of the Atlas



HALF AN HOUR LATER, the deer's carcass is completely devoured. Here, hissing, growling griffons, their plumage

fouled, still linger over bare bones. The few scraps were left for the lesser scavengers—kites, ravens and magpies.





NINE-FOOT WING SPAN of griffon is seen as the vultures crowd about carcass. Black vulture, *left*, is still larger.

mountains in Morocco. A remnant subspecies of the original population, the Spanish Imperial was isolated by the last glaciation, which squeezed the surviving birds southward into the ice-free peninsulas of Spain, Italy and Asia Minor. The range of the main population now extends from Greece eastwards across palearctic Asia. Like many geographically-isolated offshoots, the Spanish subspecies has developed distinctive characteristics—brilliant white patches on its forewings and upper back. The eastern race, in contrast, is almost uniformly brown in color.

THE Spanish Imperial is a bird of the plains, nesting in small trees, and is therefore very vulnerable to the usual senseless persecution which, throughout the world, is reserved for the large birds of prey. Nevertheless, no fewer than six pairs were found breeding in the Coto Doñana sanctuary—an amazing number considering that probably not more than one hundred pairs survive elsewhere. A high pylon was gradually built near the nest tree of the pair selected for study; in the course of the following month the first complete photographic and biological documentation on this rare species was carefully assembled.

Another interesting and beautiful species which was closely studied is the short-toed eagle. Although this eagle feeds almost exclusively on snakes and lizards, and can, therefore, by no stretch of the imagination be called harmful, it has already been driven out of Germany and is fast disappearing from France and Switzerland. Unfortunately, it lays but a single egg and its chances of long survival seem slender. In flight and hunting behavior, it is every inch an eagle, but its long legs, shaggy thighs and small feet (a special adaptation for catching snakes on the ground) recall the typical European harriers, while its round head, vivid yellow eyes and small bill are distinctly owl-like. Unlike most eagles, the male short-toed takes an equal share with its mate in feeding and brooding the nestling. At the nest under observation, the chick proved to have a phenomenal appetite. Though barely ten inches long at the age of three weeks, it succeeded in swallowing a three-foot snake in thirty-seven minutes; three hours later it cheerfully ate another



BRINGING SNAKE TO NESTLING, male short-toed eagle, *above*, lands at his

nest tree. *Below*, the female eagle and chick stare up at male bringing meal.



almost as large. The parents brought snakes and occasional ocellated lizards to the nest in their crops, with the tips of the tails hanging from their bills. On arrival, one foot was placed on the protruding tail and the carcass was pulled out. While the chick was small, it was fed on small pieces; but within three weeks it tackled whole snakes greedily: thanks to its extremely powerful stomach acids, it was able to digest one end before swallowing the other!

Three vulture species occur regu-

larly on the Coto. The black vulture, which was the least numerous, is as large as a California condor: the griffon, which was common, is only fractionally smaller, while the Egyptian is about half its size. A fourth species, the rare bearded vulture, which is essentially a bird of the high *sierra's*, has been seen on the Coto only once. All vultures are shy and difficult to approach and it was not until the third expedition that a vulture feast was finally filmed at close quarters, from a hide. More

than thirty of the great birds were observed—fighting, growling, hissing and clambering on each other's backs in their haste to demolish the carcass of a red deer. In half an hour, nothing remained but bare bones. Gorged and with fouled plumage, the vultures then sat somnolently digesting their meal, while the lesser scavengers such as kites, ravens and magpies hunted for leftover scraps.

Among the innumerable smaller birds of the Coto, two merit special mention. One is the beautiful azure-



MALE SHORT-TOED EAGLE passes lizard to his mate, who will then feed nestling. Unlike most other eagles, male

short-toed takes equal share in feeding. Note small feet, adapted for seizing reptiles which are bird's chief diet.

MR. MOUNTFORT, who is honorary secretary of the British Ornithologists' Union, led three expeditions to the Coto Doñana. MR. HOSKING, England's foremost photographer of birds, accompanied him. An account of the work, *Wild Paradise*, is soon to be published by Houghton Mifflin.

winged magpie, which, like the Spanish Imperial eagle, is a remnant population, far separated geographically from the original stock. The European race is restricted to parts of southern Spain and Portugal; one must go as far as China to discover the nearest neighbors of its kind. It is a splendidly-colored bird, with pale blue wings and tail, a conspicuous black "hood" and a pinkish-gray body. Unlike the European magpie,

it is strictly gregarious. Considerable numbers were found nesting at high density in the pine woods of the Coto, having annexed this habitat from the European magpies, which were much more numerous and were obliged to nest in low bramble bushes on the open scrub, where they were heavily parasitized by the great spotted cuckoo. This differentiation was much more marked than the corresponding ecological division between the jay and magpie in northwest Europe. Another notable local bird was the handsome spotless starling, which here filled the ecological niche held elsewhere by the common starling. Its plumage is a glossy blue-black, entirely lacking the characteristic brownish speckles that mark the more familiar species.

During the three springtime expe-

ditions, 222 different species of birds were identified. One, the masked shrike (*Lanius nubicus*) from eastern Europe, was new to Spain; another, the sand lark (*Calandrella raytal*), is an Asiatic species and had not previously been recorded anywhere in Europe. Nests of sixty different species were found and half-a-dozen very rare birds were photographed for the first time. The full report of the work of the expeditions in all spheres of natural history has just been issued as a book. The volume has created widespread comment among conservationists. The revelation of the Coto Doñana's fabulous riches will not result in any rush of sightseers, however, for the owners are determined that it shall remain what it is today: one of the most strictly guarded and undisturbed sanctuaries in the world.



MIXED HERON POPULATION was found on Coto, with colony totaling some 15,000. Little egrets like those above,

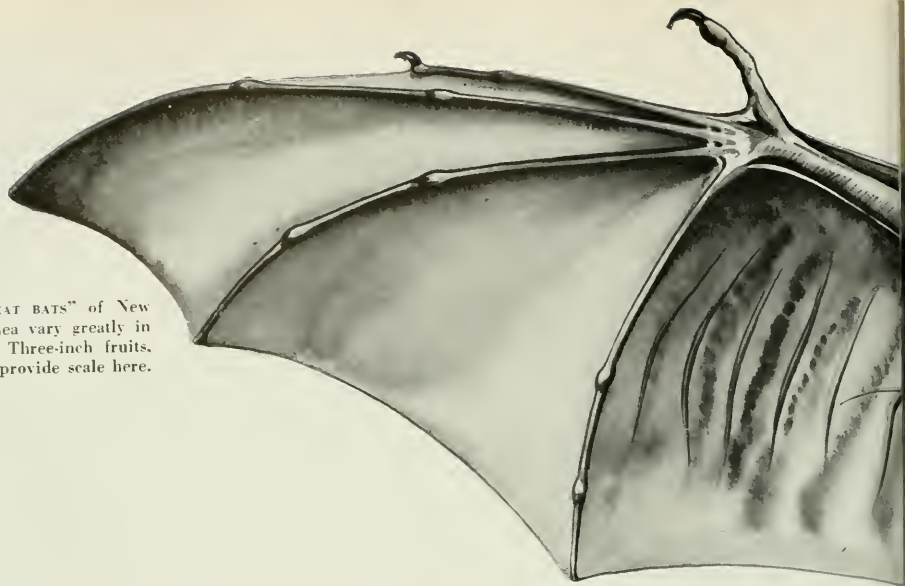
are now known to have flown to New World from Spain; nestling ringed on Coto was found next spring in Trinidad.



LITTLE EGRET'S DISPLAY is of rare beauty. Fact that many related species breed in same area suggested that,

despite similarity, herons had basically different diets. Study showed they had different foraging ranges, as well.

"GREAT BATS" of New Guinea vary greatly in size. Three-inch fruits, top, provide scale here.



CHIROPTERA OF NEW GUINEA

This island's air is aswirl with bats

By HOBART M. VAN DEUSEN
and RUSSELL F. PETERSON

THE LAST RAYS of the sun flame the hurrying clouds of the south-east trade winds. Swifts tumble and circle on flickering wings over the green-yellow treescape. Then it is dusk, and the swifts are not alone in the darkening sky. Joining them now are fluttering shapes whose maneuverings the eye can scarcely follow.

From now, a few moments before nightfall, until the quiet of tomorrow's dawn is shattered by the screech of the sulphur-crested cockatoo, the air above and within the vast, rolling tangle of New Guinea's forests will be aswirl with the beat of soft wings. Giant bats, with saber teeth in a fox-like muzzle and wings spanning five and a half feet, will settle into the crowns of towering fruit trees. The peanut-vendor whistle of the tube-nosed bats will cut through the still

air of the high forest canopy. Small bats, echolocating their insect prey, will twist through gullies filled with tree ferns, circle the flaring buttresses of huge flood-plain trees, or follow the strings of drying pools along the beds of intermittent streams.

Well over a hundred million years ago, a severe dislocation of the earth's crust isolated the land mass of Australia and New Guinea from the Eurasian continent. The water barrier formed at that time has persisted to the present day. The East Indian Archipelago, however, has provided a series of island steppingstones between the two continental masses.

In 1860, Alfred Wallace, the pioneer zoogeographer of the Australasian area, pointed out the striking difference between the faunas of the western and eastern islands in this





Pteropus

Dobsonia

Rousettus

Syconycteris

ene



THE four orders of land mammals which naturally occur in the Australian Region are rodents, marsupials, monotremes (of which the egg-laying platypus and spiny anteater, or echidna, are the only survivors) and bats. Rodent stock probably arrived in this Region by "rafting" (on storm-blown vegetation) from island to island along the chain. Although the majority of the modern rodents of New Guinea and Australia are very distinct from those of Asia, they have undergone a less spectacular radiation than the marsupials. A fifth order—the carnivores—represented by the wild dog, or dingo, is believed to have accompanied the aboriginal settlers. But it is with the bats—and, particularly, the bats of New Guinea—that we are concerned here.

Bats have colonized the entire East Indian island chain, and many genera are common to both sides of Wallace's Line. Yet this spread through the islands must have taken thousands of bat generations. Like other mammals, bats have definite areas of distribution: most are of rather sedentary habit, and it is believed that many species have home ranges and territories. The wild monsoonal storms, the pressure of numbers (resulting in emigration), nomadism (unpredictable wandering), and alimantal migration (seasonal search for food) are all factors involved in the populating of new islands. Natural selection over the ages has resulted in considerable divergence from ancestral forms. Systematists have recognized these differences by describing

WALLACE'S LINE is shown on map of Australasian area. It "divides" rich

Archipelago. From his observations, he concluded that the Strait of Lombok (between Bali and Lombok) and the Strait of Makassar (between Borneo and Celebes) served as a "boundary" separating the Oriental from the Australian Region. T. H. Huxley, in 1863, gave this "boundary" the name of "Wallace's Line." If one graphs the number of species of animals of Asiatic origin on each island of the Archipelago, the Asiatic percentage drops as one goes eastward from Sumatra to New Guinea.

In effect, the barrier straits between the islands act like a filter for the animals spreading out from both ends of the chain. For example, tigers and squirrels have reached Bali but have gone no farther eastward: the marsupial cuscus, or woolly possum, is to be found on Celebes but has not extended its range to Borneo.

A plotting of species of Australian origination shows a similar drop as one proceeds westward. Wallace's Line, then, represents the point on such a graph where a relatively sharp break is found in the number of animal species of both Oriental and Australian origin.

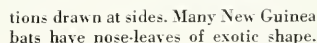
Although many species transgress the Line in both directions, Wallace's concept is useful in pointing up the fact that the rich, Asiatic faunal region to the west is separated from the eastern, Australian one, the animal life of which is relatively impoverished. In Australia and New Guinea, a majority of the land habitats

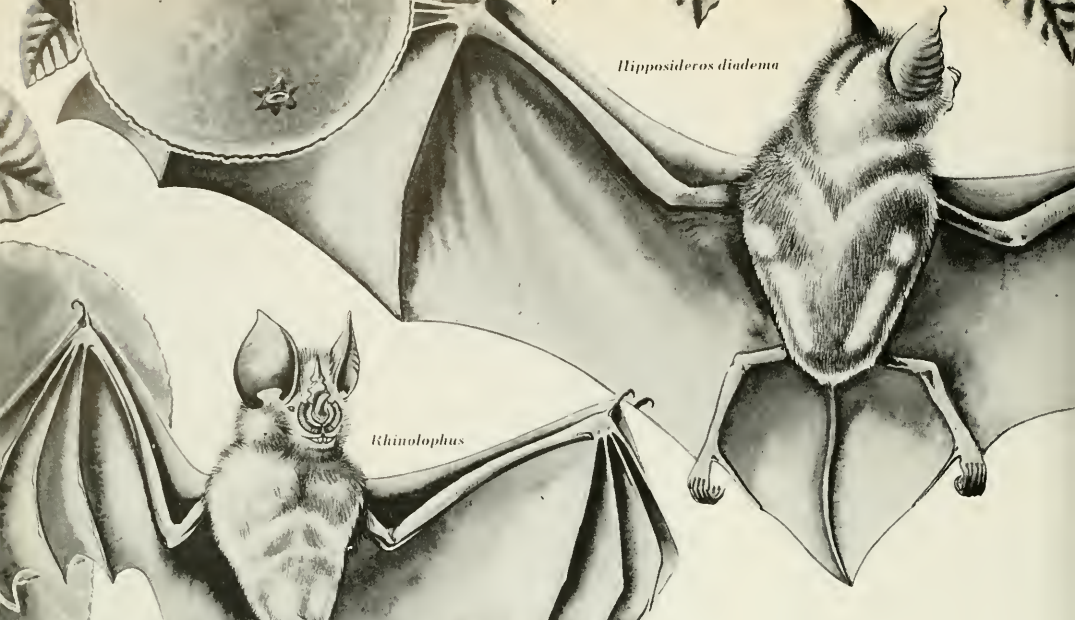
New Guinea is an immense island (next to Greenland, the largest in the world), stretching along the path of the sun for over fifteen hundred miles just south of the equator, lying above Australia like the lid of a teakettle. In its wonderfully varied 317,000 square miles of bold mountain ranges, isolated high valleys, escarpments notched by waterfalls and extensive lowland rain forests lives a rare assemblage of plants—orchids, mosses, ferns and flowering trees—birds, including the unique birds of paradise, and nocturnal mammals, that has made the island a veritable mecca for the field biologist.

Other genera of fruit bats roost in caves. The wings of one of these, the barebacked *Dobsonia* (that also frequents gold-mine tunnels and deserted houses), are attached to the back along the spine, giving a more effective wing area that aids the bat in hovering, not only in the close quarters of caves, but also in the tangled interior of the rain forest where it


Nyctimene, the tube-nosed bat, wears a clown costume of rounded yellow, white and green spots on its ears, wings and legs. When at rest during the day, this strikingly patterned, solitary bat, with the face of a terrified horse, fades into a back-

This brings us to a most interesting discovery: the blossom bats have been



A detailed black and white illustration of a bat, *Hipposideros diadema*, shown from a dorsal perspective with its wings spread. It has a large, rounded body, a small head, and a distinctive dark, star-shaped marking on its forehead. The wings are large and thin, with a complex network of veins.

Hipposideros diadema

A detailed black and white illustration of a bat, *Rhinolophus*, shown from a dorsal perspective with its wings spread. It has large, prominent ears and a small, dark, star-shaped marking on its forehead. The wings are large and thin, with a complex network of veins.

Rhinolophus

A detailed black and white illustration of a bat, *Iselliscus*, shown from a dorsal perspective with its wings spread. It has a small, rounded body and a small head. The wings are large and thin, with a complex network of veins.

Iselliscus

A detailed black and white illustration of a bat, *Tadarida*, shown from a dorsal perspective with its wings spread. It has a large, rounded body and a small head. The wings are large and thin, with a complex network of veins.

Tadarida

found to be pollinators of several genera of tropical plants. Cross-fertilization by insects and birds has, for centuries, been a well-known fact. Observational proof that bats also aid in this process has been difficult to gather, but enough evidence is now at hand to show without doubt that such is the case. As a corollary, many night-blooming tropical flowers are notable for their strong odors; well-developed olfactory lobes, in turn, are found in the Macroglossinae.

THE remaining five families of bats to be found in New Guinea belong to the suborder Microchiroptera—or “little bats.” They make up possibly eighty per cent of New Guinea’s total bat population and are present everywhere—from the high subalpine grasslands to the mangrove swamps that fringe the shores. One of these families, the Vespertilionidae, has a world-wide distribution: in this group we discover genera common both to New Guinea and North America, *Pipistrellus* and *Nycticeius*. We often locate these little “twilight bats” and pipistrelles roosting by day in holes in the trunks of coconut palms. The ubiquitous *Miniopterus*, which certainly ranks near the top in numbers among the New Guinea populations, is to be found in caves. This “long-fingered” bat has the terminal portion



THE MAJORITY of New Guinea's bats are from five families that belong to the suborder Microchiroptera, "little bats." Again, fruits provide a scale.

of the third finger greatly lengthened. If there were no provision for folding the finger out of the way when the "bent-winged" bat is at rest, it could interfere with the bat's ability to "hang up" by its hind feet (a habit common to most bats): but the overdeveloped tip folds back upon the wing, and has given this genus the alternate name of "bent-winged" bat.

The subgenus *Phoniscus*, genus *Kerivoula*, another member of this family, is so difficult to find that less than a dozen specimens are in museum collections. During the 1953 Archbold Expedition to Papua, we found but a single *Phoniscus* during eight months in the forest, and that one only by accident: we came upon the luckless creature one night when it had been caught by one wing on the sharp spike of a "lawyer cane" vine. Only in the morning sun, next day, when we saw the glistening golden hairs of this beautiful little bat with its tricolor fur, did we realize that we had been lucky enough to acquire a particularly valuable specimen.

Perhaps, if we knew more about the life and habits of *Phoniscus*, we would find that—far from being rare—it is actually a common bat. The same may be true for other New Guinea bats. Allied species in Africa have been found roosting by day in the crevices of bird nests!

SOME of the smallest of New Guinea's bats are in the genus *Emballonura*. These tiny creatures weigh a scant fraction of an ounce and have a wingspread of only nine inches, but they are evidently just as efficient at "hawking" for insects as their larger insectivorous relatives.

Emballonura has a wing pattern common to the rapid fliers among bats: the wing is narrow in relation to its length (to use an aeronautical

term, it has a high aspect ratio). The wings of the large fruit bats, in contrast, have a low aspect ratio.

The emballonurids are also called "sheath-tails"—the tail, instead of continuing to the hind edge of the skin which stretches between the two hind legs, pokes through the upper surface of this interfemoral membrane and ends well short of the posterior border (illustration, above, bottom).

There is great variation in the tails



FEEDERS ON FRUITS AND BLOSSOMS include these five: (l to r) the large bat, *Pteropus*; the hooverer, *Dobsonia*; dog-faced *Rousettus*; the nectar-eating *Syconycteris*; and the solitary,

of bats; many of the Pteropidae, in fact, are without tails. But it is another variable anatomical structure that has aroused the greatest curiosity among students of bats.

In the families Rhinolophidae and Hipposideridae (and the two are considered one family by some systematists), the face has developed highly specialized dermal growths; the peculiar shapes of these "nose-leaves" give the owners the look of creatures out of fantasy. Words cannot do these picturesque structures justice: they must be seen to be believed (illustrations, lower right). These horseshoe bats, so called because such is one of the basic shapes of the nose-leaf, are among the most common of all the New Guinea bats.

WE do not know the detailed story of the use of these amazing skin flaps, but we have reason to believe that they are somehow linked with the faculty of echolocation known to be possessed by many bats.

There is evidence that at least one genus possesses the ability of using its "nose-leaves" to beam its high-frequency "sonar signals." Perhaps, too, these various flaps of skin may aid in sorting out, or dampening, the sound waves bouncing back from obstruction or prey. Speculation is easy, but experimental proof is needed to clear up this question, one of the most fascinating physiological problems remaining to mammalogists.

One interesting family remains to be discussed, the Molossidae, or bull-

dog bats. In this family, the tail extends beyond the hind border of the interfemoral skin and is thus partially free of the membrane. A highly successful group on continents, these "free-tailed" bats—strangely enough—appear to be scarce in New Guinea. In the southwestern United States, they occur in cave colonies by the hundreds of thousands. In New Guinea, a few specimens of the genus *Tadarida* have been found in hollow trees, and in 1953 we collected a single individual flying along the grass- and bracken-covered mountain ridge near our 7,000-foot-high camp on the Maneau spur of Mount Dayman. Two species of *Otomops*, a genus with out-sized ears, have been described: these are the only other rep-



FEEDERS ON INSECTS include the most numerous and the most grotesque. Among them (l to r) are: the long-fingered *Miniopterus*; sheath-tailed *Emballonura*; golden-haired

Kerivoula; world-wide *Pipistrellus*; the scarce *Tadarida*; and three "horseshoe bats," *Ascelliscus*, *Rhinolophus* and *Hipposideros diadema*. Nose-leaves may aid echolocation.



tubed-nosed *Nyctimene*. All are of the family Pteropidae, suborder Megachiroptera ("great bats"), one of the six families of bats to have been found thus far in New Guinea.

representatives of the bulldog bat family thus far to be found in New Guinea.

IN Australia, *Tadarida* emerges in the early dusk and is easy to recognize by reason of its swift, and often direct, flight. It is possible, of course, that in New Guinea *Tadarida* delays its hunting until after nightfall, and thus escapes observation.

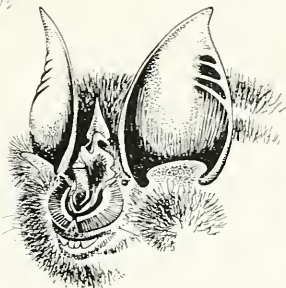
Indeed, such problems as this serve to underscore the fact that we have much to learn about the flight habits of bats. The larger fruit bats are airborne only for the relatively short time it takes them to fly from their "camps" to their feeding grounds. We are now learning that the insectivorous bats have regular flight and resting periods during the long night:

feeding flights, no doubt, are correlated with the activity of the insects on which they prey, although we know that bats can locate insects at rest as well as in the air. Experimental light-trapping of insects throughout the night could give us answers to such perplexing questions. But to know more of the life history of these or any other New Guinea bats demands of the mammalogist a long period of residence and observation.

THERE are many puzzling gaps in the geographical distribution of mammals. In New Guinea, for example, a wide-spread family, the Megadermatidae, is conspicuous by its absence. This group is represented in Africa, southern Asia, some of the East Indies

and Australia. Yet, not one genus of this family of cannibal bats (so called because of its habit of feeding on smaller bats and even birds) has ever been reported from New Guinea. This is, perhaps, not too surprising when we remember that this island is still one of the least-known areas in the world, and that many thousand square miles still remain to be touched by biological exploration.

Perhaps even that elusive creature of some zoologists' dreams, a marsupial "bat," exists undiscovered on this island of fifty million bats. The total could just as well be seventy-five million: this figure is no more than an educated guess, and it is very unlikely that the exact number of New Guinea's bats will ever be known.



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REVIEWS (cont. from page 413)

of verbal expression and the use of words." For the latter, except in man, there is not one shred of conclusive evidence, and much evidence to the contrary. Using the word "language," therefore, tends to impute higher faculties to nonhuman mammals than we have any right to assume exist. With what justification, then, can anyone speak of the "language" of bees? A successful foraging bee returns to her hive and, by means of certain stereotyped movements over the comb, she passes on to her fellow workers the location of the source of food she has just found. Unless "language" is redefined, which Scott does not do, only poetic license permits us to speak of a bee's language.

MANY such difficulties disappear if we confine comparisons to animals that are more closely related to each other. For this reason, and others, a number of animal behaviorists prefer to group their subjects phylogenetically; that is, starting with the protozoans, to pass through the sponges, the jellyfishes and their relatives, the many worms and the insects (to mention only a few), finally reaching the vertebrates—the fishes, amphibians, reptiles, birds and mammals. These groups show ever-increasing complexity of structure and physiological organization, accompanied by increasing complexity in behavior. It is possible to pick out, from this graded series, stages at which specially significant psychological capacities appear—such as the ability to become conditioned, the ability to learn in various ways and the ability to reason. The recognition of different levels of behavioral development has made animal behaviorists particularly cautious when comparing animals with different levels of capacity. Meaningful comparisons that involve similarities as well as differences can, and have been, made, but they are not to be undertaken lightly.

Once again, however, these criticisms are directed against *Animal Behavior* in the role of a textbook. As an introduction to a sensible view of the behavior of animals, it stands head and shoulders above all other popular and semipopular books in the field. Scott's enthusiasm for his work, and the book's many attractive and instructive photographs and sketches, do so much to assist the scientific approach to animal behavior. It will convince otherwise those who have not thought of animal behavior as a scientific discipline in its own right. Like other disciplines, the study of animal behavior must compete for the students who will eventually make up its complement of research workers and teachers. Scott, through the medium of this volume, has proselytized well.

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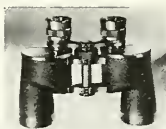
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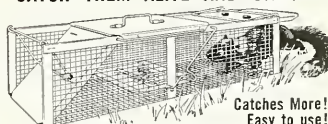
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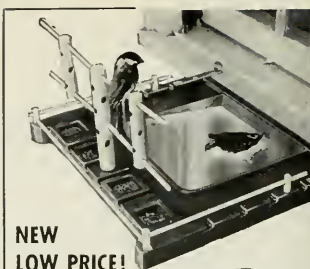
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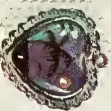
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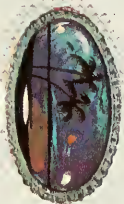
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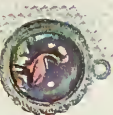
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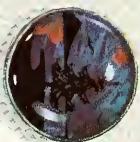
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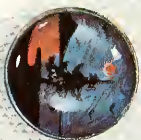
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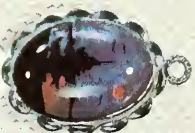
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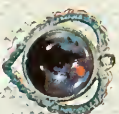
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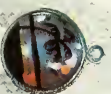
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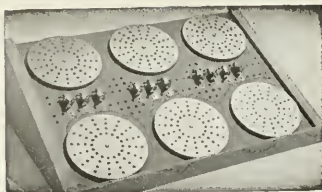
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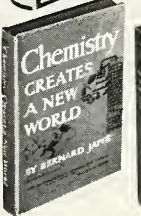
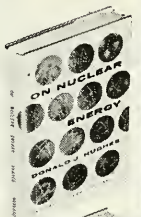
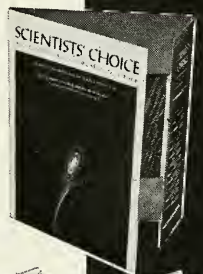
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November 1958

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Amid the sere leaves that still cling to this red oak branch, the reader will be able to detect the fresh forms and brilliant coloring of new foliage. For, despite the autumnal qualities of this photograph, the time is spring (the red oak being one of the trees that carries many of its dead leaves, still attached, throughout the winter months). Although the physiological process of abscission (as a plant's dropping of leaves, petals, whole flower and fruit is called) was long ago completed, tough vascular connections remain preventing the separation of the withered foliage from the plant.

Last autumn, NATURAL HISTORY told of the biochemistry that accounts for leaf color in autumn. For an account of the biochemistry of leaf fall, turn to p. 198.

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General

HARVARD CASE HISTORIES IN EXPERIMENTAL SCIENCE, edited by J. B. Conant, Harvard University Press, \$10.00; 639 pp. (2 vols.), illus.

VALUABLE, and successful, attempt to present the principles of science by retracing the most significant among the experiments that comprise its history. The eight chapters concern biology, as well as physics and chemistry. The emphasis on actual laboratory experimentation has been altogether too rare in popular scientific books; the present volumes (prepared originally for college students of the social sciences and humanities) should have as great—and deserved—a success among general readers as they have had among undergraduates (illustrations, right).

SCIENCE IN PROGRESS, Tenth Series, Hugh Taylor, Ed. Yale University Press, \$6.50; 253 pp., illus.

THIS book maintains the standard set by its predecessors in this series of biennial volumes. Of particular interest are the essays on Pittdown Man, by Kenneth P. Oakley and J. S. Weiner; "Control of Growth and Reproduction by Light and Darkness," a lucid summary of the subject by Sterling B. Hendricks; and a brilliant "Life History of the Cell," by Daniel Mazia.

WATER, by Ivah Green. Coward-McCann, \$3.50; 95 pp., illus.

WATER, our most valuable resource, is discussed here in most of its manifestations, albeit briefly. After treating water's use and misuse, and the importance of the hydrologic cycle in our understanding of conservation, the author closes with some teasers on water skiing, fishing and skin diving. A simplified but most readable primer.

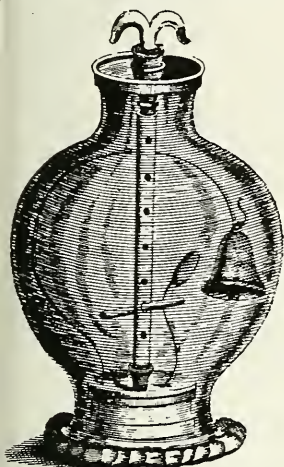
THE EARTH AND ITS ATMOSPHERE, D. R. Bates, Ed. Basic Books, \$6.00; 324 pp.

REALLY excellent book. Its chapters on all aspects of geophysics, written by authorities active in their field, are intended to provide the background needed to follow the work of the IGY intelligently. It is difficult, given the general level of excellence, to single out certain chapters as particularly outstanding. It is only to be regretted that here and there—especially in J.B.S. Haldane's chapter on the "Genesis of Life"—the discussion is a bit too technical to be followed in detail by the wide public this book deserves.

Reviews in Brief

EW BOTTLES FOR NEW WINE, by Julian Huxley. *Harper & Bros.*, \$4.50; 318 pp.

WHATEVER one may think about the efficacy of Julian Huxley's rational optimism, he has done more than most scientific thinkers to contribute new ideas toward a fruitful unity of science and mankind. These essays,



CELL IN VACUUM, devised by Boyle in 1660s, proved sound travels only in air.

representative of his brilliant and wide-ranging mind, include such varied subjects as mimicry in nature, human population, love and the natural history of Ireland. A number of them develop Huxley's thesis that man is now sole proprietor of evolutionary progress—a role which may result in a new science of human possibilities.

THE STORY OF LIFE, by H. E. Mellersh. *Putnam*, \$3.95; 263 pp., illus.

THE author, who admires *The Science of Life*, (a work of popular biology by Julian Huxley, H. G. Wells and C. P. Vells) has evidently used that work as prototype for his own, although he has written with far less scope, knowledge and ambition. Still, the story of evolution, as he tells it, is eminently readable and written—as many English books on natural science seem to be—with intelligence and humor. There are three intriguing chapters on the behavior of those, to us, nearly spiritual creatures, the birds.

POISON ON THE LAND, by J. Wentworth Day. *Philosophical Lib.*, \$6.00; 246 pp.

A LIVELY account, by a prolific British writer, of the dangers—to wildlife, plants and probably human health in his country—in the reckless use of modern chemicals. The book is written from the viewpoint of English gamekeepers and farmers, now threatened by the spread of urbanism everywhere on the island. But the work should be of great interest to everyone concerned with the protection of natural resources in the larger area of the United States, where the indiscriminate use of such "poisons" is also commonplace.

WE LIVE BY THE SUN, by J. Gordon Cook. *Dial Press*, \$3.00; 192 pp.

THIS addition to the Science for Everyman series is as graphic and readable as its predecessors. Some of the chapters seem rather abbreviated but, on the whole, a fascinating subject is discussed with lucid thoroughness. There are chapters on the nature of light, heat conversion, man-made light, color, the reception and use of light by the eyes of men and animals, telescopes and, finally, power from the sun.

ELECTRONS GO TO WORK, by J. Gordon Cook. *Dial Press*, \$3.00; 192 pp.

AN instructive, well-organized book on a momentous subject, and another in the Dial series. Dr. Cook describes the historical thought that led to our modern theory of electronic particles and their role in the nature of matter. Chapters follow on the industrial uses of electrons, on magnetism, the nature of radio waves, the development of radio, radar and television and, lastly, electronic computers.

VIRUS IN THE CELL, by J. Gordon Cook. *Dial Press*, \$3.00; 203 pp.

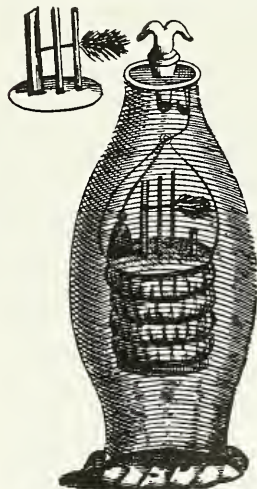
ANOTHER proof of Dr. Cook's clear-headedness and his ability to make the complexities of science easily understood. He discusses the history of the various virus diseases that have plagued mankind and our growing success in understanding the problem—especially since the electronic microscope, which makes the virus visible. A virus is a chemical entity that can come alive, and its similarity in structure to the living cells it enters is leading us toward an understanding of life itself.

THE COLUMBIA RIVER, by Ross Cox. *University of Oklahoma*, \$5.75; 382 pp.

ORIGINALLY published in 1831, Ross Cox's *Columbia River* is now reprinted as part of Oklahoma University's American Exploration and Travel Series. Despite its faults—which are legion and which the present editors carefully enumerate in their introduction—Cox's book is one of a handful of really important accounts of the opening of the Pacific Northwest. Cox went out to the River at the age of eighteen on Astor's boat, the *Beaver*. He tells of sailing round the Horn and up the Pacific coast, of the Indians and their customs, of animals and fur trading, of the War of 1812 and finally of his eastward journey across the Canadian wilds—all in an energetic style that never is allowed to flag.

NATURE IS YOUR GUIDE, by Harold Gatty. *Dutton*, \$4.95; 287 pp., illus.

THE distinguished navigator, Harold Gatty (who flew round the world with Wiley Post in 1931) wrote a precursor to the present work, known as *The Raft Book*, which was Army Air Force standard equipment during World War II. This new volume, invaluable to any who may need actually to use it in the field, also possesses broad interest for the general reader who finds nature's sign-



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Children's Book Suggestions

The American Indian

by S. Fletcher. 152 pp. This well illustrated book contains interesting scenes and events in the history of the principle Indian tribes. Highly readable. It makes the exciting times of the past come to life. Ages 10-16. \$3.10 postpaid

Exploring by Satellite

by F. Branley. 12 pp. A timely book containing many interesting facts about satellites and their uses. Numerous illustrations aid in making this one of the best books for the interested beginner. Ages 12-16. \$3.10 postpaid

The Golden Book of Animals

by W. Suschitzky. 96 pp. Ample illustrated with over 100 black and white photos. This book will delight every youngster. Over 100 animals from the world over are depicted. Ages 8-11. \$3.10 postpaid

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by R. Platt. 176 pp. Hundreds of dramatic full color photographs take readers of all ages on an adventure filled visit to the wonderful worlds of nature. Based on the best of Walt Disney's "True-Life Adventures", it is a perfect gift for any youngster. Ages 9-14. \$5.25 postpaid

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by L. Hausman & F. Sutton. 101 pp. Many strange and wonderful creatures of the sea are depicted here in full color. This big, 10 x 13 inch. book is filled with interesting facts and will be a colorful addition to every youngster's library. Ages 10-11. \$4.10 postpaid

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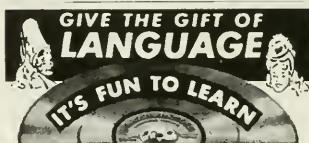
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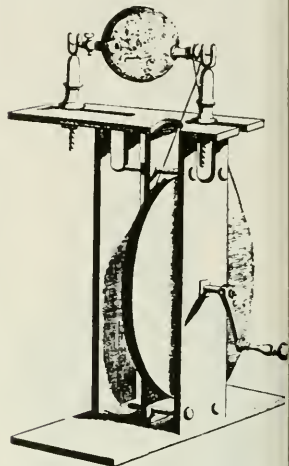
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STATIC GENERATOR of 1706 is another illustration from *Harvard Case Histories*

Zoology

PACIFIC SEA SHELLS, by Spencer Willink. Tuttle, \$3.25; 240 pp., illus.

A new and revised edition of a popular handbook. Of the five groups of mollusks, the gastropods get the lion's share in this volume since, in fact, they are the most numerous. Examples are described individually, with photographs on every other page.

ANIMALS IN MOTION, by Eadweard Muybridge; L. S. Brown. Ed. Doubleday, \$10.00; 416 pp., illus.

Few classic photographic works have been more famous and less available than Muybridge's pioneering studies of animal motion. The publisher, who has previously reprinted Muybridge's studies of human motion, is to be thanked for rounding out his selection with this substantial volume.

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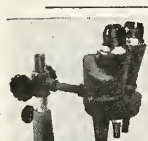
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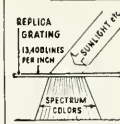
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Muybridge tells in his own text, excerpted in this volume, of the device he developed to display his pictures in actual motion—which he showed to Thomas Edison some years before the inventor announced the earliest motion picture projector. It is sad that Edison could not at least have used the name that Muybridge gave to his own machine—the "zoopraxiscope."

THE ANTS, by Wilhelm Goetsch. *University of Michigan Press*, \$4.50; 106 pp., illus.

THIS book, like "The Stars" (see below), is one of the new Ann Arbor Science Library series. Goetsch approaches ants primarily from a behavioral point of view. His discussion of ant societies in general—castes, colonies and marriage, hunting, food and shelter—are followed by chapters on particular types (wood, meadow and desert ants); and these by several rather more experiment-oriented chapters on mental faculties, learning and communication among the ants.

KINGDOM OF THE BEASTS, by Julia Huxley. Photographs by W. Suchitzky. *Vanguard*, \$12.50; 159 pp., 175 illus.

THE reader's appreciation of this book will be largely determined by his reaction to Mr. Suchitzky's photographs. Mr. Huxley's fifty-odd pages of text—once-over-very-lightly discussion of the mammals—is perforce a graceful exercise in padding. To some, the 175 well-lit and beautifully printed photographs will be fascinating, although they were made in zoos and lack both the sympathetic characterization of an Ylla and the excitement and immediacy of true nature photography. They are, however, undeniably furry and, in many instances, may be considered cute.

(continued on page 52)

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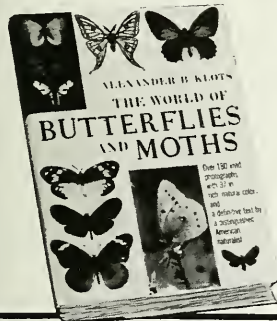
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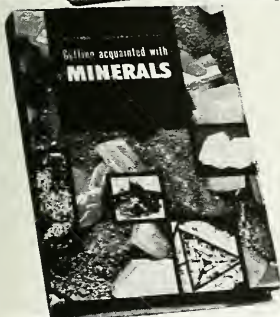
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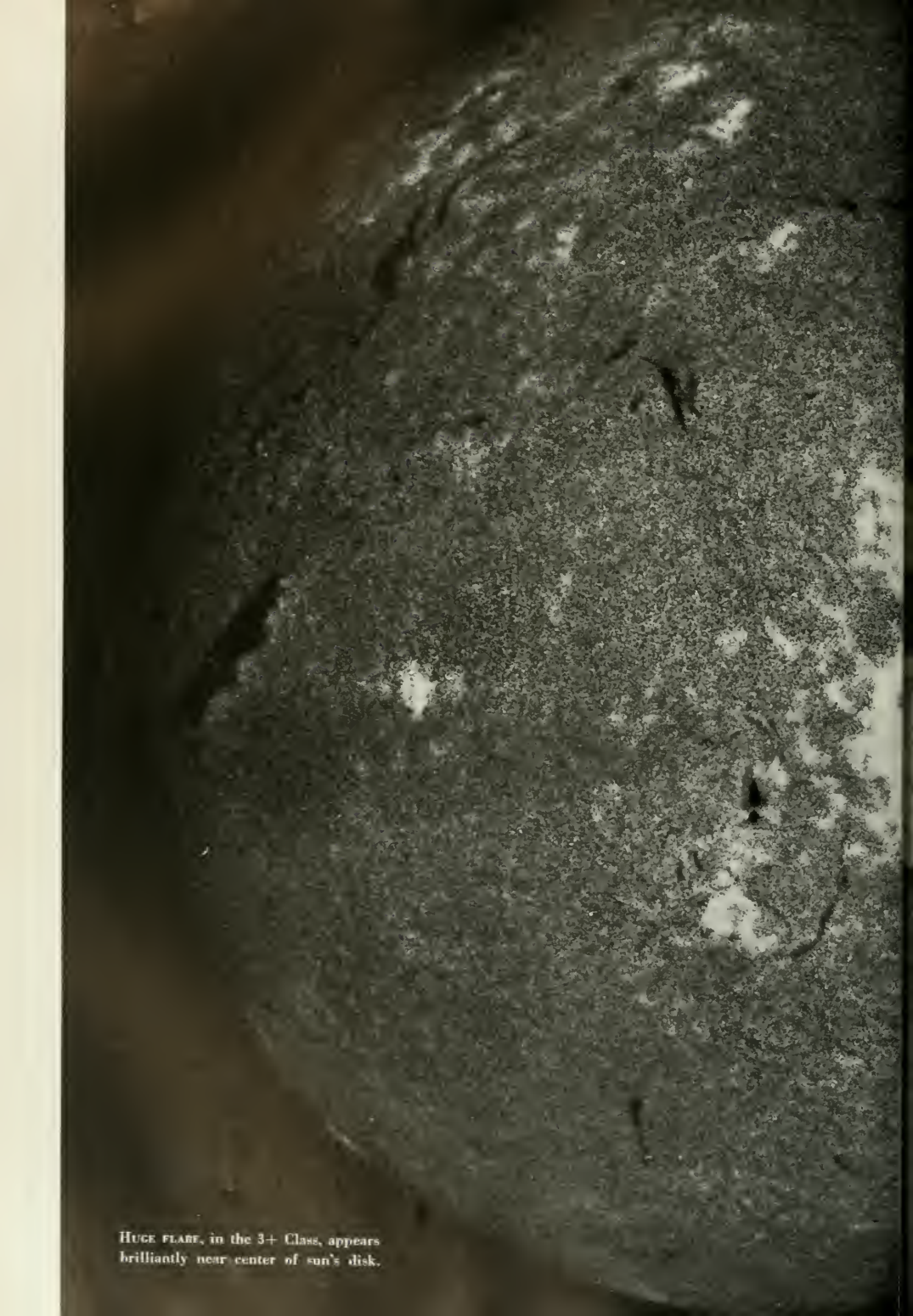
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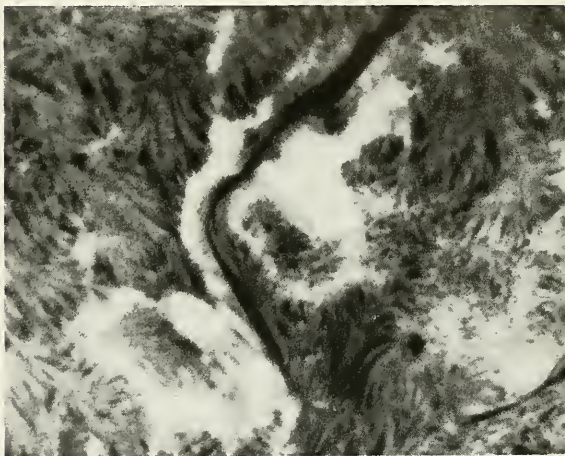


HUGE FLARE, in the 3+ Class, appears
brilliantly near center of sun's disk.

THE SUN'S FLARES AND EARTH

These solar phenomena have many
important effects on our planet

By R. GRANT ATHAY



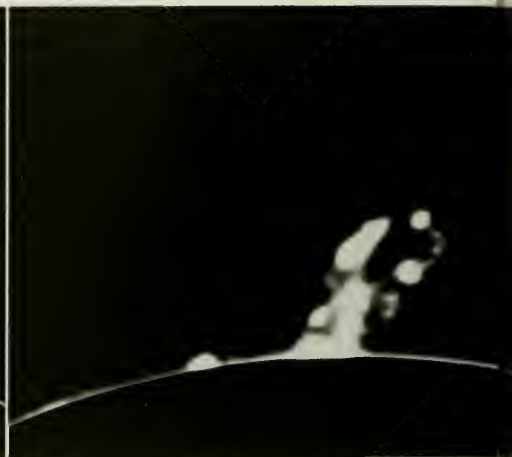
TURRULANCE of solar activity is indicated in close-up of small flare. Flares are most violent solar phenomenon.

IT SEEMS STRANGE, in the light of the discoveries of modern astronomy, that until fairly recently in the history of mankind the sun was thought of as constant and unchanging. Yet this view was so entrenched that, in 1611, Galileo's discovery of sunspots evoked anger and persecution from the traditional school of astronomers, for whom the sun was "pure fire," undefiled by any manifestations of variability. In fact, however, as we have since come to realize, such manifestations are many and striking; and among the most important is the solar flare.

Quite by chance, in the year 1859, R. C. Carrington, an astronomer at the British Royal Observatory, while engaged in making routine sunspot observations, saw a small area of the sun brighten for a few minutes, then fade back to normal. This was the first recorded observation of a



SURGE PROMINENCE associated with flare is seen through narrow-band filter. The surge, composed of hydrogen, is



visible in the corona as the sunspot area crosses sun's limb, carried from east limb to west by the sun's rotation

solar flare, the most dramatic of all known solar events. Carrington's flare was all the more remarkable because it was observed within the white light of the solar disk—since only a very few flares have been observed in this way, it was evidently a flare of great proportions. It was not until thirteen years later that Professor Charles A. Young of the Princeton Observatory next saw a flare, when he observed, in the monochromatic light coming from hydrogen, a sudden, marked brightening of a small area near a sunspot group. We have subsequently learned that flares are much more readily observed in this way than they are in the white, undispersed light of the solar disk.

AT the time of Young's observations, astronomers were working to perfect methods for observing the sun in monochromatic light. Young's method, which employed a spectrograph for dispersing the colors of the spectrum, worked for some purposes, but it was not practical for extensive observing. In 1891, George E. Hale of Yerkes Observatory perfected the spectroheliograph, a spectrograph modified so as to photograph a small area of the sun in the light emitted in a single narrow band of the spectrum. By 1924, he had finally adapted his instrument to visual observing by sweeping the slit of the spectroheliograph back and forth across an image of the sun so rapidly that, through persistence of vision, the human eye saw an image of the entire disk of the sun. A few years later, Robert R. McMath of the McMath-Hulbert Observatory developed a technique for taking motion pictures of the solar surface in the monochromatic light of the single spectral band provided by a spectroheliograph.

The primary disadvantage of the spectroheliograph is that it is necessary to take pictures of many small areas of the sun in order to obtain a composite picture of the solar disk. This disadvantage was in turn overcome by the development of narrow-band filters that made it possible to form a monochromatic image of the entire solar disk at one time. The use of these filters—which were perfected by Bernard Lyot of France, Ingve Ohman of Sweden and John W. Evans of the United States—has greatly accel-

erated our programs of solar observing. Narrow-band filters have their own disadvantages, however, and the spectroheliograph still finds considerable practical application in the tasks of solar observing.

THE sunspot areas with which flares are associated particularly those areas in which the spots are evolving rapidly, reveal several distinguishing features. Bright clouds called faculae lie in the dazzling surface layers of the sun, the photosphere. Bright plages—similar in appearance to the faculae—lie above the sunspots in the chromosphere, the lowest region of the sun's atmosphere; and still farther out—in the hot, tenuous corona—the coronal emission brightens markedly. As the sun rotates on its axis, it carries visible sunspot areas from its east limb around its west limb; and as a spot area crosses the limb, loop-shaped prominences of hydrogen gas, which are formed in the corona in the intense magnetic fields radiating from sunspots, come into view. Faculae, plages and prominences retain their general form throughout all or a large part of the life history of the sunspot areas; if they are present when the spots come into view on the east limb, chances are they will also be present two weeks later when the solar rotation carries them around the west limb.

Flares are distinguished from these other visual phenomena by their extreme brightness and relatively short lifetime. When observed against the solar disk, they almost always appear to occur in a pre-existent plage while the sunspots are still visible. When observed at the limb, however, they are frequently found in the corona, elevated well above the chromospheric layers where plages are found. Whether they occur in the chromosphere or in the corona, they are easily distinguished from the other, less violent manifestations of solar activity.

Most flares rise to maximum brightness in less than ten

Trained in meteorology and astrophysics, DR. ATHAY is on the staff of the High Altitude Observatory, Boulder, Colorado—which has a leading role in the IGY program.



its axis. Flares are distinguished by violence and short lifetime—the first photo (left) was taken at 9:16 P.M., next

at 9:18, third at 9:21, and final view at 9:33. Most flares reach top brightness in ten minutes, die within an hour.

minutes, but a few require an hour or more. The decline from maximum brightness is much slower than the rise, but even so, the life history of most flares is less than an hour. In size, the largest flares cover an area of about 0.2 per cent of the solar disk, which is equivalent to a square with 70,000-mile sides. The smallest flares cover less than 0.01 per cent of the solar disk. In almost all cases, the flare structure is filamentary and irregular in outline.

Flares are classed according to an importance scale ranging from 3+ for the largest flares to 1- for the smallest flares. In general, the large flares are brighter than the small flares, but the importance classification is based principally upon the size of the flare, rather than upon the somewhat subjective criterion of brightness.

Large flares of Class 3 and 3+ are relatively rare phenomena. Only a few such flares occur in the course of a year, even during periods of great solar activity. During periods of low solar activity, they are practically nonexistent. Class 2 flares occur far more frequently than Class 3 flares, and Class 1 flares are still more frequent. An active sunspot region may produce several Class 1 and 2 flares during the two weeks it is visible on the forward face of the sun. Interestingly enough, some of the largest geophysical effects associated with flares come from lower class flares, not the biggest ones.

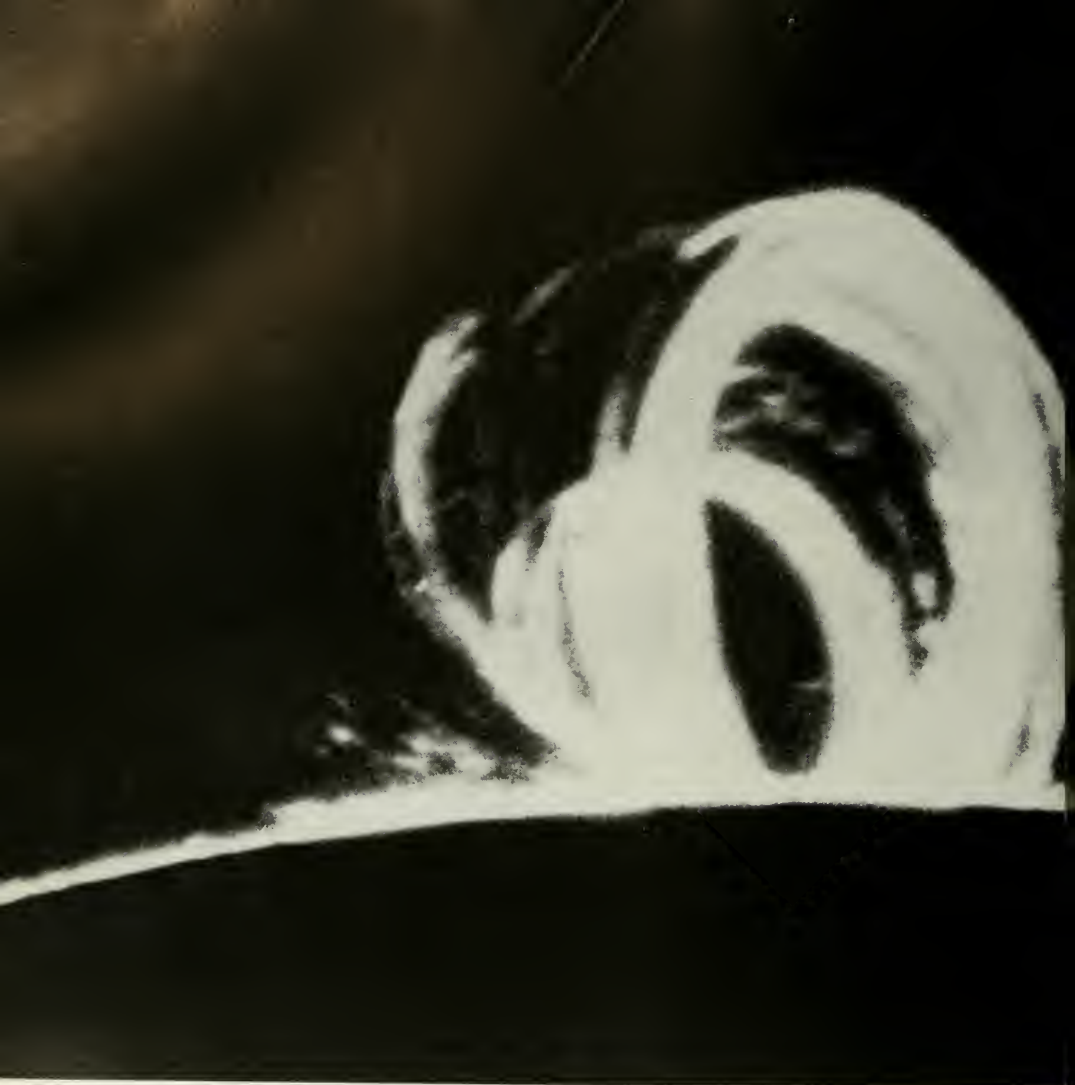
The sudden, visible burst of light as a flare brightens naturally attracts our attention and stimulates us to seek an explanation for what we see. But an equal, or perhaps greater, stimulus comes from the unseen radiations—the so-called corpuscular radiation—evidenced by a variety of terrestrial events following flare outbreaks.

THE very first flare observed led some to suspect that flares were accompanied by unseen radiations. Carrington's flare was followed one to two days later by a sudden fluctuation in the strength and direction of the earth's magnetic field, as was Young's flare thirteen years later. Could these geomagnetic storms be related directly to the flares, so remote in both time and distance? Although a conclusive answer required much more evidence than

was available at that time, the sequence of events was noted with considerable interest; and a few, including Young, believed that the association was real rather than coincidental. It is now evident that this tentative association was correct, although it is somewhat fortuitous that it was noted at the time the first flares were observed.

Our collection of flare data is now fairly extensive, at least for purposes of comparing flares with geophysical phenomena. There can be little doubt that flares and geomagnetic storms are associated, but the association is not a simple one. Some large Class 3 flares have apparently no effect on the earth's magnetic field, whereas Class 1 flares are sometimes followed by intense magnetic storms. In all such associations of solar-terrestrial events, we must keep in mind that all visual manifestations of solar activity are interrelated. Each manifestation of solar activity is a symptom of a more deeply rooted disturbance, and cannot be regarded as a separate event unconnected with other solar events. This complex interrelationship makes it easier to discover possible correlations between solar and terrestrial events, but it also makes it more difficult to establish direct cause-and-effect relationships. Magnetic storms provide a good example. There is a well-recognized parallel between the eleven-year sunspot cycle and the rise and fall in the frequency of geomagnetic storms. The detailed associations are not well understood, but flares, sunspots and the corona all seem to play definite, if elusive roles.

The real value of the hypothesis that flares and geomagnetic storms are related lies not in its correctness, but in its implications. How can a flare on the sun change the earth's magnetic field, and why should this require one to two days? Both questions can be answered by advancing a single postulate: *the flare ejects streams of electrically charged particles from the sun.* Because these particles have mass, they must move at speeds less than the speed of light, and they will therefore arrive at the earth after the visible radiation from the flare. Because they are electrically charged, they interact with the earth's magnetic field, giving rise to magnetic storms. The time delay of one to two days, sometimes three to four days, between flares and



LOOP PROMINENCE, above, has very different form from surge. Prominences retain form throughout life of sunspot

geomagnetic storms indicates that the particles travel at moderate speeds of about 300 to 1,000 miles per second.

IF the rather nebulous association between flares and geomagnetic storms were the only evidence that electrically charged particles are ejected from the sun at the time of flares, the problem would demand much less attention than it has actually received. However, the clues leading to the explanation of the Aurora Borealis, or Northern Lights, which were relentlessly followed by the Norwegian scientists Birkeland and Störmer, also pointed toward electrically charged particles coming from the sun. Auroras, like geomagnetic storms, tend to follow flares by one to

areas: if they are present when spots appear on east limb, they will probably be present two weeks later on the west

two days. In addition, the frequency of auroral displays, especially in low latitudes, increases along with flare activity in parallel with the sunspot cycle. Again, however, the correlation is not found for every flare or every aurora.

Auroras occur most frequently in belts encircling the earth's magnetic poles. In these so-called auroral zones, auroral displays are very frequent, even during periods of low sunspot activity. Since the auroral zones are centered about the geomagnetic poles, whatever causes them must interact with the earth's magnetic field. Only electrically charged particles can logically satisfy this requirement. And since, as we have just seen, the bright auroras are associated with solar activity, the particles must have their



limb. Photo was taken with a coronagraph, presenting sun's disk as in eclipse so phenomena of corona may be observed.

origin in the sun. Finally, geomagnetic storms and strong auroral displays correlate closely with each other. It is quite likely, therefore, that the same streams of solar particles cause both events.

In the case of these particles causing the auroras, it happens we have more than just speculation to base our theories on. The spectra of the auroras, when observed along the lines of force of the earth's magnetic field—which is the direction supposedly followed by the incoming particles—show features characteristic of hydrogen atoms hurtling toward us at speeds up to 2,000 miles per second. The sun is composed largely of hydrogen, and there can be little doubt but what it is the source ejecting the electrons

and protons from which these hydrogen atoms are formed. Besides producing magnetic storms and auroras, these incoming streams of solar particles are believed to be the cause of polar blackouts, during which radio communications over the polar caps are disrupted.

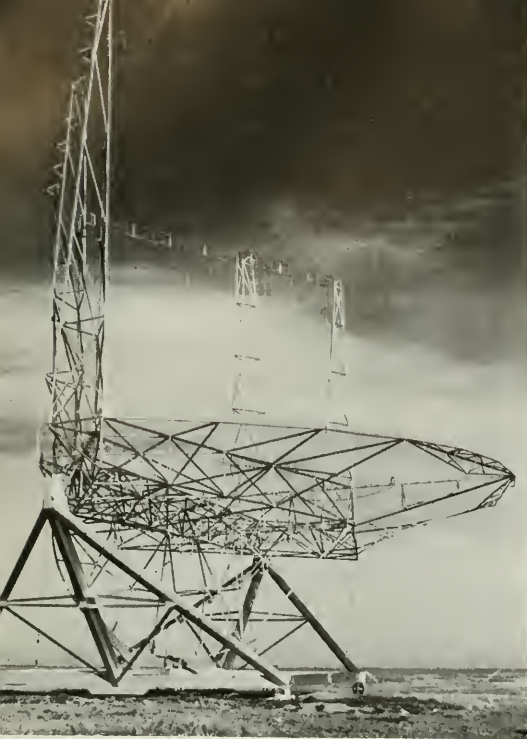
A third evidence for corpuscular emission from the sun during flares is more direct; it comes from cosmic rays and, in this case, it would seem indisputable. On a few occasions, large increases of cosmic ray flux have accompanied solar flares. By far the largest such increase occurred on February 23, 1956, in association with a Class 3 flare which climaxed a period of great sunspot activity. Neutron counters monitoring secondary cosmic ray particles at Climax, Colorado, the University of Chicago and elsewhere abruptly increased their counting rate by several hundred per cent shortly after the flare maximum, then returned slowly to normal. Other, less spectacular increases associated with flares indicate that probably all major flares emit cosmic rays. Since cosmic rays travel with speeds near the speed of light, they arrive only slightly behind the visible solar flares.

Finally, there is evidence from still another source for the existence of corpuscular emission from flares. In recent years, astronomers have "listened" to the sun with giant radio telescopes. At the time of flares, there is commonly an intense outburst of noise at radio wave lengths. The wave length of the strongest noise increases steadily with time, in a manner suggesting a disturbance moving outward through the solar atmosphere at a speed of about 600 miles per second. With optical telescopes we frequently see clouds of hydrogen atoms surge upward from the solar surface in the vicinity of flares, with about the same speed as that indicated by the radio disturbance. It is not yet clear whether these surges account for the radio noise, but it is a likely association. Perhaps it is the hydrogen surge or the outward-moving radio disturbance in the solar atmosphere that results in the auroral or magnetic storm-producing particles.

Just what mechanism in the flares exerts the force required to eject streams of protons and electrons from the sun with such high energies, we cannot say with assurance. Nor will we be able to, until we learn much more about both the streams of particles and the flares. For this, we must consider evidence of still other radiations from flares: ultraviolet and X-ray radiation.

ULTRAVIOLET and X-ray photons emitted by the sun are absorbed in atmospheric layers high above us. Each photon that is absorbed liberates one or more electrons from molecules and atoms in the earth's atmosphere, which are then said to be ionized. Some of these liberated electrons recombine with the ions, but in the meantime, still other electrons are freed. The balance between the electrons freed by the solar photons and those recaptured by the ions results in a semisteady formation of ionized layers in the earth's atmosphere. Collectively, these layers are known as the ionosphere. If the solar radiation increases, the number of free electrons in the ionosphere increases also.

The ionosphere acts as a reflector for radio waves, thus making long distance radio communication possible. For some radio frequencies—as, for example, those used by normal a-m radio stations—the ionospheric reflection is



GIANT ANTENNA records cosmic radio noise, which drops in intensity through effect of solar flares on ionosphere.

better when the number of free electrons in the lower ionosphere is not too great. It is for this reason that distant radio stations broadcasting in the a-m bands are generally received better at night, when the ionosphere is shaded from the sun's rays—and ionization is reduced—than during the day, when it is exposed to them.

For some high frequencies, however, long distance transmission is better in the daytime than at night. But accompanying the occurrence of solar flares, there frequently are sudden disruptions in daytime high frequency communications such as are used in air-to-ground, ship-to-shore, transoceanic and international transmissions—for although these transmissions fall in the class that is generally best when the ionosphere is bathed in full sunlight, during a flare they may fail completely. Their failure is caused by intense ultraviolet and X-ray radiation from the flare, which greatly increases the number of free electrons in the lowest layer (the D-layer) of the ionosphere. The magnitude of this sudden ionospheric disturbance (SID) indicates that the radiation absorbed in the D-layer may be over 100 per cent more intense during the flare than it normally is in full sunlight, even though the flare may cover less than one part in a thousand of the solar disk—the flare may be a thousand times brighter than the rest of the sun at the frequencies of the radiations producing the D-layer.

In addition to the sudden failure of high frequency communications, there are several other indications of SID's, two of which will be mentioned here. The first

comes from radio signals generated near the earth: during SID's, radio receivers operating at very low frequencies pick up static generated by lightning discharges in thunderstorms too distant to be normally received. The second comes from radio signals from outer space. At the High Altitude Observatory in Boulder, Colorado, we operate large antennas specially designed for recording the radio noise from cosmic sources far beyond the bounds of the solar system, and in some cases beyond our own galaxy. As a flare brightens on the solar disk and the number of free electrons in the D-layer increases, the radio signals from outer space drop rapidly in intensity, then recover slowly to normal as the flare fades. The study of these sudden decreases of cosmic radio noise and sudden increases in atmospheric noise, therefore, may further our understanding of both the ionosphere and the solar flares that cause the ionospheric disturbances. But for this, it is vitally important that we identify the precise flare radiations. A particular ultraviolet line of the spectrum technically called the Lyman-alpha line, emitted by hydrogen atoms, and X-rays, emitted by high energy electrons, are likely suspects.

WHATEVER the nature of radiation producing the ionization in the ionosphere, it is totally absorbed there. The D-layer lies about forty-five miles above us, the E-layer sixty-five miles and the two F-layers 110 to 160 miles. Therefore, in order to identify the radiations producing these layers, we must fly instruments, which are often rather delicate, to these heights. Following World War II, the German V-2 rockets and our own improved models were turned to scientific uses. One of the first projects was to equip these rockets with instruments capable of detecting and identifying the solar radiations in the ultraviolet and X-ray spectrum. In some cases, the spectrum is actually photographed, in other cases photon counters are used. Thus far, we have penetrated the D-layer and have gone into the E-layer, but the F-layers still lie beyond the reach of most rocket-borne instruments.

But the problem of identifying the flare radiation causing sudden ionospheric disturbances is not so simple as it might seem—in spite of the fact that we can fly rocket-borne instruments into the D-layer quite easily. The difficulty lies in getting the rockets there at the right time. Most flares require only a few minutes to reach maximum brightness, and a great many of these are not observed until after they are past maximum. The rocket must be in the ionosphere during the time when the flare is near maximum brightness in order to catch the strong blast of flare radiation. Thus, the rocket must be fueled, instrumented and ready to fire on a moment's notice. In addition, the rocket crew must be in constant communication with solar observatories where observers are watching carefully for flares. These are not easy problems.

In spite of the immense difficulty of such an operation, some success has been achieved. During the summer of 1956, the Naval Research Laboratory stationed a ship carrying several pre-equipped rockets off the west coast of Central America. In order to reduce lost time to a minimum and to get the rockets as high as possible, they were carried aloft in large balloons where they awaited firing time. These rockoons, as they are called, were fired by remote control from shipboard. The ship carried a specially designed flare detector, and its radio receivers

were tuned to transmitters at the High Altitude Observatory station at Climax, Colorado, and the Sacramento Peak Observatory at Sunspot, New Mexico. In spite of the difficulties of cloudy weather, instrument failure and the disruption of radio communications during the major flares, one rocket reached the D-layer during the waning stages of a flare. X-rays were present in increased abundance, but the ultraviolet Lyman-alpha line was near normal intensity. Unfortunately, the ionosphere was only slightly disturbed during the flare, and the failure to register an increase in ultraviolet Lyman-alpha radiation is, therefore, not conclusive.

Similar rocket firings have since been tried from San Nicolas Island with similar difficulties. In 1957, a rocket reached the D-layer during the late stages of a flare. The X-ray flux was again above normal, but the ultraviolet equipment failed to operate.

Perhaps a successful rocket flight will soon give us a more conclusive answer to the nature of the ionizing radiation, but our real hope lies in a somewhat different direction. The problem of identifying and studying short blasts of ultraviolet or X-ray photons accompanying a solar flare is very similar to that of studying the solar corpuscles ejected by flares and producing geomagnetic storms, auroras and cosmic ray increases. Furthermore, there are many features of the earth's outer atmosphere that are challenging problems. Thus, our hope lies not only in getting instruments into the outer atmosphere, but in keeping them there for relatively long periods of time. These were the problems that gave birth to the space satellites, and to a vigorous effort to get them aloft during IGY. Soon, if not already, one of our own satellites or one of the Russian Sputniks will telemeter data back to earth that will solve many of the mysteries connected with the ultraviolet, X-ray and corpuscular radiations that are associated with solar flares.

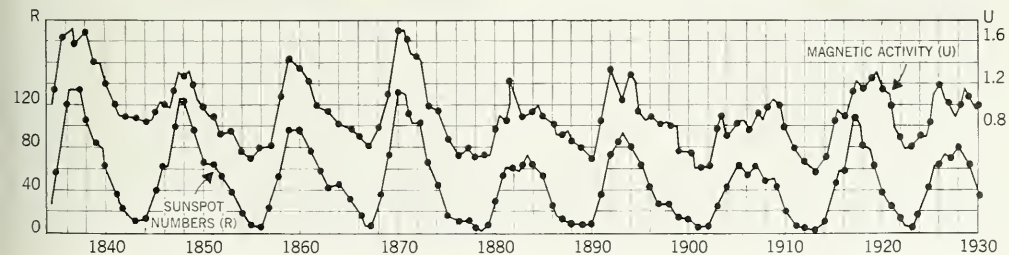
IN THE PAST, there have been attempts to blame almost all terrestrial cyclic phenomena on sunspots, flares or related solar features irrespective of any reason for doing so. Perhaps the most controversial of these endeavors is the effort to explain some of our unpredictable weather in terms of changes in the sun's radiation. The subject is probably as old as the human race. Historically, it dates back into the early days of astronomy; and only recently there has come to light some evidence that rather strongly suggests an association between weather and geomagnetic storms, which, by implication, is an association with corpuscular emission from the sun.

Much of the controversy over solar-weather relation-

ships centers around the question of whether such a relationship is possible rather than whether one exists. On the one hand, we can argue that the sun is the ultimate cause of all weather, and we should not be surprised to find that a change in the sun's radiation is reflected by a change in the weather. On the other hand, we can argue, as many do, that the known changes in the sun's radiation are small compared with its total radiation. Furthermore, this argument contends, variable parts of the sun's radiation are absorbed in the tenuous outer atmosphere far above the more massive troposphere where the weather occurs, and we should not expect the "tail to wag the dog." In some ways, this latter argument is valid, but it leaves some vital questions unanswered. How much does the solar radiant energy change during outbreaks of solar activity? How much change in solar radiation is required before it affects the weather? Neither of these questions can be satisfactorily answered at this time.

Only a small percentage of the total solar energy received at the earth is actually effective in promoting the circulation of the atmosphere. Thus, even though the variations in the energy received from the sun are a small fraction of the total energy received, they are not necessarily negligible. Furthermore, the variations in solar energy evidenced by corpuscular emission are selectively attracted into the magnetic polar regions where so much of our weather is born. Finally, there are large regions of the solar spectrum which are as yet unexplored. From our knowledge of flares and associated solar phenomena, we expect these unexplored regions of the spectrum to exhibit marked fluctuations in radiant energy. Just what fraction of the total solar radiant energy these variations represent, we cannot say. However, it would seem to be premature to dismiss them, together with the known variations in ultraviolet, X-ray and corpuscular radiations, as having no noticeable effect on subsequent weather patterns. The subject of solar-weather relationships is an especially intriguing field for research because of the great practical value, in a number of different fields, of an even slightly improved weather forecast.

OUR PURSUIT of flares and their terrestrial responses is as much in search of an answer to the cause of flares as it is in search of a better understanding of flare manifestations and effects. Even though we have been observing flares for many years, the sum total of data on which we can base a theory of flares is frustratingly limited. Our lack of knowledge is due in large part to the fleeting, unpredictable nature of flares and the difficulty of getting the needed observations during their short life-



VERY CLOSE CORRELATION between solar and terrestrial phenomena is illustrated by the graph, above, which shows

fluctuations in the earth's magnetism (upper line) beside sunspot activity (lower line), during the years 1835-1930.

times. An observer must exercise extreme patience in awaiting his chance to observe a flare. If his patience is rewarded, he finds that he can observe only a restricted number of features in the flare spectrum during its lifetime. Even then, the flare is evolving so rapidly that different features of its spectrum observed at different times cannot be properly compared. Not one single flare has been observed in enough detail to unambiguously specify its physical nature. Therefore, in our efforts to advance a theory to explain flares, we are not completely certain of what it is we must explain.

What information we have that is relevant to the nature of flares indicates that they have temperatures of about 30,000 to 50,000° centigrade. The temperature in the upper layers of the chromosphere is about the same as it is in flares, whereas farther out in the sun's atmosphere, in the corona, the temperature is normally about 1,000,000° centigrade. Gas densities in both the chromosphere and corona are much lower than they are in flares. Thus, if flares grow out of the chromosphere, they represent primarily an increase in density, with temperature changes perhaps playing a secondary role. On the other hand, if they grow out of the corona, they represent both an increase in density and a marked decrease in temperature from the normal coronal values. Unfortunately, we do not know which of these alternatives best describes flares, but we generally assume that the former alternative is in fact the case.

SINCE flares occur almost exclusively in areas near active sunspot groups, some property of these regions must be vital to the formation of flares. All sunspots are accompanied by strong magnetic fields, which, aside from their dark appearance, are perhaps their most characteristic feature. For this reason, most theories of flares try to relate them to the magnetic fields of sunspots.

A varying magnetic field in an ionized gas, such as the solar atmosphere, generates electric currents, which form the basis for some flare theories. Magnetic fields also act as barriers to the motion of ionized gases, unless the fields move with the gases. If the fields move, the gases are carried along. Because of this effect of the magnetic field being "frozen" to the gases which it permeates, compressions and expansions of the field will compress and expand the gases. This latter phenomenon, together with the concept of the magnetic field acting as a barrier to the motion, forms the basis for other theories of flares.

The few existing theories of flares are all speculative in nature. In order to test the basis on which they rest, we need observations of magnetic field strengths and their variations throughout the life histories of flares. We also need a better understanding of the behavior of ionized gases in magnetic fields. Observations of magnetic field strengths in flares are being started at Sacramento Peak Observatory, and several groups are working to further our understanding of the effects of these fields.

As is almost always the case in any science, we are spurred on to further research by the poorly understood features of flares perhaps more than we are by the well understood features. Our redoubled efforts during IGY should greatly advance our understanding of flares and their terrestrial effects. At the same time, we fully expect that many new and difficult problems of which we are not yet aware will be brought to our attention.



BRIGHT AURORAL DISPLAY seen, *above*, was photographed by Prof. V. P. Hessler of Geophysical Institute, University



of Alaska. Light of auroras is radiated by the collision of atoms and molecules in earth's atmosphere with electric-

ally charged particles from sun. Auroras tend to follow flares by day or two, parallel changes in the sunspot cycle.

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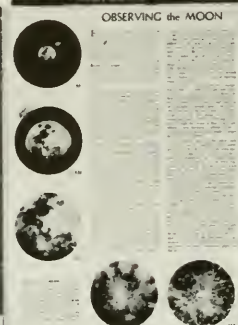
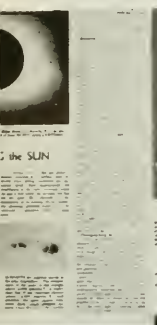
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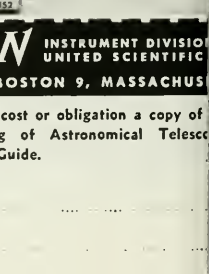
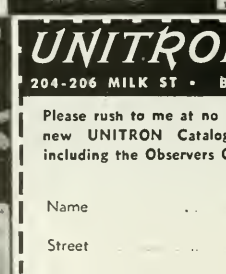
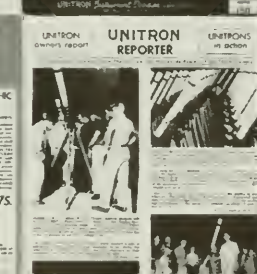
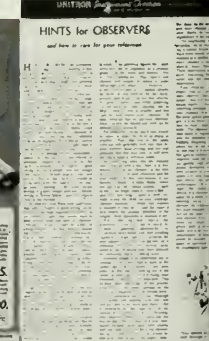
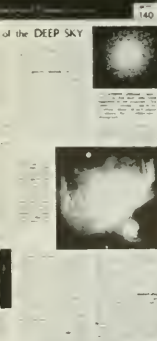
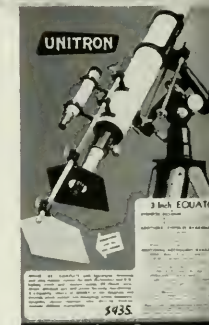
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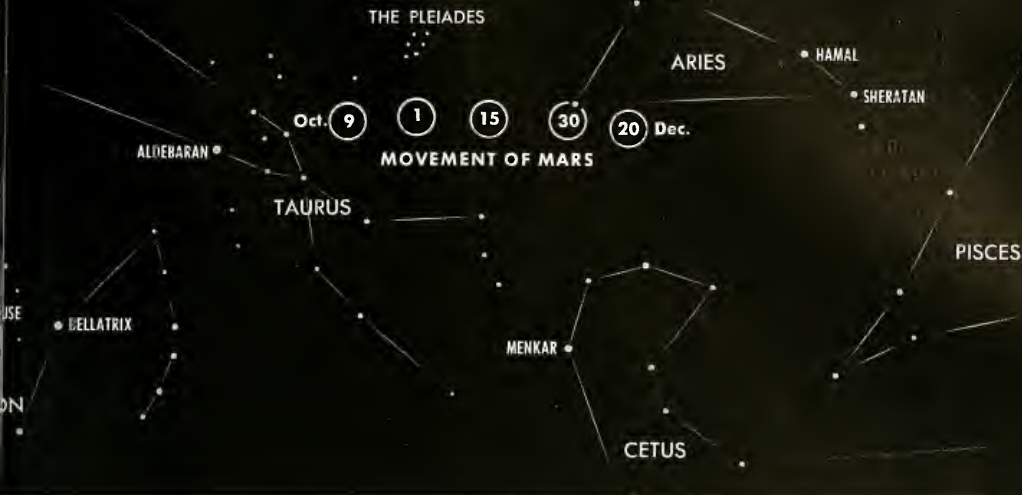
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RETROGRADE MOTION of Mars, *above*, is easily detected this month by reference to fixed points in the sky. From

November 1 to 30 (dates on chart), the bright planet will shift from a position near The Pleiades westward to Aries.

SKY REPORTER

By
Henry M. Neely

THE PLANET MARS, this month, is scheduled to give a performance that confirmed stargazers always find fascinating. Mars will be seen apparently moving westward—"backward," compared to the normal eastward motion of all planets against the background of the heavens.

This "retrograde" motion (as astronomers call it) is actually an illusion for which there is an analogy in our day-to-day experience. Imagine that you are traveling in an express train that is passing a local—going in the same direction, but much more slowly—on the next track. As the express passes, you have the illusion that the local is actually traveling "backward."

Something like this is happening in the sky this month: the earth is the "express" and Mars is the "local." We are speeding past Mars and have the illusion that Mars is traveling in the opposite direction.

This phenomenon is particularly easy to observe this month, for there are three easily recognized points of reference nearby in the sky. These are, respectively, the first magnitude star, Aldebaran, in the constellation of Taurus; the little cluster of stars known as The Pleiades; and the second magnitude star, Hamal, in the constellation of Aries (see illustration, *above*).

Observation every third or fourth night will soon make it obvious that Mars is moving away from Aldebaran. During the first ten days of November, it will be passing westward, to the south of The Pleiades. By November 15, it will be leaving The Pleiades behind, moving not directly toward Hamal but constantly closer to it. By month's end, the planet Mars will be in the constellation of Aries.

This retrograde loop started October 9 and will continue until December 20, when Mars will seem to be stationary or a night or two. After that, the planet will again resume its normal, eastward motion.

On November 8, Mars and the earth will be at their closest point this year—separated by about 45,310,000 miles. On November 18, the earth reaches a line drawn from the sun directly to Mars; this is what astronomers call "opposition," because the sun and Mars will be on exactly opposite sides of the earth. Opposition marks the time when the earth catches up with Mars in the two planets' circuit around the sun. During this period, Mars reaches its greatest brilliance—minus 2.0 on the astronomer's scale of magnitudes. This is much brighter than Sirius, which is the most brilliant star in the sky (minus 1.58).

WHAT about our other planetary companions? Early in October, as seen from the earth, MERCURY was on the far side of the sun. Since then, it has been moving rapidly eastward and is now speeding toward the earth around the arc of its orbit that carries it farthest "east of the sun." On November 20, MERCURY and the sun will appear at maximum separation ("elongation," in astronomers' terms) and observers will have their best chance to see it this month—low in the southwest, about 5:00 P.M.

VENUS cannot be seen this month. The second planet is on the far side of the sun. It will reach a position on a straight line drawn from the earth through the sun—known to astronomers as "superior conjunction"—at 7:00 A.M., (EST) on November 11. Continuing eastward thereafter, it will emerge—as a brilliant "evening star"—in mid-January.

The fifth planet, JUPITER, is also on the far side of the sun now. It will reach the line of "conjunction" on November 4. After that, the great planet will appear progressively farther to the west of the sun—rising before the sun rises—and, by December, it will make its appearance as a predawn "morning star."

After November 20, the last of the stargazers' planets—

SATURN—will disappear from our night sky. As darkness comes on, our sixth planet will be setting in the southwest, too low over the horizon to be visible. We will not see SATURN again until it reappears—in the southeast—as a “morning star” of mid-January dawns.

BELOW, arranged in almanac fashion, is the month's Sky Schedule—a list of notable sights to be anticipated.

NOVEMBER 1 to 10: in the early evening (about 6:00 P.M.), two planets may be seen as full darkness comes on. MARS, very brilliant, will be some 6° high, east northeast, while bright SATURN, some 10° high, is southwest. At this time, SATURN sets around 7:00 P.M., MARS, however, reaches its highest point, due south, about 12:40 A.M.

Midnight observers, from November 1 to 3, can take advantage of the waning moon to have a preview of the most brilliant area of the sky—the group of stars and constellations that is at its best during Christmas Week. At midnight on November 1, the moon will be quite high over the east; directly below the moon, halfway to the horizon is brilliant PROCYON, the Lesser Dog Star. Directly right of the moon is the great constellation of ORION; below, but well up over the southeast, is the most brilliant star in the sky, SIRIUS, the Greater Dog Star. Above, over the northeast, MARS may be found in the constellation of TAURUS, the brightest star of which, ALDEBARAN, shows a similar, ruddy color. To the left of the moon stands the constellation of GEMINI—CASTOR above, and brighter POLLUX below. On November 2, the moon at midnight will be lower, and midway between GEMINI and PROCYON; on November 3, it will be to the left of PROCYON.

The Taurid meteor shower is at a maximum between November 3 and 10; an average of six “shooting stars” an hour may be seen radiating from the constellation of TAURUS—marked now by brilliant MARS (see p. 485).

NOVEMBER 11 to 20: a modest meteor shower, the Arietid, has its maximum on November 12. Radiating from the constellation of ARIES, to the west of TAURUS, the Arietids often combine with Taurid stragglers in display.

A late-night vigil, kept by many earnest meteor-watchers, comes from November 13 to 16. The hope: a revival of the spectacular Leonid shower which, in 1833, set an all-time record of 35,000 “shooting stars” an hour. Six per hour has been the average in recent years; the best time is about 3:00 A.M. when the constellation of LEO is halfway up the sky, over the northeast horizon.

Observers with unobstructed southwest horizons have a chance of seeing MERCURY on November 20, if they are outdoors no later than 5:00 P.M. (see planetary notes, above). In the deepening dusk, the first planet will be bright enough to detect, very low on the horizon. Watchers in the south have a better chance than those north of 40°.

NOVEMBER 21 to 30: the waxing moon—full on November 26—will make a close approach to MARS on the two preceding nights. The closest will be early in the morning of November 25 (1:40 A.M., EST); observers, that evening—say at 9:00 P.M., on the 24th—will enjoy locating MARS in the bright moonlight, and seeing how many of the usually brilliant stars below the moon they can now detect.



NOVEMBER TIMETABLE

First week	7:15 to 8:15 P.M.
Second week	6:45 to 7:45 P.M.
Third week	6:20 to 7:20 P.M.
Last week	5:50 to 6:50 P.M.

OUTDOORS, AT NIGHT, experienced observers read star maps by use of a red light. A white light dulls night vision; after it is turned off, some time is required for the eyes to readjust to the dark sky. A red light minimizes this difficulty. To make a red light, one may insert a disk of red cellophane under a flashlight lens or use a red bulb. Another method is to give the lens a coat of red nail polish.



THIS "ROLL-AROUND" MAP shows the appearance of the entire sky during the hours noted. Its center is the zenith (the point in the sky directly overhead); its circumference covers the entire horizon. When facing in any direction, the user should "roll" the map around to bring that direction to the bottom. The stars can then be identified from the horizon up to the zenith. Here, the observer is facing south.



DARWIN'S WORMS

In his last years, the great man studied annelid "intelligence?" the questions he raised have engaged a generation of biologists

By GEORG ZAPPLER

CHARLES DARWIN'S NAME has become so closely linked with the theory of evolution over the past century that it is often forgotten that this same man was not only a great theoretician but also a keen naturalist—interested in a hundred different aspects of the world around him. It is fitting, during a year that sees celebration of his evolutionary hypothesis (NATURAL HISTORY, June–July, 1958), to note that Darwin also devoted considerable time to a detailed study of the activity of earthworms. The mind that proposed the . . . *Origin of Species by Means of Natural Selection* was necessarily open, also, to the minutiae of plant and animal life: only thus, perhaps, could Darwin's ultimate, classic synthesis have come about.

It was in the course of investigating the role that earth-

worms play in the formation of vegetable mold that Darwin undertook a study of this humble, but significant, invertebrate's behavior. He noticed that, at night, these annelids (known scientifically as *Lumbricus*) would seize and drag leaves, petioles, pine needles and other small bits of vegetable trash into the opening of their burrows. The end result of these labors not only constituted very efficient plugging-up of the worms' domiciles, but provided a lining for the front portion of their passageways to the surface.

If one looks for any advantages accruing to the earthworm as a result of this behavior, one is left with a number of possible choices. The most obvious benefit would be protection for the earthworm from such sharp-eyed predators as the traditional "early birds," since the worm

rests just below the hidden opening of its burrow. Another, less obvious, advantage might be a certain amount of insulation—obtained from the retention of heat produced by the blanketing, leafy plug. Possibly, a flood prevention factor may also be involved in this plugging operation. In addition to all these protective values, the nutritional factor involved in having a supply of leaves—at hand in the pantry, so to speak—should not be overlooked, for certain of the vegetation that *Lumbricus* drags into its burrow definitely serves as food.

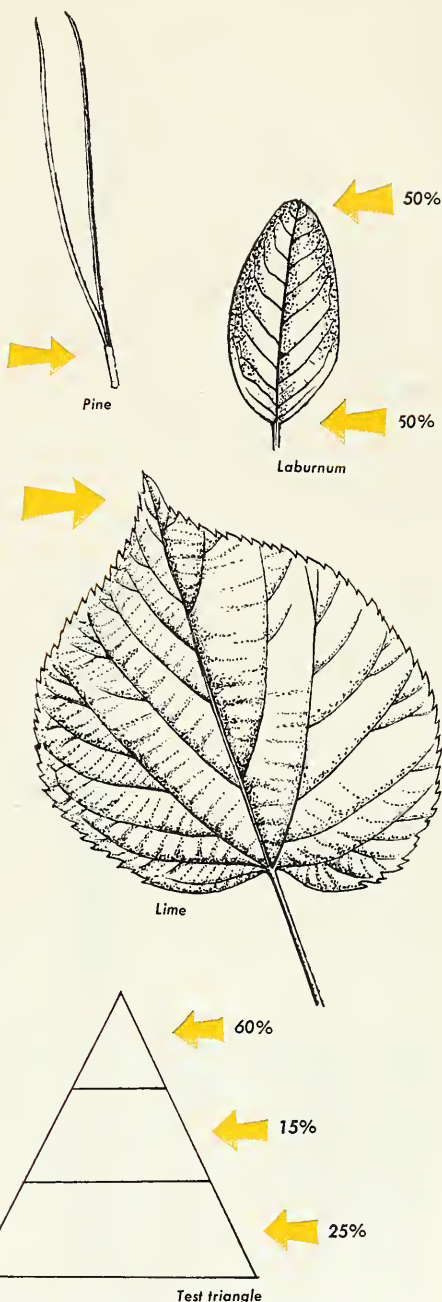
To the investigator of behavior, however, the most interesting aspect of this plugging activity is the manner of execution. How does the worm go about transporting such relatively bulky objects as leaves? In what manner are these anything-but-plug-shaped objects effectively pulled into the narrow opening of the burrow? Darwin found that about eighty per cent of the withered leaves taken from the surface by earthworms had been drawn in by the tips—obviously the most convenient method when a wide object, pointed at one end, has to be drawn into a narrow tunnel. Equal in efficiency was the way in which pine needles were handled. These evergreen leaves, each consisting of two thin, pointed needles joined at the bottom, were almost always pulled in base-foremost—evidently, the most practical procedure.

At this point, any scientist—and certainly one of Darwin's stature—starts searching for some explanation of this seemingly purposeful behavior. The searcher is faced with three conclusions: the behavior is a matter of chance, of blind "instinct" or of intelligence. Only resort to experimentation can eliminate one or more of these possibilities from consideration.

In Darwin's case, he proceeded to set up a "controlled" situation to help him decide which was the answer. Was *Lumbricus* a creature that dragged leaves into its burrow willy-nilly? Or did it possess a demonstrable ability to drag in each leaf in the most practical manner? If the latter, was this an "instinctive" or inherited talent; or was it instead, a process that somehow involved reason and the capacity to learn?

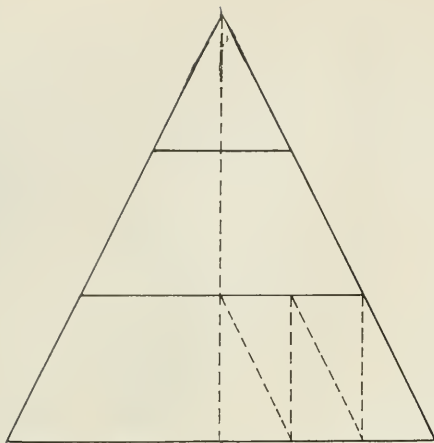
Darwin's classic experiment, aimed at answering these questions, consisted of providing earthworms with three-inch-high paper triangles, instead of leaves. Each triangle had a pair of lines ruled on it at equal distances from, and parallel to, the base, permitting Darwin's data to be grouped into three convenient categories: (a) triangles that had been seized and drawn in near the apex, (b) those tackled by the worms at a point along the base, and (c) the ones seized somewhere in the median area between the two ruled lines (illustration, right).

To prejudge the work involved for the worm in each such case, Darwin used a pair of forceps, with which he

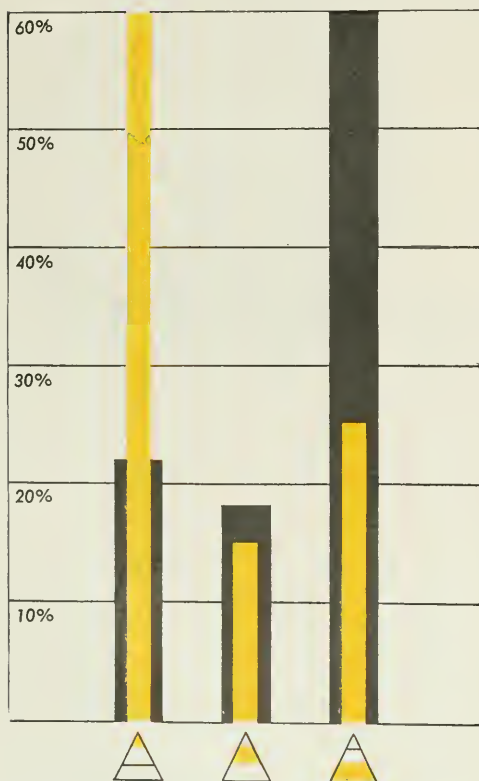


CHARLES DARWIN's last major publication, *The Formation of Vegetable Mould through the Action of Worms*, appeared a year before his death. This report of his study—and its challenge to later investigators—is the second article in a series related to Darwin's life and work to appear during the naturalist's centennial year.

WORM'S WORK in pulling vegetable trash into burrows, as analyzed by Darwin, showed pine needles usually seized at base; laburnum leaves about equally drawn in by base or tip; lime leaves usually taken by tip. In case of paper triangles, nearly two-thirds were seized by the tip end.



DARWIN'S DILEMMA arose from the geometric analysis of test triangles, *above*. Since base has five times the area, twice the points and longer margin than apex, worms were expected to pull down bases far more often than apices.



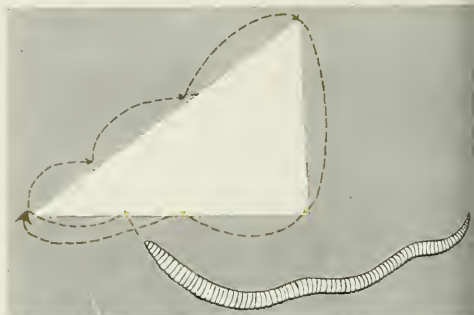
FIELD OBSERVATION upset Darwin's expectations, *above*. As colored bars show, the worms drew most test triangles into burrows by the apex, while percentage drawn in by the base was far below geometric prediction (black bars).

seized the paper triangles at various points and then drew them into a tube approximately the diameter of a worm burrow. He found that, if seized by the apex, the paper was drawn straight into the tube with its margins uncreased—forming a regularly-shaped cone. If the point of seizure was some distance below the apex, that much of the triangle would be doubled back within the tube. Such was also the case with seizure at the base, or at basal angles although the resistance offered in these cases was, as could be expected, much greater.

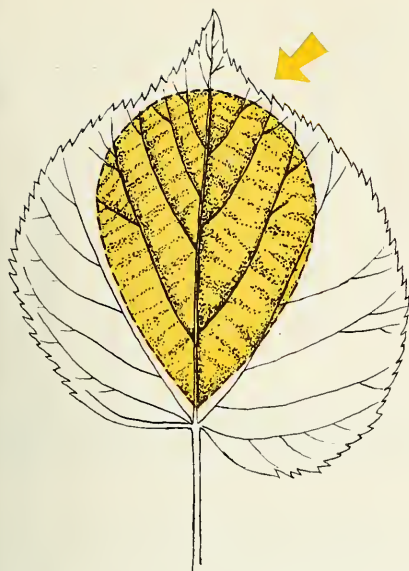
DARWIN reasoned that, if the worms' actions were determined by chance, then (since the area of the basal portion of each paper triangle was five times that of the apical region) the number of triangles drawn in by the base should maintain at least a ratio of five to one over those pulled down by the apex. In addition, the basal portion offered two convenient points of attachment at its angles, compared with only one such point at the apex; also, the marginal length available for seizure along the bottom part is greater than in the uppermost region. All these factors should favor the probability of finding the triangle pulled down by base rather than by apex.

Darwin's experimental findings, however, completely contradicted these calculations based on chance. He scattered his paper triangles on the ground near worm burrows from which leaves and other objects had been removed. Altogether, over a period of many successive nights, about three hundred triangles were drawn in by worms. Of these, more than sixty per cent had been pulled down near the apex, some fifteen per cent around the middle, and less than twenty-five per cent by the basal portion. Since nearly three times as many "leaves" had been drawn in by the apex than by either middle or base—an action that had the odds at least five to one against it—Darwin concluded that the worms' manner of handling these objects owed little, if anything, to chance.

By now, the reader, schooled in modern experimental techniques, will be ready to point out a flaw in Darwin's analysis. How could Darwin, having examined only the *end* result of the worms' successful labors, tell whether his triangles had been initially tackled at the apex or elsewhere—with the worms "shifting their grip" in the latter cases? To put it another way, where was the observed



GERMAN HYPOTHESIS, accounting for earthworms' evident "preference" for leaf-tip seizure, was proposed by Han in 1904. She postulated a reflex pulling response at the object's sharpest angle, after circumnavigation by worm



CHEMICAL CLUES as cause of worms' "preference" for the apex of leaves were also proposed by Hanel as a result of the ingenious experiment, *above*. The German zoologist at lime leaves into different shapes—the tips blunted,



left, or the tip portion wholly excised, *right*. In both cases, the earthworms still drew most leaves into their burrows by the tip ends. Hanel concluded that a chemical difference of some sort existed between the bases and tips of leaves.

While the worms were at work? The analysis of end results only—by modern standards—was valueless.

DARWIN, of course, had not been naïve enough to overlook this serious problem. From his observation of worms kept in pots indoors, he noticed that, when the triangles were drawn in by the apex, the basal portions remained clean and uncrumpled. When a triangle had been pulled down near its bottom, however, that portion would be very much crumpled and covered with slimy dirt. Darwin reasoned, therefore, that *any* triangle found drawn in

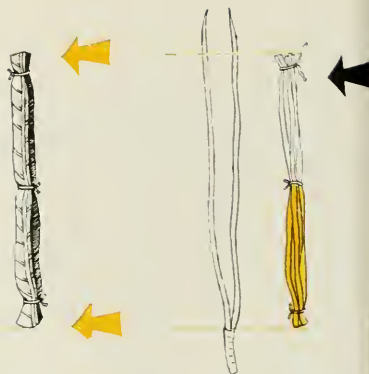
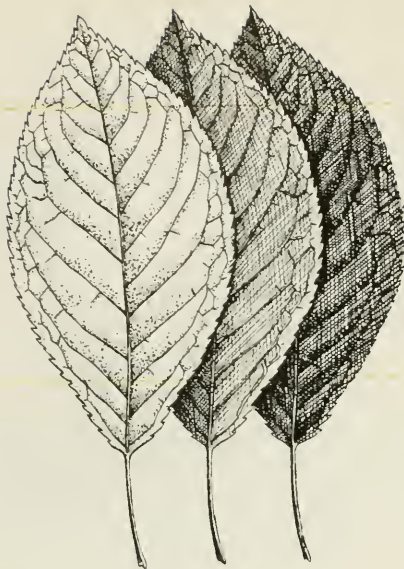
at the apex (and not stained or creased in the basal area) could be safely assumed to have been "handled" only near the upper part; indeed, such was the case in the majority of the apex-first triangles that he examined. Having thus dismissed this question of prior "handling," Darwin faced a choice between "instinctive" action or "intelligence" as an explanation for the worms' apparently nonrandom work.

He dismissed instinct for a number of reasons. In his study of worms in their natural settings, Darwin observed some striking differences in the way various kinds of leaves were handled by the annelids. The broad-based



PAPER SHAPES that Hanel used to test her hypothesis of "automatic reaction" included not only triangles similar to Darwin's, but other triangular and even quadrangular forms, *above*. As arrows show, the form's sharpest angle

was the one most frequently found inserted in the worm's burrow. Putting her chemical hypothesis aside, Hanel then plumped for a circumnavigation reflex. Like Darwin, she did not actually observe the earthworms as they worked.



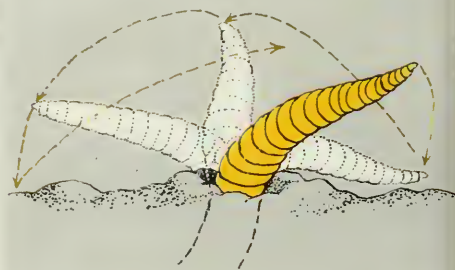
INGENIOUS EXPERIMENT by Mangold, in 1925, established the fact of chemical clues in worms' behavior. The German physiologist found that stemless bundles of leaves, *left* were seized equally by "base" or "tip" ends. Next, *above*

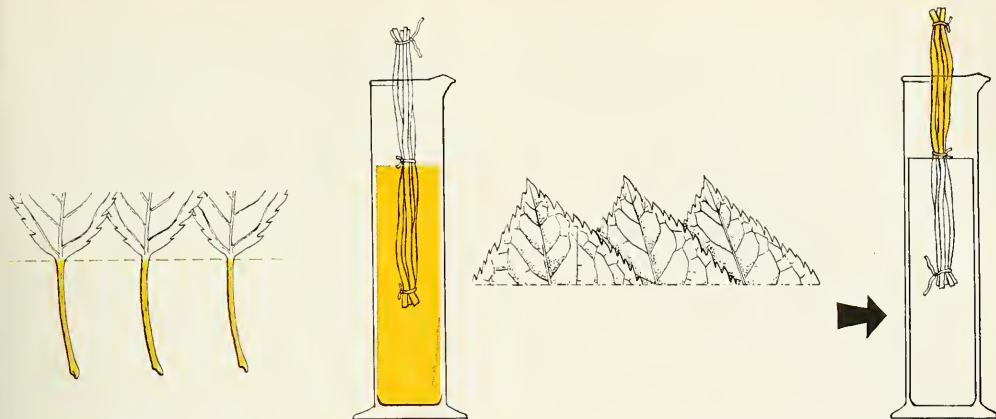
leaves of lime trees (not an endemic English species) were almost exclusively found drawn in by the apex. With laburnum leaves (almost equally pointed at both ends) however, only a little more than half were pulled down tip-first. Pine needles, as already mentioned, were almost always drawn down by the joined base: indeed, the worm continued to use the base-first method even when the tip of the twin needles were cemented or tied together by fine thread. Such a variety of reactions to different types of material led Darwin to the conclusion that instinct was not a determining factor: it seemed improbable to him that earthworms should have such a range of specialized instincts for different situations. Further, he asked himself how "English" annelids could have developed hereditary innate behavior in reference to objects totally unknown to their ancestors and so various as man-made triangles and the leaves of introduced foreign plants. Darwin's own alternative explanation was to credit *Lumbricus* with some degree of intelligence.

DARWIN's case for *some* sort of reasoning and learning in the earthworm remained fairly well established until the turn of the century, a time when students of b



FIRST BREAKTHROUGH in puzzle of annelid "intelligence" came when Jordan, in 1913, did what both Darwin and Hanel had not done: he watched the worms at night. Jordan saw that the worms stayed partly in their burrows; searched at random, *right*; often changed grip on leaves, *opposite*.





he made bundles of deodorized pine needles, coating half their length with a solution of pulverized stems, *left*, and half with pulverized leaves, *right*. Of twenty "half-and-half" bundles placed among the earthworms' burrows,

only one was drawn down by its "stem" end. Thus, Mangold simultaneously demonstrated the existence of a chemical difference between stem and leaf matter, the worms' ability to detect it, and their "preference" for leaf matter.

behavior—carried away by the discovery of reflex responses—were prepared to ascribe to these newly discovered mechanisms all the functions previously considered "psychic" in the behavior of animals. As with so many creatures, such was the case with the worms.

In 1904, Elise Hanel, the German zoologist, ran a study on the leaf-pulling behavior of *Lumbricus* along lines similar to Darwin's, and obtained very similar results. However, her interpretation of the findings was quite different. Like Darwin, she dismissed instinct. Such behavior, she reasoned (not very logically), could not be inherited since it had first to be acquired—acquired traits, by definition, not being transmitted hereditarily. She also denied the possibility of associative learning or learning through experience in as lowly an animal form as this invertebrate plowman. Having dismissed both these possibilities, she interpreted her data along the lines of the period's prejudice—namely, a purely automatic response on the earthworm's part to specific stimuli provided by the objects encountered in its wanderings.

Hanel's theoretic approach may not have been purely objective, but her experimental procedure was ingenious. She cut lime tree leaves into different shapes. In some, the

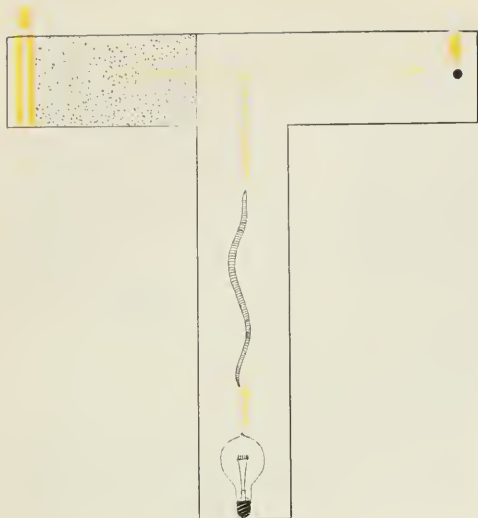
distal end was made broad and rounded and the basal end narrow. In others, the leaf was split and a portion excised down the middle. In either case, she found (by examining the plugged burrows the next morning) that the lime leaves were still always seized by the distal end (or by one of the distal ends, in the case of the split leaf, although this was not a favorable place from the point of view of mechanical efficiency). Her conclusion was that the leaf's *form* is not the determining factor; instead, the determinant must be chemical in nature—there must be some difference in the chemical constitution of different parts of a leaf. However, no thorough experiments were run to test this "chemical preference" theory.

Hanel did not stop with altered lime leaves. She went on to test paper shapes—as Darwin had done—but shapes cut to various dimensions. In addition to elongated triangles like Darwin's, she made right-angled triangles and even four-sided figures. On the whole, she found that the sharpest angle was the one most often inserted in the worm's burrow, and the shortest side the one least often drawn down by the worm.

HANEL then proposed a complex hypothesis to explain these results. An automatic reaction was involved, she held, stimulated by the relative length of the sides of the paper as perceived by the crawling worm. A succession of perceptions—shorter side, angle, longer side, angle—stimulated the worm to a pulling response. Like Darwin, however, Hanel stayed indoors at night, and did not watch the worms at work.

Now, the Principle of Occam's Razor states, with obvious common sense, that the first hypothesis to test is the one that satisfactorily explains all the available facts in the simplest fashion. Darwin did exactly this in setting up his initial triangle experiment: he was testing the hypothesis that the worm's work was a matter of pure chance. The flaw in his work was that Darwin did not actually watch the mechanics of the drawing-in operation as it proceeded in his own garden. Hanel, too, who dashed the earthworm's brief reputation for intellect, did so by examining the results of their work, but not the work itself.





MODERN DEMONSTRATION of worms' capacity to learn from experience was performed by Yerkes in 1912 with "T-maze," *above*. Presented with choice between safe burrow, *right*, or combination of sandpaper and shock, *left*, worms under test learned—after a hundred trials—to avoid latter hazards.

Had either done so, each would have observed what Hermann Jordan, the naturalist, was able to see with the aid of an oil lamp in 1913. For not in a single instance among the annelids that Jordan watched by night did any one of the worms crawl all the way *out* of its burrow! So much, then, for Hanel's hypothesis of an elaborate stimulus resulting from the worm's circumnavigation of the object to be seized. What about Darwin's initial (and abandoned) hypothesis of trial-and-error attachment?

As Jordan watched, a worm's front portion would suddenly appear from its burrow, rotate slowly in all directions and then grasp the first object with which it came in contact. This was the very essence of a random procedure, with no signs of testing any particular point of attachment. Most of the objects seized were leaves and, as the worm quickly withdrew its front portion, the leaf would be pulled down into the burrow.

Now, most of the time the worm's first tug would be unsuccessful: the leaf would catch itself in a position that straddled the burrow's opening. At this point, Jordan found, the worm would either give up and withdraw or, letting go momentarily, would reattach itself to another spot on the leaf. Then, in these cases, through chance and perseverance, a point near the leaf's apex might eventually be got hold of. The mechanics of the situation then permitting, success would attend the worm's efforts.

Jordan's nocturnal fieldwork dissipated both the aura of mystery that attached to Darwin's statistics on purposeful leaf-pulling by the earthworm and, at the same time, destroyed Hanel's hypothesis of complex reflex chains. We are left with a trial-and-error manner of procedure, the possibility of which Darwin had realized but which the great naturalist had felt justified in dismissing.

Lest, at this point, *Lumbricus* seem reduced to utter

aimlessness, let us not forget that the earthworms' "purposeless" actions could not be so labeled were it not for the repetitive "perseverance" which often impels a worm to let go and then attach itself again and again. The essence of this particular phenomenon—which may be dramatically proclaimed the "vital urge" or, more soberly, the "reactivity of the organism"—remains as much in the realm of conjecture as ever.

BUT the story does not end here. Jordan's 1913 observations were submitted to a rigorous analysis by Otto Mangold, the German physiologist, in 1925. He amply substantiated Jordan's conclusions, and added a number of additional—and intriguing—points.

Mangold was able to establish the correctness of one observation by Hanel—a certain amount of chemical discrimination exists in the earthworm, so far as preferred points of attachment to various leaves are concerned.

To demonstrate this, Mangold worked very ingeniously. First, he took wetted-down cherry tree leaves and, removing the stems, rolled them into narrow, cigarette-shaped cylinders. In these cylinders, one end consisted entirely of leaf tips and the other was composed of basal portions only. Out of fifty such plugs pulled into earthworm burrows, Mangold found that half had been drawn in by the "base" end and half by the "tip" end. These results seem to eliminate any possible chemical discrimination so far as different parts of the *stemless* leaf were concerned.

But what about stems? Mangold took pine needle bundles that had been completely deodorized by soaking in a strong acid-alcohol solution. These bundles were then dipped half their length into a gelatinous suspension composed of pulverized stems. After this coating had hardened, the other half of each bundle was similarly soaked with ground-up leaf suspension. Some twenty of these cylinders (with equally divided outer coatings of different composition) were set out: only one was drawn down by the "stem-half" thus demonstrating the earthworms' clear-cut "preference" for the "leaf" chemicals over the "stem" ones.

THE case for an initial random method of procedure—together with mechanical and chemical elements—now being more or less complete, there remains another aspect of earthworm behavior open to question. Is it possible for this invertebrate to profit from previous successful experience? Yerkes, perhaps best known for his work on anthropoid apes, studied this aspect of earthworm behavior early in his career (1912). Using a laboratory maze, he demonstrated that worms possess both some sort of memory and the ability to modify their behavior in terms of previous experience. Yerkes' apparatus was a T-shaped passage: the floor of one arm was lined with sandpaper, beyond which were situated a pair of electrodes that would shock an advancing worm. The T's other arm led to an artificial burrow, while the open stem was directed toward a light. To avoid the light, the worms moved toward the crosspiece of the T, where a choice presented itself: one "decision" led over very rough ground to a literally shocking experience; the other to a cozy burrow.

Yerkes' worms, through repeated trials, avoided the sandpaper "decision" increasingly, and also avoided the shock—"warned" by the rough floor. In addition, early tendencies to retrace a path down the stem of the T, or to turn back after progressing well toward the "reward"

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burrow, disappeared. However, a hundred trial runs through the maze were required before the earthworms evidenced any benefit from their experience.

A later investigator, Rudolf Malek (1926), tested the annelids in Prague for associative learning ability in a more natural environment and found that, in their normal surroundings, earthworms seemed capable of learning much more quickly than would have seemed possible on the basis of Yerkes' results. Malek worked with worms that had partly emerged from their burrows and were rotating their upper bodies—"searching." He offered them leaves that he held firmly in his fingers. Such fixed leaves were first gently seized by the annelid, then gripped harder three or four times in the same place in rapid succession. Then, exploring the leaf between attempts, the worms would try ten to twelve times at other points. After this, the animal abandoned the task, showing no further interest in that particular object.

It is not fatigue that causes the worm to desist. It will fasten onto another object at once after having abandoned the previous one. Indeed, a renewed attempt is made if the same leaf is offered in a place only an inch or so removed from the first. But a localized immovable object will not be tried again, although the memory thus indicated only lasts for a short time.

SOME evidence exists, then, for a limited learning ability in *Lumbricus*. However, the main operation we have been examining—the apical drawing-in of the leaf—is accomplished mostly as a chance effect. There is, thus, a certain irony in the history of earthworm behavior studies. Darwin, one of the first scientists to regard seem-

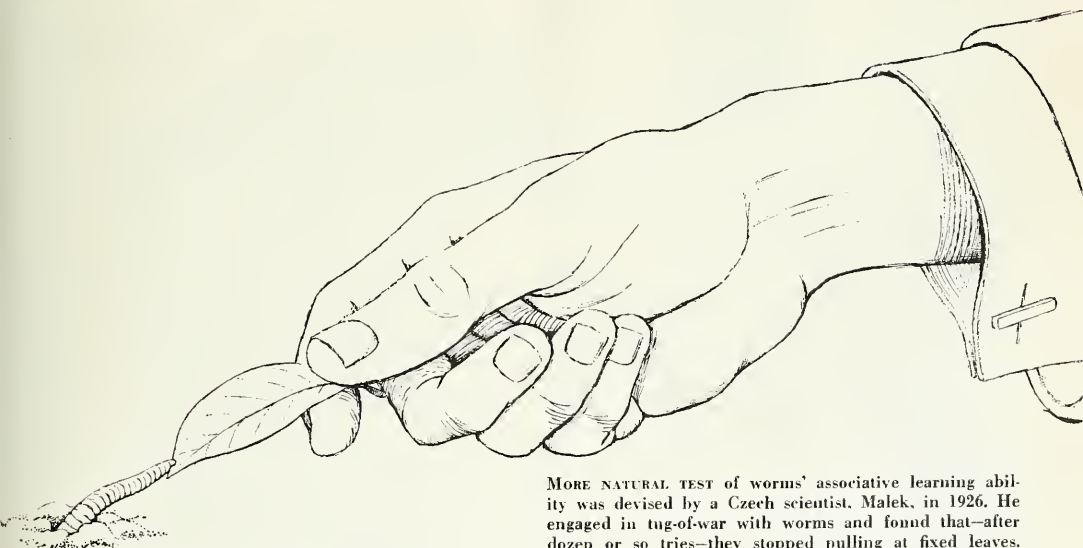
ingly purposeful changes merely as the remnant of many random effects, screened out by natural selection, felt justified in dismissing this same possibility as applying to the activities of the lowly annelid.

Indeed, the crux of Darwin's renowned theory of the origin of species, lies in its demonstration that the marvelous and precise "hand-in-glove" fit of organisms to their environment is *not* purposeful adaption to the situation but, rather, the end result of a long process of elimination—"nature" acting as the filtering agent.

Out of a constant stream of randomly occurring hereditary variations, only those which give the organisms possessing them some sort of biological advantage, compared to others of their own kind, are preserved and passed on. This advantage makes itself felt mainly in terms of an increased potential for producing offspring. All other hereditary variations (and these constitute the majority of such changes) fall by the wayside.

Thus, there is a selective premium on certain genetic differences; since they enable the possessor to live "better" and thus produce more young, they can be passed on more frequently to more descendants than hereditary contributions of lesser value in the environmental situation. Eventually, the greater portion of the existing population will carry more and more of those traits which make for being "well-adapted."

In the case of the earthworm, the situation is really no different, procedurally. Here, too, the "natural selection" imposed by the diameter of the burrow and the shape of the leaf acts to weed out most of the varying and random modes of attachment—only those are successful which happen to "fit" the environment. That, in the majority of cases, the successful method happens to be pulling down by the leaf's apex, certainly offers no surprise. Thus, the seeming puzzle that attracted Darwin's attention is, at last, quite simply explained in terms of Darwin's own grand scheme of variations rendered adaptive through the filtering process imposed by the environment.



MORE NATURAL TEST of worms' associative learning ability was devised by a Czech scientist, Malek, in 1926. He engaged in tug-of-war with worms and found that—after dozen or so tries—they stopped pulling at fixed leaves.

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THE PANTHER — ferocious and cunning — obtains its prey by springing from ambush. (Lark photo from Western Ways)

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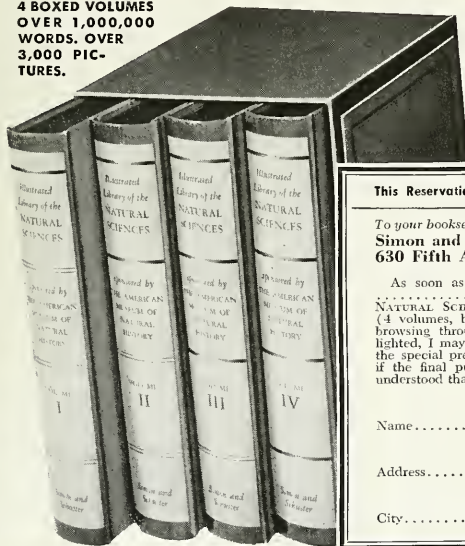
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LOSS OF PETALS by fertilized Oriental poppies is demonstrated, *above*. At left, petals are mature; abscission is

under way at center and complete at right. The most spectacular display of abscission process is autumn leaf fall.

IN MANY PARTS of the country, each autumn season brings a dramatic change in the color of foliage and, eventually, separation of the leaves from their branches while they are still alive. This shedding of leaves, or leaf drop, is but one instance of the process called abscission, whereby plant parts that are no longer useful are removed. Other examples of abscission are the dropping of petals and other parts of flowers after pollination, and the dropping of the entire flower if pollination and fertilization do not occur. Even after fertilization, developing fruits may be shed by the plant well before maturity. We can say that abscission appears to be the means for maintaining a strict economy in the functioning of a plant.

All plants do not show the same type of leaf drop. Red oaks, for example, may have dead leaves remaining on the tree throughout the winter; here, the separation of the living cells of the leaf from the rest of the plant takes place in the usual manner, but strands of nonliving cells persist between the leaf and stem and prevent shedding. In evergreen trees, such as

spruce, fir and pine, the leaves are retained throughout the year—leaf drop does occur, but it is not strictly seasonal, and the needle leaves may remain on the plant for several years.

TEMPERATURE and moisture supply are among the factors affecting abscission, as is indicated by the reports of the sudden shedding of leaves by ornamental shade trees on hot days. Abscission of the leaves of evergreen citrus trees has been observed to take place after periods of low moisture supply, but not until water is again available to play its part in the physiologic changes which lead to leaf fall. The effect of low temperature on the abscission of cotton leaves is interesting in that, if an early frost is severe, the leaves do not drop but remain

attached indefinitely; but if the first frost is not severe, the leaves drop prematurely—the severe frost kills the plant and prevents the physiologic change usual in abscission, whereas the light frost hastens the change, as other types of injury do. The effects of high temperature on abscission may be explained in similar fashion.

A third factor affecting leaf drop is the length of the periods of light and darkness to which the plant is exposed. Abscission of the leaves of oaks, sugar maple, tulip tree, black locust, white ash and red gum has been induced experimentally, simply by shortening the period of exposure to light each day. In such cases, the leaf color changes to red or yellow, as it would in normal leaf fall. And still another treatment which will cause abscission, irrespective of soil moisture, temperature and light, is exposure to ethylene, an anesthetic. Here, too, abscission is preceded by the loss of green color.

It is evident, then, that abscission is not, in the first instance, related to one or even several factors of the environment but represents a change in the chemistry of the leaf which may

DR. MUIR, Associate Professor of Botany, and DR. YAGER, Assistant Professor of Science Education, are on the staff of the State University of Iowa and are both concerned with plant physiology; the former especially with the development of fruit; the latter with flowers' abscission.



BLOSSOMING MOSS ROSE, above, exhibits petals, pistil and stamens at their peak. In a few days, all will have fallen off.

ABSCISSION

The leaf fall of autumn is but a single instance of the process whereby parts of plants—no longer useful—are discarded

By ROBERT M. MUIR and ROBERT E. YAGER

be induced by a number of such situations. Generally, the disappearance of chlorophyll foretells abscission: the leaf's color changes from green to yellow—the color of the carotinoid pigments remaining—and red and purple appear, due to the production of other pigments. At the same time, measurements show that the water content diminishes, carbohydrates move out of the organ, and minerals such as nitrogen, phosphorus and potassium also move to other parts of the plant. In general, the environmental conditions which do not favor carbohydrate production tend to accelerate abscission, and many botanists have emphasized the role of carbohydrate formation and accumulation in the control of leaf drop.

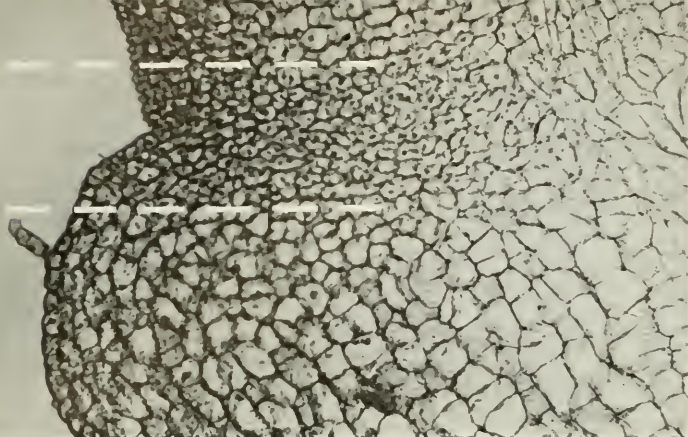
ONE of the earliest attempts to establish the direct chemical control of abscission was that of a German, Laibach, in 1933. Placing masses of orchid pollen in the ends of stalks (petioles) of coleus leaves whose blades had been removed, he found that this treatment retarded the abscission of the stalk by some twenty

days when compared to untreated specimens in which the blade had likewise been removed. Previously, a substance responsible for enlargement of the orchid ovary after pollination had been extracted from the orchid pollen: and Laibach had identified it as an auxin, an organic substance causing enlargement of cells. An additional function was therefore suggested for the auxin—that it inhibits abscission. Subsequently, the auxin was identified as indoleacetic acid, and applications of this chemical in pure form affirmed its effect of retarding abscission.

Such observations naturally led to the view that abscission of a part of the plant takes place when its auxin content drops below a critical level. This relatively uncomplicated relationship appeared to be substantiated in 1951, when Shoji, Addicott and Swets, of the University of California at Los Angeles, found that the amount of auxin in the leaf blade of the bean decreased sharply as yellowing and other signs of approaching abscission appeared, about fifty days after the leaf reached full size. They proposed

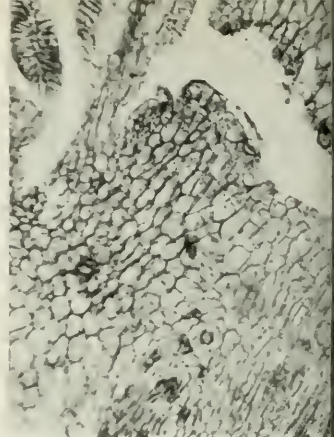
that the abscission process is governed by the amount of auxin on either side of the place where abscission occurs. When the auxin content in the part that is to be shed is greater than that of the stem to which it is attached, abscission does not occur. When the content of auxin is the same in both, then abscission occurs in a normal manner. If the auxin content of the part to be shed is less than that of the stem, abscission is accelerated.

But it should be noted that abscission is not always accelerated when auxin is added to the stem side of the abscission region—a fact which seems to imply that perhaps auxin is not the only controlling factor involved; and in 1955, Daphne Osborne, in England, reported evidence for this view. Examining the effects of substances obtained from the leaves of a variety of plants *at the time of abscission*, she found them to accelerate the abscission process in test plants. Green leaves did not yield such accelerants. She therefore proposed that leaf abscission is controlled not only by the auxin in the leaf, but also by some other substance produced as the leaf ages.



ABSCISSON ZONE of tobacco flower is marked by a definite layer of small

cells, *above*. Flower's ovary is mature and time for fertilization approaches.



PERIWINKLE LEAF, viewed in process of abscission. *above*, still shows one

Now, the abscission of plant parts results from separation of cells in a definite region termed the abscission zone. Generally, the abscission zone is found at the place where the organ joins the stem. For example, in the simple leaf with a flat, thin blade attached by a stalk or petiole to the stem, the abscission zone is at the base of the petiole. Similarly, the abscission zone of the flower is located at the base of a short stalk on which the flower is borne. The zone may consist of only a few tiers of cells or of several tiers. In some instances, the cells of the abscission zone are smaller than the cells in other regions.

Initially, the cell walls in this region are held together firmly by a "cementing substance" found in a layer between them; it is known chemically as calcium pectate. When abscission occurs, the cementing substance disappears, the calcium pectate being transformed into pectin—the same substance a housewife uses to make fruit jellies—which is soluble in the water of the cell. When this dissolution has occurred between a sufficient number of cells over the area of attachment, the weight of the plant part or a slight external mechanical force will cause complete separation.

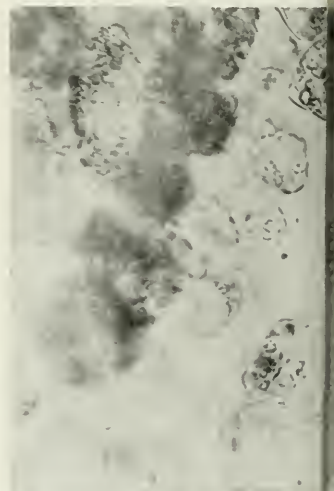
The effect of auxin in preventing abscission must, then, involve a repressing of this dissolution process. An accelerator, on the other hand, would favor the dissolution. And one direct manner in which this might be accomplished is by somehow supplying the chemical group whereby calcium pectate is changed into pectin, a methyl group or carbon atom with

three hydrogen atoms attached. In biological reactions, the best known donor of such methyl groups is the amino acid methionine, whose terminal methyl group has been shown to be rapidly incorporated into the pectic material of plant cells. It was these facts that led us to examine the effect of methionine upon abscission. Our experiments, conducted during the past two years, have shown that methionine is, indeed, extremely effective in accelerating the abscission of both leaves and flowers.

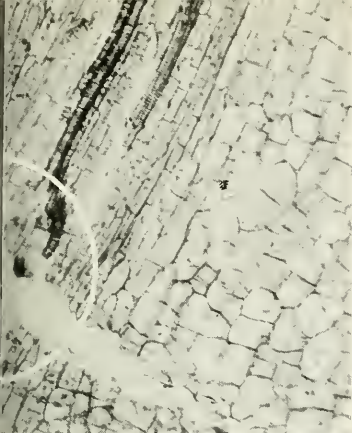
It will be helpful if we first describe some further findings about auxin, for the light they shed on the falling of flowers. Probably the most striking effect of the application of auxin in pure form is the one we see when the chemical is applied to the ovary of the flower structure. Not only does such an application prevent the dropping of the flower when pollination and fertilization do not take place, although in this case the flower would normally fall off; but in many plants it also causes the ovary to develop into a fruit—without seeds, but closely similar to a normal fruit produced by fertilization. If the flower is untreated, and fertilization is artificially prevented by covering the stigma on which pollen would usually germinate, abscission of the entire flower takes place in a very regular fashion. In tobacco, the flower drops about a week after opening—in contrast with the leaf, which ordinarily does not drop off until several months after full expansion. These differences in time correspond to differences in function:

the flower's sole function is the formation of seeds, and the success or lack of success in function is determined within a short time; but the function of the leaf is the synthesis of foods using light energy, which takes place over a period of months.

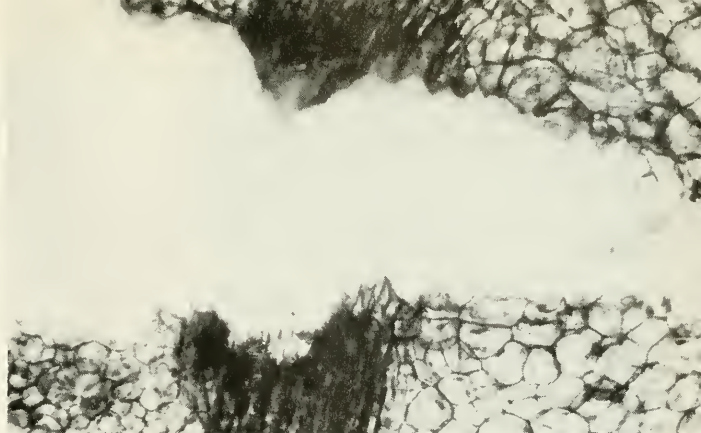
Now, several investigations have shown that auxin appears in the ovary of the tobacco flower immediately following pollination; and after fertilization, a considerable increase in auxin takes place. Little auxin, however, is found in the *unpollinated* ovary, which eventually undergoes separation. There is, then, an auxin-abscission relationship in the ovary



ENZYMES' ACTION on cementing layer is seen, *above*, as calcium pectate is



vascular connection—like a stretched coil spring—across the widening gap.



VASCULAR LINK is broken, *above*, and abscission process is nearly complete.

Chemical dissolution of the cementing layer has caused separation of cells.

closely resembling the one which we have already described for the leaf.

WE are now better able to see how methionine acts on this process. As we have already seen, abscission of the entire flower is usual if the ovary remains unfertilized. Our experiments on tobacco flowers have shown that if a small amount of methionine (0.3 mg.) is injected into the unfertilized ovary of a tobacco flower, the time for abscission is reduced from four to eight days to about one day—the dropping process is accelerated. If, on the other hand, a smaller amount of *auxin* (0.02 mg.) is in-

jected, the accelerating effect of methionine is completely overcome, and if a little more (0.2 mg.) *auxin* is injected, abscission is wholly prevented and the ovary develops into a seedless fruit of the sort we have already described. Initial results from studies of the interaction of methionine and *auxin* in the abscission of leaves indicate similar relationships for leaf fall as well as for flowers.

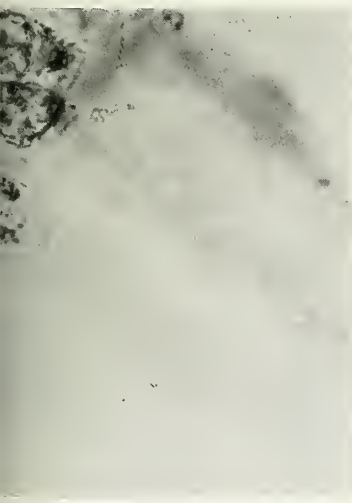
The chemistry of the abscission process can be followed in still greater detail. We will recall that abscission can take place in the so-called abscission zone of the plant part—leaf, flower or petal—only because the “cementing substance,” calcium pectate, is there transformed into pectin. Since pectin is soluble in the water of the cells, this chemical change means that the plant part is no longer fastened hard to the main body of the plant, and consequently falls or is knocked off. Now, the transformation of calcium pectate into water-soluble pectin must take place through the action of an enzyme, one of the “catalysts” of living cells, which bring about a chemical change without themselves being affected.

Our knowledge of the pectic enzymes is incomplete, and interpretations involving them must, therefore, be very tentative. However, it appears that an enzyme which will bring about incorporation of methyl groups in the pectate of the cell wall—thus making it soluble in water and causing abscission—is present in the cells of the abscission zone, and its action is increased by the presence of methionine and decreased by high concentrations of *auxin*. Such an enzyme is “pro-

topectinase.” Another enzyme, acting to remove methyl groups—thus blocking the formation of water-soluble pectin and preventing abscission—is also present, and its action is increased by the presence of *auxin*. The enzyme pectin-methylesterase is known to perform this function.

IN future findings, it will be very important to identify the chemical substance, or substances, produced by old leaves, which accelerates abscission when applied to test plants. Although methionine is expected to be found, other controlling factors may be discovered. Additional study of the physiology of abscission will also be of immediate practical value. Sprays containing *auxin* are currently being used to prevent or delay leaf drop, the dropping of flowers and of flower parts, and the dropping of young fruit as well as ripe fruit. In the case of cotton and some fleshy fruits, the sprays contain chemicals causing leaf fall, and they are used to facilitate harvest as well as to control insect pests. Thus, the partial regulation of abscission is already a practice, although it is only partly understood.

Further investigation will very likely show that the control of leaf, flower and fruit drop by the interaction of *auxin* and methionine is similar to growth processes in plants generally—processes controlled by several chemical factors, whose total expression depends upon levels and ratios of concentrations, upon the interrelation of several chemical substances rather than upon the isolated action of any one in particular.



transformed into water-soluble pectin, loosening cells of the abscission zone.



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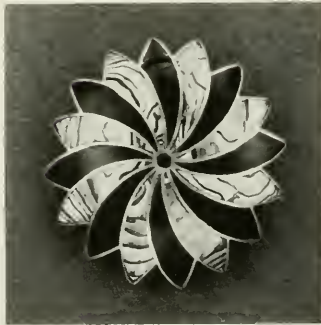
Average height 11 inches.

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From Mexico comes this enchanting iridescent swirl. Made of abalone shell set in sterling silver, it will delight every lady on your list. May be used as a pin or pendant. Approximate size 2 inches.

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◀ Court Dancer

The original of this figure is in the collections of The American Museum of Natural History. It was carved of jade during the late Ming Dynasty (1368-1644). The pale pink color was produced by heating the jade. The reproduction is done in Alastone and may be used as a pin or pendant. 3 inches high.

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Japanese Folk Dolls

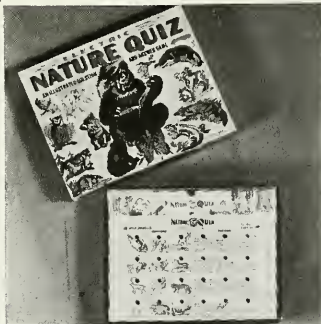
These charming Japanese dolls are handmade of cloth on a wire frame. Their costumes are typically Japanese. Each doll stands $4\frac{1}{2}$ " high and comes individually boxed. Any child will be delighted to add this woodcarrier and sweeper to her collection.

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Study of the Indus Valley civilization is gradually revealing its full originality, as well as the extent of its debt to Mesopotamia

THE ANCIENT EAST

By WALTER A. FAIRSERVIS, JR.

Photographs by LEE BOLTIN

THE complexities of modern civilization conspire to veil the fact that civilization is a natural phenomenon no more unusual to man than a nest is to a bird. This fact, of course, does not diminish its importance, but rather enables us to study its details not as if civilization were a nebulous concept, but as a concrete fact—with the same precision we would apply to a problem of geology or astronomy. If, today, we can begin to understand the phenomenon of civilization in general, it is because we have studied in detail specific civilizations of the past. And one of the most significant instances of this interplay between the general and the specific is the ancient civilization of the Indus Valley, and its relation with the Near East, where all civilization is thought to have originated.

After World War I, a number of institutions in Europe and America carried on extended archeological field campaigns in the Near East. In Iraq, continuing interest in the high cultures of Assyria, Babylon and Sumer led to extensive exploration of the mounds that marked the sites of the old cities. As the excavators of these mounds probed deeper and deeper, indications of more primitive ways of life became increasingly evident. For example, beneath the great Assyrian city of Nineveh, archeologists dug to a depth of nearly one hundred feet before reaching virgin soil, and almost all of that accumulation represented human occupancy *before* the final construction of one of Assyria's greatest cities—occupancy which had started with a simple village of agriculturists almost five millennia before Christ. More recently, cultures hitherto known only from evidence provided by these excavations deep beneath the great cities have also been located elsewhere and

have been studied individually, in small village mounds which were abandoned and never reoccupied. These more homogeneous sites enable us to know the ancient cultures in greater detail than ever before.

The evidence indicates that probably some time after 10,000 B.C., when the retreat of the last glaciation of the Ice Age drew the Atlantic winds northward, the desiccation of Southwest Asia and North Africa compelled man and the animals he hunted to move to more favorable locales. Some men probably moved to river valleys, such as those of the Nile or the Euphrates, where game and the wild fruit or berry-bearing plants were abundant. Others, perhaps not so fortunate, found refuge in oases like that of Jericho in the Jordan rift. Still others followed grazing animals into the highlands of Anatolia, Iran and perhaps Ethiopia, where they dwelt in caves or in the simple, open camps usual to both the oasis and the riverine peoples. All these people were essentially hunters and gatherers, subject to the vagaries of their habitat.

When and where the next step was taken is still a question, but all the evidence would indicate that, probably before 8000 B.C. in western Asia, the inhabitants were aware of the nutritional value of wild grain. For example, sickle blades have been found in the Natufian levels of the caves of Wadi-el-Mughara, in Palestine. Subsequently, techniques of grain cultivation and the process of making bread do not seem to have remained undiscovered for long. Grain agriculture appeared on the scene by perhaps 7000 B.C., and it was developed to such an extent that villages of several acres in size were established. At Jericho, a "town" about eight acres in extent and fortified with stone walls has recently been assigned to

this period. Similarly, another village, Jarmo in northern Iraq, belongs to the same or a slightly later time.

Agriculture was probably followed by animal husbandry; so that, by perhaps 5000 B.C., actual food production had begun to keep pace with, and indeed to exceed, mere gathering as the means of obtaining food in western Asia. During the fifth millennium B.C., the invention and use of pottery, the development of techniques for grinding and pounding, the elaboration of weaving, the beginning of metallurgy, the use of mud as a building material—initially as pisé, or pounded earth, and then in standardized brick—and the adjustments of society to the increasing complexity of village life, were manifestly the natural result of a stable and prosperous agricultural society living under equable conditions. The lower levels of many of the great mounds of the Near East provide ample evidence for these early village cultures. Mersin and Amouq in Syria; the Hassuna, Halaf and Ubaid cultures of Iraq; Badari, Merimdeh and El Tasa in Egypt; and the middle levels at Jericho in Palestine, all bear evidence of this dynamic stage of neolithic life.

THE fourth millennium B.C., was probably one of the most rapidly changing eras in human history. In Iraq, for example, it starts with small prehistoric villages and ends with sizable towns and cities, whose citizens possessed the knowledge and use of writing, bronze-making, wheeled vehicles and irrigation-systems, constructed great buildings, actively engaged in international trade, employed armies, had an established social hierarchy of kings, priests, craftsmen, merchants and peasants, and knew the luxuries of precious metals, clothes, food and drink. By about 2600 B.C.,

the rise of city-states—such as Lagash, Babylon and Ur in Mesopotamia—and the splendors of the Old Kingdom in Egypt indicate both the complete achievement of civilization and, at the same time, the full dawn of history.

It should be noted that, in outlining the origins of civilization, we have confined ourselves to the Near East. This is because the essential chronological priority of the Near East has never seriously been challenged by the evidence gathered from other centers of high culture—a fact of crucial importance. For it would seem that agriculture, animal husbandry, metallurgy, the potter's wheel, the wheeled vehicle, brickmaking, astronomy, mathematics, monumental building, concepts of morality, writing—the basic ingredients, in fact, of what we call civilization—all had their origin in the Near East.

It is clear that, as soon as an invention or a discovery was made, the idea or the process spread in many directions from this central point. The archeological evidence would indicate that agriculture reached Europe, and perhaps India, during the fifth millennium B.C., China around 3000 B.C., and, finally, the New World about 2000 B.C. Pottery-making shows a similar diffusion in time: India and Europe after 4000 B.C., China probably around 3000 or 2500 B.C., and the New World about 2000 B.C. Writing, which diffused over the earth more as an idea than as a specific style, appeared in India and Europe around 2500 B.C., certainly was known in China shortly after 2000 B.C. and has left undeniable traces in Middle America about 500 B.C. It is partly because of this chrono-

Leader of two expeditions for THE AMERICAN MUSEUM, MR. FAIRSERVIS has excavated at sites of the Indus Valley civilization in what, today, are Afghanistan and West Pakistan.

logical scale that the concept of a "nuclear Near East" has been advanced by various authorities.

This is not to say that *all* facets of civilization originated in the Near East. On the contrary, we are aware that each of the various high cultures had a distinct character differentiating it from the others; each civilization made its own contribution to itself and the world about. The civilizations of the ancient world were not pale reflections of the Near East's civilized achievement, but were individual entities in their own right. It appears that what tended to diffuse from the Near East was the stimulus of new ideas and new methods, which caused change wherever they went, but particularly in those areas where resources of population and geography provided the physical foundations for the structure of civilization. One such area was the Indus Valley, in what is now West Pakistan.

IN the early 1920's, excavations in the Indus Valley began to reveal a complex ancient civilization. At two sites, Mohenjo-daro in Sind and Harappa in the Punjab, the remnants of extensive cities were laid bare. It is now recognized that these cities, constructed largely of fired brick, were built around citadels—walled enclosures within which ritual baths or tanks, and perhaps temples, have been unearthed. The cities were laid out in a fairly regular plan with broad

avenues intersected by cross streets, the houses being placed in block patterns. Each house contained stairways, fire pits, kitchens and living quarters. The plumbing arrangements were remarkable—drains carried waste away from each house, while wells and tanks insured fresh water supplies.

The people who lived in these Harappan cities used wheeled oxcarts almost identical with those found in modern Sind. They knew how to weave cotton and had a developed metallurgy which included the manufacture of tools and weapons. Among the smaller objects, we have found necklaces and bangles made of metal, shell or clay and ornaments in both copper and bronze, as well as a very distinctive pottery, which was decorated by painting in black on a bright red surface. The designs include such floral motifs as the pipal, a plant common to the Indus River area. Female figurines made of terra cotta, probably used for ritual purposes, have been uncovered in great numbers. Some of them have elaborate coiffures and were ornamented with necklaces and bangles. Among the other artifacts were animal and bird figurines and little clay carts, which may have been playthings. Sculpture in stone was known, and while it is rare, it exhibits a mastery of the craft.

Probably the most provocative objects to be found are the square stamp seals. Since these are recovered in fairly large numbers at the sites, we can assume that they were in common usage. The usual picture engraved in the seal's soft stone is that of an animal; bulls seem to be the favorite theme, although buffalo, tigers, rhinos and elephants are frequently represented. Of particular interest are the three-headed figures. We find, for example, a mythological creature with the body of a bull and three enormous, bovine heads. Another seal depicts a three-faced human figure with a curved horn headdress, seated in yoga fashion on a podium and surrounded by various kinds of animals. This multi-faced god appears to be a peculiarly Indian form, as it is rare in the West; the three-faced human figure certainly recalls images of the modern Hindu god Siva—of which it is probably a prototype. As we shall see, other elements of this ancient civilization are also to be found in modern India.

The most interesting aspect of the seals is the writing on them. It appears to be hieroglyphic or ideo-



CYLINDER SEAL technique is shown in this photograph. The impressions were

made by rolling cylinder on wet clay. Cylinder itself appears in lower line.



ANCIENT EASTERN REGION may be seen in the map, above, illustrated by elements in the civilizations of this area.

Main travel routes, along which basic features of civilization moved east from Mesopotamia, are also indicated.

graphic in form. Human, animal and floral figurines are readily recognizable; multiple dashes probably represent numbers, while such objects as wheels, bows and arrows, and trees very likely represent themselves—it would seem that they are not phonetic symbols. Nevertheless, this writing has so far defied the efforts of the few scholars who have attempted to decipher it, and since no texts of any length have been found, it is doubtful that translation will greatly enlarge our understanding the ancient Indus civilization. Still, in the light of our present knowledge, every additional scrap of information has great value.

BESIDE the city sites of Mohenjo-daro and Harappa, there exist, scattered over the plains of Sind and the Punjab and reaching into the foothills of the Iranian Plateau, numerous small mounds that mark the villages, forts and trading posts of this civilization. But in the archeological investigations of the Harappan civilization, the emphasis has been upon the great sites. We cannot be certain, at this stage of research, just what this emphasis has done to color our

interpretations of this ancient culture. However, a theory adopted by many experts is that in the vast Indus empire, Harappa and Mohenjo-daro were twin capitals, connected by the Indus River and one of its tributaries, the Ravi. The empire, they assert, was ruled like the city-states of Sumer and Akkad—by priest-kings who received the tribute of grain which they stored in granaries. And certain barracks-like buildings and work-floors at Harappa would seem to give evidence of social stratification—as if there were a body of slaves or serfs whose lives were bound to the state. This concept of empire and priestly rulers reflects the determination of scientists to make the Indus civilization another Sumeria, where exactly that form of control existed; and it is certainly a legitimate interpretation of the facts.

Nonetheless, there is ample room for speculation in another direction. Whereas in Sumeria we very soon become aware of local differences in political, economic and even cultural concern, we discover no such differences existing along the Indus. For the 300 miles of its spread, the Harappan civilization seems to present an

almost monotonous homogeneity of culture. Pottery, seals, tools and building methods are virtually identical from the Arabian Sea coast to the foothills of The Himalaya—there is little apparent difference between Mohenjo-daro in Sind and Harappa in the Punjab. Further, this static quality is apparent in time as well—at the major sites, excavations have indicated very little change from the top of the site to the bottom or, in other words, from late to early. Once established, the Indus Valley culture appears to have remained the same throughout its centuries-long life.

THIS static, unchanging quality of the Indus civilization is extraordinary. There is no parallel for it elsewhere in the world; and the idea of an empire holding political control over divergent peoples, with probable enemies at the borders, tends to contradict the evidence for changelessness. Soldiers, slaves, traders, serfs, court officials, interregional invaders, diplomacy and war are aspects of empire that bespeak variety and dynamic action—they are the reverse of



PREHISTORIC WARE from border area took styles from both East and West.

Mesopotamian designs decorate cups; shards duplicate common Indus motifs.



ANIMAL MOTIFS on these examples of Baluchistani ware show stylized bird,

static. How are we to resolve this contradiction between the changeless aspect of the great cities and the activity and tensions which were inevitable in this vast civilization?

For one thing, the bulls we so often see on the seals, the seal writing, the female figurines with their various headdresses and the citadels with their walled baths complete with drains all seem to serve a ritual function, probably as a part of the worship of nature gods. Fertility, as personified by the bull and by the human female statuettes and invoked for the benefit of the crops, is of course a familiar aspect of early religions over a wide area of the Old World, and its primitive cult survives, in modern

Hinduism, in the sacredness of the cow and the religious use of figurines. Ritual bathing appears to be another ancient Indian trait—it, too, is commonplace in modern Hinduism—and here the drains and baths may fit.

In view of this evidence, it seems possible that the great cities we have excavated were not cities in the Near Eastern sense, like Thebes and Babylon, but were rather ceremonial centers such as Mecca or Benares. Centers of this sort would have parallels among the Maya of Middle America and, in fact, among the ancient Egyptians, for whom Abydos was so sacred that thousands yearly were buried there, in the hope of the eternal life given by the gods to Osiris, Lord of

the Dead. Mohenjo-daro, then, would seem to have been the largest ceremonial center in Sind, a center to which offerings were brought on special occasions and where the priesthood of a farming culture maintained the places of worship. If, therefore, the large sites reveal a particularly static quality, this might be due to the tendency of religion to change more slowly than secular culture.

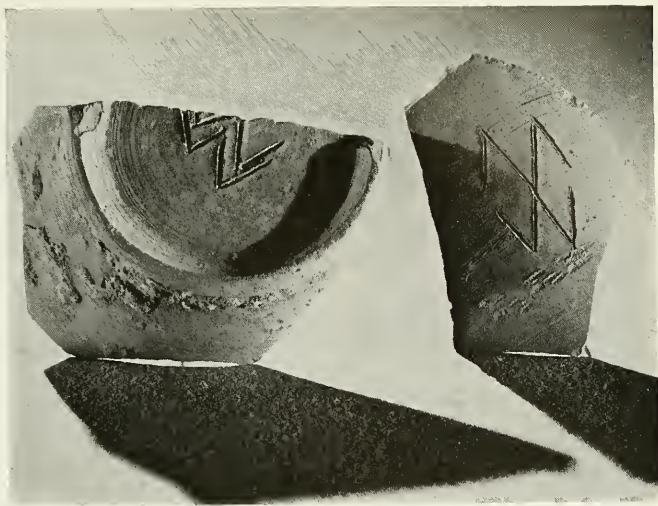
It is of interest, in this regard, to note that in the few excavations that have been carried out in the village mounds *outside* Mohenjo-daro, there is considerable evidence to indicate that these village cultures were by no means static. In western Sind, immediately below the Harappan levels appears another, different culture, the Amri, which exhibits in some of its traits a transitional stage to the Harappan. Recently, the Pakistan Department of Archeology has discovered, at a site on the east bank of the Indus, a whole series of levels below the Harappan which indicate a definite preamble to the civilization. It would appear that archeologists digging only in the great city mounds and interpreting the unearthed evidence in terms of the Near East, have arrived at conclusions that may be



EARLY INDUS QUERN indicates making of flour and grain-growing typical of agricultural society in Harappan age.



right; horned heads (probably Brahman cattle); and small, spotted beast.



POTTERS' MARKS such as those on the shards seen, above, are thought to be

possibly the oldest method of written expression in the Indian border areas.

short of the facts. The truth, of course, must await further excavations.

HARAPPAN seals have been found in Mesopotamia—mostly associated with materials of the so-called Akkadian period, which is now dated on or about 2000 B.C. Their discovery allows us to date the Harappan civilization at a later time than the Sumerian, indicating that the citadel structure, writing, wheeled vehicles, irrigation and so many other features of the Indus Valley culture probably derived from the Sumerians, among whom they were common. Of the details of this process, we cannot be sure. However, the study of the process itself has its merits, for it casts some light on the general question of why civilization springs up in some areas and not in others. It also allows us to approach an answer to the more particular question of what, in the Indus Valley civilization, is derived from Mesopotamia and what is of indigenous Indian origin.

Between the Indus Valley and Mesopotamia lies the semiarid plateau of Iran. This plateau is actually a basin, for around its fringes are mountains and, in its interior, low desert sub-basins in which only an occasional

oasis occurs to break the monotonous aridity of barren hills and gravel plains. Around the rim of this basin, prehistoric farmers found good soil and water close to the mountains, and occasionally a few hardy souls tilled the oases around or in the subbasins. The small mounds that mark these villages are found in great number in what are today Iran, Afghanistan, Russian Turkestan and the West Pakistan province of Baluchistan. The few that have been excavated indicate that these farmers were tilling the soil of the plateau at least as early as the fifth millennium B.C.—before the use of pottery, in fact. As time rolled on, the developments in agriculture and technology which have already

been outlined, as they occurred in Mesopotamia, spread to the neighboring plateau. Villages became larger and the search for soil and water resources more intense.

It was about this time that the fashion of painting designs on pottery became very popular; and for perhaps a millennium or more, the mark of these prehistoric farmers was their painted pottery. Characteristically, the designs on these painted vessels fall into two groups. The first group includes designs in common use from Mesopotamia to India. Most of these are simple, geometric motifs; but others, such as the Maltese cross, are more elaborate. And as it is unlikely that an elaborate design would origi-



TEXTILE ART of ancient Baluchistan is known from tools, top, clay casts (l. to r.) of basketry, matting, cloth.

nate independently in widely separated regions, their frequent occurrence suggests that these designs all originated in Mesopotamia and spread east across the plateau.

The second group of designs, on the other hand, consists of those expressing local contributions. In Iran, for instance, the familiar fauna of the plateau—the ibex, the bush leopard and the gazelle—are frequently depicted on Iranian vessels. Further east, in Baluchistan, we find the ibex replaced by the indigenous, humped Brahman bull. The peacock and the pipal leaf are other common motifs that express the proximity of India.

This expression of the local situation is of great importance. The typical Iranian prehistoric village is much like the typical Mesopotamian prehistoric village, that is, a collection of mud huts in the midst of a cultivated area. But while the early Mesopotamian villages developed into the later Mesopotamian cities, the Iranian villages never seem to have developed beyond the village stage. Certainly, the seeds of civilization were sown all over the Iranian plateau, but they do not seem to have borne fruit. Yet, at the eastern end of the plateau—where a geographical situation comparable to that of the Tigris-Euphrates region occurred—the Harappan civilization developed far enough to rival in advancement that of Sumer and Akkad. The evidence for sea contact between the Indus Valley and Mesopotamia being slight, we are forced to think that it was the villagers of Iran who conveyed the ideas of civilization to the Indus, without ever taking full advantage of those ideas themselves. This was not because of any lack of intelligence, of course. Rather, it is likely that the geographical situation in Iran afforded no use for the new insights, while in India it bared the need for a developed civilization. Civilization is in a way a mere clustering of ideas and people to accomplish more efficiently the reaping of their natural advantages, and such a clustering could not occur within the limited resources offered by ancient Iran.

BUT in addition to suggesting why a civilization developed in the Indus Valley, the study of the small sites between Mesopotamia and the Indus gives us our best gauge of the *originality* of the Indus Valley culture. In the northeast of Baluchistan, there are two of these peasant village sites

worth mentioning in this connection. One of them is a little mound called Sur Jangal, situated in a narrow, arid valley near a stream bed. Excavations indicate that, in the site's beginning, an Iranian farming culture was there. But because of the proximity of an Indian environment, the people of Sur Jangal gradually adopted some Indian elements in their culture: an interesting transition occurs from the normal sheep and goat husbandry, which supplemented agriculture on the Iranian plateau, to a dependence upon Indian cattle in their stead. And in the last stage of the site's occupancy, we find signs of the worship of a mother goddess, whose form, as we know it through statuettes, is common to many areas of the Indo-Iranian borderlands: goggle-eyed and heavily ornamented, she is a fearsome figure.

This site was abandoned for reasons unknown, but some fifteen miles to the southeast, and 1,000 feet lower in elevation, is located the enormous mound of Dabar Kot. Its central part rises 110 feet above the surrounding plain, and for hundreds of yards on all sides are strewn the artifacts of centuries of human occupation of the place. So vast is the site that no one has yet been able to excavate there with any success, but erosion has revealed much of the mound's cultural contents. Deep within it are the earliest cultures we know from the region—and these are exactly like those from

Sur Jangal, thus revealing Dabar Kot to have been another outpost of Indian civilization in the foothills of the Iranian plateau. There are even the familiar mother goddesses, one of which was found associated with a drain made of fired brick, perhaps part of a ceremonial building. *Above* this, and therefore dating from less remote times, lies a vast accumulation of the pottery, bangles and figurine of the Harappan civilization—apparently superimposed, then, on still older Indian cultures.

THERE are other interesting sites of this sort. In the Quetta Valley to the west, on the top of an excavated mound, a mud brick platform was found, in the midst of which were drains. The mother goddesses were found on this platform—as at Dabar Kot—along with some bull figurines, and in the platform's foundation was a disarticulated human skull—probably a sacrifice, laid there in a sort of ceremonial cache. In southern Afghanistan, near the city of Kandahar, more of the mother goddesses and the bulls were found, some of them associated with platforms and drains—like those of Quetta and Dabar Kot. At Fort Sandeman, on the main route to the Indus Valley through the hills that border Afghanistan and Pakistan, more bulls and figurines were found, and the fact that they occur high on the site suggests that they, too, were





CLAY BULL'S HEAD, left, found near Fort Sandeman in northern Baluchistan, was perhaps associated with fertility cult. Bull appears often on seals.

MOTHER GODDESS, above, a central figure in prehistoric India, was most probably passed down to the Harappan period from an earlier forest people.

part of a building complex at the top of a mound. In Sind, the pottery below the levels of the Harappan culture is like that found along with the mother goddesses in the north—thus enabling us to conclude that the goddess symbol, like the pottery, antedates the Harappan civilization. In the very lowest levels at Harappa, in the Punjab, more of this pottery occurs.

What all this information suggests, when it is added up, is that platforms, drains, mother goddesses, bull figurines and human sacrifice were part of a ritual complex. In a more evolved form, these elements, as we have seen, are all characteristic of the Harappan civilization. Even the ritual platforms with their drains, high on the mounds of the earlier sites, suggest the vast citadels at Harappa and Mohenjodaro. Yet their occurrence, in these border sites, at levels lower than those of the Harappan culture—and therefore from a more ancient society—indicates that they *antedate* the high Indus culture and are ancestral to it. At the same time, while some of these elements may be paralleled elsewhere, as an aggregate they occur nowhere else in ancient Asia. We can conclude, then, that this complex forms an original contribution, characteristic of the Indian subcontinent.

It is interesting, for the clues it may give us about this original Indian culture, to consider the ancient climate of the Indus region. The area in which the greatest number of Harappan sites is found is now in either a completely arid or a semiarid condition—a fact which has caused considerable speculation. The evidence of the seals—which depict tropical fauna such as the Indian rhino, the water buffalo, the elephant, and the tiger: the fact that fired brick—which requires abundant fuel in its manufacture—was the principal building material, and the almost omnipresent drains, would indicate a considerable rainfall and abundant vegetation during the heyday of the civilization and earlier. Furthermore, although the province of Sind is west of the rain shadow of the summer monsoon, it has been shown that a shift of but a few degrees in the wind direction would bring rain to this desert province.

It is possible, then, that there was more rainfall formerly than there is today. Of course, until we have confirmatory evidence from geographers and botanists, we have to admit that



ANCIENT SYMBOLS' SURVIVAL is here confirmed. Mohenjo-daro figure, *above*, closely resembles statuette, *below*, used by modern aborigines of Orissa.



this is speculation. But even today not all of Sind is a desert waste. The drive north from Karachi is generally in the midst of the Indus River irrigation system. Tropical birds, lizards and water buffalo are frequent sights, and wherever there is water there is lush vegetation. The region is somewhat comparable to southern Iraq, where the desert encroaches right to the river banks—yet as far as the eye can see are sites representing the prosperous civilization of the Sumerians. At present, there seems to be no evidence for climatic change in southern Iraq since the Sumerian period, forty-five hundred years ago. Sumerian prosperity thus appears to have arisen because of the elaborate irrigation system—a fact which future archeological research must consider in the Indus Valley.

In any case, it seems likely that ancient Sind was a forested region, increasingly so the further back we go in time—for man, after his usual fashion, must have helped denude the countryside of its woods, which his society, as it developed, required for fuel. These forests were probably an arm of the better-watered forest regions to the north and east, which extended along the Indus River system from Punjab to the Arabian Sea.

Now, all this is of great interest for our understanding of the origins of the Indus civilization. For in *modern* India, we find aboriginal groups of forest people whose way of life offers many suggestive parallels with what we know of *ancient* India. Among some of these groups, for example, we find horned headdresses that recall the Harappan figurines, ritual bathing reminding us of the Harappan temples with their baths and drains, animal and human sacrifice as on the high Harappan mounds and the adulation of natural objects like the pipal plant and the tiger—elements whose occurrence we have already noted for the ancient cultures. Even some of the statuettes used in both the modern aboriginal and the ancient Harappan societies bear a close resemblance. It would seem, then, that the prehistoric Indian forests were inhabited by a people whose culture passed on to the later Harappan society many of its features.

But at the same time, the earliest inhabitants of the ancient Indian forests must have had a very different culture from that of the Harappan

people. These latter were agriculturists. Their predecessors seem to have been hunters, subsisting on the animals of the forest, using animal skins for clothing, wood for building, reeds or grass for baskets, gourds as containers—all aspects of the contemporary, but aboriginal, forest cultures of India. We cannot, of course, be sure that these traits existed in pre-agricultural times in Sind, but their presence among the modern aborigines and the suggestion of parallels with later, Harappan remains is certainly suggestive.

When the Iranian farmers reached the Indus Valley, there must have been a clash of cultures, for in one very clear sense they were opposites. Agriculture and hunting could not coexist for long. With the elaboration of agricultural techniques, the population spread must have been considerable. Perhaps the technique of slash and burn (*bevar*), which has until recently been practiced by the aborigines of India as a means of clearing land for planting, was used in Sind—the first step in the destruction of the forests. In any case, it must have been the contact between the hypothetical forest cultures of primitive India and those of western Asia, and the fusion of the two, that laid the foundation for the distinctive civilization of the Indus Valley. Although this Harappan civilization parallels that of ancient Mesopotamia in many details which illustrate its debt to the West, its Indian character makes it unique. The subcontinent's influence was not to be denied. We may say that if the Harappan civilization was conceived in Mesopotamia, it was born as the child of India.

And when this child had grown to maturity, it repaid part of its debt to the West. We find the peoples of the Mediterranean world using cotton and fired brick, employing the elephant for war and labor, and using drains and reservoirs to maintain their cities. These appear to be Indian contributions to the development of civilization: they demonstrate that although the world owes its civilization's origins to the ancient Near East, the evolution of the phenomena of civilization was not entirely one-sided.

Obsidian mirror reflects fearsome mother goddess. Figure is frequently found at border sites like Sur Jangal in levels antedating Harappan culture.





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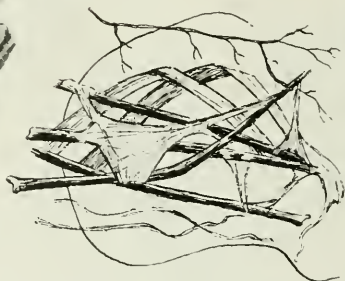
IDENTIFYING

WITH THE LEAF FALL of autumn, the student of nature finds a hundred new treasures exposed to view. A walk in the naked forest or the frosty marsh will reveal birds' summer nesting sites by the dozens. Yet, many who are expert at identifying birds are at a loss to tell with certainty, in fall, which discovered nest was made by



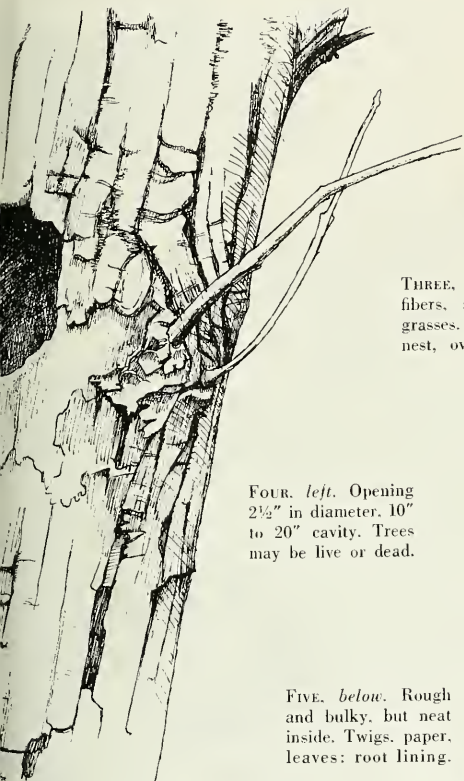
ONE, above. Felted of bark strips, leaf stalks, plant fibers and fluff. Cup-shaped.

TWO, below. Of fine grass, plant fibers; lichens on exterior. Neat, saucer-shaped.



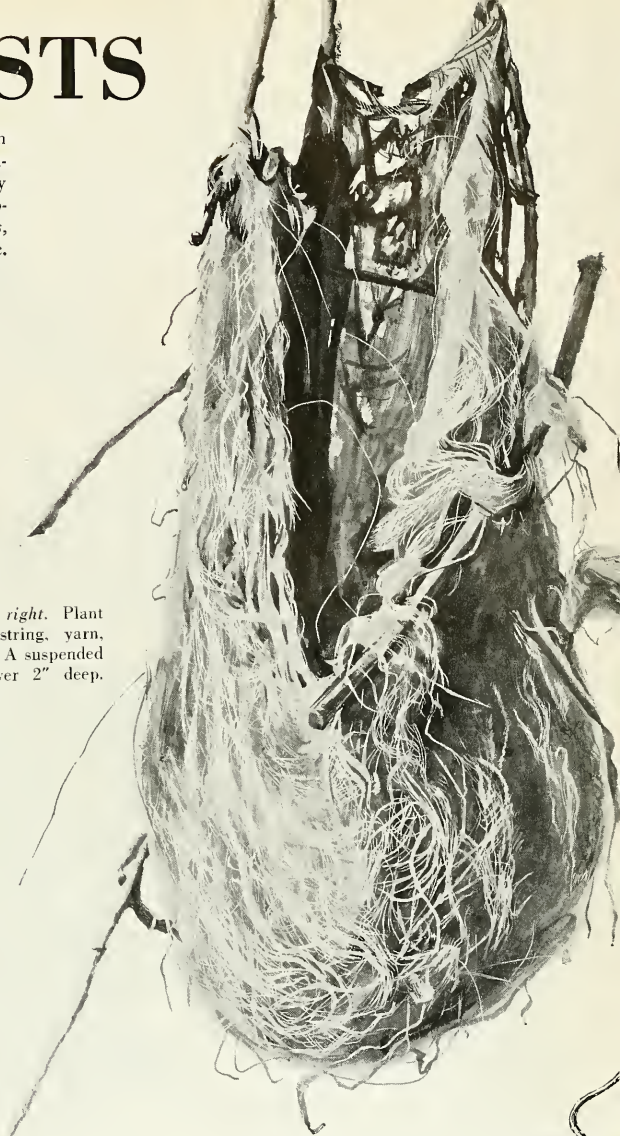
BIRDS' NESTS

which bird. The thirteen nests, and their construction materials, shown here include eight of the nests most commonly found. Readers are invited to see how many they can identify. Answers appear on pp. 522 and 525, abstracted from Richard Headstrom's text, *Birds' Nests*, 1 *Field Guide*, through the courtesy of Ives Washburn, Inc.



FOUR, left. Opening 2½" in diameter, 10" to 20" cavity. Trees may be live or dead.

THREE, right. Plant fibers, string, yarn, grasses. A suspended nest, over 2" deep.



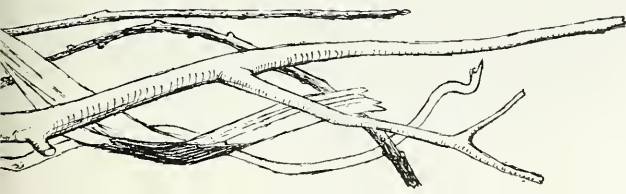
FIVE, below. Rough and bulky, but neat inside. Twigs, paper, leaves: root lining.



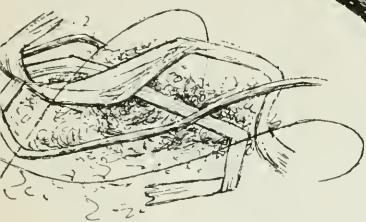




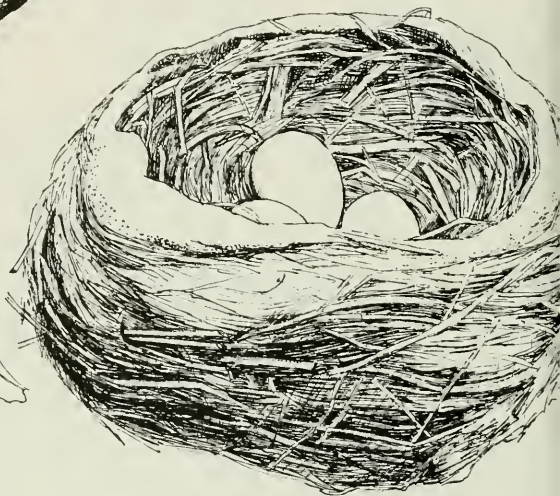
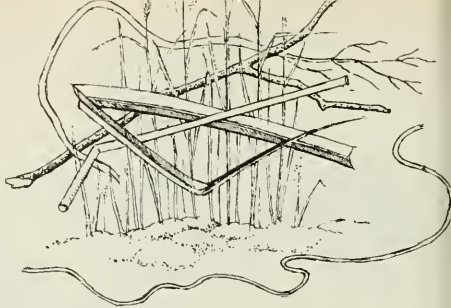
Kotschnig



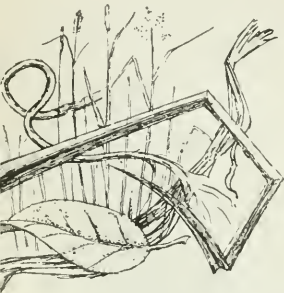
Six Large and bulky, made of strong sticks. Lining of moss, grasses, grapevine bark strips and roots. 30' high in trees.



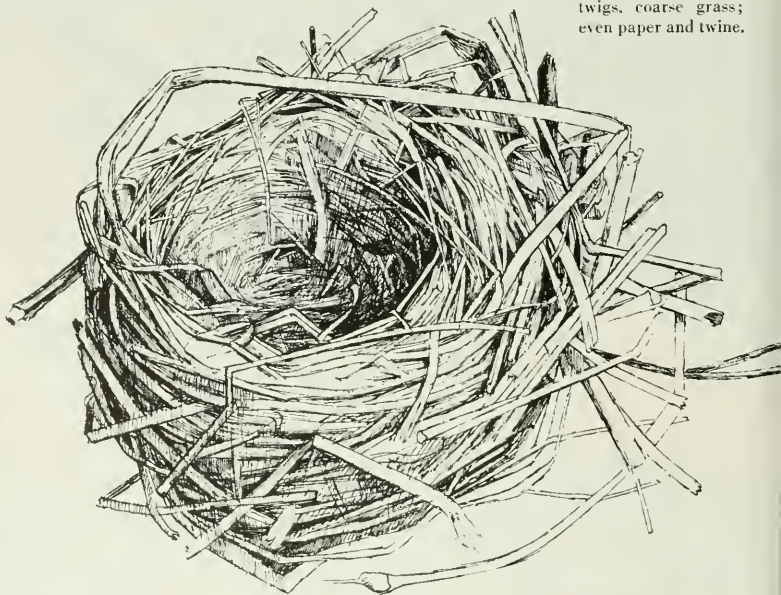
SEVEN, *above*. Plant fibers, fine grasses and bark. Long hair sometimes in lining.

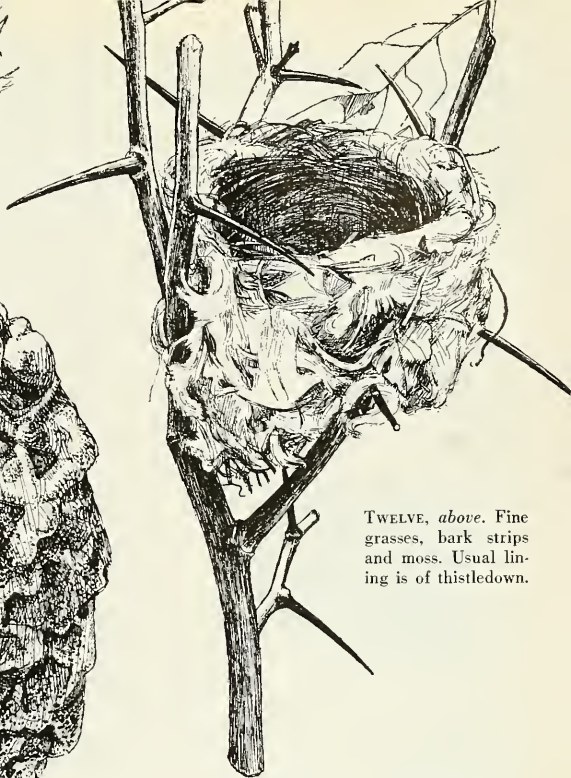


NINE, *above*. Inner wall of mud. Rootlets, twigs, coarse grass; even paper and twine.

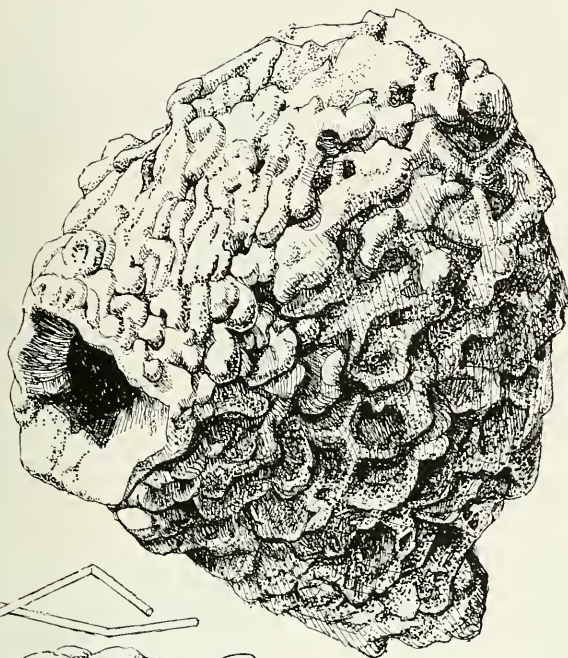


EIGHT, *right*. Weeds, grass, bark, leaves. Sometimes lined with hair or fine rootlets.





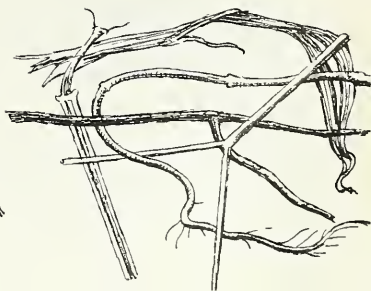
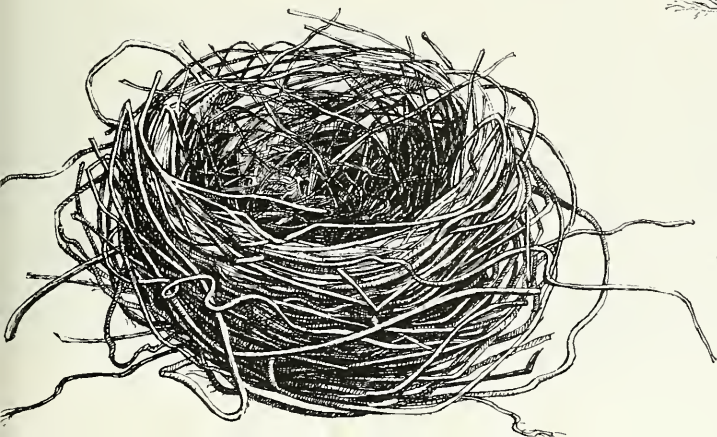
TWELVE, *above*. Fine grasses, bark strips and moss. Usual lining is of thistledown.



ELEVEN, *below*. Fine bark strips, grasses, weed stems, twigs; fine rootlet lining.



THIRTEEN, *above*. A delicate nest: grass and rootlets. Lining: horse (or other) hair.



TEN, *above*. A gourd shape: mud, strengthened with horsehair, straw. Beneath eaves.

NESTS FOUND ABOVE THE GROUND

I: HANGING (or semihanging) NESTS	IN MARSHES AND SWAMPS		Spherical, sometimes mud-plastered; grass & feather lining Spherical; plant-fluff lining Rather bulky; bowl-shaped and deeply hollowed	Long-billed Marsh Wren Short-billed Marsh Wren Redwing
	IN UPLAND TREES & BUSHES	A. FULLY SUSPENDED B. PARTLY SUSPENDED	Cup-shaped; usually in terminal forks of evergreens Cup-shaped; in low tree branches, or forks of saplings Gourd-shaped, inside depth over 2"; bulging at bottom; string 5" to 20" off ground; thin bottom; exterior decorated In evergreens; globular; moss and lichen, feather lining Usually in fruit trees; basket-shaped; inside depth over 2"	Blue-headed Vireo Red-eyed Vireo BALD ORIOLE (THREE) Acadian Flycatcher Golden-crowned Kinglet Orchard Oriole
II: NESTS WITH LAYER OF MUD	BUILT IN TREES	A. 1 IN. DIAM. UNDER 1" B. 1 IN. DIAM. OVER 1"	Cup-shaped, thick-walled; inner mud wall lined with grass Cup-shaped; includes leaves; inner wall lined with rootlets Large, rough structure; mud lining Usually in evergreens; loose and bulky; grass lining	ROBIN (NINE) Wood Thrush Boat-tailed Grackle Purple Grackle
	AMONG BUILDINGS OR ROCKS	A. MUD OUTER LAYER B. MOSS OUTER LAYER	Cup on flat surface; cone on upright; feather lining Gourd-shaped; side entrance; scanty lining Cup on flat surface; semicircle on upright; fiber & hair lining	Barn Swallow CLIFFSWALLOW (TEN) Eastern Phoebe
III: NESTS COATED WITH LICHENS				
IV: FELTED NESTS OF COTTONY MATERIALS			Cup-shaped, thick-walled; plant-fluff and fine grass lining Cup-shaped, thin-walled; rootlet, grass and hair lining Cup-shaped, but wider than high; thistledown lining	YELLOW WARBLER (SEVEN) REDSTART (ONE) GOLDFINCH (TWELVE)
V: NESTS CHIEFLY OF FIBERS, BARK, TWIGS & ROOTLETS	USUALLY IN EVERGREENS		Ex. diam. under 2"; cup-shaped; fluff, hair or feather lining Ex. diam. under 2"; cup-shaped; pine needle lining Ex. diam. under 2"; shallow and frail; lined chiefly with hair Ex. diam. over 2"; saucer-shaped; grass, moss and rootlet lining	Yellow-throated Warbler Pine Warbler Purple Finch Olive-sided Flycatcher
	IN BUSHES OR LOW TREES		Loose and bulky, but well-cupped (1½" deep); cloth and string Cup-shaped, rough and bulky; cloth and string Cup-shaped, thin bottom; rootlet lining Usually set low; loosely made; grass or hair lining	Kingbird Cedar Waxwing SCARLET TANAGER (ELEVEN) Cardinal
VI: NESTS CHIEFLY OF GRASSES, STRAW, LEAVES & ROOTLETS	IN BUSHES AND WEEDS		In. diam. under 2"; cup-shaped; grass lining (occ. hair, feathers) In. diam. under 2"; cup-shaped; hair lining (occ. all horsehair) In. diam. over 2"; grass, rootlet, pine needle or hair lining In. diam. over 2"; well-concealed, cup-shaped; grass lining	Indigo Bunting CHIPPING SPARROW (THIRTY-ONE) Veery Yellow-breasted Chat
	IN TREES		Cup-shaped (often with snake-skin); rootlet or hair lining Spherical; side entrance; feather lining (often on buildings)	Blue Grosbeak House Sparrow
VII: NESTS BUILT OF STICKS AND TWIGS	EX. DIAM. 30" TO 60"		Treetop, near water; re-used until 3' high; grass lining Tree, phone-pole, building; re-used; grass or seaweed lining	Bald Eagle Osprey
	EX. DIAM. 15" TO 30"	A. SAUCER- SHAPED B. CUP- SHAPED C. PLATFORM- SHAPED	In evergreens; sticks small; twig lining Substantial, broad structure; bark chip lining Usually in evergreens; bark lining 30" off ground; bulky; bark, grass, moss and root lining In marshes, swamps; usually in tall tree Frail; usually in low tree or bush, near water	Sharp-shinned Hawk Cooper's Hawk Long-eared Owl CROW (SIX) American Egret Green Heron
	EX. DIAM. UNDER 15"	A. USUALLY IN EVERGREENS B. IN CHIMNEY C. IN TREES AND BUSHES	6' to 8' off ground; bulky, high-walled; warm, soft lining 10' to 20' off ground; bulky, ragged; wide range of materials Semicircular basket; sticks glued & attached with bird's saliva Firm platform; catkin and leaf lining In. diam. 3" or less; cup-shaped; neatly lined In. diam. over 3"; cup-shaped and bulky; rootlet lining	Canada Jay Blue Jay Chimney Swift Black-billed Cuckoo CATBIRD (FIVE) Brown Thrasher
VIII: NESTS IN HOLES				
	SELF-DRILLED (No interior construction)		Opening 2½" diam.; cavity 10" to 20" Opening elliptical, 1¾" x 2"; cavity 8" to 24" Opening 1½" diam.; gourd-shaped cavity, 11"	FLICKER (FOUR) Red-headed Woodpecker Yellow-bellied Sapsucker
	USING EXISTING HOLES		Open, cup-shaped nest; white feather lining Moss, lichen and fur, felted; occasional feather lining Twigs and grass; bark, hair or feather lining Bulky; grass or straw; thin lining of feathers or moss	Tree Swallow Brown-capped Chickadee House Wren Starling

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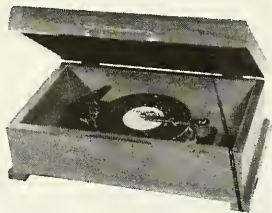


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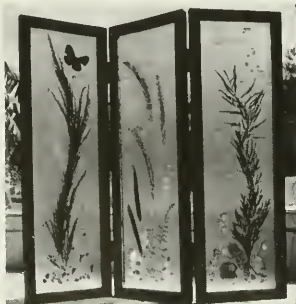
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We'll be delighted to tell you more about Nancy Hutchings and her work—and share with you the knowledge and skill she has learned from first hand experience. Address your request to Dept. L-90, The Castalite Co., Woodstock, Illinois. Please enclose 25¢ to cover mailing and handling charges.



Next month we have the pleasure of featuring Dorothy Thorne's handcrafted table accessories. You'll love her honest designs and her easy way of demonstrating the simple principles of this fascinating craft.

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NESTS FOUND ON OR IN THE GROUND

OPEN NESTS	A. IN OR UNDER TUSOCKS OF GRASS	Well concealed: grass, leaves, moss; lined with rootlets	Nashville Warbler
		Grass and stems; vegetable fluff in lining	Lark Bunting
		Grass, bark and leaves: fine lining (sometimes hair)	SONG SPARROW (EIGHT)
OPEN NESTS	B. IN TALL GRASSES	Well concealed: circular; grasses, stems and rootlets	Bobolink
		Bulky, well-cupped: fine grass and hair lining	Vesper Sparrow
		3" ex. diam.: grass; well-lined with hair or feathers	Palm Warbler
		Coarse grass; fine grass and hair lining	Field Sparrow
OPEN NESTS	C. UNDER BUSHES AND THICKETS	Slight hollow: rush, straw and dark down lining	Pintail
		Slight depression: thin feather and grass lining	Prairie Chicken
		Grass, solidly woven: thistledown and feather lining	Horned Lark
		Carefully concealed: cup-shaped: fine grass and hair lining	Lark Sparrow
ARCHED NESTS	A. IN OR UNDER TUSOCKS	Grass and weeds: fine lining: occasional covered tunnel	Meadowlark
		Bulky: lined with fine grass, hair or rootlets	Grasshopper Sparrow
ARCHED NESTS	B. ALONG FENCES	Grass, straw and leaves; well-hollowed: arched passageway	Bobwhite
OPEN NESTS	A. AT FOOT OF TREE	Twigs and leaves; moss and grass lining	Spruce Grouse
		Shallow depression: leaf lining	Ruffed Grouse
		Bulky: bark-shred lining laid across cup	Blue-winged Warbler
		Moss: lined with moss-stems	Northern Water Thrush
OPEN NESTS	B. UNDER BRUSH	Bulky: rootlet and horsehair lining	Kentucky Warbler
		Bulky but neat: pine needle or fiber lining	Hermit Thrush
		Leaves and moss: moss lining	Warm-eating Warbler
ARCHED NESTS	A. AT FOOT OF TREE	Twigs, leaves and moss: small, circular opening	Winter Wren
ARCHED NESTS	B. AMONG DEAD LEAVES	Bulky: grass and leaves; roofed with arch, opening at side	Ovenbird
		7" diam., cylindrical: opening well-hidden	Pine Woods Swallow
OPEN NESTS	A. AMONG REEDS AND RUSHES	Floating reed mat, tethered	Western Grebe
		Flat platform among cattails: few inches above mud	American Bittern
		Hollowed, flimsy reed and flag platform: 4" deep	Least Bittern
		Bulky; deep and well-made: down lining	Redhead
OPEN NESTS	B. IN WEEDS OR GRASS	6" ex. diam.: well-constructed	Sora
		In hummocks: beautifully built of grass; some down lining	Fulvous Tree Duck
		Reeds and grasses: warmly lined with down	Mallard
		18" ex. diam.: neatly constructed: down and feather lining	Black Duck
OPEN NESTS	C. ON THE GROUND	20" (or over) ex. diam.: often on stick platform	Marsh Hawk
		5" diam.: of finest grasses	Yellow Rail
		In hollows: grass and sedges; much down lining	Green-winged Teal
		Well-built of fine grass: down and feather lining	Blue-winged Teal
ARCHED NESTS	D. BENEATH BUSHES	Grass lining; down rim	Shoveller
		Grass: grass and hair lining	Wilson's Warbler
		Matted vegetation: some feathers in lining	Short-eared Owl
		Fine grass; deep and cup-shaped: concealed in grass-tuft	Leconte's Sparrow
ARCHED NESTS	A. (as in D., above)	Reeds and grass; concealed by canopy of interlaced grass	Clapper Rail
		3 1/2" ex. diam.: fine grasses; standing grass woven as canopy	Black Rail
IN COLONIES	A. (as in D., above)	Usually on lagoon islands: sticks and coarse grass	Brown Pelican
		Mosses and sticks: lined with gray down	Common Eider
		Bulky and well-cupped: dry grasses; usually on small island	Gr't Black-backed Gull
		Eelgrass and other seaweeds: marsh grasses and sticks	Herring Gull
SINGLY	A. (as in D., above)	Rather well-built: grasses, seaweed and sticks	Laughing Gull
		Well-built mound: grasses and seaweeds	Common Tern
COASTAL ISLANDS	A. (as in D., above)	Rough: sticks and reeds; near water	Common Loon
		Sandy hollow: lined with pebbles, shells, driftwood	Piping Plover
LEDGE OF CLIFF	A. (as in D., above)	Rather loose platform: sticks, weed stalks, seaweed	D'bl-crested Cormorant
IN COLONIES	A. (as in D., above)	Bulky stick structure: hay, grass or twig lining	Golden Eagle
		12", scraped hollow: lined with grass	Duck Hawk
SINGLY	A. (as in D., above)	Tunnels in sand-banks	Bank Swallow
		Short, "rat-hole"-like burrows	Leach's Petrel
IN COLONIES	A. (as in D., above)	4" diam. hole in sand or clay bank	Belted Kingfisher
		Bulky nest; usually in abandoned burrow	Rough-winged Swallow

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REVIEWS (cont'd from page 472)

LIVING REPTILES OF THE WORLD, by Karl P. Schmidt and Robert E. Inger. Hanover House, \$10.00; 287 pp., illus.

IT is difficult to see how a popular book on animals could be better conceived than this one. The authority of the text is guaranteed by the standing of the authors, both zoologists associated with the Chicago Museum of Natural History. Resisting the temptations of writing up to the specialists or down to the much-maligned general public, they have produced a book that is both comprehensive and comprehensible. It is copiously illustrated with excellent photographs, 115 of them in color and all of them handsomely reproduced.

SALT-WATER FISHES FOR THE HOME AQUARIUM, by Helen Sinkatis. Lippincott, \$6.00; 254 pp., illus.

THIS volume should prove indispensable to the serious lovers of salt water aquaria and their colorful inhabitants. Instructions for the maintenance of marine aquaria (a rare indoor hobby until recently) are treated vigorously and practically. Many species of "salt-water tropicals" are described in detail, and their needs and habits clearly presented.

Astronomy

THE STARS, by W. Kruse and W. Dieckvoss. University of Michigan Press \$5.00; 202 pp., illus.

AN excellent little book, destined for a wide public but nonetheless serious and informative. Its plan is a sensible one: since our knowledge of stars is determined entirely by our techniques of seeing them, the authors treat this aspect of astronomy first. En route along with such stellar matters as direction, brightness and color, there are discussions of variable stars, novae, stellar temperatures and composition, giants and dwarfs. The second part of the book deals with the structure of the

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universe and the earth's place therein. The publishers are to be congratulated on translating this work from the German (in which—as in French—many excellent science books of the same sort already exist).

EARTH, MOON AND PLANETS, by Fred L. Whipple. *Grosset & Dunlap*, \$2.95; 293 pp., illus.

This re-edition of one of the classic volumes from the "Harvard Books on Astronomy" series is welcome. Despite the seventeen years that have elapsed since its original publication, it remains the most convenient introduction to the subject. It is, however, regrettable that the author could not revise the text, incorporating recent findings and speculations on his subject.

THE SUN AND ITS FAMILY, by Irving Adler. *John Day*, \$3.00; 128 pp., illus.

Here is a useful book for beginners. It explains some elementary—although complicated—facts about the earth's rotation, the measurement of stellar distances, the phases of the Moon and of Venus, the weight of earth masses and so on, with simplicity and ease. Useful for the reader who is not already erudite about such things, and particularly useful for older children just entering the field.

EXPLORING THE DISTANT STARS, by Clyde B. Clason. *G. P. Putnam's Sons*, \$5.00; 384 pp., illus.

A MEMBER of the Astronomical Society, Mr. Clason has tried to translate a prodigious amount of complex material into terms that will be generally understood. He has succeeded to a large extent; at least, the reader will become more aware, through his book, of the classes, distances and variety in motion and light of the stars. But the author tries to temper complexity with slang throughout. Stars go on benders, or blow their tops. Writing of a cluster of galaxies some 137 million light years away, he adds: "Don't you feel small?" Dig that universe!

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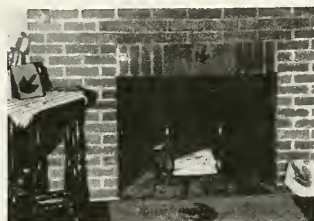
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485—Helmut Wimmer, AMNH, after Henry M. Neely.
486-7—star map by Henry M. Neely.
488-95—Enid Kotschnig.
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504-13—photographs by Lee Bollin; maps by Nicholas Amorosi, AMNH.
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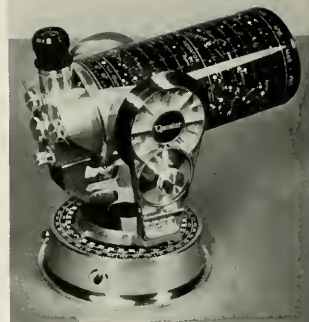
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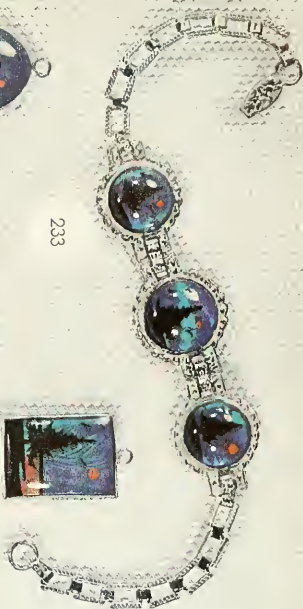
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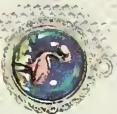
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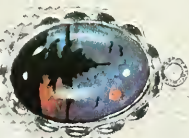
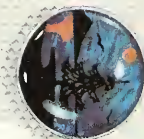
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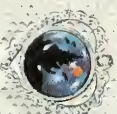
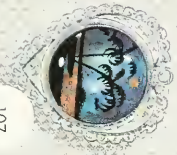


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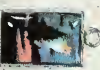
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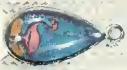
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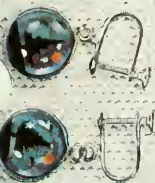
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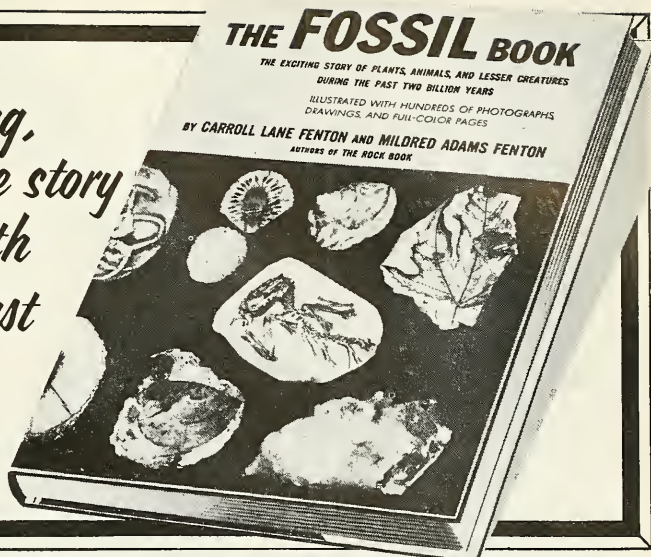
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NATURAL HISTORY, SENIOR—as is its custom in the holiday season—has turned to its sister, JUNIOR NATURAL HISTORY, for advice on those books in the field of nature and the sciences that seem particularly appetizing fare for the sons, daughters, nephews, nieces and multitudinous cousins of our readers, all of whom are already counting up their Christmas loot in advance. Herewith are JUNIOR's recommendations:

GENERAL

Penn's Woods West, by Edwin L. Peterson (University of Pittsburgh Press), is something for the family reading circle. The book is written as a series of seasonal experiences from spring to winter in western Pennsylvania, an area that the author knows well. Sensitive, and showing a highly developed appreciation of the beauty and drama of the natural world, the result is far more than just another set of observations of wildlife. More than three hundred photographs add their share to the excellence of the book. \$15.00, 249 pp.; all ages.

Orbit, by Hy Ruchlis (HARPER), is the story of force, motion and gravity. It clearly explains, with many examples, the physical laws involved and how they act in such everyday feats as walking and in the—as yet—extraordinary phenomenon of space flight. \$2.75, 147 pp., well illustrated with photographs and diagrams; ages 10 and up.

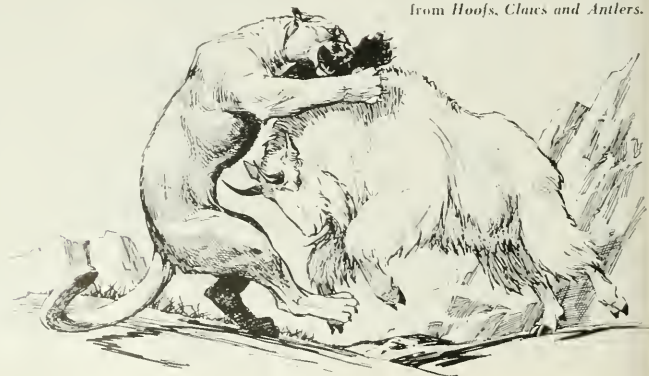
Wider Than the Sky, by Charles M. Daugherty (HARCOURT, BRACE), begins with a general discussion of what air and space are, and then tells of the span from the pioneers of flying to today's jet

pilots and missile planners. An interesting feature of the book—although perhaps a bit premature for youngsters—is the final chapter, "Help Wanted," which lists a variety of jobs in private industry and government service, along with their requirements. \$2.95, 151 pp., indexed, illustrated with photographs; with interest for ages 10 and up.

Going from the air above us to the waters below, we were attracted to *Boy Beneath the Sea*, by Arthur C. Clarke and illustrated with excellent photographs by Mike Wilson (HARPER). The area covered is around Ceylon; the characters, young divers. The book clearly explains the rules and precautions of safe skin diving and what equipment is needed for underwater exploration. The fascinating life to be found in the warm waters around coral reefs is shown in photographs and described in simple text. \$2.50, 64 pp., excellent pictures; ages 12 and up.

A broad general introduction to the world of science is offered in handsome format by a "de luxe" Simon and Schuster Golden Book, *The World of Science*. With chapters on biology, geology and astronomy—each subdivided into a number of topical discussions—as well as similar treatments of physics, chemistry, mathematics and engineering, this lavishly illustrated volume runs to 216 pages, and includes a good index. Photographs and diagrams, for the most part, are reproduced in color. The author, Jane Werner Watson, is the wife of the dean of the faculty at CalTech, who has provided an introduction. \$4.95; ages 12 and up.

Mountain goat and cougar,
from *Hoofs, Claws and Antlers*.





Sinewy spider monkeys,
from *All About Monkeys*.

The lives of the great men of science offer stimulating fare for the younger reader. One such, in this season's crop, is *A Scientist of Two Worlds*, a biographic study of the late Louis Agassiz, who came to the United States after a Swiss birth and a European education and—from his chair in zoology at Harvard—revolutionized the study of natural history in this country. The author, Catherine Peare, has published a similar biography of Einstein. (LIPPINCOTT) \$3.00. 188 pp., ages 12 and up.

Gregor Mendel, by Harry A. Sootin, is another such excursion in biography, and an excellent one. The son of an Austrian farmer, Mendel was a contemporary of the zoologist, Agassiz, and—like him—was destined to revolutionize science. (VANGUARD) \$3.00. 224 pp., ages 12 and up.

For an introduction to outdoor life, there is *Discovering Nature*, by Charlotte Ott Gantz (SCRIBNERS). The author has an inquiring mind and a sharp eye.

as the material she has included reveals. The book is written as a series of personal adventures, in many parts of the world. \$3.95. 239 pp., illustrated with line drawings; ages 10 and up.

Another book along the same lines is *Listening Point*, by Sigurd F. Olson (KNOPF). Confined to one area—that of the ancient Quetico-Superior region in the north country of Canada—the book conveys the adventures of a naturalist who has succeeded in capturing in his text the poetry and beauty of a land he knows very well. This is pleasant and instructive reading, tastefully done. \$4.50. 243 pp., illustrated with beautiful drawings; all ages.

Below the Surface, by Alice I. Hazeltine (ABINGDON PRESS), tells stories of explorers not only under the sea but below the ground. The author has compiled experiences of both men and women, written by themselves or by others, and the result is a fascinating one. The stories cover a wide range of

Book Suggestions

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by F. Clark. 250 pp. The most delightful anthology written to-date on this subject. Each story is a gem; sparklingly alive in interest and humanism providing cat lovers rich reading enjoyment.

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by A. Beiser. 127 pp. A simple, well-written guide, this book is designed to give the beginner a grasp of the first basic principles. Valuable information on buying a microscope, preparing permanent slides. Includes 8 plates of the microscopic world.

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THE FASCINATING WORLD OF BUTTERFLIES

by L. H. Newman. 92 pp. A lavishly illustrated study of the most beautiful butterflies and moths in the world. Breathing-taking photography and text combine in making this an exciting volume.

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by L. Eiseley. 378 pp. An exceptional contribution on the origin of evolutionary theory. Authoritative portraits of Darwin and the foremost evolutionists of his time make this an outstanding book.

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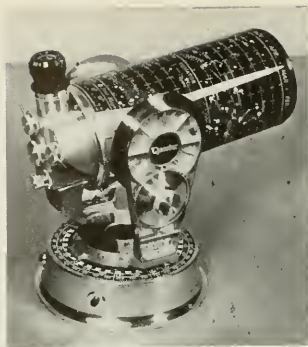
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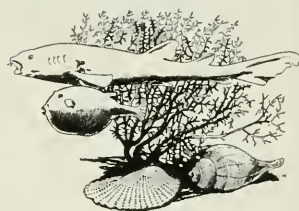


time and locale. \$3.95. 223 pp.; for older children, ages 12 and up.

ZOOLOGY

Going from the adventures of man to those of mammals we found two new "All About" books: *All About Monkeys*, by Robert S. Lemmon and *All About Animals and Their Young*, by Robert M. McClung (both from RANDOM HOUSE). In the first book, the author discusses monkeys of the New World and of the Old, selecting well-known as well as unusual ones. His text is not profound; it describes the simpler characteristics, habitats and feeding habits of the animals. 144 pp., illustrated. The second book has been done in much the same way. Starting with the lower forms of life, the text moves on to include fish, birds and mammals. There is a short account of the care of a few animals that are easily captured and kept in cage or aquarium. 148 pp., both books \$1.95; ages 9-12.

A general introduction to nature is



Aquatic scene from *Discovering Nature*.

often gained through books written as stories about a particular animal, in which many facts are displayed. These books fall into this category and are recommended for ages 7-10.

Little Red Nect, by Louise Dyer Harris and Norman Dyer Harris (LITTLE, BROWN). \$2.75. 57 pp., illustrated; a true story for ages 9 to 12.

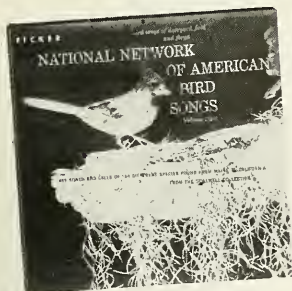
Whitetail, the Story of a Prairie Dog, by Rutherford C. Montgomery (WORLD). \$2.50, 64 pp., illustrated.

Home: The Tale of a Mouse, by Miriam Schlein (ABELARD-SCHUMAN). \$2.50, full-page illustrations in color.

With winter at hand, we can recommend *Winter-sleeping Wildlife*, by Will Barker (HARPER). The author writes about many familiar North American creatures, detailing their wintering habits, life cycles and other facts both clearly and simply. A very informative book. \$3.00, 136 pp., illustrated; of interest to ages 12 and up.

The name Ernest Thompson Seton is tantamount to saying "adventures with wild animals." His ability to communicate his love of the outdoors and its creatures with intensity and power have made his books known to generations of readers. *Animal Tracks and Hunter*

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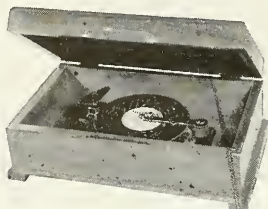
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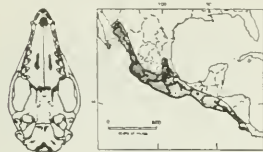
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Signs (DOURLEDAY) was an unpublished manuscript which his wife has recently finished. \$3.75. 160 pp., illustrated with the author's sketches; ages 9 and up.

A new book on prehistoric mammals is **Ancient Elephants**, by William E. Scheele (WORLD). The author gives a graphic history of these extinct mastodons, mammoths and others, illustrating his points with fascinating line drawings. \$2.50. 64 pp.; ages 8-12.

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Changing locale, we come to the desert and some of its animal life. **Wild Folk in the Desert**, by Carroll Lane Fenton and Evelyn Carswell (JOHN DAY), is a book about creatures of the desert areas of North America. The chapters are variously narrative, de-

(Continued on page 592)

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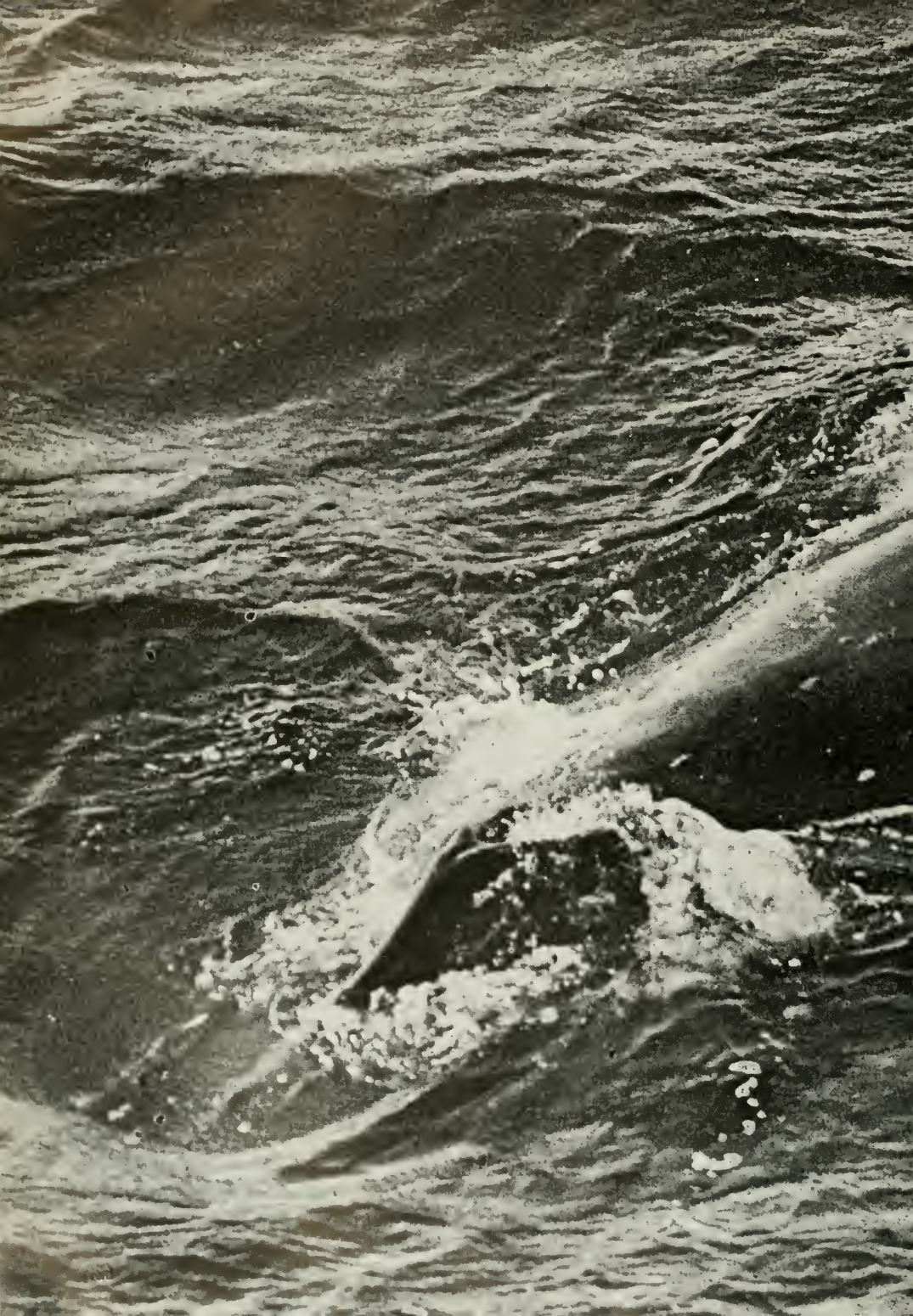
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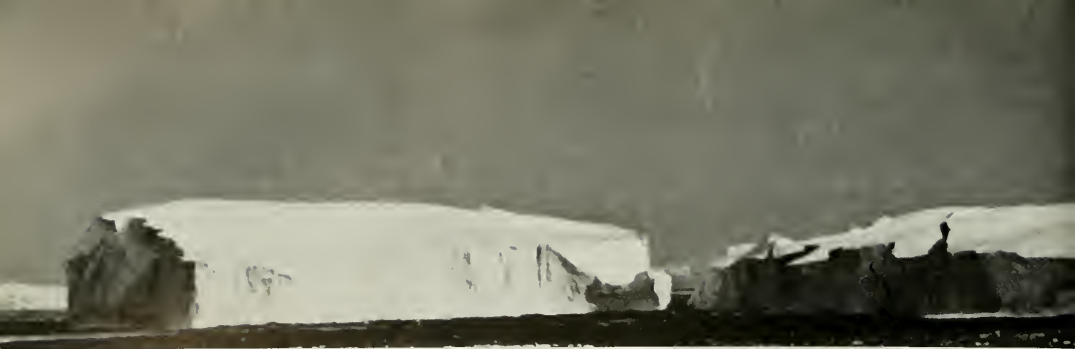




The Great Whales of the Antarctic

by ROSS LOCKRILL

Photographs by C. E. ASH



VARIETY IN ANTARCTIC WATERS is provided by an endless succession of icebergs of all shapes and sizes—products

of the great polar continent's uncounted glaciers, broken away and drifting at the bid of current and wind. Some of

Today, man's ancient pursuit of cetaceans has become



OLD ICEBERGS are carved in various shapes by the actions of wind and sea.

Oblique light, *above*, exposes record of over fifty years' snow deposition.

TO SAY "WHALING" is, for most of us, to think of *Moby Dick* and to recollect Melville's encyclopedic work. But the great days of the American sperm fishery are over. The American industry's demise was caused by its failure to adopt the modern techniques which were extending operations to the distant waters of Antarctica.

Today, the heroic age of the sailing whale ship and the hand harpoon is gone forever. In its stead, the invention of the swivel cannon and the explosive head harpoon was followed by the floating factory, with open stern and an ingenious "claw" by means of which the whole whale may be hauled into the ship for processing.

These developments, together, revolutionized a lagging industry and the last thirty years has seen a phenomenal growth in deep-sea, or pelagic, whaling operations. The industry, today, makes a notable contribution to the food stocks of the world, an annual—and most important—harvest of edible fats and proteins, derived from the wild seas of the Antarctic.

There are few occupations more dangerous, lonely and difficult than that of pelagic whaling in antarctic waters. The weather is unpredictable, and the wildest storms of the world are born and blow themselves out in these watery wastes. For days on end, the small catcher vessels have to halt their chase and shelter in the lees of icebergs, that are themselves a deadly menace in fog or snow or by night. Pack ice, too, is a constant danger.

A choppy, pewter sea, a low, gray overcast and a brisk, intensely cold



them, like the one above, are huge—as much as a hundred feet high and miles in length—flat-topped, and sagging

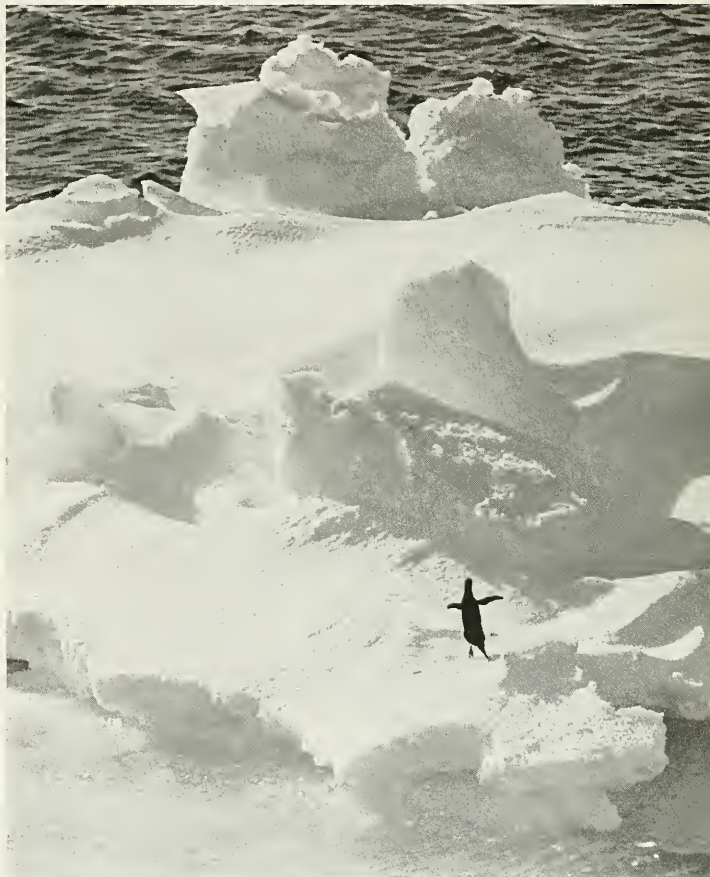
at the edges, where the great mass of underlying ice is most rapidly melted. To see more of this one, turn page.

a yearly test of fortitude in the earth's wildest waters

wind is the usual weather for a whale hunt. Yet, there are occasional days of incredible beauty—with blue skies, a blue-and-white sea, and the pack ice gleaming in the sun with an iridescence like moonstone lit from within. At such times, sunrise and sunset fill the wide sky with luminous tints and bathe the pack ice and the bergs and the sea with a great wash of color.

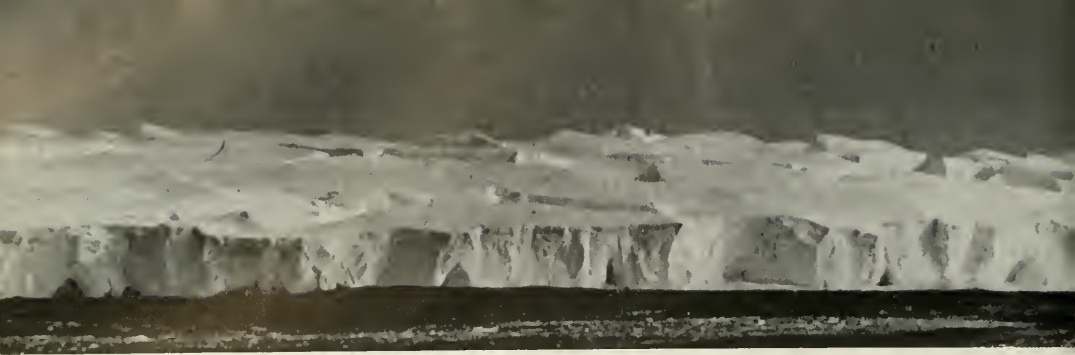
The seascape is never dull. There is an infinite variety of ice, and bergs of all shapes and sizes. Some of them are flat-topped, often a hundred feet high, and have been reported up to ninety miles in length. As they grow older, they become weathered and sculptured into fantastic shapes.

SUCH is the setting for the chase. As for the quarry, whale stocks are conserved—perhaps in some respects inadequately—by the International Convention for the Regulation of Whaling. There are provisions for the protection of certain species of whales, the fixing of a closed season, limitation of the total catch, minimum lengths of whale that may be killed and the complete prohibition of hunting in certain areas. Yet the greatest single limiting factor in the slaughter is none of these man-made regulations but, instead, the unpredictability of antarctic weather. It is the respite of the gale that gives leviathan—the Biblical “dragon that is in the sea”—temporary safety from death, dismemberment and rendering into oil in barrels, meat meal in sacks, meat and meat extract in cans and whalesteak fillets in massive frozen blocks.



THESE WATERS abound with wildlife: among the most common sights are the

friendly, curious penguins. An Adélie is seen, *above*, standing on pack ice.



THE TURBULENT SEA, itself is the ultimate source of food for all the creatures that exist over, under and on antarctic waters. The region abounds in wildlife. Overhead, there are the albatrosses—including, in lower latitudes, the mystic wanderer—the skuas, gulls, terns, fulmars and petrels, and the ubiquitous Cape pigeons—myriads of which surround the factory ship at all times. And in the water, or perhaps perched on a passing floe, are those other well-known residents, the droll, quasi-human penguins. Seals of many species are also to be seen on the ice floes, from the harmless crab-eater to the ferocious leopard. In the water, the plankton—microscopic plants and animals—live on dissolved nutrients and are, themselves, food for larger and more complex creatures, such as the fragile, shrimplike krill that are the staple of the baleen whale.

For hundreds of years, whales have been hunted and studied and written about, but—even as specimens for biological investigation—they still retain a great deal of their essential mystery. In primer terms, whales are marine mammals, warm-blooded and air-breathing. They are viviparous and the young are suckled from twin mammary glands, situated on either side of the vulva. Along with the Sirenia (sea cows), whales are the only mammals that must give birth under water. It is, therefore, not surprising that very few observations on the birth of whales—or their mating, which occurs under similar circumstances—have been made. From the dissection of carcasses aboard factory ships, we know that single birth is the rule, with twins and triplets seen occasionally—apparently in about the same proportion to single births as in humans. As many as six fetuses have

been reported. At birth, a blue whale is approximately twenty feet in length. There is no reason to believe that whales are particularly long-lived. Indeed, what little evidence we have seems to point in the other direction. It may prove that their lives are singularly short: a thirty-year-old whale may be nearly in its dotage.

THE untoothed, or baleen whales (*Mysticeti*) found in antarctic waters include the blue—the greatest creature in the world's long history—and four others: the fin, the sei, the minke and the humpback. These baleen whales browse perpetually on the lush krill pastures of the ocean. In place of teeth, they have—as appendages to the hard palate, and lining the upper jaw—baleen plates, misleadingly termed “whalebone.” These consist of a horny, flexible substance, frayed at the inner edges into long “hairs” which form a filter, causing the krill to be retained in the mouth while the water is expelled.

Of the toothed whales (*Odontoceti*), the commonest here are the sperm and the killer. The latter, a voracious creature, is of little value in commercial oil production, but some of them are shot from the stern of the factory as they attack the tethered carcasses.

The sperm whale, of which only old bulls are found in the southern whaling grounds, has a very narrow lower jaw that carries a double row of sharp teeth. There are opposing sockets in the palate of the upper jaw. The sperm's teeth form the medium for whalers' traditional scrimshaw work.

The numbers and the average length of blue whales taken annually are declining steadily. A good blue is now rare: such a one may be over ninety feet long and weigh a quarter of a million pounds. Many more fin whales

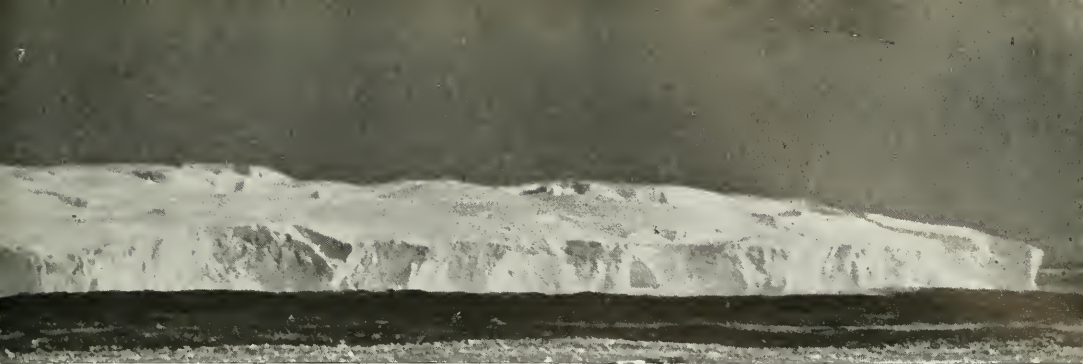
are killed, and these average well over sixty feet in length and an estimated fifty tons in weight. Fins, humpbacks and sperms make up the bulk of today's catch: it is a poor outfit that does not kill two thousand whales.

Whale hunting is not a sport. It is big business, ruthless and efficient. All the aids of technology, from radar to aircraft, may be brought to bear to find, hunt and kill the biggest of all “big game.” Whales are the most beautiful and harmless of creatures: perfectly adapted to their environment, as agile, vigorous and graceful as the clean-run salmon.

They are located by the lookout in the catcher's crow's-nest. The hunt may last from twenty minutes to several hours. The sperm can remain submerged for more than an hour; baleen whales for approximately fifteen minutes. These underwater periods lessen as the chase progresses.

A modern harpoon—fired from a swivel cannon in the catcher's bow—has four hinged grapples that prevent its withdrawal when the line takes the strain. Its explosive head has a time fuse which detonates after entering the whale's body and the damage caused by the grenade is extensive. The whale's death struggle may last for some hours but is usually over in forty minutes. Thereafter, the catcher's crew trims the flukes, inflates the carcass with compressed air, gives it an identifying mark and either flags the whale and casts it adrift for later collection or delivers the carcass directly to the factory.

Electrocution — as an alternative method of killing—has been under experiment for some years. It offers the possibility of eliminating the prolonged death struggle and reducing the amount of tissue damage.



IN HEAVY WEATHER, this little catcher vessel appears half-submerged in the trough of an antarctic swell as it beats up to the shelter of the distant Balleny Islands. Each factory ship has a flotilla of such catchers at work

chasing whales, which are frequently taken in this sort of weather. The whales, spotted when they surface to blow, are pursued until in cannon range (see next pages). The photograph on pp. 538-9 shows such a surfaced humpback.





SWIMMING AT FULL SPEED, these two fin whales seek to escape the pursuing catcher vessel. At moments of panic,

such as this, the whales throw such a cloud of spray as they surface to breathe that the misty vapor produced by



their blowing is obscured. If the hunted whales kept to a constant course, they could outstrip most catchers. But

they soon take alarm and make frequent changes in course so that, by cutting corners, the catcher can reach them.

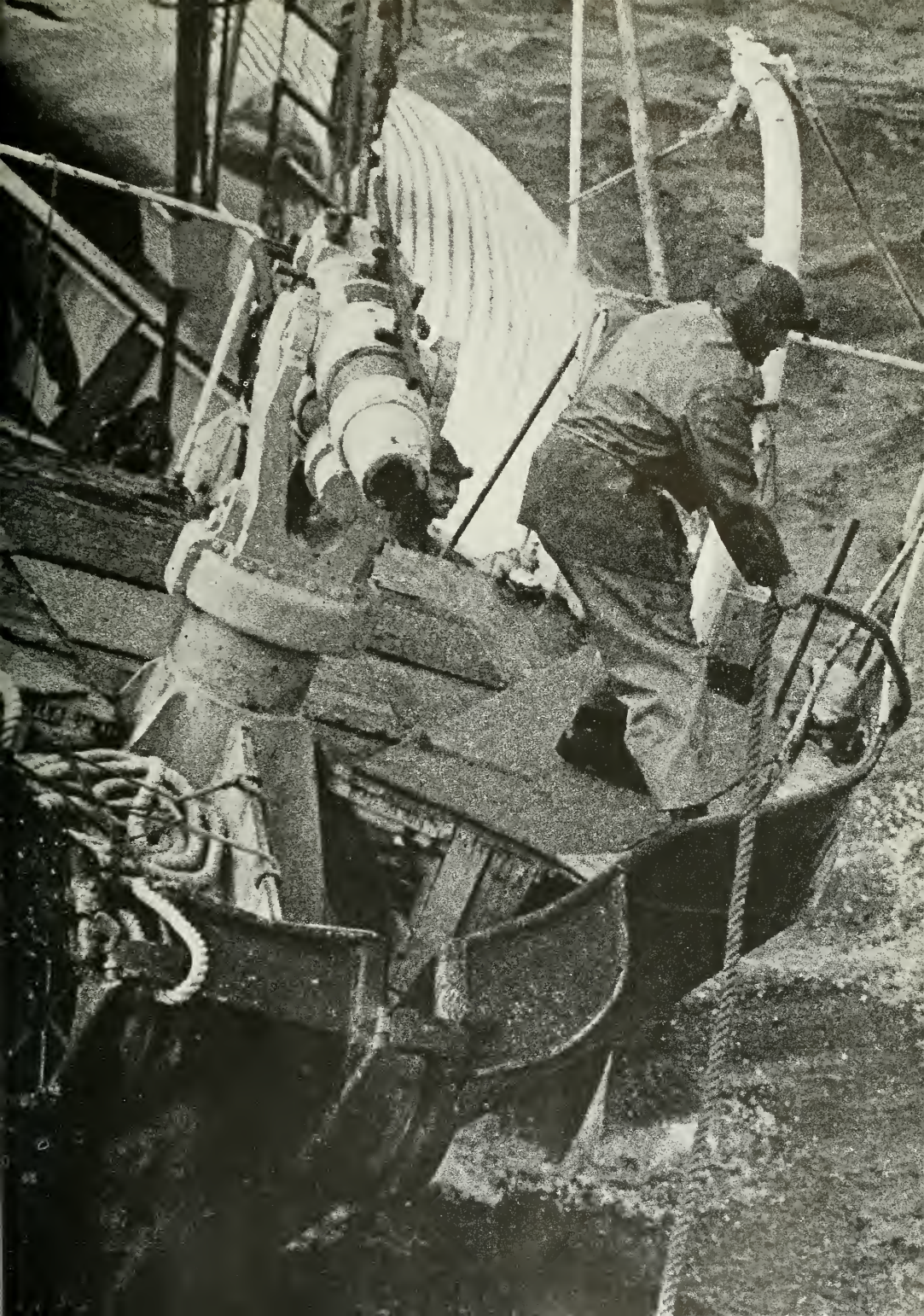


CLIMAX OF CHASE comes as the gunner, having maneuvered catcher as close to quarry as possible, *above*, aims and fires his cannon. Harpoon is visible, to right of rigging, about to strike fin whale. The gunner, Arne Jensen, took twenty-three fin whales on his best day of 1957-8 season.



AFTER THE KILL, the whale's carcass is frequently set adrift for subsequent recovery, *left*, while the catcher continues the hunt. Beside being flagged, it is protected from sinking by inflation with compressed air which may, as here, cause loose mouth tissue to form a huge balloon.

THE WHALE IS DELIVERED to factory ship's stern, either by the catcher, *right*, or by an auxiliary vessel following the hunt. In rough weather, as here, the task calls for superb seamanship. Harpoon-firing swivel cannon, seen in bow, was a key development in the modern whaling industry.





THE FLOATING FACTORY SHIP dwarfs an auxiliary vessel, refueling alongside, as she rides the antarctic waters at

"full cook." Carcasses of whales, waiting to be pulled up the slipway, are floating astern, *below*. Most crew accom-



EACH AUTUMN, some twenty whaling expeditions—from such nations as Norway, Great Britain, the Soviet Union, the Netherlands and Japan—make their way southward for a hundred-day hunting season.

Each such expedition consists of a factory ship, perhaps twelve catchers, one or two whale-tugs and small transport ships, one or more tankers, and often a refrigerator ship—the latter to freeze and transport whale-meat. As many as eight hundred men are needed in each flotilla.

The parent ship is the floating factory—one of the most extraordinary of all seagoing vessels. Its open stern leads to a ramp up which two London double-decker busses could be driven side by side. Twin funnels are situated aft. There are two wide decks, or "plans," where the whale carcasses



modation lies aft, over the slipway that runs up from the open stern, and the seeming forest of fishpoles, there, is

actually an array of crewmen's radio aerials. This is the "Balaena," a ship of the British firm, Hector Whaling, Ltd.

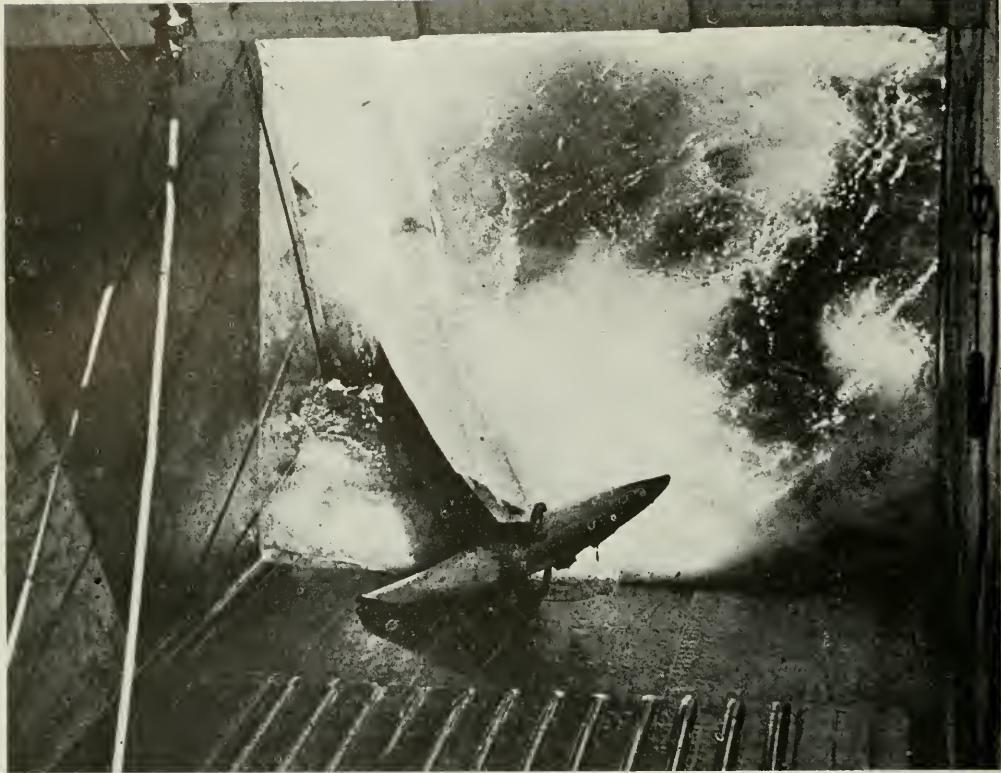
are peeled, dismembered and hacked into manageable pieces with incredible speed, amid whipping winchlines, clouds of steam and the loud whine of bone saws. On the after deck, or "flensing plan," the whale's fatty, investing membrane—or blubber—is removed. This area is separated from the forward deck, or "lemming plan," by a wide archway, called Hell's Gate, where powerful winches are mounted. These winches drag the great carcasses out of the sea and up the ramp.

Every cubic inch of factory ship space is utilized. Within the hull is condensed an intricate mass of machinery, processing apparatus, storage tanks, laboratories and workshops. Life on board is cramped, noisy, oily, dirty, malodorous and strangely exhilarating. Year after year, whalemén sign on for "just one more season."



HARPOON'S DAMAGE may be gauged by the shrapnel scars surrounding shaft

protruding from this flensed carcass. A lung shot is fatal in forty minutes.



OPEN SLIPWAY at factory ship's stern is the point of delivery for whale carcasses, such as this fin, with its

flukes trimmed and its towing hawser already aboard. In a moment, the "claw" will descend and haul whale aboard.

IT IS NO SURPRISE that today's whaling industry has a strong cast of Norway about it. It was a Norwegian, Svend Foyn, who invented both the swivel cannon and the explosive harpoon, while the great Norwegian explorer and ship's master, C. A. Larsen, established one of the first whaling stations in the southern regions—on the island of South Georgia. Today, Norwegians are usually in the majority aboard the whalers of most Western nations, not excluding the cosmopolitan fleet, of Panamanian registry, owned by that eminent Argentinian, Aristotle Socrates Onassis.

And the gunners—who are also the masters aboard the little catchers—are,

inevitably, Norwegians. Theirs is an hereditary occupation and it is commonly accepted—particularly among the Norwegians—that only Norwegians can hunt whales with any degree of success. In point of fact, the gunner's job consists of three parts—good seamanship, good luck and experience; and the first two of these are scarcely a national monopoly.

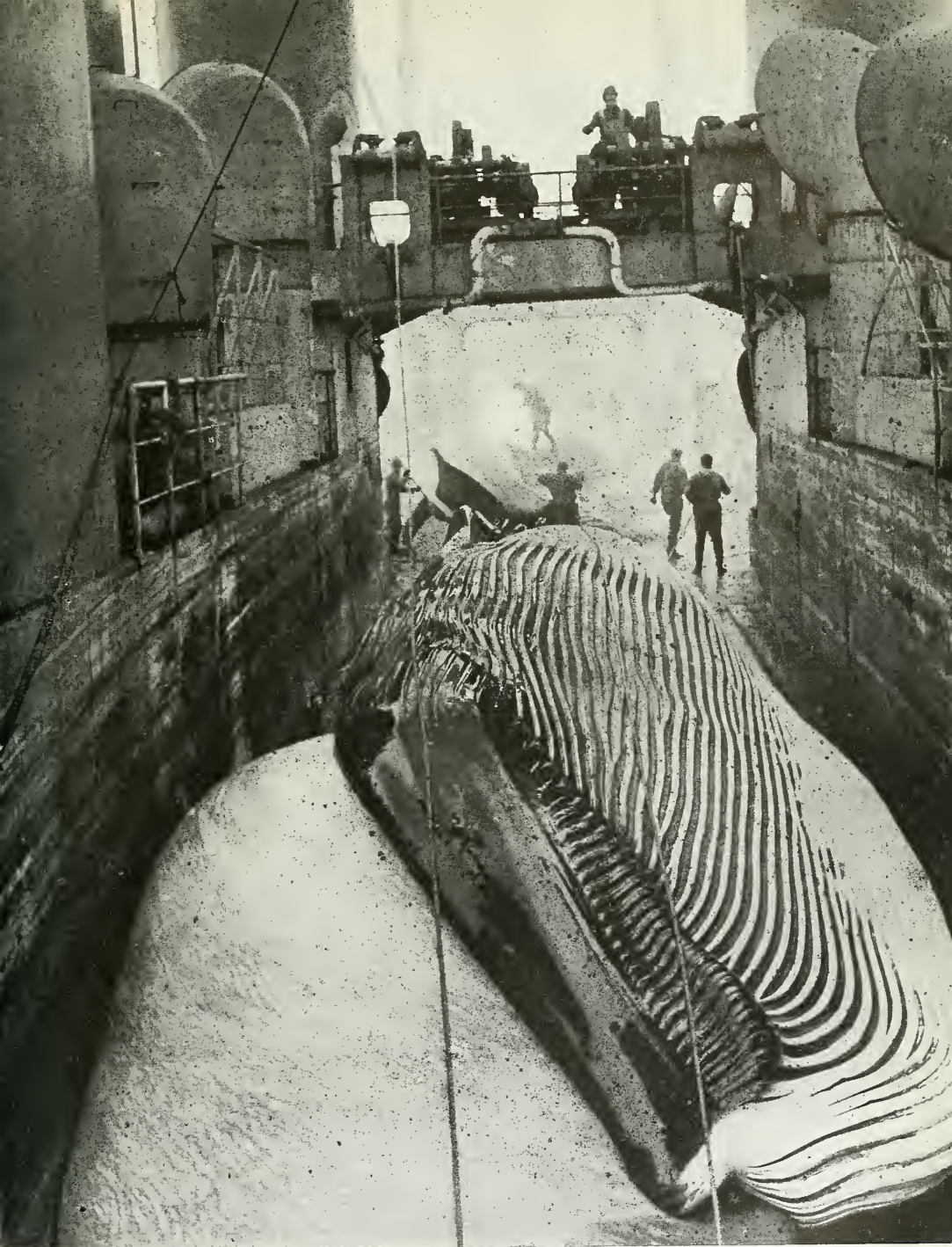
AN expedition's success or failure depends on its gunners. And what a group they are! They are intensely superstitious—to a degree that borders on the neurotic. They are tough and self-assured: they live by their nerves, doing their work under the most trying conditions and existing on a minimum of sleep—and, often enough, on a maximum of alcohol. These men bear the heaviest sort of responsibility, sailing their ships in the world's most dangerous waters.

At home in Norway, between voyages, a gunner is an important man,

with a position in the community. What is he like at sea? My portrait is a composite: a short man, with broad shoulders and several gold teeth. He has not shaved for several weeks nor washed for several days. He is somewhat deaf, and the deafness—caused by the loud bangs of his swivel cannon—increases as the season continues. He wears a variety of heavy clothing, and sleeps in most of it. His eyes are bloodshot; partly from his short hours of sleep and partly from the effects of alcohol. He appears as suspicious as a bad-tempered boar. His reasoning powers are blunt. "Always," a friend of mine said, "gunners are thinking not from the head but the heart."

DR. COCKRILL is a veterinarian who recently went to the Antarctic with British whalers to study whale diseases and their effect on whale meat's suitability for human consumption.

MR. ASH, whose photographs provide most of the illustrations for this article, is a Fellow of the Zoological Society and chief chemist of the British factory vessel, "Bahana."

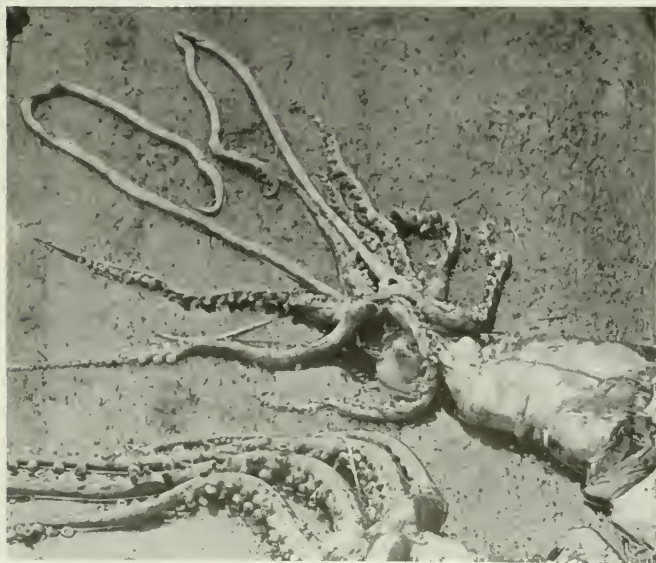


FIN CARCASS seems to occupy the whole slipway as it is winched toward the first of the factory's work areas,

the "flensing plan," where blubber will be stripped away. White mass, *foreground*, is "balloon" of air-filled tissue.



TOOTHED JAW identifies this as a sperm whale. Scars of old fights with its own kind—and struggles with the squids it fed on—mark its dark skin.



PAIR OF SQUID formed part of the stomach contents of a sperm. They are four feet in body length and had been gobbled whole shortly before capture.

WHALING is rich in folklore, and I have been assured that whales suffer from tuberculosis, cancer and even anthrax. Perhaps they do. But the twelve thousand and more whales—blue, fin, sperm, sei and humpback, in representative numbers—that have been studied on the decks of various floating factories in the antarctic whaling grounds have shown no evidence of specific disease and seldom any pathological lesion that might appreciably have shortened life. On the record, whales are probably among the healthiest of living creatures.

This robust condition may be largely due to the animals' environment, which seems to preclude infec-

GREAT ARCHED JAW, *below*, together with fragments of baleen "strainer,"



tion by most of the normal routes. However, whales are hosts to a great variety of parasites, both internal and external. The humpback is infested with lice, and often encrusted with barnacles—particularly in the regions of the throat, lower jaws and leading edge of the large flippers. These whales have frequently been seen to rub their bodies against ships, and this may be an attempt to relieve a severe skin irritation. Whale lice—the size of smallish spiders—occur most commonly around the genitalia, but may be found in skin corrugations almost anywhere on the ventral surface.

Whales are also hosts to many kinds of tapeworms. Some species, like a

previously unidentified *Tetrabothrius*, are only a few inches long; others may be fifty feet long, two inches wide and tough as strips of rubber.

Invariably, the sperm whale's stomach—a large, compound organ—is spectacularly infested with round worms. The weight of these parasites in the first portion of the stomach may be as much as a hundred pounds. Yet, I have observed no evidence of local damage or general detriment, and it even appears possible that these nematodes are commensals. In general, then, I would say that—of all the animals utilized for food—the whale is among the least likely to transmit disease to human consumers.

identifies this carcass as one of the *Mysticeti*, or "untoothed" whales. The

flensers, seen at work in background, can butcher a whale in thirty minutes.



MINKE WHALE, above, had length of twenty-eight feet, weighed seven tons.



THEY that go down to the sea in whale ships, today, include butchers, bakers, boilermakers and bacteriologists; cooks, carpenters and chemists—and a dozen other sorts of experts. All their energies and skills are directed to one end: the capture and processing of the greatest of living creatures (the average value of which—in oil, meat, meat meal and by-products—is some \$5,500).

In recent years, whale oil has sold for as much as \$336 a ton. A modern expedition may bring back some thirty thousand tons of oil, and five thousand tons each of frozen meat and

meat meal. Liver oil, meat extract, and endocrine glands are also items of commercial importance.

From the blubber, meat and bones of the baleen whales comes the golden edible oil that is used in many food products—margarine, in particular. Sperm oil is inedible, but it is used as a base for cosmetics and unguents, as a lubricant, and in the making of high-grade candles. Historically, as we know from Shakespeare:

"...the sovereign'st thing on earth Was parmaceti for an inward bruise." And sperm oil is still used today in several proprietary remedies.



FILLET OF MEAT is hoisted and cut free of whale carcass on the "lemming

plan." Weighing as much as five tons, it may be frozen or turned into meal.





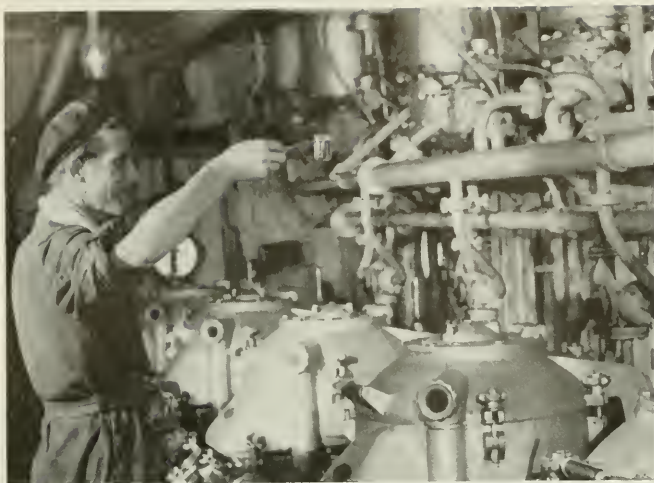
STEAM-DRIVEN saw on "lemming plan," *above*, is used to cut up carcass into chunks which are fed to kettles below

decks for oil extraction. Here, the crew is at work on a skull. After oil is removed, residue is powdered for feed.



STRIP OF BLUBBER is cut from fin whale, *left*. Most oil comes from this

source, but other parts — such as the bit of fluke, *above* — are also cooked.



OIL SAMPLE is examined for clarity by a technician in machinery-crammed

factory space below decks. Ashore, a similar plant would cover four acres.

AT "FULL COOK," a factory ship is all color and noise by day and the nights are a mad cacophony under the yellow floodlights. The flensing and lemming decks are crisscrossed by whipping steel ropes, piled high with blubber and meat, punctuated by open manholes and obscured by drifts of steam. Nothing is allowed to impede the steady, clock-round procession of whales up the slipway to oblivion. The only respite comes on December 24. That day, beards are trimmed, vast amounts of food are eaten, and many toasts are drunk.

Cables from home are distributed: there are cigars and brandy, paper hats and carols. For a few hours, the decks are empty; then, the deep thudding of the main winches begins again.

As an industry, whaling is as tough and tenacious as the men who take part in it. It has an ancient heritage and many years may pass before other sources of edible oils and fats will squeeze the last of the venturesome, deep-sea whaling companies out of business. Until then, there remains a great field both for enterprise and for continuing scientific observation.



A CHRISTMAS PARTY, left, breaks the hundred days of round-the-clock work.



NIGHT AND DAY aboard a factory ship are equally busy in a good season. On the floodlit "lemming plan," above,

one of the two twelve-hour shifts is at work. Aft, beyond "Hell's Gate," a fresh carcass lies stripped of blubber.

The Animal Lore of the Past

De naturis serpentium.



Raco maior cunctoy serpentū siue am-
mantum omniū sup̄ terrā. hunc gre-
ci draconta uocant unde & deriuatū
est in latinum. ut draco diceret̄. Qui sepe
ab speluncis abstractus fert̄ in aerem. concu-
raturq; p̄pt̄ eum aer. Est autē cristat⁹. ore
paruo. & artus fistulis p̄ quas trahit sp̄m.
& linguam exerat. Vim autē non in dentib⁹

IT IS CUSTOMARY to credit the start of astronomy, in a hazy fashion, to the Chaldeans and offer lip service to the ancient Egyptians' part in the origins of chemistry, but—so far as the biological sciences are concerned—little attention has been given to origins that predate the “natural histories” of the European sixteenth or seventeenth centuries.

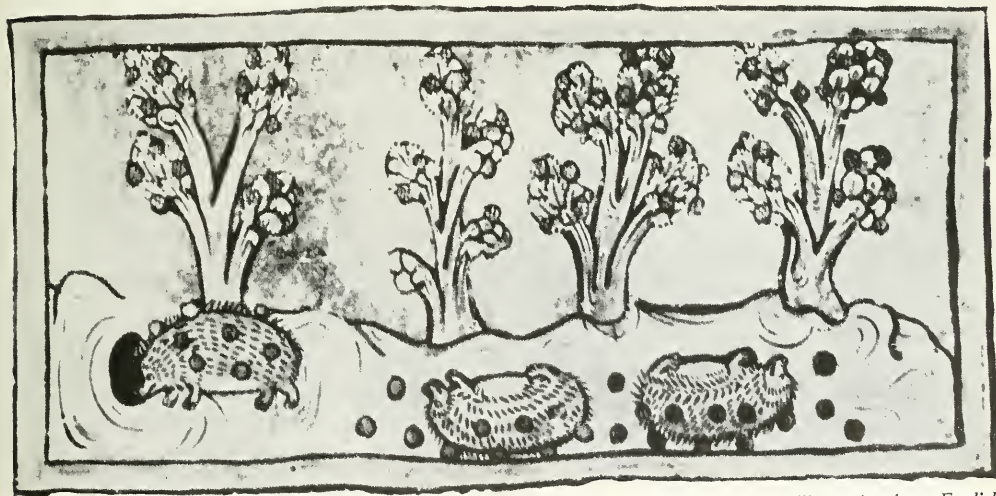
Yet many intriguing “encyclopedias” of antique zoology are available for study—the so-called “bestiaries,” or “books of beasts,” the great majority of surviving examples dating from England of the twelfth and thirteenth centuries A.D. These manuscripts were serious works of natural history, whose origins have been traced at least to the fifth century A.D. and perhaps as far back as the third century.

Sometime during this earlier period, an anonymous person—respectfully titled “the Physiologus,” and probably a resident of Egypt who wrote in Greek—compiled a sort of naturalist's field guide—with strong overtones of Christian morals. The work was fabulously successful. “Perhaps no book, except the Bible,” one scholar has written, “has ever been so widely diffused. . . . It has been translated into Latin,

Ethiopic, Arabic, Armenian, Syriac, Anglo-Saxon, Icelandic, Spanish, Italian, Provençal and all the principal dialects of the Germanic and Romanic languages.”

There were some fifty animals listed in the earliest copies of the *Physiologus*: by the thirteenth century, the English bestiaries contained three times this number of entries. The English medievalist T. H. White—whose recent volume *The Book of Beasts* is an invaluable introduction to the subject—has pointed out that “The bestiary is a serious scientific work . . . the real pleasure comes with identifying the existing creature, not with laughing at a supposedly imaginary one.”

ON these pages, NATURAL HISTORY presents a selection of illustrations and text from two quite different sorts of medieval “books of beasts.” The first is an English one, the Lincoln bestiary, a handsome manuscript of the late twelfth century. The second derives from another historical background altogether—it is a Persian manuscript of the late thirteenth century, the *Manâfi al-Hayawân*, or *Uses of Animals*. The illustrations of the *Manâfi* reflect the Mongol influence that domi-



Hedgehogs, in this illustration from English medieval bestiary, gather grapes for their young. Opposite, elephant is entwined by a serpent.



Dromedary is realistically portrayed in this Persian painting. The Oriental bestiary reported that camels were vengeful and had long memories.

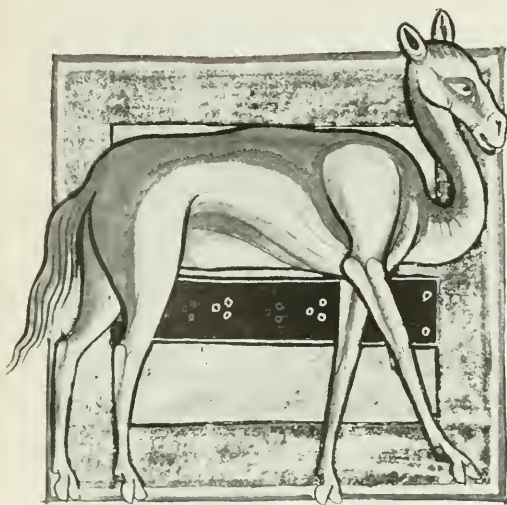
nated Persia in this period and its text apparently stems from Arabic sources.

Both manuscripts repose in the Pierpont Morgan Library and NATURAL HISTORY is indebted to the Library both for permission to reproduce these illustrations and for the courtesies shown the translator of the *Manâfi*. The scholar who undertook this latter task is Miss Shakeh Agajanian, a graduate of Teheran University and authority on Dari, the language of the manuscript. The Latin translation, in turn, is drawn from White's sympathetic rendering of the Cambridge University Library mss. 11.4.26 (which forms a part of his previously mentioned study).

THE separation in space between medieval England and Persia under the Mongols, as well as the centuries that divide both manuscripts from some unknown, common source (possibly even more ancient than the *Physiologus*), makes it remarkable that any parallel exists between these two bestiaries. Yet, parallel texts are frequent and, in one instance (p. 566), even the illustrations are parallel. It is also intriguing to discover—preserved in both these medieval documents, like insects in amber—folk beliefs about animals that survive today.

The Persian accounts appear somewhat closer to the realities of observation than do those of the *Physiologus*, perhaps because the latter perforce carries an added burden of moral allegory. As an example, the *Manâfi*—speaking of the behavior of elephants—states: "The elephant is afraid of piglets, cocks and rams. It is very much annoyed and frightened by mosquitoes and mice. It has a strong animosity toward snakes and, when it sees a snake . . . tramples it to death; in this manner, it guards its young from snakes."

In a parallel passage, the English bestiaries have this to say: "The father-elephant guards (its mate) while she is in labor,



English version of the dromedary was a fair job for an artist who had never seen one. Both English and Persians agreed that camels detest horses.



باشد در هیچ جانوری دیگر نباشد گویند وقتی مرغی کبابی روف و دنیا دی چند باوی بود و شکلی باخورد داشت
 مرغی با او هم زیاده شد و بوی خال او و قوف یافت نود یکی شهر او را شکست و در بسند و در خال کوز و شکلی با او و زیاده
 همی کوز مرغی دوشه سک و خال مرده ماید و بعد از آن خانه آمد و مالک و زاری می کوز خوش و اقربای نو فوج سگ را
 دید ز وحداوند شکلی اندیدن هم برآمدند و شکلی روف و زاری می کوز و می ستاد مردم در می سگ رفتند و کال کشند و بود

Hunting dogs and keeper are shown in this painting from the *Manâfi al-Hayawân*. Persians believed that the best hunting dogs were yellow and red in color and that bitches made the finest hunters.



و خداوند ذات الحجب دهسد تا دفع نماید **خون طراوت** خوردن زبانش کار نمند و الکن شود و بر دبل و مانند آن
 بالذئبق شود **مغز** او را با سداب و غسل خوردن سود دارد در دم معده و قولنج را زهره طراوت
 با سکنجبین و آب کرم خوردن شکم را بر روی بسته گوید اند و زهره تنها خوردن دیوانه شوند **استخوان او**
 بر حوشنند و جسم زده کی زانک باشد **جگر او** بر اش هفتاد و دو برن رسد که بد شخواری که آرد با سانی باز دهد

القولی فی ذکر الجرز و خواصه و منافعه

جرز را گویند که از او عرق بر مرغی میسازد و بجه و خایه نکه دارد و کلاه زه با هه زهر کی بجه و خایه کم کرد اند و هیچ
 مرغ از تو تر نبزد **گوشت** او غلیظست و موله شود و گوشت و بیه او را میگویند و با نمک و سنبلیله میازند
 و جب سازند و خشک کنند و سایه و خداوند شعال دهند بج چپ باغ باشد **گوشت** جرز بر خوردن در دنیا

Peacock in display, with pair of peahens,
 is subject of this Manāfi painting, which reflects the
 Chinese influence introduced by Mongol conquest.
 Persians shared popular belief in peacock's vanity.

Two "fabulous" ungulates of the English bestiaries
 are the Parandrus, top, and the Yale, bottom,
 with its movable horns. First may be garbled reindeer;
 the second a mountain goat (ya'el in Hebrew).



Ethiopia mittit bestiam parandorū no- mine
 bouū magnitudine. ibico uestigio ramosis
 cornibz capite ceruino. urfi colore. & pariter
 uillo p̄fundo. hē parandorū affini ant habitu
 meū uertere. & cum dehuescat fieri ad similitu-
 dinē cuiusq; rei p̄ximā iūt. siue illa saxo alba sit
 seu fructo uirēs. siue quē alium modū p̄ferat.



صُورَتِ کَاوِ کُوهی

کاو کوهی ز بجایگاه دشواری که گریختن از آن دشوار است و همتا را یار نیفتد و ابتدا از دُشمنان لزد و گویند همت



تا لکن زیادت شود و تمام جانوران را ترس و خوف باشد الا مَر و کاو کوهی که بستنت سخت و ماده جزو که
بیارد شیهه خورد و ز جال و جز سماپ دزد کوش او کمند میدرد و جز او از غنا درود بسود کوش برادر دهد

Gay buck and doe gambol in another Manāfi painting.
The deer's hatred of snakes, according to the
Persians, included the habit of carrying mouthfuls
of water to snakes' holes, drowning them out.



Common folk belief concerning porcupines' ability to cast their quills is echoed above. Persians also held the animal's flesh cured back ailments.

because there is a certain large serpent which is inimical to elephants. Moreover, if a snake appears, the father tramples on it until dead. He is also formidable to bulls—but he is frightened of mice, for all that." And, in a pious gloss, the English text compares the elephant parents to Adam and Eve and the "inimical serpent" to Satan, who "subverted them and made them strangers to God's refuge."

However, neither the Persian nor the English manuscripts is free from the sort of fabulous tale that—when it is not pure fiction—may stem from misunderstanding or the misinterpretation of second-hand reports. In another elephant parallel, for example, the Persian text states: "They (hunters) know which tree the elephant leans against in sleep, by the great amount of dung they find at the foot of the tree. They saw this tree through to the middle, or more than that: when the elephant leans against it, the tree breaks and the elephant falls. Then, the hunters kill it..." And the English: "The elephant's nature is that if he tumbles down he cannot get up again. Hence it comes that he leans against a tree when he wants to go to sleep, for he has no joints in his knees. This is the reason why a hunter partly saws through a tree, so that the elephant, when he leans



Teamwork by egg-stealing rodents is delineated in the *Manâfi*. Same observation is included in La Fontaine's "Fables," first published in 1678.

against it, may fall down..." It is evident that neither writer had ever hunted an elephant or seen one in action.

Two of the most detailed parallels between these manuscripts concern the Ibex (called "mountain goat" in the Persian text) and the hedgehog. In the first instance, the *Manâfi* states: "A strange fact about the mountain goat is that it may drop itself nearly a hundred spear-lengths from a precipice and yet, by falling on its horns, is then able to get to its feet and run off, unharmed." And the English bestiaries: "There is an animal called Ibex, the chamois, which has two horns. And such is the strength of these that, if it is hurled down from a high mountain peak to the very depths, its body will be preserved unhurt." The roots of this fabulous tale surely lie in some early hunter's wonder over the ibex's leaps from crag to crag.

As to hedgehogs, the Persian text states: "When this animal wants to bring grapes to its babies, it climbs the vine and picks the grapes and drops them down. Then it rolls over these grapes until its quills are full of grapes and thus bears them off to its young." And the English: "This creature has a kind of prudence, for—when a bunch of grapes comes off the vine—it

rolls itself upside down on top of the bunch, and thus delivers it to its babies." Commenting on this, White states: "That urchins should be met . . . in vine-growing countries, with desiccated grapes upon their spines, is not improbable. They are untidy, or possibly camouflage-loving animals, who often have a collection of leaves and detritus upon their spikes. . . ."

BOTH manuscripts share the belief that bears eat ants to cure illness, that camels detest horses, that dogs are notably faithful to their masters and that the deer has an affection for music, hearing it well when the ears are raised, but deaf to it when the ears are laid back. It is also of interest to note that the Persian text, while using the Arabic word for giraffe (*zarafeh*), reports that the name for this animal in Persian is "camel-cow-leopard." The early English word for giraffe—camelopard—was a similar construction.

Two beliefs that still have currency may be found in the Persian bestiary. The porcu-



Standing bear, in Persian picture, clutches some unidentifiable object to chest. Text states that cubs are held up in air to "strengthen" them.

pine is credited with an ability to throw its quills "wherever it wishes," and mice with the "fine trick" of stealing eggs by teamwork—one on its back, egg in paws, while another sleds the egg-holder away by pulling its tail. An eye-witness report of rats using this method of egg transportation was published in *Scientific Monthly* less than twenty-five years ago!



Acrobatic mountain goat, left, shows no apprehension as it plummets off precipice. Its horns will absorb the shock.

Ibex, in English bestiary, is equally unconcerned over its seemingly suicidal plunge. Both texts tell same story.





*English belief about bears inspired Pope's lines:
"So watchful Bruin forms, with plastic care,
Each growing lump, and brings it to a bear. . . ."*

In his own review of the English bestiaries, T. H. White emphasizes the "tangle of traditionary evidences among which the bestiary was trying to discriminate." His comments make a fitting conclusion for this brief discussion. Even today, White points out, "... in public houses the English peasantry are at this moment assuring one another that owls cannot see in daylight

... that eels are bred from horsehairs . . . and that adders swallow their young for protection. All this and much more have beset the bestiary. He had no reason to suppose that bears did not give birth to formless lumps. The hunters had told him that they did; and, indeed . . . they seem to do so. He himself probably had no access to bears. Nature, moreover, really is a peculiar concern. What medieval dupe would believe the commonplaces of twentieth-century biology; that so many creatures really do give birth without fertilization (parthenogenesis) and that the life-cycle of the fluke in a sheep's liver depends upon a snail in a puddle? Where our own scientists can show that the amoeba is to all intents and purposes immortal, why . . . not the Phoenix . . . ?

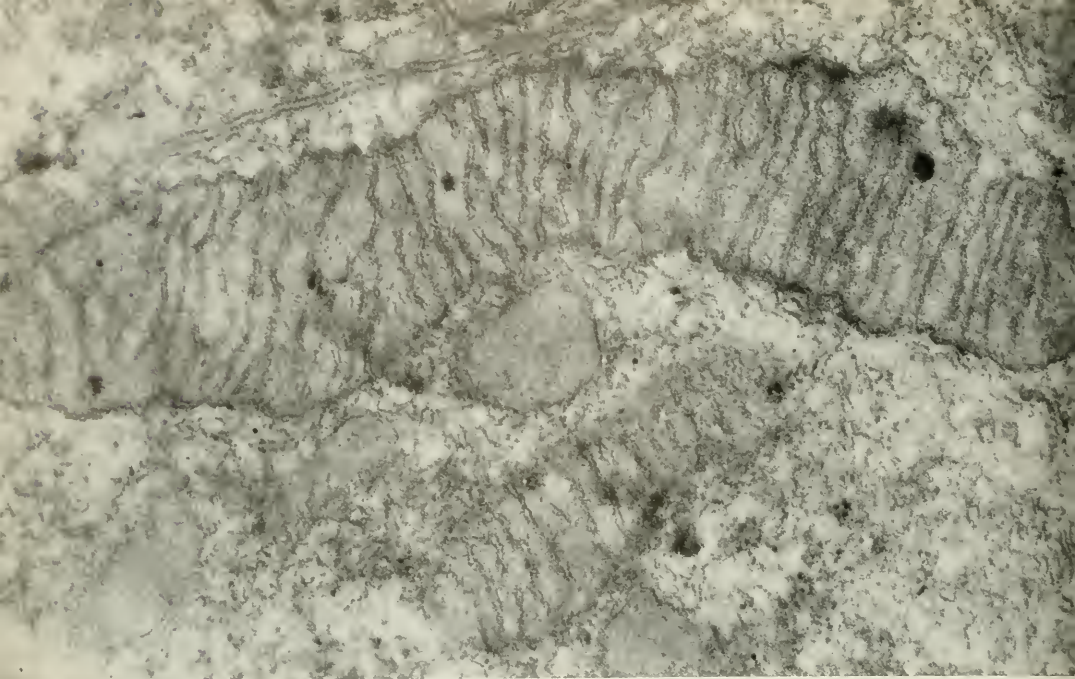
"A little humility in this matter can hardly come amiss," White suggests. "... the Physiologus . . . beset by a hundred fables... was doing his best, and a wonderful best it was, when all things are considered, to write a serious text-book on biology."

Persian painting of giraffe, left, is remarkably accurate, considering unlikelihood that the artist had actually ever seen "camel-cow-leopard."



English drew Cocodryllus, the crocodile, with bird's legs and feathery tail—perhaps confusing its Latin name with the cockatrice, a fabulous beast.





CELL SURFACE

Contrast of intestinal cell, as known from light vs. electron microscopy (*l.* and *r.*), reveals two new features in cell's surface: finger-like projections, or villi, covering surface; and surface membrane, resembling two thick lines.

MITOCHONDRIA

Grublike black bodies seen with light microscope, *left*, are now known to have a definite membrane structure, *right*.

CYTOPLASM

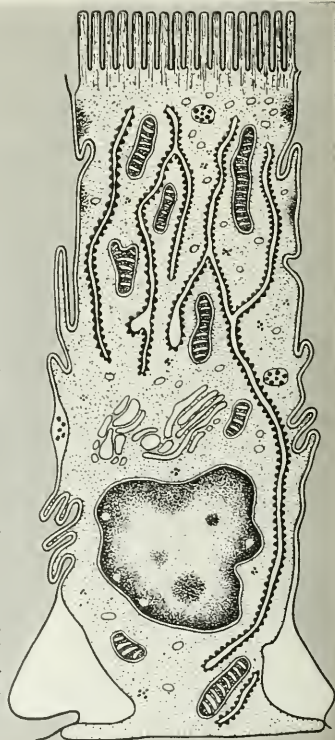
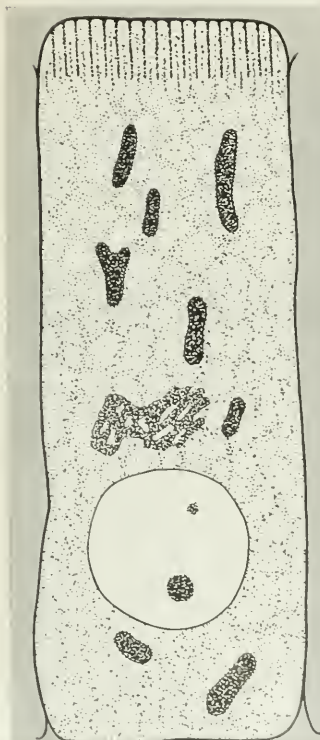
With electron microscope, structural components of cytoplasm can be seen, *right*. System of tiny canals bounded by membranes, granules and vacuoles all make up major portions of cytoplasm.

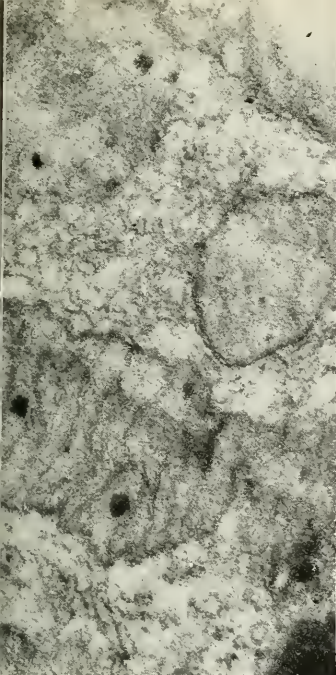
GOLGI COMPLEX

Previously seen, *left*, as ill-defined structure near nucleus, Golgi complex is now described, *right*, as system of thin membranes forming large vesicles.

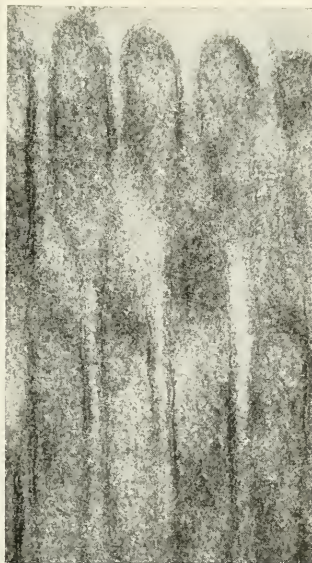
NUCLEUS

Electron microscopy has added little to knowledge of nucleus; but "pores" found in membrane probably permit exchange between nucleus and cytoplasm.





MITOCHONDRIA MEMBRANES are seen, above, to have an organized structure suggesting relation to enzyme systems.



BRUSH BORDER of an absorptive cell in intestinal lining is seen in side view, left, and from above, right. The



finger-like projections increase cell's absorptive area; spaces may contain enzymes to facilitate food absorption.

SCRUTINIZING THE MICROCOSM

Electron microscopy has shown the biologist a complex, new world

By HUNTINGTON SHELDON

TODAY, one of the most exciting research frontiers in biology is the once-invisible region beyond the limit of the conventional microscope—the level at which proteins, carbohydrates, fats, minerals and water are organized in the pattern we call life. Investigation of the macromolecular structure of cells and their components has become increasingly rewarding with the development of electron microscopy—a biophysical technique which, in a few short years, has answered many old questions and raised an equal number of new ones.

The electron microscope is not a new research instrument (the first successful ones were produced in the early 1930's), but the application of this "supermicroscope" to biology has recently taken a giant stride ahead with the refinement of techniques for preparing specimens for study at high magnification. This development of "ultramicrotomy"—or thin-section techniques—grew out of the

need to overcome some of the limitations posed by the very nature of the electron microscope. For, while the electron microscope can magnify an object many thousands of times more than can a light microscope, the instrument makes certain demands of the microscopist. A comparison of the light and electron microscope will be helpful in making this clearer.

In the light microscope, magnification of the image is achieved by transmitting light from a source through glass lenses. Details in the image are visible because of the light absorbed or scattered by the object being viewed. In electron microscopy, a beam of electrons is substituted for the conventional microscope's beam of light: magnetic "lenses" take the place of glass; and most of what is visible is seen because of the scattering of electrons by the material of the specimen.

In other words, the specimen is cut so thin that those

portions which appear white in the electron micrograph have not retarded or deflected the focused beam of electrons at all, while those portions of cells, such as the nucleus, which appear darker in the electron micrographs seem so by virtue of the density of the material originally present in that area. In the case of a completely black area, the specimen under study has completely retarded the electron beam and has, in this way, prevented it from reaching the exposed photographic film.

WHY is there a limitation to what can be seen with the light microscope? Both theory and experiment have shown that it is the wave length of the light which sets an absolute and unalterable lower limit to what can be seen. Because it is impossible to form a correct optical image of objects smaller than about half the wave length of the observing light, it is impossible to see anything smaller than about two-tenths of a micron (a micron, one one-thousandth of a millimeter, is equal to 0.00004 inch) with the conventional light microscope. But the wave length of the associated electrons in the beam of a 50 KV electron microscope is many hundreds of thousands of times smaller than the wave length of visible light. Theoretically, the electron microscope should be able to resolve objects as small as 0.05 Angstrom units. Since an Angstrom unit is one ten-millionth of a millimeter in length, this theoretical resolution comes to .000,000,000,197 (1.97×10^{-10}) inch.

In practice, however, any microscope's resolving power depends not on the wave length of the observing "light"

After studying biology at McGill University, Montreal, under N. J. Berrill, another NATURAL HISTORY contributor, DR. SHELTON went to the Johns Hopkins Medical School, where he now teaches pathology. He received his training in electron microscopy from Fritiof Sjöstrand, in Sweden.

alone, but on the lens system and on the aperture of the objective lens. In electron optics, in order to keep "lens" aberrations to a minimum, limitations are imposed on the size of the aperture. This, of course, leads to a reduced value of the actual resolving power of the electron microscope from what theoretically might be possible. In a properly trimmed electron microscope, it is actually possible routinely to achieve 30 Angstrom unit resolution—which means the difference between being able to observe a virus particle and merely theorizing its existence.

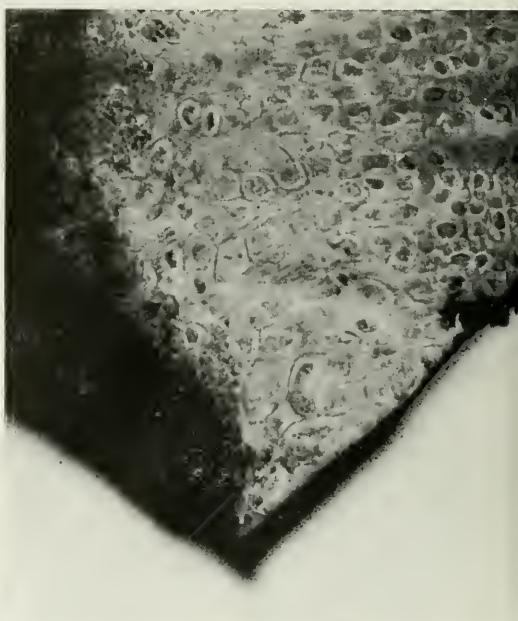
It is important to remember, in this connection, that the resolution of a given electron micrograph depends not only on the performance of the electron microscope but also on the nature of the specimen viewed. For example, living matter, thus far, has not been observed. It would be necessary to confine a living specimen to a chamber the walls of which would not scatter or absorb the electron beam; even then, it seems likely that the rapid vibration of microscopic particles in a wet preparation would probably obscure the hoped-for detail.

Another problem is that of specimen thickness. Because the beam of electrons is more easily scattered than a beam of light, it is necessary to use an extremely thin support

BROADENING THE NARROW VIEW:



LIQUID PLASTIC used in electron microscopy to fix slice of tissue is contained in test tube. Fingers hold a bone, one segment of which is embedded in the capsule at bottom.



LIGHT MICROSCOPE MAGNIFICATION of a segment of bone is shown in photo, above. Individual cells appear only as round bodies; details of structure are indistinguishable.

for specimens. For a while, the electron microscopist was caught between the Scylla of too thick and dense films and the Charybdis of films so thin that they tore when subjected to the electron beam. But, with practice and experimentation, appropriate supporting films and nets have at last been developed.

A third and more complex difficulty—but one fundamental to successful high resolution—is the problem of “contrast.” This is as important, in a way, as the problem of resolving power, since an object can be seen (if it is larger than the resolving power of the microscope) only if it has enough mass to scatter electrons and if, at the same time, the supporting film does not scatter the electrons *to the same degree*. Many early attempts at demonstrating particles of macromolecular dimensions failed because this contrast between the specimen and the supporting film was not sufficient. It was like trying to see a black bear in the middle of a dark night.

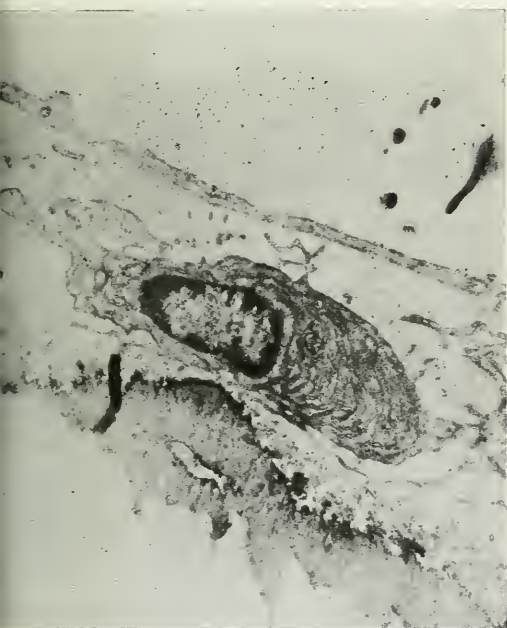
Before the development of methods for thin sectioning, this problem of contrast was partially solved by an ingenious method devised by R. Robley Williams—the preferential attachment of atoms of a heavy metal to the surface of the object under study. One of the ways of doing this was a “shadowing” technique: the specimen was placed in a vacuum jar and the metal placed beside a tungsten filament. At the moment the filament’s heat vaporized the metal, the metal atoms traveled in straight lines in all directions: some of them were deposited on the specimen.

Since the greatest amount of deposited metal was on the specimen surface facing the filament, the specimen appeared in the electron microscope as if it were casting a shadow. Such structures as collagen fibers are admirably suited to this shadowing technique, as Schmitt, Hall, Jakus and Gross have demonstrated at M.I.T.

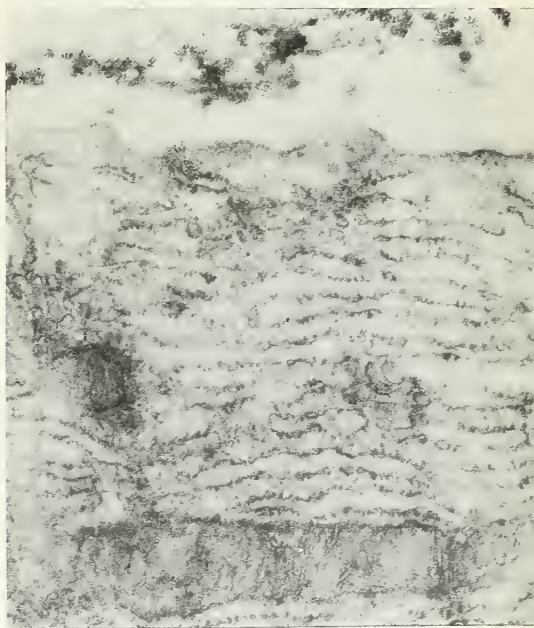
Another approach to the problem, before today’s sectioning techniques were developed, was put forward by Dr. Keith Porter at the Rockefeller Institute. Taking advantage of the spreading characteristics of some cell types, Porter allowed cells in tissue culture to spread out on thin films. He then fixed the cells and transferred these whole mounts to the electron microscope. Despite such techniques, however, the absence of any method for sectioning meant that it was not possible to look at a cross-section of a cell’s surface membrane, to examine the relation of the nucleus to the cytoplasm, to compare the sub-microscopic morphology of different cell types or to hope to define the macromolecular structure of such organelles as mitochondria or the Golgi apparatus.

THE development of ultramicrotomy grew from contributions by many different groups of workers. In 1949, Newman, Borysko and Swerdlow at the National Bureau of Standards in Washington, D. C., described a method for embedding tissue in a plastic—methacrylate—rather than in the paraffin used routinely by light microscopists. This acrylic plastic is relatively transparent to the electron beam; moreover, it does not change from a solid to a gas

CELLS, A CELL, ITS CYTOPLASM



LOW POWER ELECTRON MICROGRAPH discloses single cell of bone. Nucleus lies in middle of cytoplasmic membrane, which, at this low magnification, can barely be resolved.



HIGH ELECTRON MAGNIFICATION of the bone cell reveals regularly arranged membranes of the cytoplasm, with small granules seen in the center and a mitochondrion at bottom.

as readily as does paraffin under electron bombardment. More important is the ease with which the plastic may be sectioned, as thin as three or four hundred Angstrom units. Thinness of section is extremely important, since the electron beam has a comparatively limited penetrating power and the great depth of focus makes for superimposition of particles in different planes of the section, which tends to obscure very fine structures.

In order to obtain sections thin enough for successful high resolution microscopy, much effort was spent on designing new microtomes. Two of the most successful and widely used microtomes are the Sjöstrand microtome and the Porter-Blum. In both methods, the specimen to be sectioned is mounted on the end of a metal rod which passes a cutting edge once during each cycle. By timing the rate of revolution and controlling the heating element (in the Sjöstrand microtome), the specimen can be sectioned to such thinness that the ribbon of sections is practically invisible. The thickness of these sections, as they float in the collecting basin, may be estimated by the reflected color of incident light—the thicker ones appearing yellow or red, while the thinnest seem bluish-white.

WITH these developments, it has now become possible routinely to section specimens from all parts of the plant and animal kingdoms. Naturally, much more attention must be paid to optimal fixing, embedding and sectioning techniques than in the case of light microscopy—since the very high magnifications at which specimens are ultimately viewed exaggerate any and all artifacts of technique. A typical procedure is to take the specimen for study as quickly as possible (to prevent post mortem changes), at low temperature (to slow enzymic activity) and immerse a minute quantity of tissue in a fixative (the smaller the quantity the better, in order to permit fixative penetration). After fixation for an appropriate period, the specimen is rinsed and dehydrated in graded alcohols until it is free of water. It is then allowed to rest in liquid plastic until the plastic has completely penetrated the tissue; then the plastic is hardened and the specimen is ready to be trimmed and oriented for sectioning.

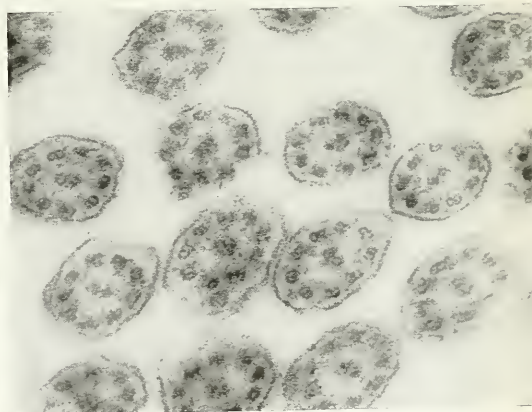


SEA URCHIN SPERMATAZOA is studied in cross-section, *above*, and cut lengthwise, *right*. Cross-section micrograph shows spokes which extend from center to peripheral cylinders.

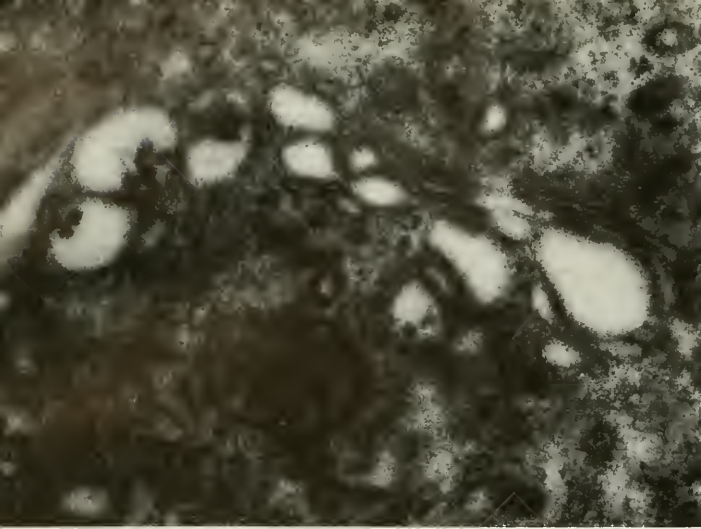
The procedure of trimming requires an intimate knowledge of the anatomy of the tissue, as well as delicacy and patience, since the final result depends largely on precise orientation of the desired cells to the plane of section. The specimen is usually trimmed in the form of a pyramid—with the base about 0.5 millimeter on a side. The sections which are cut from the trimmed block may be about 0.1 millimeter square and can only be seen with the help of a dissecting microscope. When they float from the microtome's knife-edge onto the fluid surface of the collecting basin, they are collected on a grid which is then placed in the microscope for scrutiny.

THE first major discovery with this new technique of sectioning was the demonstration in 1952 (by G. Palade and F. Sjöstrand, independently) that the cellular respiratory centers, the mitochondria, have a highly organized structure—quite in keeping with the biochemical evidence of their complex function, which allows the many steps involved in the transfer of energy to take place in an orderly manner. While appearing in whole cells as long rods, mitochondria—studied at high resolution in sectioned material—were shown to have well-organized systems of internal membranes, bounded by an outer limiting membrane. As evidence accumulates from studies on different tissues, it becomes apparent that the mitochondria of all cell types do not look exactly alike. Today, there is much discussion among biologists about the true structure of the mitochondria, and some experiments have shown that mitochondria may be altered from “normal” by various means. It seems likely that well-designed experiments may show that these alterations in morphology are coincidental with alterations in function. But it is imperative that the “normal” appearance be thoroughly investigated first.

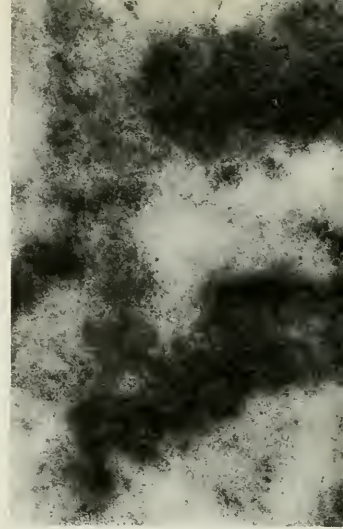
The study of cell sections in the electron microscope has demonstrated many variations which the cell surface membrane can assume. Ordinary epithelial cells—cells covering an outer surface or lining an internal cavity—most often have small, finger-like processes projecting from their surface. A study of epithelial cells in the developing hen's egg showed that, when the cell was experimentally infected



HAIRLIKE CILIA of cells lining mammal's windpipe—seen in cross-section (above) and lengthwise (left)—are quite similar to spermatozoa, *opposite page*, although unrelated.



GOLGI APPARATUS from absorptive cell of the intestine, *above*, and from surface of the cornea, *right*, are compared in two electron micrographs. The Golgi apparatus is always



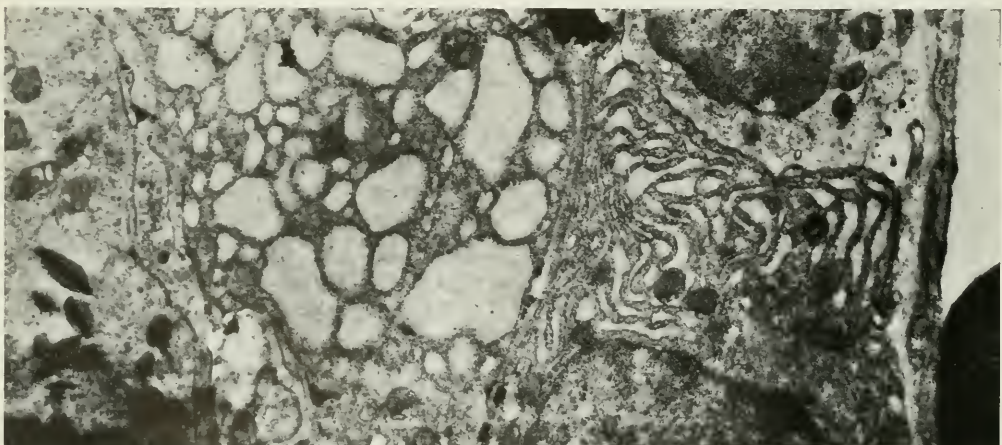
a system of membranes and vacuoles, bladder-like cavities which lie within them. But in the intestinal cell, whose principal function is to absorb and secrete, the vacuoles

with an influenza virus, filaments of virus particles could be seen in all stages in and out of the finger-like processes. This *could* mean that new virus particles are liberated from the surface of these cells and thence are delivered as infectious agents to the world at large.

Other studies have shown that virus particles not only have distinct shapes, sizes and submicroscopic structures, but that at least some viruses are apparently produced in the nucleus of cells and others in a particular component of the cytoplasm that has already been identified as a probable site of protein production.

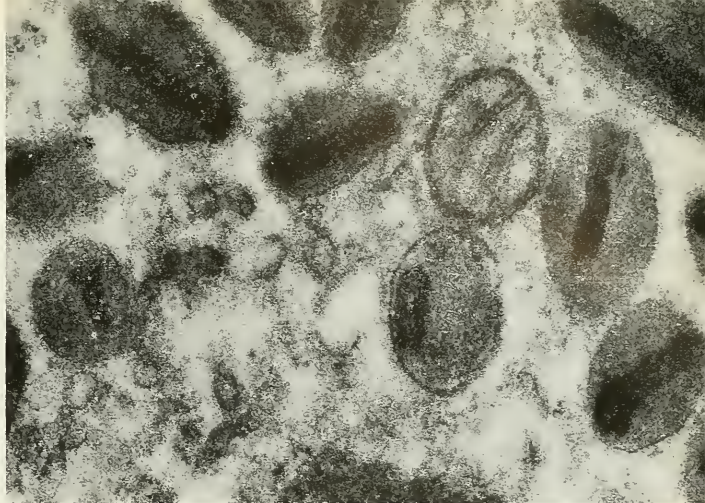
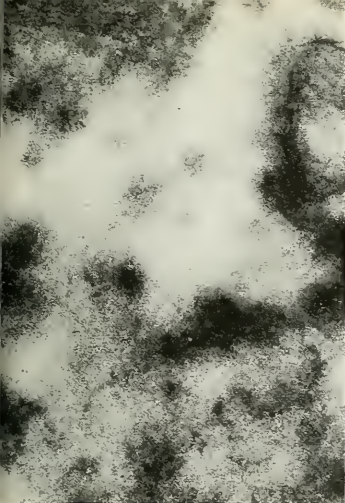
The brush border of the absorbing cells in the kidney

and intestine has been shown in the electron microscope to consist of longer and thinner fingers of the cell surface. In the intestine, these cells themselves are arranged in tiny projections, or villi, that give the inner surface of the intestine the appearance of velvet. These villi are a device for increasing the absorbing surface of the tube many times. Studies on many thousands of sections with the electron microscope have made it clear that there are probably six or seven hundred finger-like processes at the surface of each cell, increasing the surface area of the cell itself at least fifteen times. So we have adaptations on adaptations, all to allow a better absorption of what we eat.



FOUR DIFFERENT BLOOD CELLS are seen, *above*. On left are granules similar to those shown, *opposite page, top*; to their right are two types of plasma cells, one cell with

dilated spaces containing an amorphous material, the next with comparatively little of this material; and, finally, at far right, part of a red blood cell lying in a capillary.



are large and bulging. In the cornea, however, the surface cell's function is to serve as a flat cover; so we seldom see large vacuoles in the Golgi apparatus of these cells.

GRANULES OF LEUCOCYTE, or white blood cell, are shown in electron micrograph, *above*. Crystalline inner structure of granules is visible in middle of one of the dense bars.

THE cilia of cells, in the animal kingdom, are another kind of modified cellular extension and are used in one way or another as transport mechanisms. It is a puzzle how these thin, small processes can wave back and forth so vigorously, even when separated from major portions of the cell. Electron microscope studies on cross-sections of cilia show that their submicroscopic organization (and presumably the component necessary for their motion) is nine pairs of cylinders arranged in a circle within the cytoplasm. In the center of these nine paired cylinders is another pair. It is a problem in geometry to relate these cylinders at their termina to one another and to see whether

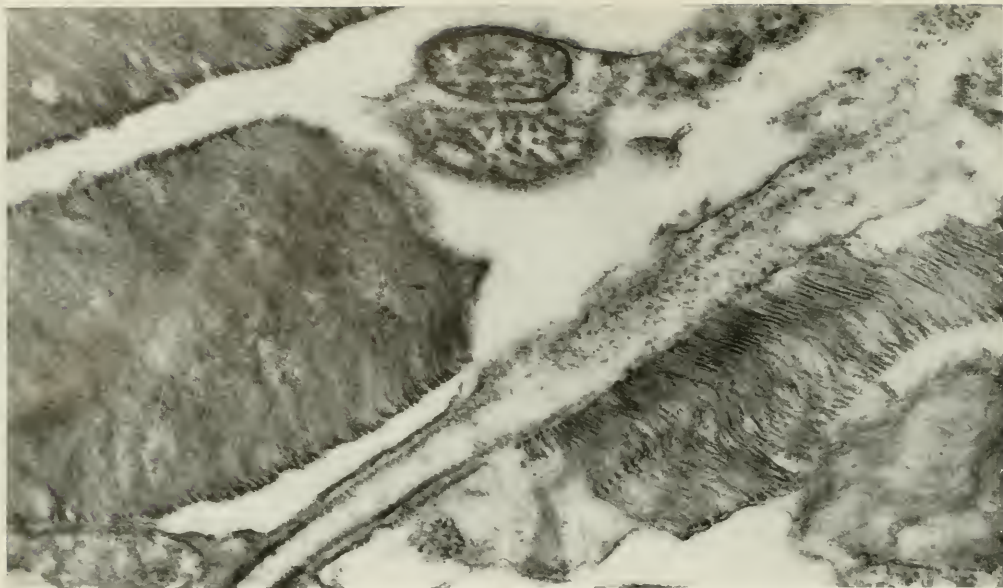
they are in truth continuous. Now, the tail of the spermatozoan is organized in a similar manner and looks quite identical. We can imagine that, as in the cilia, the mitochondria of the sperm middle piece supply the energy necessary to allow the tadpole-like cell to wiggle its tail until it has moved far enough to reach and fertilize an egg.

Furthermore, electron microscopy on sections of the retinal rods of eyes (the dim vision receptors) shows that there is a small portion of the outer segment which connects the stacks of plates with the inner segment. This region, which must in some way transmit the energy of light to cells nearer the brain, has a similar submicroscopic



CAUGHT IN THE ACT, the white blood corpuscle, *above*, was frozen in plastic for microscopic study just as part of the cytoplasm, marked "c," reaches out to englobe two

bacteria ("b")—which appear to be in process of dividing. The white blood cells, of which there are five different types, are mainly active in combating bacterial infection.



RETINAL ROD of mammal's eye is shown in this electron micrograph. Stack of flat plates in outer segment of rod—similar to granules of chloroplast, the light receptor in

plants—is clearly visible. Linking outer and inner parts is connecting segment (center of photo), identical in its structure with the cilia and spermatazoa on pages 512-3.

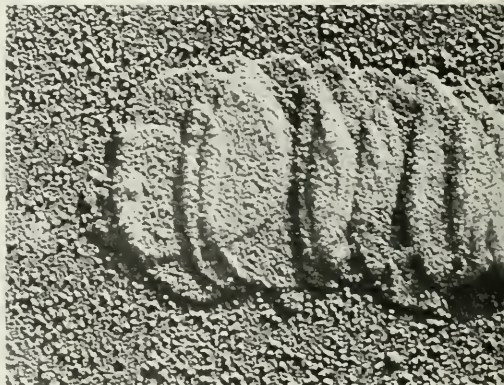
structure to that of the cilia and the sperm tail. Is this another demonstration of Nature putting the same arrangement of living matter to different uses?

THE examination of such similarities can lead us still further. Studies of sections of such retinal rods have confirmed Dr. Fritiof Sjöstrand's earlier work (on isolated fragments) and shown that the stacks of plates, when sectioned in the proper plane, appear as very regular, platelike lamellae. This arrangement of the photoreceptors has also been confirmed as the structure of the chlorophyll-containing grana, or granules, of the chloroplast, where plants manufacture their starch. The very regular lamellar construction of photoreceptors—in animal and plant alike—is a striking feature that bears further investigation.

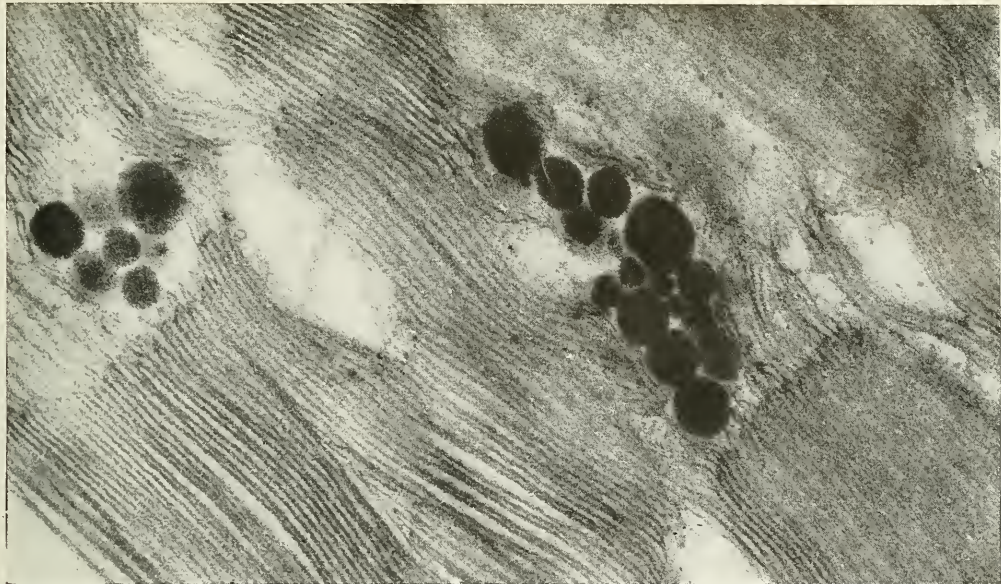
Long ago, an ingenious investigator showed that if electrodes are placed on two spots of a green leaf, and one of the electrodes is shaded from the sun, the electrode in the light becomes electronegative to the electrode in the shade. This reaction can also be obtained when electrodes are placed on the green and white parts of a variegate leaf—the green part is negative to the white when light falls on both. Since the white part of the leaf has no chlorophyll, this electrical evidence has been interpreted as a demonstration that chlorophyll is necessary for the leaf's perception of light. Similar electrical patterns can be recorded from the retinal rods of animals when the retina is stimulated by a flash of light; and we know, as well, that vitamin A is essential for the function of these rods. Recently, some electron microscope studies on chloroplasts from white leaves (the plants were grown in the dark) showed that the usual lamellated appearance of the grana was not present. When the plants were put in the light and recovered

their green color, the lamellae of the grana also reappeared. It was suggested, therefore, that chlorophyll is in some way necessary for the appearance of the lamellae of the grana. If the lamellae are really uniformly arranged molecules of protein and fat, as has been suggested, we now have to answer this question: was it the light, or the chlorophyll, which caused the very regular appearance of the layered structure?

Trying to answer such a question is something like trying to find out what the shade of an unexposed bit of



PLATELIKE LAMELLAE of chloroplast granule are magnified 16,000 times in the electron micrograph, above, revealing their structure very distinctly. In the present instance,



GRANULES OF CHLOROPLAST, a tiny plant organ which is the seat of photosynthesis and starch manufacture, appear, *above*, to have the same lamellated, disklike structure as

the mammalian retinal rods, *opposite*. The light receptors in both animals and plants are shown, under the electron microscope, to be similar in form as well as in function.

photographic paper is. If one turns on the light to see, the paper's shade may be changed by the action of the light needed to observe it. Perhaps one way of getting at this problem would be to look at the photoreceptors of animals raised in the dark. If their retinal rods showed a lamellated structure, then perhaps some essential metabolite—such as vitamin A—might be removed from their diet. If vitamin A-deficient animals raised in the dark showed a nonregular structure of the light receptors, then some animals could be given the metabolite to see whether

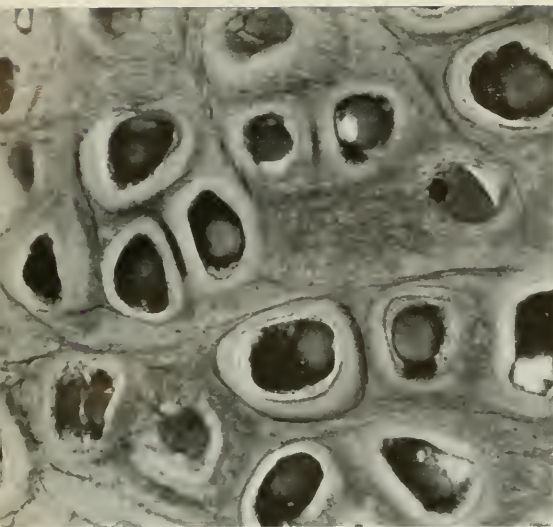
it would cause the reappearance of the lamellae. Others could merely be allowed to see light, to determine what effect this energy had in aligning the molecules.

ANOTHER interesting structure within cells which has been the subject of electron microscopic studies is the Golgi complex. The Golgi complex has been the matter of controversy for fifty years—some investigators bitterly contend that all evidences for this juxtanuclear apparatus are artifact, to which others retort that the only artifacts present were those caused by the complaining experimenters themselves because they are not using the technique correctly. With the help of careful correlation between living and fixed cells studied with the light microscope, and electron microscope studies on the same material, it seems that the controversy is at least partially resolved. A system of membranes, granules and vacuoles has been seen near the nucleus of almost every cell type examined in the electron microscope, and it seems justifiable to conclude that this structure must be the basis for what was described earlier by light microscopists.

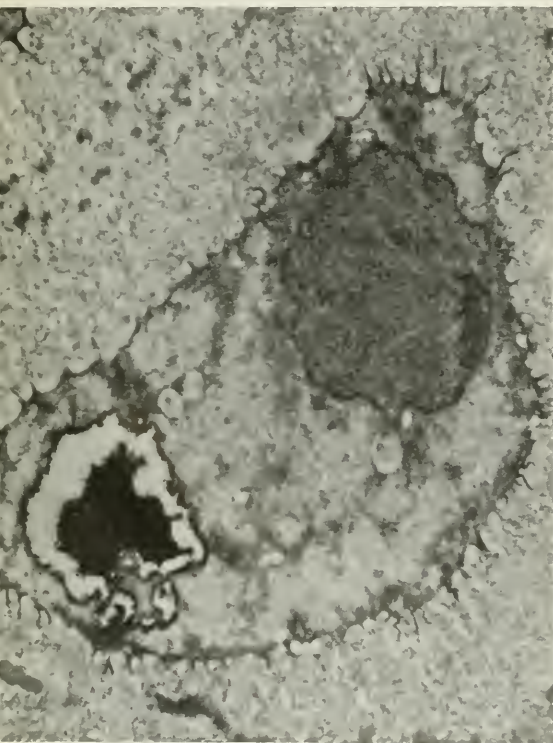
Apart from the similar appearance of the membrane component of the Golgi complex in many different cell types, it is becoming obvious that the other components, the vacuoles and granules, are different in different cell types. In the absorbing cells of the kidney tubule, there are often large vacuoles between the membranes; in the absorbing cells of the intestine, these same vacuoles often contain small black granules. Could they represent some difference in what the Golgi complex is metabolizing? The same large vacuoles are present in the zymogen-secreting cells of the pancreas, but they do not exist in the epithelial cells of the cornea, which functions only as a transparent



the material has been "shadowed," according to the method devised by R. Robley Williams; material in other photos has been *sectioned*, by techniques developed subsequently.



CARTILAGE CELL from rabbit ear, stained to show fat, is seen in a light micrograph (above, $\times 600$) and an electron micrograph (below, $\times 7300$). Chief difference between two instruments for purposes of study, however, is less their magnifying power than their resolving power—clarity and lack of fuzziness with which the details can be observed.



covering for our eyes, and so far as we know does not produce or absorb any foodstuffs for our general use. In these same cells of the pancreas, large granules of the digestive enzyme zymogen are produced, and these granules seems to be most intimately associated with the Golgi membranes. In fact, a whole range of different-sized granules can be seen in and around the Golgi complex. We wonder if these large and small granules represent various stages in the development of the enzyme, which is then discharged in this form to where it helps digest foodstuffs.

INTERPRETING electron micrographs can lead the most careful investigators astray, if they are not aware of the many factors to be considered before they can draw summary conclusions. One of the most difficult problems is to reconstruct what we know are dynamic processes from the static pictures we obtain in the electron microscope. Also, before any study is complete, it is necessary to know something of the variations which can be manifested even in supposedly "normal" biological material. This means that any comprehensive investigation must include a study of many samples from different organisms. Only then is it time to alter conditions experimentally in an effort to see how infections, injury or different functional states may be reflected by changes in the structure of the tissue.

It has often been remarked that the best experiment is the simple experiment. Once systematic electron microscope investigations of "normal" tissues have been completed, it should be possible to begin experiments where, in so far as possible, only a single variable has been introduced. Using specific enzyme poisons or removing an essential metabolite (such as a vitamin) should cause changes to appear which, while they are not easily seen with the light microscope, would be obvious at the macromolecular level. Such approaches should yield new information in which morphological and biochemical knowledge can be correlated. Dr. Lindstrom-Lang, working at the Carlsberg laboratories in Copenhagen, showed very clearly how such correlations could be achieved at the level of the light microscope when he cut alternate sections from a frozen cylinder of tissue and did chemical studies on one slice and microscopy on the next. A similar study with the electron microscope could help to identify the dense and non-dense structures seen in electron micrographs. Another technique for correlating biochemical properties with morphological appearance may be found in applying the principle that different substances absorb light of different wave lengths. Professor Caspersson, in Stockholm, has devised methods which allow him to make not only qualitative but quantitative determinations on particles as small as one-tenth of a square micron. All of these techniques offer new possibilities to the biologist who would better understand the complex nature of life.

In the future, the electron microscope will be used on an infinite number of problems—ranging from what may be the causes for cancer to what is the structure of an enzyme. But, at the moment, the most inviting problems seem to lie in correlating some of the new information we have already gleaned about biological material with the functional properties of these submicroscopic structures. The most difficult thing to do is to ask biological questions in such a way that they can be answered. We hope the electron microscope may be used as a new key with which to unlock some of these still-closed doors.

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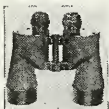
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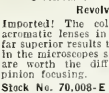


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CONCERNING QUETZALS

In which an amateur naturalist examines the bird, itself, its Nahuatl name and the divine "Feathered Serpent," Quetzalcoatl

By N. PELHAM WRIGHT

A VISITOR to Mexico rarely fails to encounter the divine "Feathered Serpent." Quetzalcoatl, on some occasion: if not at San Juan Teotihuacán, then in the halls of the Museo Nacional, in tourists' brochures, or the commentary of guides. Perhaps the casual visitor accepts the peculiarity of this image—a plumed reptile—without question. But some of us, who have made our homes in Mexico and have an inquiring turn of mind, are inclined to ask questions. Why a *feathered* serpent? What sort of feathers? And what, if anything, has this Aztec deity to do with the Central American bird of similar name, the quetzal? When these questions of ours are addressed to guides or similar voluble exponents of "simplified" Mexican history, there usually follows an embarrassed silence or a change of subject. Therefore, the more tenaciously curious among us have, perforce, sought further sources of information on this subject.

To start with the more tangible element—the bird, itself—the quetzal is perhaps the most effulgent form of natural life to be found anywhere in the Americas. One of the trogons (*Pharomacrus mocinno*), the quetzal cock, outshines, in my opinion, the most extravagantly colored of New Guinea's birds of paradise. The male quetzal's upper parts are an iridescent

green, its belly is a hardly-less-brilliant crimson, its head is crowned with a modest, yet pleasing, crest and the central upper tail coverts are elongated to such an extreme that the nine-inch bird may trail a pair of curving feathers over three feet long.

To make a choice between this "Resplendent Trogon" (as the nineteenth-century English ornithologist, Gould, christened the bird) and the various feathered oddities of the Southwest Pacific is, of course, a matter of personal esthetics; but let the reader be warned at the outset that my own prejudices are in the quetzal's favor.

A creature with such magnificent attributes would make its mark anywhere in the world. So far as we can tell, the quetzal's splendor first entered pre-Columbian records—in central Mexico, at least—with the decorations at Teotihuacán. There, some thirty miles from Mexico City, a frieze is to be found—composed of serpent heads, in bold relief, with chokers of stylized feathers. These, we are assured, are effigies of Quetzalcoatl, the divine "Feathered Serpent," apparently first brought into the hierarchy of the gods by the unknown architects of this vast monument, and later accepted as a deity by the Toltecs and, in turn, by their more familiar successors, the Aztecs.

Yet, the evidence of these feathers—and recognizable feathers—in monumental stone demonstrates only that, some thousand years ago, men had conceived the idea of embellish-



QUETZAL HEN is marked by shorter and less spectacular plumage than the cock.

ing a snake—possibly already revered—with the prime attribute of *some* sort of bird. That the bird chosen was what we now call the quetzal is nothing more than conjecture. We know nothing of the language spoken by the creators of Teotihuacán, nor what their feathered serpent deity was named, nor even if they were aware of the Resplendent Trogon in the distant rain forests to the south.

It is only many centuries later that we find linguistic clues. The Toltecs apparently spoke a Nahuatl language, and we may drop this precautionary "apparently" with regard to the later Aztecs. The Aztecs—as we know through the careful work of many historians and geographers—used the word "quetzal" to such an extent that it has survived to this day in about twenty proper names. The majority of these are the names of

LONG-TAILED quetzal cock may still be found in Middle American mountains.

personages; but eight, at least, are place names. What, then, did the ancient word "quetzal" mean?

Fortunately for us, the evidence is plain. Father Molina's classic dictionary, published in 1571, renders *quetzalli* as "the exquisite feather (*pluma rica*), long and green." Again, the classic French compilation by Simeon, in 1835, gives the same primary meaning and then expands on figurative uses: "treasure, jewel, beloved child." The distinguished Mexican linguist-historian, Orozco y Berra, holds that, in many cases, the figurative meanings outweigh the literal one ("exquisite feather") and are generally equivalent to "precious."

For example, there was a princess named "Xochiquetzal," and "*xochi*" means "flower." Now, while it may be argued that "quetzal," to us today, means "a green and crimson tropical bird," it still seems most doubtful that this lady of the past was known

A contributor to NATURAL HISTORY for many years, MR. WRIGHT is an amateur ethnologist and naturalist, who now makes his home in Mexico.

as "flower of the bird," or even "flower of the exquisite feather." "Precious flower" as a cognomen, however, is suitable to any princess, whether she be Aztec or other.

Similarly, there is a place name—"Quetzalostoc"—of which the last two syllables are equated with "grotto." Now, our quetzal birds are dwellers of the lush deep forests, so it seems improbable that the name of the rocky, barren locale called Quetzalostoc can be tortured into "the grotto of the quetzals." But "precious grotto" fits the place quite nicely.

The reader may judge from this flow of argument that the Nahuatl word *quetzalli* was applied largely to the abstract concept, "precious," or

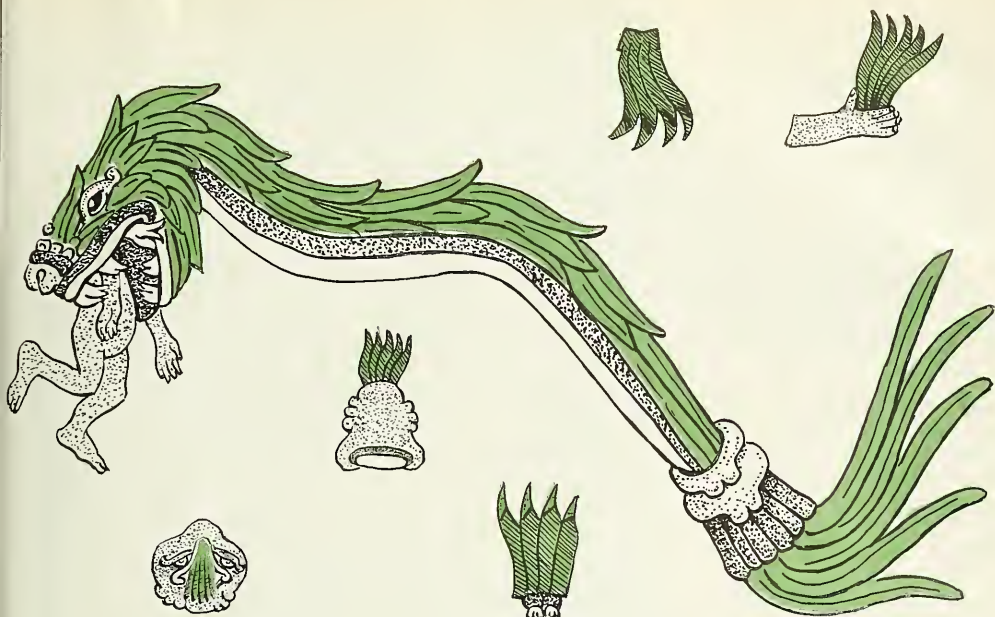
its various equivalents. What evidence do we have for "quetzal" as the concrete name for a real object, our Resplendent Trogon? Well, Guatemala's second city—Quetzaltenango—received its name from Alvarado's victorious Tlaxcalan (and Nahuatl-speaking) soldiery early in the sixteenth century, after they had defeated the Quiches in battle there. Now, triumphant defenders might have called such a battleground "precious." But for the tough mercenaries of a ruthless Conquistador, I hold, an alternate meaning—"place where quetzal birds are abundant"—makes far more sense, particularly since the Resplendent Trogon was almost certainly abundant there four-hundred-and-some-odd years ago.

What other evidence can be derived from such linguistic interpretations? In Aztec imperial "heraldry"—the ideographic symbols for the empire's domains—five towns have names that



FRESCO FROM BONAMPAC, in State of Chiapas, Mexico, depicts two assistants completing the costuming of Mayan

priest. The priest wears a sort of quetzal-feather arch, which frames his figure. Second priest watches, at left.



QUETZAL MOTIFS excerpted from two manuscripts are seen, above. Central figure represents the god Quetzalcoatl in

serpent form receiving human sacrifice. Other motifs are city names compounded of "quetzal," signified by feathers.

begin with the word "quetzal." Not one of the five shows a bird as part of the ideograph, but all of them display feathers. Such evidence strengthens the belief that, for the Aztecs, the abstract feather left the concrete bird largely out of account—the *pluma rica* had come to symbolize "preciousness" or "splendor" directly.

If our argument is accepted, how, then, to render Quetzalcoatl — the deity's name — appropriately? Cannot we do better than "Feathered Serpent," with its monotonous, presumed identity of abstract symbol with concrete feather? I believe so. Why not "Serpent, Made Resplendent," as the god undoubtedly was, with its ruff of iridescent green feathers at the neck?

Now, the "Feathered Serpent" deity (or "Splendid Snake," if my argument is accepted) was present in the divine hierarchy of at least two Middle American civilizations other than the Aztecs and their predecessors. And, in both these cases, the civilizations were in regions where the Resplendent Trogon, itself, had its habitat. Thus, the Maya — who, in their "Early Empire," lived in the home of the bird — recognized a serpent god, adorned with feathers, that

they called "Kukulkan." And the Quiche, of the Guatemalan highlands, had a similar deity, known as "Gukumatz." Neither Maya nor Quiche historico-linguistic reconstructions, alas, are advanced to the point that permits us to examine evidence similar to the Nahuatl data regarding the literal meaning of these divine names.

Thus, it is simply an extrapolation which underlies my personal conviction that — for perhaps as much as two thousand years — our Resplendent Trogon has been a Middle American synonym for "preciousness," "splendor," "effulgence" or any other abstract superlative that the reader wills, in whatever language was spoken by those who knew the bird.

HOWEVER this may be, let us return to the quetzal of today. A fair amount of nonsense has been written, or taken for granted, about our Resplendent Trogon, and it behooves us, here, to get our facts straight. First, it is fact that today, *Pharomacrus mocinno* is a rarity. The bird's rather tragic past history as an object of man's greed — which is continuing today — dictates this. The quetzal's present range is the densely-forested,

humid, mountain area of Middle America — and perhaps this was always the case. Man has been penetrating these mountain habitats with increasing determination in recent centuries and, when man arrives, the quetzal soon disappears. Nevertheless, the Resplendent Trogon is still to be found in four areas, which continue to offer suitable environment—at least in part. If the geography of what follows seems vague, it is purposely so. We cannot wish to guide adventurers to the bird's last refuges.

I. CHIAPAS, in Mexico. There, a friend of mine who is a good woodsman, hunter and, incidentally, taxidermist, goes off from Comitán to privately known areas once a year and usually returns with one or two specimens of the quetzal cock, which he mounts with extreme skill and, presumably, sells. Do not ask whether I consider his actions proper: I only report that he does it, and very well.

II. GUATEMALA. When this republic achieved its independence, the quetzal was chosen as the national emblem. It was assumed — wrongly, and as a result of blundering experiments — that the bird could not sur-

vive in captivity and was therefore the perfect emblem of freedom. Although mistaken, this charming image was perpetuated in the national coat-of-arms, the flag and sundry stamps and coins of the nation: the basic unit of currency, equivalent to the U.S. dollar, is also the "quetzal." Enough for the honor: the bird, itself, may still be found in a certain department, which possesses the right climate.

III. HONDURAS. Here, in the humid, inaccessible mountains, inhabited only by Indians, the quetzal still survives. The evidence for this is best presented in the accounts of the American author Victor von Hagen, who managed to take fledglings, in the early 1940's, evolved an ingenious method for transporting them safely, and brought some both to London and to the New York Zoological Society's Bronx Zoo, where individual quetzals still flourish, in defiance of the *mythos* of neighboring Guatemala.

IV. COSTA RICA. Here, my evidence is a peculiarly unsatisfactory sort of hearsay. Some years ago, I was invited to participate in a Costa Rican quetzal hunt (*not* shooting, of course, but a search for living specimens), but last-minute commitments in Mexico City prevented my journey. The area to be hunted was the tropical forest surrounding a certain volcano, and those who undertook the endeavor, being scientists, can be presumed to have known what they were about. Alas, I have not yet heard the results of this hunt!

The past few centuries, and even the past few decades, have seen the virtual disappearance from the face of the earth of half a hundred species. The list of threatened mammals is impressive enough. The list of birds, extinct or threatened, reads like a conservationist's bitter litany—the great auk, the dodo, the passenger pigeon, are among the fallen. The whooping crane and the nene are well-publicized causes for concern. The quetzal, today, is threatened by a similar sorry fate. Surely, due consideration should be given to a creature that, for centuries, appears to have been Middle America's personification of the precious, the regal and the splendid.

MAYAN RELIEF of the ninth century A.D. represents priest or god wearing huge headdress of quetzal feathers, which are symbol of the figure's high rank.



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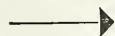
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MAN'S IMAGINATION has peopled the heavens for untold generations, turning the patterns of stars into imaginary figures. In Western culture, the "signs" of the zodiac and the other constellations have, for the most part, derived from Greek and Roman myth, although there are illuminating exceptions. The Great Bear of the Greenman tradition, for example, is the Big Dipper to us, but the Plow, or King Charles' Wain (wagon), to the English.

One robust Greek myth—re-enacted in the December sky—the tale of Perseus, half-divine son of Danaë, whom Zeus visited in a shower of gold, and his rescue of the lovely Andromeda, daughter of King Cepheus and his queen, Cassiopeia. As the myth is told, Perseus—on his way home after successfully completing the task of slaying the Gorgon, Medusa—spied Andromeda, naked except for her jewels, chained to a sea cliff. He instantly fell in love.

Andromeda had found herself in this uncomfortable position as a result of her mother's loose tongue: Cassiopeia boastfully boasting that both she and her daughter were more beautiful than the Nereids, Poseidon's attendant nymphs. To avenge the insult, Poseidon sent a sea monster to ravage the coast of Cepheus' kingdom.

When the unfortunate king asked the oracle how this disaster could be stemmed, he was told that only the sacrifice of his daughter to the monster would suffice. Thus it came about the spectacle that met Perseus—Andromeda in peril, and the monster, Cetus, rushing toward her.

After a hurried consultation with the royal couple, Perseus—who demanded Andromeda's hand as his fee—took the air on his winged sandals and, with the same blade that had blooded on Medusa, struck off Cetus' head.

In the ensuing jubilation, which included the couple's wedding, Cassiopeia's unfortunate character again came to the fore: she secretly summoned her daughter's rival for the throne, who—backed by an armed party—claimed Andromeda as her own. In the battle that followed, Perseus made use of the Gorgon's severed head to turn two hundred of his opponents into stone and escaped with Andromeda.

For her treachery, the mythographers say, Poseidon set Cassiopeia among the stars—tied to a market basket (now, more politely, known as her chair) that, at some seasons of the year, turns upside down, so that she is a figure of ridicule. Poseidon vengefully set Cepheus in the heavens, too; but Andromeda, it is related, was awarded an honorable constellation by Athene, for faithfulness to Perseus. This constellation, too, stands among the stars, eternally caught at the moment of his gallant attack on Cetus.

THE ILLUSTRATION, right, exemplifies the imagination of artists of the past, who have traced these mythical figures in the sky. *Opposite*, NATURAL HISTORY presents with pride a twentieth century rendering of the same myth that limnologist-extraordinary, Walt Kelly. As a aside to this Okfenokee iconography, Mr. Kelly has appended some notes: Perseus is played by Pogo; Andromeda by Miss Ma'm'selle Hepzibah; Cepheus by Howland Owl; Cassiopeia by Miz Beaver; Cetus by Albert the Alligator.

"Pogo," Mr. Kelly continues, "would be reluctant to kill Albert, so they would have made an offstage deal of some kind. Miss Ma'm'selle appears to be protesting too much. She probably can get free any time she wants to. Owl got late and is still wrapped in a blanket. Miz Beaver, who is actually a widow woman, is usually off her rocker a little bit, despite this picture."

SKY REPORTER

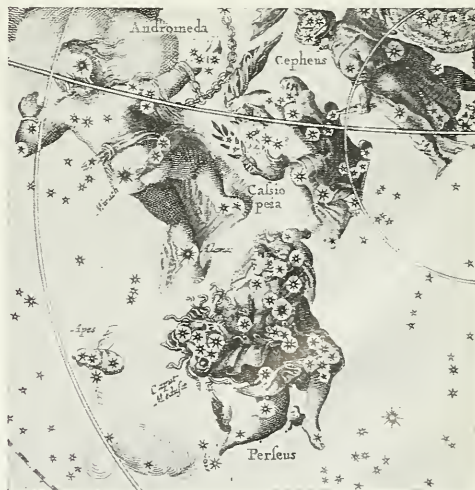
The stars of the December night include, in their vivid display, five figures from a famous myth

By HENRY M. NEELY

AMONG THE PLANETS, this month, MARS remains the most brilliant object in the night sky (except for the moon, which, incidentally, is full the hour before midnight on Christmas and—in areas with snowfall—should help to provide a seasonal spectacle of twinkling, bright nights for the holiday). MARS ends its retrograde loop on December 20 (see NATURAL HISTORY, November, 1958), and then resumes its normal, eastward motion among the stars. MARS is shown on this month's map (page 589) in its position for December 15—very high over the south horizon.

Of our other planetary companions, MERCURY lies too nearly in line with the sun to be visible until shortly before and after December 29, when it may be seen—low over the southeast—as dawn begins. Observers in southern states will have a better chance to glimpse MERCURY at this time than those living north of 40°.

VENUS is also close to our line of sight to the sun, and therefore not favorably placed for observation. Toward the end of the month, the second planet will begin to be visible over the southwest horizon shortly after sunset.



MR. NEELY, editor of *Sky Reporter* since 1947, now prepares this monthly feature for NATURAL HISTORY.

JUPITER, after being on the far side of the sun last month, is now in position to be a "morning star"—a brilliant object over the southeast horizon as dawn begins.

SATURN, the most distant planet visible to stargazers, will not be seen this month. It is circling round the far side of the sun, now, and will reach the line of "conjunction" on December 20. SATURN will not reappear until the middle of January, when it will be a "morning star."

BELOW, arranged in almanac fashion, is the month's SKY SCHEDULE, a listing of the various sights to be anticipated in December's heavens.

DECEMBER 1 to 9:

MERCURY reaches "inferior conjunction"—on a line between the earth and the sun—at 10:00 P.M., (EST) on December 9. The first planet will then begin circling to the west, as viewed from the earth, and will be at maximum separation from the sun ("elongation," in the terminology of astronomers) on December 29.

DECEMBER 10 to 19:

Meteor-watchers have an excellent opportunity throughout this period to watch a shower that is visible during most of the night and does not require the early morning vigil needed for most "shooting stars." This is the GEMINID shower, one of the best meteor displays. The meteors seem to radiate from near the bright star, CASTOR, in the constellation of GEMINI (shown on the map, *opposite*, over the east horizon). During most of this period, moonlight will not interfere with observation.

DECEMBER 20 to 29:

The retrograde motion of MARS, which commenced October 9, ends on December 20 (*see planetary notes, above*).

A meteor display discovered a few years ago—known as the URSID shower—occurs on the nights of December 20 through 22. For best results, the observer should keep a watch in the hours before dawn. The meteors seem to radiate from near the star, KOCHAB, in the constellation of URSA MINOR, the Little Dipper (*see map*). At 6:00 A.M., KOCHAB will be halfway up the sky, NNE.

At 3:40 A.M., (EST) on December 22, the earth reaches that point in its annual orbit at which the North Pole is tilted at a maximum angle *away* from the sun and our southern hemisphere has its maximum exposure to sunlight. For observers on the Tropic of Capricorn ($23\frac{1}{2}^{\circ}$ south latitude), at a point in the Indian Ocean off the east coast of Madagascar ($49^{\circ} 36'$ east longitude), the noon sun will appear directly overhead. The sun is then at the point in the sky known as the Winter Solstice: its arrival there marks the official beginning of winter in the northern hemisphere and summer in the southern hemisphere. Residents of the northern hemisphere now see the sun, at noon, at its lowest possible altitude above the south horizon.

As dawn begins on December 29 (about 6:00 A.M.), the planet MERCURY reaches its most favorable position for viewing this month. The first magnitude star, ANTARES, in the constellation of SCORPIUS, will be to the right of MERCURY, over the southeast horizon, but will not be as bright as the first planet. Above both, at this same time, will be brilliant JUPITER, a "morning star."

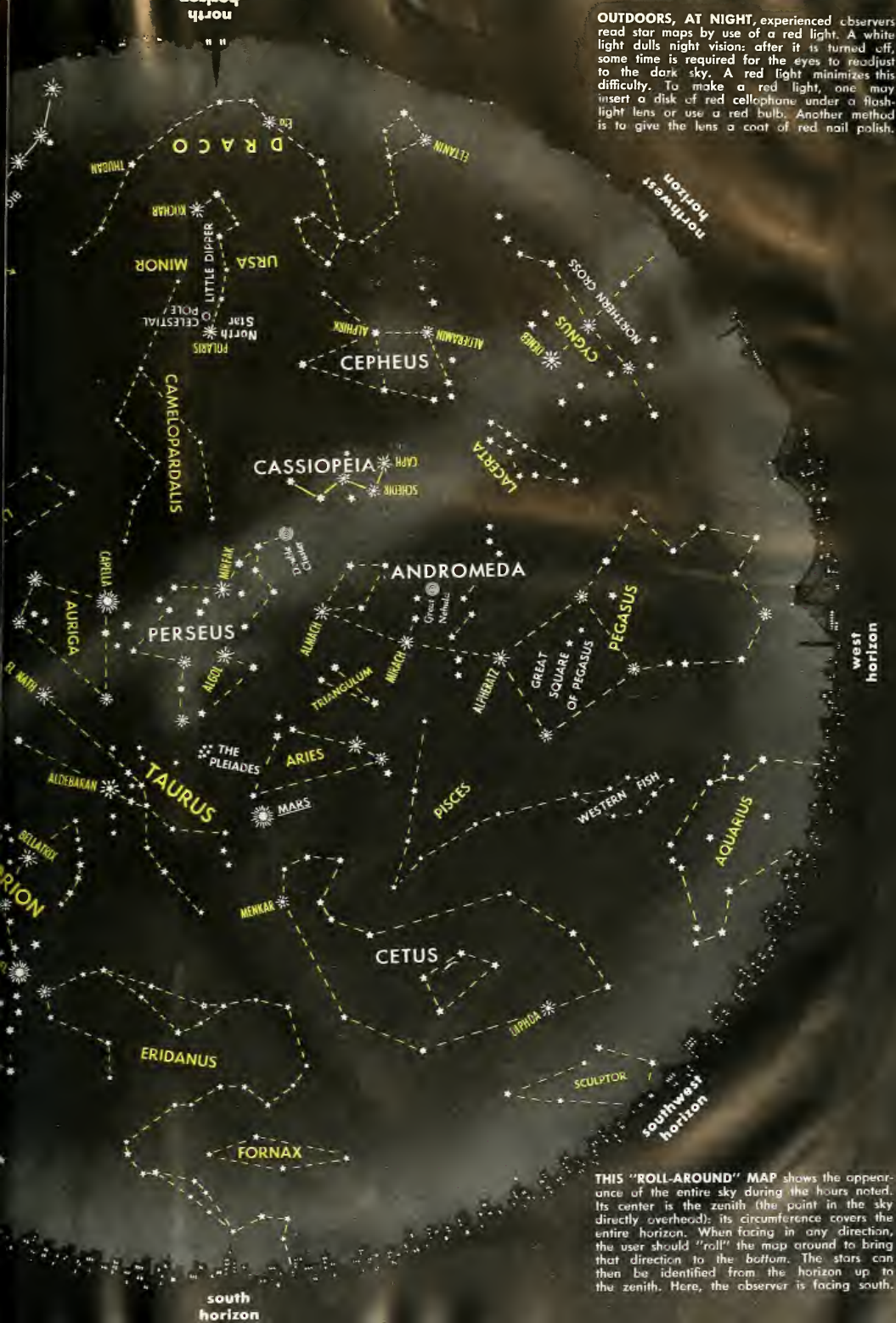
THE MOON'S PHASES, this month, begin with Last Quarter (December 3): the moon will rise just before midnight, ENE. The New Moon comes on December 10: it will not appear in the night sky. First Quarter (December 17) will see the moon high and near the Western Fish during the time for using this map. The Full Moon comes on December 25: in the sky all that night, it will set only as dawn begins to dim the stars.



DECEMBER TIMETABLE

First week	9:55 to 10:55 P.M.
Second week	9:30 to 10:30 P.M.
Third week	9:00 to 10:00 P.M.
Fourth week	8:35 to 9:35 P.M.
Last week	8:10 to 9:10 P.M.

OUTDOORS, AT NIGHT, experienced observers read star maps by use of a red light. A white light dulls night vision; after it is turned off, some time is required for the eyes to readjust to the dark sky. A red light minimizes this difficulty. To make a red light, one may insert a disk of red cellophane under a flashlight lens or use a red bulb. Another method is to give the lens a coat of red nail polish.



THIS "ROLL-AROUND" MAP shows the appearance of the entire sky during the hours noted. Its center is the zenith (the point in the sky directly overhead); its circumference covers the entire horizon. When facing in any direction, the user should "roll" the map around to bring that direction to the bottom. The stars can then be identified from the horizon up to the zenith. Here, the observer is facing south.



QUARTER-INCH STALKS of *Pilobolus* cover the surface of this bit of dung, above. In the macrophotograph, below,

atop slim stalks, the plants' swollen "lenses" (each with black spore case) are turned uniformly toward sunlight.

Lens for

The sunlight controls

Photographs by

PHOTOTROPISM, or the response to light, is commonplace in the plant world, but few more elegant examples are to be found than in the life of *Pilobolus*, the tiny "ball-thrower" fungus. Growing on the droppings of grazing animals, the plant develops overnight and, by dawn, glistening colonies are found—each individual composed of a delicate stalk and a transparent, swollen subsporangium which is topped by the black "ball" of its spore case.



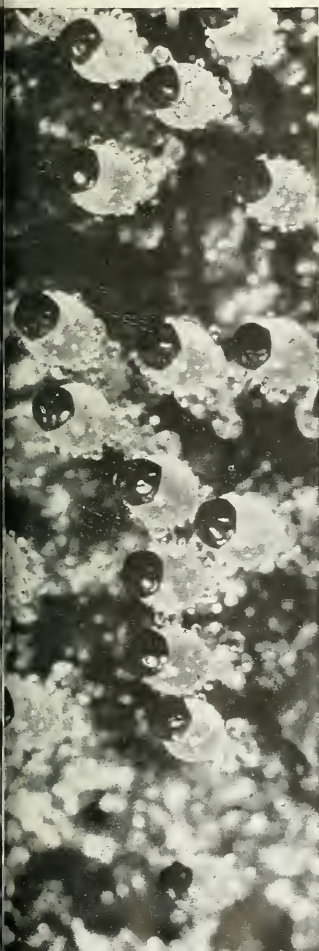
a Fungus

Naturalist's
Notebook

Pilobolus' life cycle

ERIC V. GRAVE

At sunrise, the swollen cell acts as a lens that concentrates light on a pigmented area of the stalk, and accelerated growth bends the plant toward the sun. Simultaneously, the pressure within this "lens" builds up—to as much as five atmospheres—until the cell bursts, casting the spore case as far as eight feet away. The flying "ball" usually lands on a grass blade—to be eaten and voided by some grazing animal, whereupon *Pilobolus*' life cycle starts once again.



CLOSE-UP OF FUNGUS shows inclined stem, swollen subsporangium and "ball" just before sunlight-induced

pressure ruptures the "lens," thereby throwing the spore case off. Chance ingestion of spore case starts new cycle.



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See *Up the Mountain*, by Betty Morrow (HARPER), is a general, ecological study, written in an intimate, yet accurate, style. \$2.50. 17 pp., illustrated; 8-11.

A new Simon & Schuster Golden Book line, just introduced, is the Golden Library of Knowledge. These small, hard-cover books are illustrated in color and encompass a variety of subjects. Four of them caught our attention: *Butterflies and Moths*, by Richard A. Martin; *Birds of the World*, by Eunice Hol-aert; *Prehistoric Animals*, by the editorial staff of *Life* and Lincoln Barnett; *The Sea*, also adapted by Mr. Barnett from the pages of *Life*. \$50 each, 56 pp., indexed; ages 9-12.

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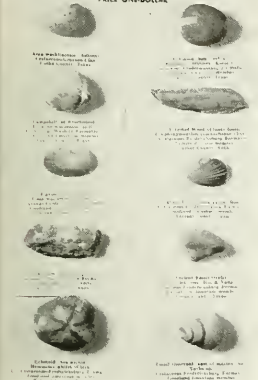
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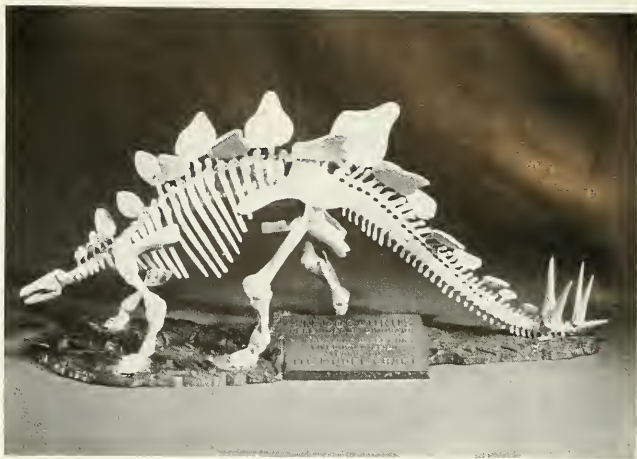
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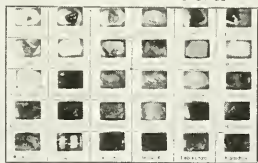
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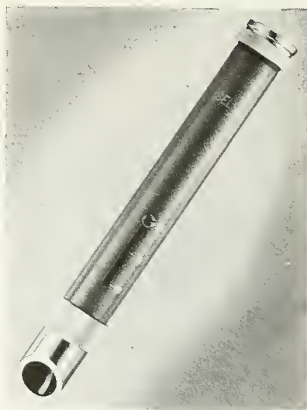
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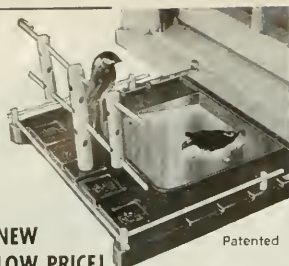
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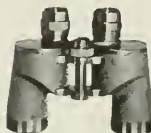
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Let's Go to a Planetarium, by Louis Wolfe (Putnam), is an introduction to the wonders of these places of brilliant stars and black heavens. A map shows the locations of seven large planetariums in the United States and clear descriptions of their exhibits are given. \$1.95 47 pp., well illustrated; ages 8–11.

For the more advanced reader, there is *Looking At the Stars*, by Michael W. Ovenden (Philosophical Library). Nebulae, star clusters, sunspots, craters, telescopes and rockets are among the many things discussed by the author who shows a selectiveness of subject matter that makes for a compact, handy book with fascinating information. \$4.75 192 pp., illustrated; ages 14 and up.

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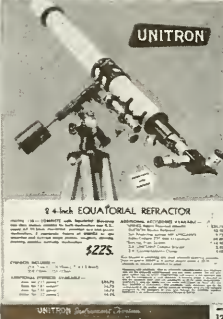


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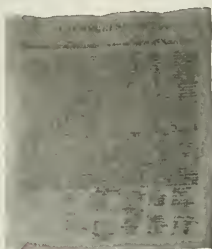


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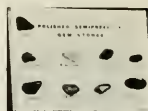


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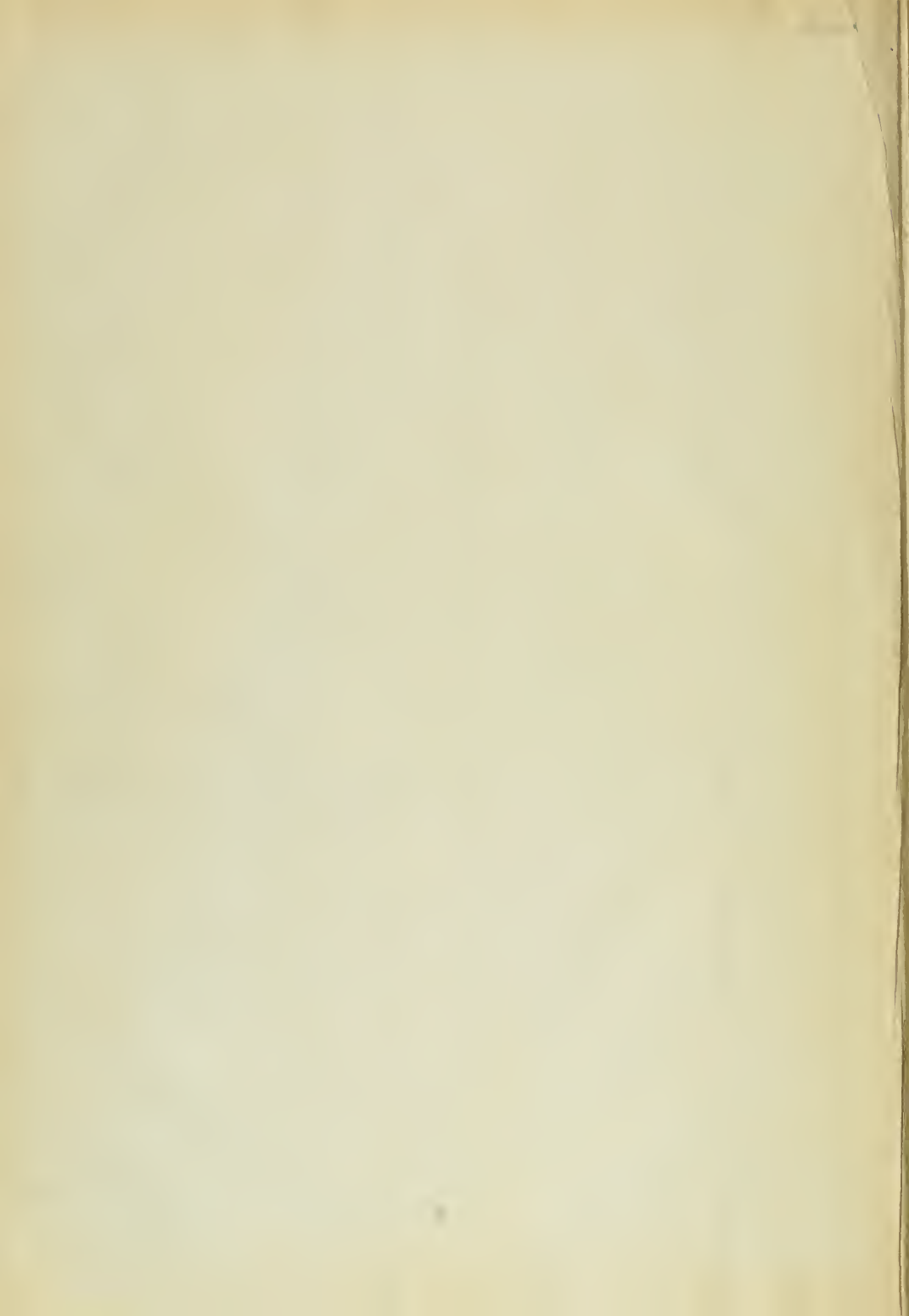
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