

BULLETIN
OF THE
American Museum of Natural
History.

Vol. XXVII, 1910.

EDITOR, J. A. ALLEN.

THE ORDERS OF MAMMALS.

BY
WILLIAM K. GREGORY.

NEW YORK:
Published by order of the Trustees.
February, 1910.

FOR SALE AT THE MUSEUM.

(Continued from 3d page of cover.)

Vol. XI. Anthropology.

**Jesup North Pacific Expedition, Vol. VII.*

PART I.—The Chuckchee: Material Culture. By W. Bogoras. Pp. 1–276, pll. i–xxxii, i map, and 199 text figures. 1904. Price, \$8.00.

PART II.—The Chuckchee: Religion. By W. Bogoras. Pp. 277–536, pll. xxxii–xxxiv, and 101 text figures. 1907. Price, \$4.00.

PART III.—The Chuckchee: Social Organization. By W. Bogoras. Pp. 537–733, pl. xxxv, and 1 text figure. 1909. Price, \$3.00.

Vol. XII. Anthropology (in preparation).

**Jesup North Pacific Expedition, Vol. VIII.*

Vol. XIII. Anthropology (in preparation).

**Jesup North Pacific Expedition, Vol. IX.*

Vol. XIV. Anthropology.

**Jesup North Pacific Expedition, Vol. X.*

PART I.—Kwakiutl Texts. Second Series. By Franz Boas and George Hunt. Pp. 1–269. 1906. Price, \$2.80.

PART II.—Haida Texts. By John R. Swanton. Pp. 271–802, 1908. Price, \$5.40.

ETHNOGRAPHICAL ALBUM.

Jesup North Pacific Expedition.

Ethnographical Album of the North Pacific Coasts of America and Asia. Part 1, pp. 1–5, pll. 1–28. August, 1900. Sold by subscription, price, \$6.00.

BULLETIN.

The matter in the 'Bulletin' consists of about twenty-four articles per volume, which relate about equally to Geology, Palæontology, Mammalogy, Ornithology, Entomology, and (in the recent volumes) Anthropology, except Vol. XI, which is restricted to a 'Catalogue of the Types and Figured Specimens in the Palæontological Collection of the Geological Department,' and Vols. XV, XVII, and XVIII, which relate wholly to Anthropology. Vol. XXIII contains no anthropological matter, which now forms a separate series, as 'Anthropological Papers.'

Volume	I, 1881–86.....	Out of print	Volume	XVI, 1902.....	Price, \$5.00
"	II, 1887–90.....	Price, \$4.75	"	XVII, Part I, 1902	" 1.50
"	III, 1890–91.....	" 4.00	"	" " II, " "	" .75
"	IV, 1892.....	" 4.00	"	" " III, 1905	Out of print
"	V, 1893.....	" 4.00	"	" " IV, " "	Price .75
"	VI, 1894.....	" 4.00	"	" " V, 1907	" 1.25
"	VII, 1895.....	" 4.00	"	XVIII, " I, 1902	" 2.00
"	VIII, 1896.....	" 4.00	"	" " II, 1904	" 1.50
"	IX, 1897.....	" 4.75	"	" " III, 1905	" .50
"	X, 1898.....	" 4.75	"	" " IV, 1907	" 2.00
"	XI, Part I, 1898.	" 1.25	"	XIX, 1903.....	" 6.00
"	" " II, 1899.	" 2.00	"	XX, 1904.....	" 5.00
"	" " III, 1900.	" 2.00	"	XXI, 1905.....	" 5.00
"	" " IV, 1901.	" 1.75	"	XXII, 1906.....	" 6.00
"	" (Complete)...	" 5.00	"	XXIII, 1907.....	" 9.00
"	XII, 1899.....	" 4.00	"	XXIV, 1908.....	" 6.00
"	XIII, 1900.....	" 4.00	"	XXV, Part I, 1908.	" 1.50
"	XIV, 1901.....	" 4.00	"	XXVI, 1909.....	" 6.00
"	XV, 1901–1907....	" \$5.00	"	XXVII (in press).	

ANTHROPOLOGICAL PAPERS.

Volume	I, 1908.....	Price, \$3.50	Volume	III, 1909.....	Price, \$3.50
"	II, 1909.....	" 3.50			

AMERICAN MUSEUM JOURNAL.

The 'Journal' is a popular record of the progress of the American Museum of Natural History, issued monthly, from October to May inclusive. Price, \$1.00 a year. Volumes I–IX, 1900–1909.

**The Anatomy of the Common Squid.* By Leonard Worcester Williams. Pp. 1–87, pll. i–iii, and 16 text figures. 1909.

For sale at the Museum.

**Published by E. J. Brill, Leiden, Holland. Not on sale at the Museum. American Agent, G. E. Stechert, 129 West 20th Street, New York City.*

BULLETIN
OF THE
American Museum of Natural
History.

Vol. XXVII, 1910.

EDITOR, J. A. ALLEN.

THE ORDERS OF MAMMALS.

BY

WILLIAM K. GREGORY.

NEW YORK:
Published by order of the Trustees.
February, 1910.

FOR SALE AT THE MUSEUM.

American Museum of Natural History.
Seventy-Seventh Street and Central Park West, New York City.

BOARD OF TRUSTEES.

President.

HENRY FAIRFIELD OSBORN.

First Vice-President.

J. PIERPONT MORGAN.

Second Vice-President.

CLEVELAND H. DODGE.

Treasurer.

CHARLES LANIER.

Secretary.

J. HAMPDEN ROBB.

EX-OFFICIO.

THE MAYOR OF THE CITY OF NEW YORK.
THE COMPTROLLER OF THE CITY OF NEW YORK.
THE PRESIDENT OF THE DEPARTMENT OF PARKS.

ELECTIVE.

CLASS OF 1909.

JOSEPH H. CHOATE.
HENRY F. OSBORN.

J. PIERPONT MORGAN.
JAMES DOUGLAS.

CLASS OF 1910.

J. HAMPDEN ROBB.
ARTHUR CURTISS JAMES.

PERCY R. PYNE.
JOHN B. TREVOR.

J. PIERPONT MORGAN, JR.

CLASS OF 1911.

CHARLES LANIER.
ANSON W. HARD.

WILLIAM ROCKEFELLER.
GUSTAV E. KISSEL.

SETH LOW.

CLASS OF 1912.

D. O. MILLS.
ALBERT S. BICKMORE.

ARCHIBALD ROGERS.
ADRIAN ISELIN, JR.

CLASS OF 1913.

GEORGE S. BOWDOIN.
A. D. JULLIARD.

CLEVELAND H. DODGE.
ARCHER M. HUNTINGTON.

ADMINISTRATIVE OFFICERS.

Director.

HERMON C. BUMPUS.

Assistant-Secretary and Assistant-Treasurer.

GEORGE H. SHERWOOD.

Scientific Staff.

DIRECTOR.

HERMON C. BUMPUS, Ph.D., Sc.D.

DEPARTMENT OF PUBLIC INSTRUCTION.

Prof. ALBERT S. BICKMORE, B.S., Ph.D., LL.D., Curator Emeritus.
GEORGE H. SHERWOOD, A.B., A.M., Curator.

DEPARTMENT OF GEOLOGY AND INVERTEBRATE PALÆONTOLOGY.

Prof. R. P. WHITFIELD, A.M., Curator.
EDMUND OTIS HOVEY, A.B., Ph.D., Associate Curator.

DEPARTMENT OF MAMMALOGY AND ORNITHOLOGY.

Prof. J. A. ALLEN, Ph.D., Curator.
FRANK M. CHAPMAN, Curator of Ornithology.
ROY C. ANDREWS, A.B., Assistant in Mammalogy.
W. DE W. MILLER, Assistant in Ornithology.

DEPARTMENT OF VERTEBRATE PALÆONTOLOGY.

Prof. HENRY FAIRFIELD OSBORN, A.B., Sc.D., LL.D., D.Sc., Curator.
W. D. MATTHEW, Ph.B., A.B., A.M., Ph.D., Associate Curator.
WALTER GRANGER, Assistant.
BARNUM BROWN, A.B., Assistant.

DEPARTMENT OF ANTHROPOLOGY.

CLARK WISSLER, A.B., A.M., Ph.D., Curator.
HARLAN I. SMITH, Assistant Curator.
ROBERT H. LOWIE, A.B., Ph.D., Assistant Curator.
CHARLES W. MEAD, Assistant.
Prof. MARSHALL H. SAVILLE, Honorary Curator of Mexican Archæology.

DEPARTMENT OF MINERALOGY.

L. P. GRATACAP, Ph.B., A.B., A.M., Curator.
GEORGE F. KUNZ, A.M., Ph.D., Honorary Curator of Gems.

DEPARTMENT OF BOOKS AND PUBLICATIONS.

Prof. RALPH W. TOWER, A.B., A.M., Ph.D., Curator.

DEPARTMENT OF INVERTEBRATE ZOÖLOGY.

Prof. HENRY E. CRAMPTON, A.B., Ph.D., Curator.
ROY W. MINER, A.B., Assistant Curator.
FRANK E. LUTZ, A.B., Ph.D., Assistant Curator.
L. P. GRATACAP, Ph.B., A.B., A.M., Curator of Mollusca.
WILLIAM BEUTENMÜLLER, Associate Curator of Lepidoptera.
Prof. WILLIAM MORTON WHEELER, Ph.D., Honorary Curator of Social Insects.
ALEXANDER PETRUNKEVITCH, Ph.D., Honorary Curator of Arachnida.
Prof. AARON L. TREADWELL, B.S., M.S., Ph.D., Honorary Curator of Annulata.

DEPARTMENT OF PHYSIOLOGY.

Prof. RALPH W. TOWER, A.B., A.M., Ph.D., Curator.

DEPARTMENT OF MAPS AND CHARTS.

A. WOODWARD, Ph.D., Curator.

DEPARTMENT OF ICHTHYOLOGY AND HERPETOLOGY.

Prof. BASHFORD DEAN, A.B., A.M., Ph.D., Curator of Fishes and Reptiles
LOUIS HUSSAKOF, B.S., Ph.D., Assistant Curator of Fossil Fishes.

THE ORDERS OF MAMMALS

BY

WILLIAM K. GREGORY

PART I.—TYPICAL STAGES IN THE HISTORY OF THE
ORDINAL CLASSIFICATION OF MAMMALS.

PART II.—GENETIC RELATIONS OF THE MAMMALIAN
ORDERS: WITH A DISCUSSION OF THE ORIGIN
OF THE MAMMALIA AND OF THE PROBLEM OF
THE AUDITORY OSSICLES.

PREFACE.

In 1904 Professor Henry Fairfield Osborn requested his assistant, the present writer, to prepare a brief outline of the history of the ordinal classification of the mammals for use in the Columbia University course on the Evolution of the Mammalia. The preliminary sketch having raised so many interesting problems relating to important principles, Professor Osborn suggested the continuation of the work and very generously assumed the chief expense of the investigation. Part II, dealing with the genetic relations of the mammalian orders, was begun in 1907 and has been carried on through the generosity of Professor Osborn and of Charles Gregory, Esq., to whom the author's cordial acknowledgments are hereby tendered.

Part I of the present work is offered not as an exhaustive history of the subject but as a series of stages in the history of the ordinal classification of the mammals, *i. e.*, as an outline with sufficient details to make clear the more important steps.

The main interest of the writer has been centered, however, not so much upon the history as upon the actual problem of ordinal classification, which involves the theme discussed in Part II, namely, the evolution and genetic interrelations of the mammalian orders. This problem in its manifold aspects has long engaged the attention of the writer, especially in connection with his duties as assistant and lecturer in the above mentioned university course on recent and fossil mammals conducted by Professor Osborn. It also continually recurs at the American Museum of Natural History, where during the last decade the writer has had the privilege of working in the midst of a wonderful collection of fossil vertebrates and of assisting the curator, Professor Osborn, in the monographic revision of the Titanotheres, in the work on the 'Evolution of the Mammalian Molar Teeth' and in many minor studies. The preparation, for the Osborn Library of Vertebrate Palæontology in the same Museum, of a subject-index including some thousands of titles bearing on phylogeny, led into the literature of the subject; while many stimulating discussions with Dr. W. D. Matthew, as well as frequent reference to his numerous palæontological contributions, have placed the writer under the most lasting obligation. Observations relating to the present work were also made in various other museums, especially the British Museum (Natural History), the Field Museum of Natural History, and the United States National Museum, where the officials extended every courtesy.

Realizing that phylogenetic speculation has often been rendered nugatory by faulty reasoning even more than by insufficient material, the writer,

at the suggestion of Professor F. J. E. Woodbridge of Columbia University, devoted attention to a study of Descartes and to the principles of the inductive process, and also had the pleasure of acquiring from Professor Woodbridge's lectures a certain point of view regarding the nature of evolution which has been of much service in the following studies. The author's ideas about ordinal classification were developed partly as a by-product of studies in ichthyology under his honored friend and instructor Professor Bashford Dean, who for many years past has most heartily aided him in manifold ways. The resulting arrangement of the Teleostomous fishes,¹ which was developed from the widely divergent systems of the leading authorities, led to a general conception of the history, methods and limitations of ordinal and superordinal classification which has been applied to some extent in the present work.

To Professor Max Weber's epoch-making work 'Die Säugetiere' (1904) reference is constantly made in the following pages; and to that work more than any other will be due a synthetic view of the Mammalia, in which the data of systematic mammalogy, of comparative anatomy, and embryology shall ultimately be integrated with the data of palæontology, to the great advantage of each of these now more or less independent lines of study.

The long series of publications by Professor Osborn naturally enters very frequently into the consideration of the problems touched upon below. The fruitful ideas of general and local adaptive radiation, of parallel, divergent, and convergent evolution, of homology, homoplasy, and rectigradations, of polyphyletic evolution, etc., which have gained widespread acceptance, have been of constant service to the writer, and the same is true of that author's work on Tertiary mammal horizons, on the evolution of the teeth, on the foot structure of Ungulates, and on the phylogeny of the titanotheres, rhinoceroses, horses, amblypods, etc.

It is also pleasant to acknowledge indebtedness to several other friends for favors extended during the preparation of this work: to Dr. T. S. Palmer, author of the 'Index Generum Mammalium,' for reading the first rough draught of Part I and offering many very helpful criticisms and suggestions; to Dr. Theodore Gill for assistance in finding certain works and for his numerous published contributions to the history of zoölogy; to Charles Gregory, Esq., for the gift of the valuable work of Perrault (1731) described on pages 39, 40; to Mr. C. Forster Cooper, M. A., of Trinity College, Cambridge, for very kindly reading the manuscript of Part II with great care and making many helpful criticisms; finally to Dr. J. A. Allen, the honored editor of the *Bulletin and Memoirs of the American Museum of Natural History*.

¹ Ann. N. Y. Acad. Sci., XVII, 1907, pp. 437-508.

PART I.

TYPICAL STAGES IN THE HISTORY OF THE ORDINAL CLASSIFICATION OF MAMMALS.

CONTENTS.

	PAGE
Preface	3
Part I. Typical Stages in the History of the Ordinal Classification of the Mammals	5
I. The Prescientific Period	6
Two examples of early classifications	7
II. The Græco-Scholastic Period	9
1. The Aristotelian Epoch	9
2. The Scholastic Epoch	12
III. The Modern Period	13
1. The Renaissance Epoch	13
Conrad Gesner, work of 1551-58	14
Wotton, work of 1552	14
Cæsalpinus, work of 1583	15
2. The Raian Epoch	16
Ray, work of 1693	17
3. The Linnæan Epoch	23
Linnæus, early editions of the 'Systema Naturæ' (1735-1748)	23
Klein, work of 1751	24
Linnæus, the 10th and 12th editions of the 'Systema Naturæ' (1758, 1766)	27
Scopoli, work of 1777	36
Erxleben, work of 1777	37
4. The pre-Cuvierian Epoch	38
Perrault, work of 1731	39
Buffon and Daubenton, work of 1753-1767	40
Brisson, work of 1756 and 1762	41
Blumenbach, work of 1779	43
Storr, work of 1780	46
Pennant, work of 1781	50
Boddaërt, work of 1784	52
Blumenbach, work of 1791	52
Vicq d'Azyr, work of 1792	53
5. The Epoch of Cuvier and deBlainville	55
É. Geoffroy Saint Hilaire and G. Cuvier, work of 1795	56

	PAGE
G. Cuvier, work of 1798	59
Lacépède, work of 1799	60
G. Cuvier, work of 1800	63
Cuvier as the Founder of Vertebrate Palæontology, 1796-1836	67
Duméril, work of 1806	67
Illiger, work of 1811	68
The "Philosophical Zoölogists," circa 1783-1847	71
De Blainville, work of 1816	74
G. Cuvier, work of 1817	78
Gray, work of 1821, 1843 etc.	81
Blumenbach, work of 1830	81
De Blainville, work of 1834	82
Bonaparte, work of 1837	84
De Blainville, work of 1839-1864	85
Wagner, work of 1855	86
6. The Epoch of Darwin and Huxley	87
General progress of the ordinal classification of the Mammalia since 1859	88
Owen, work of 1868	89
Gill, work of 1870, 1872	91
Huxley, work of 1872	93
Huxley, work of 1880	94
Flower, work of 1883	96
Cope, work of 1891, 1898	98
Weber, work of 1904	99
Addenda	102
Appendix A. Diagram illustrating the History and Multiple Ancestry of Modern Mammalogy	103
Appendix B. Tabular analysis of the present content of Mammalogy	104

I. THE PRESCIENTIFIC PERIOD.

Synopsis.

During this period knowledge of animals was incidental or solely of the practical order, they being regarded from the following viewpoints:

As objects of the chase (cf. much of Palæolithic art and of primitive art generally), or

As flocks and herds or beasts of burden or guardians of property or pets (cf., much art and literature of all nations).

In connection with religion:

a. In fetishism and totemism.

b. In zoötheism (cf. certain palæolithic and neolithic art, much Assyrian and Egyptian art, Egyptian interest in and care of animals, mummification, etc.).

- c. In haruspication and other divinatory and sacrificial practices.
- d. As clean or unclean according to the Levitical law (*infra*).

In connection with the healing art.

As material for the Roman circus and its modern descendants (cf. Pliny's accounts).

As forming a part of the products of newly discovered countries.

TWO EXAMPLES OF EARLY CLASSIFICATIONS.

From the point of view of classification the most important step taken in the prescientific period is the listing and arrangement of the names of animals in a systematic manner. Examples are: (1) the classification of mammals under the category of technical cleanness or uncleanness given in Leviticus, XI (see below); (2) the "classification" of animals given in certain cuneiform inscriptions from the library of Assurbanapal (see below).

A. Levitical Classification of Animals (Leviticus, XI).

"1. And the Lord spake unto Moses and to Aaron, saying unto them,

"2. Speak unto the children of Israel, saying, These *are* the beasts which ye shall eat among all the beasts that *are* on the earth.

"3. Whatsoever parteth the hoof, and is cloven footed, *and* cheweth the cud among the beasts, that shall ye eat.

"4. Nevertheless these shall ye not eat, of them that chew the cud, or of them that divide the hoof: *as* the camel, because he cheweth the cud, but divideth not the hoof; he *is* unclean unto you.

"5. And the coney, because he cheweth the cud, but divideth not the hoof; he *is* unclean unto you.

"6. And the hare, because he cheweth the cud, but divideth not the hoof; he *is* unclean unto you.

"7. And the swine, though he divideth the hoof, and be cloven footed, yet he cheweth not the cud; he *is* unclean to you. . . .

"9. These shall ye eat, of all that *are* in the waters: whatsoever hath fins and scales in the waters, in the seas, and in the rivers, them shall ye eat.

"10. And all that have not fins and scales in the seas, and in the rivers, of all that move in the waters, and of any living thing which *is* in the waters, they *shall* be an abomination unto you. . . .

"13. And these *are they* which ye shall have in abomination among the fowls; they shall not be eaten, they *are* an abomination; the eagle, and the ossifrage, and the ospray.

"14. And the vulture, and the kite after his kind;

"15. Every raven after his kind;

"16. And the owl, and the night hawk, and the cuckow, and the hawk after his kind,

"17. And the little owl, and the cormorant, and the great owl,

- "18. And the swan, and the pelican, and the gier-eagle,
 "19. And the stork, the heron after her kind, and the lapwing, and the bat.
 "20. All fowls [? flying creatures] that creep, going upon *all four*, *shall be* an abomination unto you.
 "21. Yet these ye may eat, of every flying creeping thing that goeth upon *all four*, which have legs above their feet, to leap withal upon the earth;
 "22. *Even* these of them ye may eat; the locust after his kind, and the bald locust after his kind, and the beetle after his kind, and the grasshopper after his kind.
 "23. But all *other* flying creeping things, which have four feet, *shall be* an abomination unto you.
 "27. And whatsoever goeth upon his paws, among all manner of beasts that go on *all four*, those *are* unclean unto you.
 "29. These also *shall be* unclean unto you among the creeping things that creep upon the earth; the weasel, and the mouse, and the tortoise after his kind,
 "30. And the ferret, and the chameleon, and the lizard, and the snail, and the mole.
 "46. This is the law of the beasts, and of the fowl, and of every living creature that moveth in the waters, and of every creature that creepeth upon the earth;
 "47. To make a difference between the unclean and the clean, and between the beast that may be eaten and the beast that may not be eaten."

B. Assyrian Natural History.

Joachim Menant, 'Découvertes assyriennes. La Bibliothèque du Palais de Ninive,' Paris 1880. Quoted in Henry Smith Williams, 'The Historian's History of the World,' Vol. I, 1904, pp. 567-568.

"The exact sciences were cultivated in Assyria from the earliest times; nor had natural sciences been neglected. Zoology, botany and mineralogy are largely represented in the library of Nineveh, and as all these tablets contain a Sumerian as well as the equivalent Assyrian text, we are justified in believing that the Ninevites, in this respect, still followed the traditions of their predecessors.

"We find lists of animals arranged in a certain order which indicates an attempt at classification; thus the dog, lion and wolf are in the same category, whilst the ox, sheep and goat form another. In the enumeration of the different animals, there is a very evident design of establishing genera and families, and of distinguishing species. Thus we have a family comprising the great Carnivora; the dog, lion and wolf; then we have different species in the dog family, such as the dog itself, the domestic dog, the coursing dog, the small dog, the dog of Elam, etc. The scientific side of this classification is revealed by an easily recognized circumstance; thus one finds after the common name a special nomenclature, which belongs to a scientific classification with which the Assyrians seem to have been familiar.

"Among the birds similar attempts at classification are evident. Birds of rapid flight, sea birds, or marsh birds are differentiated. Insects form a very numerous class; we see an entire family whose species are differentiated according as they attack plants, animals, clothing, or wood. Vegetables seem to be classified according to their usefulness, or the service that industry can make of them. One tablet enumerates the uses to which wood can be put, according to its adaptability, for the timber work of palaces, the construction of vessels, the making of carts, implements of

husbandry, or even furniture. Minerals occupy a long series in these tablets. They are classed according to their qualities, gold and silver forming a division apart; precious stones form still another, but there is nothing to indicate on what basis a classification would be established."

Thus all the materials for a Ninevite 'Systema Naturæ' existed before the time of Asshurbanapal (*circa* 668 B. C.).

II. THE GRÆCO-SCHOLASTIC PERIOD.

Synopsis.

Knowledge recognized for its own sake.

Development of the methods and terminology of philosophy and logic.

Cosmical speculations.

Development of the idea of causation.

1. The Aristotelian Epoch.

Compilation of zoölogical lore.

First hand observations.

Preliminary analysis of the "parts of animals."

Application of terms afterward used in taxonomy.

Attention directed to feet and teeth, as affording distinctive characters in the study of mammals.

Recognition of the need of names to denominate natural groups.

The history of the classification of animals may be said to begin with Aristotle (B. C. 384-322), who summarized all that had been observed by the Greeks and added thereto many new observations of his own.

Aristotle, being the fountain head of the scholastic philosophy and much admired as an observer by the ancients, was acclaimed also by some of the moderns (*e. g.*, Macceley) as not only a great naturalist but also a great systematist, far in advance of his own age and even, in some respects, of Linnæus.

These claims were critically examined by Whewell (1837, Vol. III, pp. 344-352) and by Gill (1873, pp. 458-463) who showed that they were greatly exaggerated.

First as to Aristotle's general status as a naturalist. "Careful and repeated perusal of Aristotle's biological treatises," says Gill (*op. cit.*, pp. 462, 463), "have, in fact, failed to convey to the writer any impression save that he was a tolerably good observer and compiler, and surpassed ordinary men, perhaps, in ability to embody in words the results of his observations

of various disconnected facts. There is, however, no coördination of the facts observed, no valuation, and no subordination which would entitle his observations to be considered as a body of scientific facts or doctrines. The materials for science exist indeed, but in a very crude and imperfect condition." He distinguished homology from analogy in the abstract, but frequently confused them in the concrete. He also adopted current erroneous views, such for example as that all animals except the elephant differ from man in the contrary flexures of the limbs, that the lion has no vertebræ but only one bone in the neck (Gill, *op. cit.*, p. 461).

As to his supposed preëminence as a systematist Gill concludes (*op. cit.*, p. 461) that he had very little appreciation of groups. "It requires no penetrating acumen," says Gill, "to recognize man, the monkeys, the bats, the typical ruminants and the typical cetaceans as distinct forms existent in nature. But such are fair examples of the groups, for the appreciation of which Aristotle has been so highly lauded,—groups which from their very nature in their integrity first appeal to the senses, and which only minute analysis enables the observer subsequently to differentiate into ultimate constituents." And again (*op. cit.*, p. 462): "In fine, there is, so far as I can perceive, not the slightest evidence of any recognition of what is now understood by classification in any of the extant treatises of Aristotle on animals, and the systems framed to embody his generalizations have been constructed from isolated sentences wrested from their context and simply reflect the framer's notions or his ideas as to what Aristotle might have supposed."

Whewell also concludes (*op. cit.*, pp. 346, 348, 350) that Aristotle was quite unconscious of the classification that has been ascribed to him, the very idea of which did not develop until many centuries later. But that Aristotle did recognize some natural groups and felt the lack of generic names to denominate others is shown in the following passage from Aristotle's work 'On Animals' quoted among others by Whewell (*op. cit.*, p. 351):

"Of the class of viviparous quadrupeds, there are many genera,¹ but these again are without names, except specific names, such as man, lion, stag, horse, dog, and the like. Yet there is a genus of animals that have manes, as the horse, the ass, the *oreus*, the *ginnus*, the *innus*, and the animal which in Syria is called *heminus* (mule). . . . Wherefore,' he adds, that is, because we do not possess recognised genera and generic names of this kind, 'we must take the species separately and study the nature of each'" (Bk. I, chap. vii).

"These passages," Whewell continues, "afford us sufficient ground for

¹ Γένη.

placing Aristotle at the head of those naturalists to whom the first views of the necessity of a zoological system are due" (*op. cit.*, p. 352). And again (p. 350): "Aristotle does show, as far as could be done at his time, a perception of the need of groups, and of names of groups, in the study of the animal kingdom; and thus may justly be held up as the great figure in the Prelude to the Formation of Systems which took place in the more advanced scientific times." Aristotle also perceived the principle of adaptation (see Osborn, 1894, p. 45) and his idea of a graded series of beings from polyp to man doubtless contained the germ of the theory of evolution (Osborn, *op. cit.*, p. 44).

The true relation of Aristotle as a zoölogist to Ray and Linnæus is exhibited in the following well-known citations by Whewell (*op. cit.*, p. 347) from 'The Parts of Animals.'

"Some animals are viviparous, some oviparous, some vermiparous. The viviparous are such as man, and the horse, and all those animals which have hair; and of the aquatic animals, the whale kind as the dolphin and cartilaginous fishes ¹ (Book I, Chap. v).

Of quadrupeds which have blood and are viviparous, some are (as to their extremities), many-cloven, as the hands and feet of man. For some are many-toed, as the lion, the dog, the panther; some are bifid, and have hoofs instead of nails, as the sheep, the goat, the elephant, the hippopotamus; and some have undivided feet, as the solid-hoofed animals, the horse and ass. The swine kind share both characters ² (Book II, Chap. vii).

Ray, Klein and later writers undoubtedly had this passage in mind when they used the descriptive terms "multifido," "bifido," "solidungula," "ungulata," "unguiculata," "fissipedes." Here, also, attention is directed to the feet as exhibiting characteristic differences.

In another passage Aristotle says:

"Animals have also great differences in the teeth, both when compared with each other and with man. For all quadrupeds which have blood and are viviparous, have teeth. And in the first place, some are ambidental,³ (having teeth in both jaws;) and some are not so, wanting the front teeth in the upper jaw. Some have neither front teeth nor horns, as the camel; some have tusks,⁴ as the boar, some have not. Some have serrated⁵ teeth as the lion, the panther, the dog; some have the teeth unvaried,⁶ as the horse and the ox; for the animals which vary their cutting teeth have all serrated

¹ In reference to the viviparity of certain sharks.

² An allusion to the "mule footed" swine monstrosities in which the median digits are fused, and terminate in a solid composite hoof.

³ Ἀμφόδοντα

⁵ Καρχαρόδοντα

⁴ Χαυλιόδοντα

⁶ Ἀνεπάλλακτα

teeth. No animal has both tusks and horns; nor has any animal with serrated teeth either of those weapons. The greater part have the front teeth cutting, and those within broad" (Book I, Chap. ii).

This passage evidently directed the attention of later writers to the importance of the teeth as a means of distinguishing and hence of classifying mammals, and we shall see that Wotton, Ray and, later, Linnæus, Brisson and others were quick to avail themselves of the suggestion.

2. *The Scholastic Epoch.*

Development of the instruments of thought: e. g., Neolatin, logic, the concept of genus and species, dichotomous analysis.

Reasoning largely deductive.

Compounding of myth and facts.

Compounding of science and metaphysics.

Reliance on authority and tradition, finally becoming extreme.

From the time of Aristotle and his classical successors until the rise of scholasticism in the eleventh century, Europe was too much preoccupied with world-wide displacements and readjustments of peoples and of institutions to pay particular attention to natural science; and even the Scholastic Epoch in the history of philosophy and science was chiefly occupied with the further development and systematization of the great body of religious and metaphysical doctrines.

So far as natural history is concerned, it is perhaps rather a further interregnum than an epoch, rather an era or lapse of uneventful time than a time of the slow ascension of some great illuminative idea. The anthropocentric idea dominated in natural history as the geocentric idea dominated in astronomy; hence a knowledge of the real or supposed properties of animals and particularly of plants was chiefly cultivated in connection with alchemy, magic and materia medica.

The medieval imagination, full of mysticism, eager for the uncanny and fantastic and teeming with images of ubiquitous devils, flourished on the marvelous tales of a "Sir John Maundeville," and peopled the earth with the monsters which so long survived and ramped in the *Terræ Incognitæ* of world maps. In the schools, citations from authorities were accepted in lieu of proof, and the simple zoölogy of Aristotle and the scriptures was deeply covered by the accretions of learned exegesis.

Scholasticism reached its prime as early as the thirteenth century, in the system of the illustrious St. Thomas Aquinas, the "princeps scholasticorum." Afterward, while the renaissance movement was discovering new worlds in all directions, scholasticism in general (but with some brilliant exceptions)

rapidly reached the "phylogerontic stage" of its evolution, and produced all sorts of bizarre specializations in terminology and in dialectics.

It has been said of the scholastic philosophy that it "vigorously exercised the understanding without bringing it to any conclusions." However this may be, it cannot be doubted that the very excesses of scholasticism stimulated the reactive return to experience, which gave rise incidentally to biological science. The schoolmen furthermore perpetuated and aroused interest in Aristotle's analyses, and gave currency to many methods of analysis and description. Among these we may cite, first, the dichotomous method of division, which is a forerunner of modern classifications; secondly, the logical concepts of genus and species. Especially noteworthy was the expansion of classical Latin into a highly specialized language of philosophy and science.

III. THE MODERN PERIOD.

Synopsis.

Curiosity about nature, followed by direct appeal to nature. Rapidly widening fields of discovery. Subordination of speculation to discovery.

Reasoning becoming inductive, and inductive-deductive.

Separation of science and metaphysics.

Gradual recognition of the universality of natural law.

Gradual separation of myth from fact.

Rise of the idea of the natural classification of animals.

Search for the causes of differences and resemblances between animals.

Rise of the idea of evolution.

Comparison of all the following epochs (Renaissance, Raian, Linnæan, pre-Cuvierian, Cuvierian and Darwinian) leads to the conclusion that from the point of view of the history of mammalogy they form a natural group, here called the Modern Period, which is as sharply distinguished from the preceding Græco-scholastic, as that is from the Prescientific Period.

1. The Renaissance Epoch.

Revolt against authority and direct appeal to nature initiated (e. g., in human anatomy by Vesalius).

Rapid spread of exploration and discovery.

Collection of natural history specimens.

Development of botany:

- (a) Compilations by the earlier herbalists;
- (b) Formation of herbaria and private horticultural gardens;
- (c) Idea of classifying plants into groups and sub-groups after analogy with the brigades of an army. Cæsalpinus.

Compilation of natural history lore.

Beginning of the separation of myth from fact. Gesner, Aldrovandus.

CONRAD GESNER, 1551-1558.

Biological science, and especially zoölogy, did not respond fully to the impulse of the renaissance movement until literature, politics, astronomy and geographical discovery had made the most signal advances. Hence in Conrad Gesner's 'Historia Animalium' (1551-1558) the myths of the middle ages still linger, although a beginning is made in endeavoring to separate truth from error, while the systematic work of future generations is initiated in extensive illustrated descriptions of animals. Gesner (1516-1565) had so far broken away from the scholastic spirit that he did not fail to observe for himself, but he was essentially a compiler and was true to scholastic traditions in relying too much on authority. Of Gesner's learning and ability the late Professor W. K. Brooks (1895, pp. 49-59) conceived a high opinion. Brooks says that in the preparation of the 'Historia Animalium' Gesner "read nearly two hundred and fifty authors," and that his literary learning was almost unparalleled, that he tried successfully to make his work a complete library of all that had been observed and written about animals up to that time, and that his enormous mass of material was very judiciously selected. Many of his illustrations were grotesque, but those of the more familiar animals were of high merit. He recognized the classes of viviparous quadrupeds, oviparous quadrupeds, birds, aquatic animals, serpents and insects. He did not attempt a natural division of the viviparous quadrupeds.

Gesner was thus a describer and compiler rather than a taxonomist; nevertheless in the field of botany he was one of the first to group species into genera (Whewell) and his 'Historia Animalium,' with the similar work of Aldrovandus, furnished the raw material for later naturalists.

WOTTON, 1552.

'De Differentiis Animalium,' Paris.

Of this author's work, which has not been accessible to the present writer, Dr. E. Ray Lankester (1890, pp. 313-315) speaks as follows:

"The real dawn of Zoology after the legendary period of the Middle Ages

is connected with the name of an Englishman, Wotton, born at Oxford in 1492; who practised as a physician in London and died in 1555. . . . In many respects Wotton was simply an exponent of Aristotle, . . . It was Wotton's merit that he rejected the legendary and fantastic accretions [of the Middle Ages], and returned to Aristotle and the observation of nature. . . . Wotton divides the viviparous quadrupeds into the many-toed, double hoofed, and single-hoofed. By the introduction of a method of classification which was due to the superficial Pliny,— viz. one depending, not on structure, but on the medium inhabited by an animal, whether earth, air, or water,— Wotton is led to associate Fishes and Whales as aquatic animals. But this is only a momentary lapse, for he broadly distinguishes the two kinds."

CÆSALPINUS, 1583.

In considering the early history of the classification of mammals one would gain a very imperfect idea of the true sequence of thought if he were to leave out of account entirely the influence of the progress of other branches of zoölogy and indeed of natural philosophy. Whewell in his 'History of the Inductive Sciences' has demonstrated the general interdependence and the progressive advance and mutual aid rendered by these various sciences, especially the development of the idea of classification, which first attained modern form in the science of botany, in the works of Gesner and Cæsalpinus of Arezzo. But an important preliminary step was the casting off of the shackles of scholasticism, of the age-long habit of appealing to books, not nature, and this had been taken, for botany, by several botanists of the early sixteenth century. After this, Whewell continues (1837, pp. 277-279): "The perception that there is some connexion among the species of plants, was the first essential step; the detection of different marks and characters which should give, on the one hand, limited groups, and on the other comprehensive divisions, were other highly important parts of this advance. To point out every successive movement in this progress would be a task of extreme difficulty, but we may note, as the most prominent portions of it, the establishment of the groups which immediately include species, that is the *formation of genera*; and the invention of a method which should distribute into consistent and distinct divisions the whole vegetable kingdom, that is the *construction of a system*." Whewell also says that although it is difficult to state "to what botanist is due the establishment of genera; yet we may justly assign the greater part of the merit of this invention, as is usually done, to Conrad Gesner of Zurich."

The first *construction of a system* in Botany, says Whewell (*op. cit.*, Vol. III, p. 280), is due wholly to Andreas Cæsalpinus of Arezzo, "one of the

most philosophical men of his time, profoundly skilled in the Aristotelian lore which was then esteemed, yet gifted with courage and sagacity which enabled him to weigh the value of the Peripatetic doctrines, to reject what seemed error, and to look onwards to a better philosophy. . . . His book, entitled '*De Plantis*,' libri xvi appeared at Florence in 1583. . . . After speaking of the splendid multiplicity of the productions of nature, the confusion which had hitherto prevailed among writers on plants, the growing treasures of the botanical world; he adds, 'In this immense multitude of plants, I see that want which is most felt in any other unordered crowd: if such an assemblage be not arranged into brigades like an army, all must be tumult and fluctuation.'" His classification was founded upon the number, the position and the figure of the reproductive parts of plants. He divided plants into ten great classes, which were again subdivided. To these assemblages he gave *monomial names in substantive form*.

A reason for this precocious development of the classification of plants may lie in the very multiplicity of kinds and in the existence of large herbaria and horticultural gardens which would assist the eager student to recognize related series. In contrast with this is the delayed progress of the classification of the mammals, due to the comparative fewness of known forms and the greater complexity of organization.

Cæsalpinus thus anticipates Linnæus in the construction of a system and in the use of monomial names instead of descriptive phrases for the "natural" orders.

2. The Raian Epoch.

Ray the father of modern systematic zoölogy.

Recognition of the warm-blooded, viviparous, hairy quadrupeds, as a class very distinct from the cold-blooded, oviparous and scaly quadrupeds.

Recognition of the Cetacea, as aquatic relatives of the viviparous quadrupeds.

Summary and analysis of characters of mammals, especially those described by Marggrav, Seba, and other travelers in America.

Brief descriptions of genera and species.

Adoption of the traditional criteria of ordinal classification of the mammals, i. e., characters of the extremities (whether hoofed or clawed, divided or undivided), number of the digits, number of the front teeth.

Adoption of many systematic phrases and names used by later authors.

Use of the descriptive phrase, as well as of monomial names.

Dichotomous classification of mammals.

RAY, 1693.

'Synopsis Methodica Animalium Quadrupedum et Serpentine Generis.'

In John Ray (1627-1705) the country and century of Sir Isaac Newton produced another natural philosopher of the highest rank.

Nearly ninety years after the appearance of Ray's 'Synopsis' his countryman and successor Thomas Pennant, author of the 'History of Quadrupeds' (1781), speaks appreciatively of Ray as follows: "...living at a period when the study of Natural History was but beginning to dawn in these Kingdoms, and when our contracted Commerce deprived him of many lights we now enjoy, he was obliged to content himself with giving descriptions of the few Animals brought over here and collecting the rest of his materials from other Writers. Yet so correct was his genius that we view a systematic arrangement arise even from the Chaos of *Aldrovandi* and *Gesner*. Under his hand the indigested matter of those able and copious Writers assumes a new form, and the whole is made clear and perspicuous" (*op. cit.*, pp. i-ii).

This indeed was one of Ray's chief services to mammalogy, that out of a "Chaos of indigested material" he brought a reasonable systematic arrangement, a real basis for the taxonomic work of the succeeding century.

These admirable results, which we shall examine in detail below, were not attained until after long previous training in other fields of taxonomy. In this case, as in so many others among early naturalists, we see the felicitous application to zoölogy of the training gained in systematic botany. For in 1670 appeared the 'Catalogus Plantarum Angliæ,' in 1682 the 'Methodus Plantarum Nova,' in 1686-1704 the 'Historia Plantarum,' while in the meanwhile, in coöperation with his friend Francis Willughby, Ray published the 'Ornithologia' (1676) and the 'Historia Piscium' (1686).

In all these works the species is recognized as the practical unit of taxonomy and in the 'Historia Piscium' for example, not less than 420 species (according to Günther) are carefully and concisely described.

Ray's conception of "species" however does not appear to be entirely identical with the modern usage. He often used words merely as the equivalent of the middle English "spece," which survives in our word "spice," and meant "kind": it was also equivalent to the logical "species" (*cf.* the Greek *εἶδος*) of the schoolmen, and is exemplified in the "Historia Piscium" in such phrases as "*clarias niloticus Belonii mustelæ fluviatilis species*," "*bagre piscis barbati ac aculeati species*." Ray also used the term "species" in a quite Linnæan manner, as in the names *Ovis laticauda*, *Ovis strepsiceros* and *Ovis domestica*. In form, at least, this foreshadows

the binomial system of nomenclature and the recognition of the species in general as a supposedly objective reality and the unit of classification. The form of Ray's specific definitions seems, however, to imply that the term "species" in Ray's mind was often more a "differentia," or specific adjective modifying the generic concept than a fully developed substantive name, and Ray evidently did not realize the convenience of applying the binomial method of nomenclature universally.

The culmination of Ray's studies on animals was the 'Synopsis Methodica Animalium Quadrupedum et Serpentine Generis', published in 1693, a brief work as the word "Synopsis" implies, but one of the great landmarks in the history of Vertebrate Zoölogy.

The scope of this work may be indicated by reprinting the 'Animalium Tabula generalis' (*op. cit.*, p. 53) and the 'Animalium Viviparorum Quadrupedum Tabula' (*op. cit.*, pp. 60-61).

Animalium Tabula generalis.

Animalia sunt vel

- { *Sanguinea*, éaque vel
 - { *Pulmone respirantia*, corde ventriculis prædito,
 - { *Duobus*
 - { *Vivipara*
 - { *Aquatica*; Cetaceum genus
 - { *Terrestria*, Quadrupedia, vel ut *Manati* etiam complectamur, pilosa. Animalia hujus generis amphibia terrestribus annumeramus.
 - { *Ovipara* Aves.
 - { *Unico*, Quadrupedia vivipara [?] & Serpentes.
 - { *Branchiis respirantia*, Pisces sanguinei præter Cetaceos omnes.
- { *Ezanguia*.

Animalium Viviparorum Quadrupedum Tabula.

Animalia Vivipara pilosa seu Quadrupeda sunt, vel

- { *Ungulata*, éaque vel
 - { *Μονόχηλα*, i. e. *Solidipeda*, Equus, Asinus, Zebra.
 - { *Δίχηλα*, i. e. *Bisulca* seu ungulâ bifidâ, quæ vel
 - { *Ruminantia*, *Μηρυχάζοντα*, cornibus
 - { *Perpetuis*, quorum tria sunt genera
 - 1. *Bovinum*.
 - 2. *Ovinum*.
 - 3. *Caprinum*.
 - { *Deciduis*, *Cervinum* genus.
 - { *Non ruminantia*, Genus *Porcinum*.
 - { *Τετράχηλα* seu *Quadrissulca*, *Rhinoceros*, *Hippopotamus* etc.
- { *Unguiculata*, quæ pede sunt vel
 - { *Bifido*, duobus duntaxat unguibus donato, *Camelinum* genus.
 - { *Multifido*, *πολυχιδῆς*, quæ vel sunt

¹ Apparently this is a typographical error, or at most a *lapsus calami*, for "ovipara," compare *op. cit.*, page 51, where the reptiles are described thus: "Cor unico ventriculo instructum habent Quadrupedia Ovipara & Serpentinum genus."

- { *Digilis indivisis*, sibi invicem cohærentibus & communi cute tectis, eorum tantum extremis in margine pedis extantibus, & unguibus obtusis munitis;
Elephas.
Digilis aliquodque separatis & à se invicem divisis, quæ vel
 { Πλατυνυχία & Ἀνθρωπόμορφα, *Simiæ*.
 { *Unguibus angustioribus*, *Dentibus primoribus* seu *incisoribus* in utraque maxilla, vel
 { *Pluribus*, Hæc autem omnia vel *carnivora* & *rapacia* sunt, vel saltem *insectivora*, aut victu promiscuo ex *Insectis* & *Vegetabilibus*.
 { *Majora*, *rostro*
 { { *Brevi*, capite rotundiore *Felinum* genus.
 { { *Productiore*, Genus *Caninum*.
 { *Minora*, corpore longo gracili, *cruribus brevibus*, *Vermineum* genus, seu *Mustelinum*.
 { *Binis insignioribus*, cujus generis species omnes *phytivoræ* sunt, *Leporinum* genus.

E Quadrupedibus viviparis pede multifido anomala sunt *Echinus terrestris*, *Tatou sive Armadillo*, *Talpa*, *Mus araneus*, *Tamandua*, *Vespertilio* & *Ai sive Ignavus*. Priora quinque *rostro productiore* cum genera *Canino* aut *vermineo* conveniunt, dentium forma & dispositione ab iisdem differunt; imò *Tamandua* dentibus omnino caret. Posteriora duo *rostro* sunt breviora.

As regards both methods and results these tables deserve careful consideration.

As regards methods, we note first Ray's debt to the Greeks and the schoolmen, especially in the use of the dichotomous method of analysis. The essence of dichotomy ("A is B or not B") is antithesis, which is especially noticeable in Ray's work. The obvious advantage of such dichotomous tables as these is that they bring out both resemblances and differences with equal clearness. If judiciously constructed they display to any desired extent the characters of natural groups. When read vertically they are diagnostic, analytical, exclusive; read horizontally or rather obliquely from right to left they are synthetic, inclusive, bracketing groups within groups; read the other way, *i. e.* obliquely from left to right they fully describe and define each final subdivision. They are at once tables of classification, descriptions, diagnoses, and keys. In so far as Greek and scholastic logic emphasized this principle and made use of the 'Tree of Porphyry' (as the dichotomous tables were called) it may be said to have prepared the way for Ray's analyses and thus indirectly for all the zoological classifications which came afterward.

As regards both form and matter Ray was indebted to Aristotle and especially to Wotton (see above, p. 15). Ray developed Wotton's observations and followed his hints as to the diagnostic value of both teeth and feet. He also used some of Aristotle's terms in his tabular analysis, *e. g.*, "mono-

chela" and "dichela." Ray's terms are noteworthy because they present various stages in the evolution of systematic names. First we find long descriptive phrases such as "*animalia vivipara pilosa quadrupeda ungulata*"; secondly shorter phrases, *e. g.*, "*digitis indivisis*," "*pede multifido*," "*capite rotundiore*"; thirdly, single adjectives, "*ungulata*," "*solidipeda*," "*ruminantia*," "*bisulca*," "*anthropomorpha*," etc.; fourthly, true nouns; "*Simiæ*," "*Cetaceum genus*." The lack of true nouns to denominate natural groups had already been noted by Aristotle (p. 11), and Ray and even later writers seem to distinguish between adjectives used in a denominative or representative sense (*e. g.*, "*Ruminantia*") and true generic substantive names ("*Simiæ*"). Many of these adjectives, *e. g.* "*ungulata*," "*unguiculata*," "*solidipeda*," "*bisulca*," "*ruminantia*," "*non-ruminantia*," "*anthropomorpha*," "*simiæ*," "*carnivora*," "*insectivora*," "*verminei*" and "*cetacei*" were used by later authors as true group names.

From the foregoing consideration of Ray's methods and nomenclature we turn to a consideration of the subject matter of the two tables given above.

In his discussion of the former Ray makes many pregnant observations (*op. cit.*, p. 54) of which the following (which are here translated) are especially noteworthy: "This division of animals seems to me perhaps the most exact of all, and most in accordance with nature. On the other hand, that common division is to be rejected [which divides animals] into: 1. Quadrupeds (or as I prefer it *Terrestrial creatures*, whereunder I include also the Snakes, which differ from the Lizards and many other oviparous quadrupeds in nothing except the lack of feet); 2. Birds. 3. Fishes; 4. Insects. This division errs in that it reduces *viviparous* and *oviparous* quadrupeds to the same genus; which differ in essential and generic attributes ["notes"] while the oviparous quadrupeds agree with the snakes.

"The division of animals according to the *locus* into Terrestrial, Aquatic, and Amphibious, may sometimes be of use, but it answers little to the nature of things and is in many ways bad; because: 1. It separates things which agree in kind. For example it separates the Whales (called Fishes), and what is worse, the Amphibious animals from the viviparous Quadrupeds; it even separates the aquatic from the terrestrial Insects, contrary to reason and to the opinion of all natural philosophers ["Physicorum"]. 2. It joins things which differ in kind. For (to pass over some) certain amphibious animals are viviparous and hairy, as the Beaver, the Otter, the Seal; others oviparous, as the Water-Newt and the Frog. And in that very kind [oviparous amphibia] we have the Lizards of which some are aquatic and amphibious (such as Crocodiles and Salamanders), others terrestrial ([true] Lizards)."

In rejecting the *locus* or medium as a prime criterion of classification

Ray was more modern in spirit than Klein, Brisson, Blumenbach, Boddaert, Storr and other writers of the succeeding century, and fully anticipated Linnæus.

Among the many excellent features of this tabular analysis of the vertebrates we note the following:

(1). The higher vertebrates are contrasted with the fishes as breathing by lungs instead of by gills.

(2). The whales are classed with the viviparous animals and expressly removed from the fishes. They are, however, set off in a grand division over against all the remaining mammals. In the '*Synopsis Methodica Piscium*' (posthumous, 1713) the Cetacea are "arranged among fishes. . . . but on this point Ray wrote expressly to Rivinus to explain that he classed them thus only in accordance with common usage" (Cuvier and Thouars, quoted in Lankester, 1846, p. 106).

(3.) As remarked by Gill, the terrestrial or quadruped mammals are bracketed with the aquatic as "*Vivipara*" and contrasted with the "*Ovipara*" or "*Aves*." "The *Vivipara* are exactly coëxtensive with *Mammalia*, but the word *vivipara* was used as an adjective and not as a noun. Linnæus did not catch up with this concept till 1758 when he advanced beyond it by recognizing the group as a class and giving it an apt name." (Gill, 1902, pp. 434-438.)

(4). The double ventricle is noted as characteristic of both *Vivipara* [Mammals] and *Ovipara* [Birds]. The single ventricle of the heart is noted as characterizing the groups now called *Amphibia* and *Reptilia*.

(5.) In order to associate the *Manati* and other amphibious mammals with their terrestrial congeners the term "*Hairy Animals*" is employed as more comprehensive than "*Quadrupeda*."

In all these features Ray anticipates Linnæus (*cf.* pp. 27, 28).

When we pass from this division of the vertebrates in general to the classification of the *Hairy Quadrupeds* (pp. 18, 19) we find the analysis no less discriminating, and it is small wonder that various modifications of Ray's system continued in vogue several decades after the appearance of Linné's more brilliant but seemingly less reasonable system.

As regards the results achieved by this analysis it is surprising to note the number of natural or quasi-natural groups that were distinguished. Among these are the "*Ungulata monochela solidipeda*" including the Horse, the Ass and the Zebra; the "*ungulata dichela*," including most of the animals now called *Artiodactyla*; the "*Unguiculata pede multifido, digitis aliquodque separatis, platyonycha et anthropomorpha*," namely the *Simiæ*. But unnatural groups and allocations are not wanting, for example the "*ungulata tetrachela*," including the *Rhinoceros*, *Hippopotamus*, *Brazilian tapir*,

capibara and musk deer, which foreshadows similar unnatural assemblages such as "Jumenta," "Belluæ," "Pachydermes" etc., of later authors. Other mistakes were the inclusion of the camel and the elephant among the ungulates, the bracketing of rodents and carnivores, etc. Among the viviparous quadrupeds with unguiculate multifold feet were a residue described as "anomala" which could not be made to fit into the dichotomous scheme. These anomalous forms, including certain Insectivores, the Bats and Edentates, were also the stumbling block of the naturalists of the succeeding century, and were variously distributed among their "Bestiæ," "Bruta," "Anomalopes," etc.

As to the criteria of classification, taking the position in the system of the Cats and Dogs as an example we have the following arranged in the order of their importance: (1) number of feet (*quadrupeda*); (2) hooved or *clawed*; (3) bifid or *multifid*; (4) with digits unseparated or *separated*; (5) flat clawed or *narrow clawed* and with incisors in each jaw; (6) incisors *several*, *habits* *carnivorous*, *insectivorous* or *omnivorous*, or incisors paired, *phytophagus*; (7) *larger* or smaller forms; (8) head *rounder* (Cats) or *longer* (Dogs).

From this we see that the characters of the feet were regarded as much more important and convenient than those of the teeth, which only appear sixth in the list.

The "good" and "bad" features of the classification (from the modern viewpoint) alike arise from the *consistent and rigid application of a single set of characters*, namely *those of the feet*, throughout the class. This is an inherent defect of the dichotomous method, that it must be consistent and logical, whereas in the narrow sense, nature is neither. The associations and disassociations of the dichotomous method must sometimes be artificial, because *it commits the classifier in advance to the selection and arrangement of characters in the order of their importance and universality*; it encourages the deductive rather than the inductive method of classification. At the same time an artificial classification is a far better augury of progress than none at all and we shall see later naturalists improving and developing Ray's system with important results.

In brief, although following the pioneer Wotton, (p. 15) Ray may justly be regarded as the founder of modern zoölogy. He was the great figure of the seventeenth century, as Linnæus was of the eighteenth and Cuvier of the early nineteenth. More logical and analytical, while perhaps less original and synthetic in his genius than Linnæus, he indeed "made a pathway in the zoological field which Linné was glad to follow, and to some extent he anticipated the brightest thoughts of the great Swede." (Gill.)

3. The Linnæan Epoch.

Synopsis.

Continuation and development of Ray's work.

Application to zoölogy of the principles gained in botany.

Binomial nomenclature.

Recognition of mammæ as a class character.

Invention of term "Mammalia" to include both the hairy quadrupeds and the Cetacea.

Recognition of man's zoölogical kinship with the Primates.

Search for a natural classification.

Attempted recognition of affinities beneath external differences.

Selection of "physiological" characters as prime criteria of classification.

LINNÆUS.

Early editions of the 'Systema Naturæ' (1735-1748).

The bold originality of Carl von Linné becomes apparent in comparing his work with that of preceding and of following authors. Even in the first edition (1735) of the 'Systema Naturæ' the classification of the hairy quadrupeds (p. 102) is already essentially "Linnæan," and it is far less artificial than many that came after it, and even than his own final classification in the tenth and twelfth editions of the same work.

The principal work dealing with the mammals from which he may have drawn suggestions as to methods was that of Ray. The subject matter of the classification was largely drawn from preceding authors, including Gesner, Aldrovandus, Johnston, Ray, the new world travelers Seba, Margrav, Catesby, and many travelers in the old world.

From such sources he drew most of his generic names, but as regards his ordinal names the majority seem to be original. They are never descriptive phrases as in Ray's works but always nouns. The terms "Feræ," "Glires," "Jumenta," "Pecora," "Agriæ," "Bestiæ," and "Bruta," meaning literally "wild beasts," "dormice," "beasts of burden," "beasts of the field," "beasts," and "brutes," illustrate Linné's frequent choice of names as arbitrary "handles for ideas" rather than for their special descriptive applicability. The dichotomous method of classification, with its difficult and often artificial subordination of groups within groups, is not attempted by Linnæus, but the orders are listed in a linear series. The character of these assemblages indicates that even at this early period he was in the habit of first

'sensing' a natural group and then finding the characters to define it afterward.

The arrangement of the orders is also significant. The "Anthropomorpha" (*Homo*, *Simia*, *Bradypus*) come first, and the name emphasizes the significant fact that *Homo* appears in the same order with his lowly relatives (see below). As in Ray's classification the Anthropomorphs are followed by the flesh-eating, insectivorous, and gnawing animals. The latter, including the forms designated by Ray as pertaining to the hare kind ("Leporinum genus"), are correctly assembled under the order Glires. The ungulate orders bring up the rear, instead of heading the list as they do in Ray. They include two orders: "Jumenta" (*Equus*, *Hippopotamus*, *Elephas*, *Sus*) and "Pecora" (*Camelus*, *Moschus*, *Cervus*, *Capra*, *Ovis*, *Bos*). The order Jumenta thus corresponds to the "Multungula" of Blumenbach (1779), the "Belluæ" of Storr (1780) and the "Pachydermes" of Cuvier (1800); the order "Pecora" includes the Ruminant Artiodactyls. The Camel is rightly allocated instead of being reckoned among the ungulate orders.

In the sixth edition of the 'Systema' (1748) (the third original edition), the mammals are defined as "Quadrupedia, corpus pilosum, pedes quatuor, feminae viviparæ, lactiferæ." The possession of mammæ is thus implied but the word "Mammalia" is not yet coined.

The order "Anthropomorpha" is defined by the "Dentes incisores IV, supra et infra, mammæ pectorales." Ray had used the number of incisor teeth to define several groups of ungulates. The order "Agriæ," including *Myrmecophaga* and *Manis*, is defined by the "Dentes nulli, lingua longissima, cylindrica." The order "Feræ" still includes not only the true carnivorous animals but also the assemblage later called Bestiæ (except *Sus*) and *Vespertilio*.

The detailed discussion of Linné's principles is more appropriately given in connection with his later classification, page 27 *et seq.*

His classification of 1735 is given below on page 102.

KLEIN, 1751.

Jacobus Theodorus Klein, 'Quadrupedum dispositio brevisque Historia Naturalis.' 8vo. Lipsiæ.

This treatise appeared later than the earlier editions of the 'Systema Naturæ' but it antedated the tenth edition of that work and is essentially pre-Linnæan in character. Klein's classification is in fact a development of that of Ray, better in some respects, retrogressive in others, as follows:

(1) By avoiding the dichotomous method of subdivision Klein, like Linnæus, escapes some of its artificial restrictions and produces a simpler

classification, based as to its main subdivisions solely on foot structure, especially the number of toes.

(2) For ordinal designations, Klein avoids descriptive phrases, such as "*Digitis aliquodque separatis*," in favor of the monomial terms "*Monochela*," "*Dichela*," etc., in substantive form.

(3) The Quadrupeds are divided into two "orders" "*Ungulata*" and "*Digitata*," or *Unguiculata*. The *Digitata* include two grand divisions, the "*Pilosa*" (*i. e.* the unguiculated mammals) and the four-footed reptiles and amphibians, a very retrogressive grouping, especially in view of Ray's clear analysis.

(4) Both the "orders" "*Ungulata*" and "*Digitata*" are divided into "*familiae*," a term implying some sort of supposed natural kinship between the comprised forms.

(5) Ray's "*Ungulata*" is improved by the addition of the "*Pentachela*" (*Elephas*) but the Camel is still left among the digitated quadrupeds.

(6) The genera pertaining to the orders now known as *Rodentia*, *Insectivora*, *Carnivora* and *Primates* are still grouped together as in Ray's scheme, the embracing "*familia*" being named "*Pentadactyla*."

(7) The sloth and tamandua, which had been left by Ray among the "*quadrupeda vivipara pede multifido anomala*," are now comprised in the "*familia Tridactyla*," which is closely followed by the "*familia Tetradactyla*," containing the armadillo and *Cavia*. Thus the *Edentates* were very early separated from other mammals and brought near together, either in one group or in adjacent orders.

(8) In segregating the amphibious mammals (representing five modern orders) into a single group "*Anomalopes*," or web-footed animals, Klein anticipates many later authors, including Storr, Blumenbach and even Cuvier, and to some extent follows the erroneous example of Pliny, Aldrovandus, Wotton and other early writers who regarded the *locus* or habitat as a prime criterion of classification, but whose error had been so well exposed by Ray (see p. 20).

(9) Klein also treated the whales (in his '*Historia Piscium Naturalis promovendæ missus secundus de Piscibus per pulmonibus spirantibus ad iustum numerum et ordinum redigendis. . . .*' 1741) as a distinct division of the fishes, "*Pisces per pulmonibus spirantibus*."

(10) The principal criteria of classification for the "*familiae*" were the number of digits; but the nature of the integument was regarded as important not only in the minor divisions, as shown in the terms "*loricatus*," "*hirsutus*," "*lævis*," "*dorso aculeato*," "*cauda pilosa*," "*cauda tereti*," and "*Acanthion*," and even in the grand divisions "*Pilosa*" and "*Depilata*."

*Quadrupedum dispositio.*¹

Ungulorum sunt familiæ quinque; Monochela, Dichela [quotes Aristotle's "Διχηλα"], Trichela, Tetrachela, Pentachela.

Digitatorum vel Unguiculorum pariter quinque: Didactyla, Tridactyla, Tetradactyla, Pentadactyla, Anomalopes.

Ordo I. Ungulata.

Fam. I. Monochelon.

Equus, Asinus.

Fam. II. Dichelon.

Taurus.

Domesticus, Ferus.

Aries.

Ovis.

Tragus.

Hircus, Ibex, Rupricapra, Gazella, Moschus, Sylvestris Grimmi, Bezoarticus, Tragelaphus, Traguli Guineensis, Giraffa.

Cervus.

Nobilis, Rangifer, Capreolus, Alce, Dama recent.

Porcus.

Vulgaris domest., Ferus, Moschiferus, Babiroussa, Guineensis.

Fam. III. Trichelon.

Rhinoceros.

Fam. IV. Tetrachelon.

Hippopotamus.

Fam. V. Pentachelon.

Elephas.

Tabula Synoptica Digitatorum.

[A] Pilosa vel quadantenus (sive sint mere coriacea, s. cataphracta). Omnia vivipara, ζωοτοκα.

Fam. I. Didactylon.

Camelus Silenus.

Fam. II. Tridactylon, constanter in anterioribus.

Ignavus, Tamandua.

Fam. III. Tetradactylon constanter in anterioribus.

Tatu (loricatus).

Cavia (hirsuta).

Lævis.

Dorso aculeato.

Fam. IV. Pentadactylon constanter in anticus.

Lepus.

Sorex.

Cauda pilosa.

Sciurus.

Glis.

Lupus.

Vulpes.

Coati.

Felis.

Catus.

¹ In the original classification the subordination of the different groups is indicated by means of brackets. The same meaning is here conveyed by "indenting."

Cauda tereti.	Lynx.
Mus.	Pardus.
Talpa.	Tigris.
Vespertilio.	Leo.
Mustela.	Ursus.
Acanthion.	Gulo.
Erinaceus.	Satyri.
Hystrix.	Simia.
Canis.	Cebus.
[Fam. V.] Anomalopes (pentadactylon) pedibus quibuscumque anserinis.	
Lutra.	Phoca.
Castor.	Manati.
Rosmarus.	
[B.] Depilata (sive tecta sive nuda nequaquam pilosa; omnia ovipara sive ωοτοκα .)	
Testudinata.	Nuda.
Cataphracta.	[Lizards].
[Crocodylus.]	["Batrachus."]

LINNÆUS, 1758, 1766.

'Systema Naturæ,' Editio decima, editio duodecima.

The progress of science during Linné's lifetime (1707-1778) is indicated by the fact that twelve editions of the 'Systema' appeared between 1735 and 1766, the book growing in the meantime from a mere brochure of twelve pages to a work of 2400 pages. (Allen, 1908, p. 13.) The whole animal kingdom as then known is listed in an orderly, systematic manner, with much philosophical analysis, clear, workable diagnoses, and a vast amount of usually correct detail.

Among Linné's lasting contributions to science we may notice first his reform of botanical and zoölogical nomenclature. This included: (1) the definition of species by short descriptive phrases; (2) the adoption of single conventional names (often the Latin equivalent of the popular or trivial names), which were at first placed in the margins alongside the specific phrases. These were introduced very tentatively at first but in the 'Species Plantarum,' 1753, and 'Museum Adolphi Friderici,' 1754, finally supplanted the more cumbersome descriptive phrases or differentia. Thus arose the modern binomial system of nomenclature.

Certain authors previous to Linnæus, notably Jacob Testut in 1635 (Underwood, 1907, p. 501) and John Ray, had used names that were binomial in form (*e. g.*, *Ovis strepsiceros* Ray, see above, p. 17) but the system never came into general use until after its development by Linnæus.

A second and most enduring claim of Linnæus upon the grateful memory of posterity arises from his recognition of the fundamental importance

of the mammæ as a class character and from his felicitous coinage of the word "mammalia"¹ as a class name for the forms characterized by Ray as "viviparous hairy animals." Thus the terrestrial hairy quadrupeds and the Cetaceans were for the first time united under a single class name. This had already been foreshadowed by Ray and by Bernard de Jussieu (*vide* I. Geoffroy, 1826, p. 66). Nevertheless, the recognition of affinity underlying obvious external differences was one of the points in which Linné often excelled, and the present instance was one of several in which he traversed "common sense" and tradition to good effect.

As Dr. Gill (1907, p. 491) has recently expressed it, "Popular prejudice was long universal and is still largely against the idea involved. Sacred writ and classical poetry were against it. It seemed quite unnatural to separate aquatic whales from the fishes which they resembled so much in form and associate them with terrestrial hairy quadrupeds. How difficult it was to accustom one's self to the idea is hard for the naturalist of the present day to appreciate. Linnæus himself was not reconciled to the idea till 1758, although Ray had more than hinted at it more than three score years before. At least, however, in no uncertain terms he promulgated it. It was a triumph of science over popular impressions; of anatomical consideration over superficial views."

The definition of the term "Mammalia" shows that Linnæus had a fairly good conception of the essential features of the class. In concise phrase he states or clearly implies (1758) that mammals have a heart with two auricles and two ventricles, with hot red blood; that the lungs breathe rhythmically; that the jaws are slung as in other vertebrates, but "covered," *i. e.*, with flesh, as opposed to the "naked" jaws of birds; that the penis is intromittent; that the females are viviparous, and secrete and give milk; that the means of perception are the tongue, nose, eyes, ears and the sense of touch; that the integument is provided with hairs, which are sparse in tropical and still fewer in aquatic mammals; that the body is supported on four feet, save in the aquatic forms, in which the hind limbs are said to be coalesced into a tail (the only erroneous idea in the whole definition).

It had evidently long been well known that the anatomy of mammals was similar in plan if not in detail to that of man; and we find Descartes, for example, in his 'Discourse on Method' (Part V., 1637) advising those who wished to understand his theory of the action of the lungs and circulatory system, "to take the trouble of getting dissected in their presence the

¹ According to Gill (1902, p. 434) the name "Mammalia" was made in analogy with well known Latin words like "animal," "capital," "feminal," and "tribunal," and the form was probably suggested by *animal* ("that which breathes"); hence "mammal," that which possesses breasts.

heart of some large animal possessed of lungs, for this is throughout sufficiently like the human [heart]" (*ital. mihi*).

It was known also that of all animals the monkey tribe are most nearly like man both externally and internally, so that they were called "Anthropomorpha" by Ray and by Linnæus (1735). Now in 1738 Linnæus made a visit in Paris where Perrault's work (see p. 39), in which the anatomy of several monkeys was clearly set forth, had appeared in 1731; and where the scientific atmosphere was favorable to radical ideas. Later, also, Linnæus may have known the work of Daubenton in Buffon's 'Histoire Naturelle.' Finally, from his botanical studies he was doubtless familiar with many cases where characters which are merely apparent in certain genera are strongly emphasized in related genera, and where the structural difference was often far greater than that between man and the apes.

Various lines of knowledge, *e. g.*, human anatomy, mammalian anatomy and taxonomy, were thus joined in Linné's receptive mind with the principles gained in botany, and produced there the remarkably fertile idea of man's true place in the animal kingdom (*cf.* p. 24 above).

At any rate Linnæus did not hesitate to follow the logical consequences of these facts, namely, that in a strictly zoological classification man would be grouped not only in the class Mammalia, but even in the same ordinal division with the monkeys. Accordingly in the first edition of the 'Systema,' 1735, mankind is listed under the "Anthropomorpha" and in the tenth edition the latter name is replaced by "Primates," and the genera *Homo*, *Simia*, *Lemur*, *Vespertilio* are grouped under that order. The Primates were thus regarded as the chiefs of the graded hierarchy of terrestrial beings, and consequently, as in nearly all subsequent schemes down to the Darwinian epoch, head the classified legions of creatures. This placing of mankind under the order Primates was surely another instance of Linné's genius in surmising the true affinities of puzzling animals. It led the way to the modern generalization that man is knit by ties of blood kinship to the Primates, and more remotely to the whole organic world.

Linné's Classification of 1758¹ and 1766².

(Arranged here in tabular form.)

MAMMALIA (1758).

UNGUICULATA (1766).

Primates.	Homo, Simia, Lemur, Vespertilio.
Bruta.	Elephas, Trichechus, Bradypus, Myrmecophaga, Manis.
Feræ.	Phoca, Canis, Felis, Viverra, Mustela, Ursus.
Bestiæ.	Sus, Dasypus, Erinaceus, Talpa, Sorex, Didelphis.
Glires.	Rhinoceros, Hystrix, Lepus, Castor, Mus, Sciurus.

¹ 'Systema Naturæ,' editio decima.

² 'Systema Naturæ' editio duodecima.

UNGULATA (1766).

Pecora. Camelus, Moschus, Cervus, Capra, Ovis, Bos.

Belluæ. Equus, Hippopotamus.

MUTICA (1766).

Cete. Monodon, Balæna, Physeter, Delphinus.

Judged by later standards this classification is on the whole less natural, although more elaborate, than Linné's earlier classification of 1735 (*cf.* p. 24). It contains only three entirely natural groups, 'Feræ,' 'Pecora' and 'Cete,' each of the remaining orders including one or more improperly allocated genera. As shown in the following table it is really an attempt to express relationship between distinct orders (as they are now accepted), an attempt that was certainly premature in Linné's time, since even now when the content of mammalogy is a hundred times greater, the interordinal connections are still either wholly unsettled or at best more a matter of probability than of demonstrated certainty. More in detail the relation of the Linnæan orders to those now recognized is as follows:

Linnæan Orders.

Modern Orders.

Primates=Primates + Dermoptera + Chiroptera.

Bruta =Proboscidea + Sirenia + Xenarthra (in part) + Pholidota.

Bestiæ =Suilline Artiodactyla (in part) + Xenarthra (in part) + Insectivora
+ Polyprotodont Marsupialia (in part).

Glires =Perissodactyla (in part) + Rodentia.

Pecora =Artiodactyla minus *Sus* and *Hippopotamus*.

Belluæ =Perissodactyla (in part) + Suilline Artiodactyla (in part).

Cete =Mystacoceti + Odontoceti.

This classification may indeed be deficient in its objective results, but its underlying principles (which will become apparent by a closer examination of the Linnæan orders and definitions) are of the greatest interest and importance in the history of mammalogy.

Order Primates. Definition: "Inferior front teeth IV, parallel, lanian teeth solitary [a single pair above and below]. Mammæ pectoral, one pair. The anterior extremities are hands. The arms separated by clavicles, the gait usually on all fours ('incessu tetrapodo volgo'). They climb trees and pluck the fruits thereof."

The association of the Bats and the Flying Lemur with this order was probably on account of: (1) the single pair of pectoral mammæ, (2) the arms separated by clavicles, (3) the arboreal frugivorous habits, (4) the position of the head on the vertebral column, (5) the hand-like nature of the wings in Bats, (6) the lemur-like head of the Fox-Bats. There is something to be said in favor of this group (if it be ranked as a superorder) even at the present time (*cf.* p. 416).

All the characters chosen as diagnostic are such as are intimately related to sustenance or to the mode of feeding and obtaining food. The first character listed in this and succeeding orders (except 'Cete') is the number of front teeth, and the next is the number of laniariform teeth, whether none, solitary, or several (in reference to the more or less caniniform premolars of *Dasytus*, *Erinaceus*, etc.). These number characters were doubtless suggested by analogous cases in botanical systems. They were also used by others, especially Brisson.

The Primates being the "chiefs" of the Mammalia, the number and character of the mammæ is especially noticed. The presence of clavicles in the "Primates" is the only distinctly osteological character used by Linnæus in any ordinal definition. The *manner of progression* is mentioned in connection with limb-structure in this and in most of the remaining orders.

Order Bruta.¹ Definition: "Front teeth none either above or below. Gait more or less awkward ('incessus ineptor')."

Linné's reasons for including the Elephant and Manatee with the Anteater, Sloth and Scaly Anteater are scarcely apparent at first glance. The Manatee and the Elephant it is true are both bulky, thick skinned, dark-colored mammals, with a single pair of mammæ, which are pectoral in position; both exhibit tender care of the young, both are peaceful herbivores, browsing upon succulent herbage by means of fleshy prolongations of the snout; both are ponderous and clumsy in their gait, the elephant on land, the manatee in the rivers; both lack front teeth and the lower jaw in the two genera presents some striking peculiarities in common. Such "physiological" resemblances were often interpreted as tokens of natural affinity by Linnæus and in this case perhaps led him to anticipate de Blainville in regarding the Manatee as an aquatic and "mutilate" relative of the Elephant; just as the Whales are aquatic and mutilate relatives of other terrestrial quadrupeds. But what special characters, if any, hold together the Manatee and the Sloth, except the lack of front teeth, an awkward gait and browsing habits? Again the Great Anteater resembles the Elephant chiefly in possessing an elongate snout, stiff and post-like legs, a clumsy gait and "no front teeth," while following the same sort of superficial criteria, the smaller Anteaters (*Tamandua*) approximate the Sloths chiefly in their arboreal habits, long claws, awkward gait and "no front teeth."

Such reasoning appears to us very naïve, and even Linné's contemporaries, Klein, Brisson, Scopoli, Blumenbach and Storr, as we shall see, rejected his more unnatural groupings, although adopting almost equally bad ones themselves. Nevertheless, even in the grotesque assemblage

¹ Lat. *brutus*, heavy unwieldily, stupid. (Century Dict.)

"Bruta," Linnæus exhibits certain of his principles which were of far-reaching importance in the history of classification. It illustrates his dictum that "the genus makes the character, not *vice-versa*," that a series of forms may have very few characters which apply throughout, but nevertheless be a natural series; an undoubted and most suggestive fact. It illustrates his reliance upon "physiological characters," especially those related to the nature of the food and to the mode of securing it. It foreshadows the idea of divergent adaptation and its concealment of natural affinities, and it illustrates his habit of searching for those hidden bonds, even below the most obvious external differences.

Order Feræ.¹ Definition: "Front teeth in both jaws: superior VI, all acute; laniariform teeth solitary. Claws on the feet acute. Sustenance by rapine, upon carcasses ravenously snatched."

This definition again illustrates Linné's reliance upon sustenance as an ordinal character. "Sustenance by rapine, upon carcasses ravenously snatched" is evidently felt to be connected with "front teeth in both jaws: superior VI, all acute," with "laniariform teeth [canines] solitary," with "claws on the feet acute." This and other passages indicate that Linnæus recognized the principles of adaptation and of the coördination of parts. In including the Seals in this order he displayed a characteristic disregard of external form.

Order Bestiæ. Definition: "Front teeth of varying number in upper and lower jaws. Laniariform teeth always more than one pair. [In reference to the piercing character of the most anterior cheek teeth as well as of the canine.] Snout elongate, rooting. Sustenance upon succulent roots or worms."

This order included the Pig, Armadillo, Hedgehog, Mole, Shrew and Opossum. The elongate snout and the character "laniariform teeth always more than one pair," were seemingly related with the "sustenance upon succulent roots or worms," and were taken as sufficient hints to the eye searching for affinities even between rather unlike animals.

Order Glires. Definition: "Front teeth, upper and lower, two. Laniariform teeth none. Feet hopping in progression. Sustenance by gnawing bark, roots, vegetables etc."

It is difficult to understand why Linnæus placed the Rhinoceros in this group of Rodents; but it may well be that even this strange procedure was due, not to carelessness, but to the fact that the Indian Rhinoceros has a single pair of close-set cutting incisors in the upper jaw, which oppose the elongate incisor-like appressed canines of the lower jaw, the whole thus

¹ *Ferus*, wild; feminine form used by analogy with *Bestiæ*?

showing a superficial approach to the Rodent dentition. If Linnæus knew that *Hyrax* (which even Cuvier at first took to be a Rodent), has cheek teeth not unlike those of *Rhinoceros indicus* he might even have felicitated himself upon his supposed astuteness in placing *Rhinoceros* with the Rodents.

Order Pecora. Definition: "Front teeth inferior, several, superior none. Feet hoofed, cloven. Sustenance by pulling up plants and chewing the cud. Divisions of the stomach 4: [1] 'ingluvies' (the paunch) for macerating and ruminating; [2] 'reticulum' [the honeycomb bag, or hood] cancellate, for receiving [the food]; [3] 'omasum' (the manyplies), many-folded, digestive; [4] 'abomasum' (the reed) banded, secreting a coagulant for the fat [rennet ferment] in order to neutralize the alkali ('ut minus alcalescant')."

The assemblage of ruminant Artiodactyls had long been recognized as a natural group. Linnæus gives in some detail, as diagnostic, the characters and functions of the compound stomach.

*Order Belluæ.*¹ Definition: "Front teeth several, obtuse. Gait heavy. Sustenance by pulling up vegetation."

The horse and the hippopotamus show certain analogical resemblances, especially in the manner of feeding (a point highly regarded by Linnæus) and in the general characters of the head and mouth; hence the more essential differences in their limbs was easily discounted by him (especially in view of the alliance of *Phoca* with the Feræ), and so we may imagine that the observation that both the horse and hippopotamus also had "dentes primores plures obtusi," not only confirmed Linnæus in uniting them, but, added to the "Incessus gravis" and the "Victus extrahendo vegetabilia" gave convenient diagnostic characters of the order.

*Order Cete.*² Definition: 'Pectoral fins in place of feet, and flat flukes instead of a tail. Claws none. Teeth gristly. Nostril usually a pipe in the forehead. Sustenance upon molluscs and fish. Habitation marine.'

"These I have judged to be separated from the Fishes and to be allied to the mammals, on account of their warm two-chambered heart, their breathing by lungs, their hollow ears, [and because] the penis enters the female, [which] exudes milk from the breasts; and so according to the decree of nature, by right and merit." *i. e.*, not through any arbitrary method of the classifier.

In other orders foot-structure is mentioned if at all after the number of front teeth; and even profound difference in the extremities (*e. g.*, between *Vespertilio* and the Primates, between *Phoca* and the terrestrial Carnivores) does not avail to separate the animals. But here in the Cetacea "*Pedum*

¹ Lat. *bellua*, properly 'belua' a beast, particularly a large beast. *Century Dict.*

² n. pl. "κῆτη uncontr. κῆτα, pl. of κῆτος, any sea-monster or large fish, particularly a whale. . . ." *Century Dict.*

loco pinnæ pectoralis" is the first character listed, and the nature of the extremities is thus taken as a prime criterion. This illustrates Linnæus's dictum that a character of slight importance in one order may become fundamental in another.

Summary of Linné's contributions to the ordinal classification of the mammalia.

Linné's debt to Ray is clearly shown in his use of the number of front teeth as an important criterion, but he progressed much beyond Ray, Klein and Brisson in the variety of characters chosen to define his orders. As we have seen, the ordinal characters include: (1) nature of the food and mode of obtaining it, generally as the dominating character; (2) the number of front teeth and of laniary teeth; (3) the nature of the extremities, whether hands (Primates), clawed feet (Feræ), hoofs (Pecora) fins (Cete); (4) the manner of progression *e. g.*, climbing trees (Primates), "more or less awkward" (Bruta), "ravenously snatching the prey" (Feræ), "hopping" (Glires), "heavy" (Belluæ); (5) the number and position of the mammæ (Primates); (6) the presence of clavicles (Primates); (7) the nature of the stomach (Pecora); (8) the nature of the teeth ("gristly" in Cete); (9) the nature of the nostril (Cete).

Linnæus must have recognized that the ordinal classification of the mammals was a difficult problem. This is shown by the conspicuous changes and redistributions which he made between the first and tenth editions of the 'Systema,' and further by the fact that his pupil Erxleben abandoned the ordinal divisions entirely and merely listed the genera *seriatim*. The difficulty of the problem is in fact indicated by the circumstance that Cuvier, with far better material and more extensive knowledge, was constantly deceived by "adaptive" (or homoplastic) resemblances, while even the late Professor Cope, who wrote much on homoplastic and convergent evolution was himself often so deceived.

Accordingly many of the characters selected for ordinal diagnoses by Linnæus and all other early writers were of the adaptive or "cænotelic" kind (p. 111) which are now known to have been most easily modifiable by changes in the environment or in internal conditions. The reason for this mistake (from which few naturalists were free even down to our own generation) was that Linnæus regarded the mode of sustenance of a group as one of its most deep-seated attributes, most surely indicative of more or less hidden affinities with other groups. Like Storr, he proceeded from the basis that "because modifications had certain evident relations to the economy of the animal, they were, therefore, and to the degree of their physiological influence, of importance in determining the affinities of those animals." (Gill,

1875, p. v.) Linnæus thus attempted to classify animals *by what they did* (cf., his employment of gait, manner of feeding, etc.), as well as by their physical characters. The whole animal with all its attributes, psychic, physiological and anatomical should be considered, he thought, in drawing up classifications. This was assuredly an ideal, which those of his successors who founded their classifications on a single character or even on a narrow range of characters, would have done well to remember.

In fine, Linné's signal contributions to the classification of mammals were as follows:

(1) He summarized existing knowledge of the mammals, transmitting and developing the excellent work of Ray and making readily available the discoveries in the New World and in the East.

(2) He further systematized the study of mammals by giving brief specific descriptions.

(3) He employed the "trivial," or common name (often invented where necessary) as a convenient substitute and representative of the full specific "differentia," placing it after the generic name in the now familiar binomial form.

(4) He consistently applied this *binomial nomenclature* throughout the animal kingdom, whereas earlier authors had only occasionally employed names that were binomial in form only.

(5) The way thereto having been prepared by Ray, Brisson and Bernard de Jussieu, Linnæus finally brought together the Cetaceans and the terrestrial hairy quadrupeds within a single class.

(6) He emphasized the possession of mammæ and the secretion of milk as a peculiarity of that class; and

(7) invented for it the apt term "Mammalia."

(8) He realized that man was structurally a member of that class and more particularly allied to the apes and monkeys; and accordingly he

(9) erected the order "Primates" to comprise man and his lowly relatives.

(10) A notable feature of Linné's classification of the mammals was the comparatively large range of characters chosen for the ordinal diagnoses.

(11) He used the number and characters of the teeth and feet only in so far as they were evidently related to other characters and to the economy of the animal.

(12) He regarded sustenance and the adaptations in habit and structure for securing and digesting food as perhaps the most important criterion of relationship.

(13) He clearly recognized the principles of adaptation and of the co-adaptation of parts.

(14) In his capacity as the "lawgiver of natural history" Linnæus anticipated Cuvier. In the exactitude and range of his contributions to mammalogy he is not, it is true, to be compared with that copious author, whose ideas withal were essentially of the "matter of fact," type. In his suggestive principles of classification Linnæus is rather the prototype of Cuvier's great contemporary de Blainville. These principles were sometimes wrong in themselves and more often wrongly applied, so as to produce even grotesque results; nevertheless a close study of Linnæus reveals, so to speak, the poet and seer: uttering profound principles, *e. g.*, that the "genus makes the character and not vice versa"; proclaiming that natural affinities may exist even beneath the most striking external differences; thereby bringing into clearer view the riddle of natural relationships.

SCOPOLI, 1777.

'Introductio ad Historium Naturalem sistens Genera Lapidum, Plantarum et Animalium.' Pragæ, 8vo.

The conservative features of this classification are as follows:

(1) In segregating the amphibious mammals in a division "Aquatilia" Scopoli adheres to the ancient error, which had been so well exposed by Ray (*cf.* p. 20), of using the *locus* as a prime criterion of classification.

(2) His classification is essentially dichotomous with the exception of the last division of the Unguiculates which is threefold.

(3) He designates his groups by adjectives and descriptive phrases rather than by proper names.

(4) He uses hoofs and claws (*cf.* "ungulata," "unguiculata") as prime criteria.

(5) He divides the Unguiculates into two great groups. These, however, are of different character than the similarly named groups of Ray.

(6) He does not accept any of the more unnatural of Linné's groups such as Bruta and Bestiæ.

The progressive features of his classification are as follows:

(1) He adopts the term "Mammalia" and recognizes the propriety of including the "Cetacei" in the group but sets them apart in it as a grand division, thus following Brisson.

(2) He places man in the same division with *Simia* and *Lemur*, but goes beyond Linnæus in the taxonomic value assigned to the mammæ, since he uses the number of mammæ to separate the terrestrial unguiculates into two grand divisions.

(3) He accepts the new idea implied by Linnæus that the number of toes is not of fundamental value.

(4) He brings together *Myrmecophaga*, *Manis* and *Dasyppus*; whereas Linnæus had put *Dasyppus* in the Bestiæ and joined the other Edentates with the Elephant and Manatee. The only Edentate which Scopoli failed to place correctly was *Bradypus*, which he associated with *Vespertilio*, *Lemur*, *Simia* and *Homo*.

Taking it all in all this classification is a pretty good one. It is a conservative and intelligent adaptation of the principles of Ray, Klein, Brisson and Linnæus, avoiding for the most part the more artificial and unnatural of their groupings and only falling into one very bad grouping, the Aquatilia. It is also the simplest and most easily remembered classification so far met with.

Scopoli's Classification of 1777.

Tribus XII. Kleinii, Mammalia.

Gens I Cetacea.

Gens II Quadrupedia.

Div. I Aquatilia.

Manatus, Pusa [=“*Phoca foetida* Fabricius”], *Phoca*, *Rosmarus*, *Lutra*, *Castor*, *Hydrochærus*, *Hippopotamus*.

Div. II Terrestria.

Ordo I Ungulata.

* Non-ruminantia.

Elephas, *Rhinoceros*, *Tapirus*, *Sus*, *Equus*.

** Ruminantia.

Camelus, *Giraffa*, *Cervus*, *Antilope*, *Capra*, *Ovis*, *Bos*, *Moschus*.

Ordo II Unguiculata.

* Mammis quatuor et pluribus.

a) *Dentibus primoribus binis*.

Lepus, *Cavia*, *Histrix*, *Erinaceus*, *Mus*, *Sciurus*, *Sorex*.

b) *Dentibus primoribus anticis senis excepta Didelphi*.

Talpa, *Mustela*, *Viverra*, *Felis*, *Canis*, *Ursus*, *Didelphis*.

c) *Dentibus primoribus nullis*.

Mirmecophaga, *Manis*, *Dasyppus*.

** Mammis duabus.

Bradypus, *Vespertilio*, *Lemur*, *Simia*, *Homo*.

ERXLEBEN, 1777.

‘Systema Regni Animalis . . . Classis I Mammalia.’ Lipsiæ. 8vo.

Erxleben modestly announces his book as a new edition of the ‘Systema Naturæ,’ but he had contributed many new genera and species and had compiled an extensive, critical and exact synonymy and bibliography of names of mammals, covering the period from Aristotle to his own time. In commenting on the great difficulty of discovering a truly natural ordinal classification of the mammals, after listing Linné’s orders, Erxleben abandons

all ordinal divisions and simply sets down the genera in series, adopting as chief generic characters, the front teeth, nature of the manus, mammæ, tail, etc.

Erxleben is thus another advocate of "l'école des faits" (*cf.* Perrault p. 39), rejecting and reacting against imperfect generalizations, evidently believing that "analysis must precede synthesis," but also that the time for synthesis is not yet ripe.

About this time Sir Joseph Banks, sailing in his own vessel with Captain Cook's famous expedition round the world (1768-1771), brings back Kangaroos, Wombats, Dasyures and other marsupials from Australia. Phalangians had previously been known from the Dutch East Indies and were at first described as "*Didelphis orientalis*" by Brisson in 1762 (Palmer, 1904). Kangaroos and Wallabies were at first described as rodents allied to the Jerboa ("*Jaculus orientalis*" Erxleben, 1777), while the Wombat and Dasyure were assigned to *Didelphis* by Shaw. Thus the mammals which above all others were to illustrate the misleading effects of homoplastic evolution were at first not recognized as a distinct group, but were distributed among the forms which they paralleled.

Another naturalist-traveler who may be mentioned here conveniently is the famous Russian explorer Pallas, whose 'Reisen durch verschiedene Provinzen des russischen Reichs' were published in 1771-76. He carefully described and figured the exterior, the anatomy, and (especially in the case of small mammals) the osteology, of numerous antilopes, bats, rodents, the Aard Vark, or "*Myrmecophaga africanum*" [*Orycteropus*], the "*Cavia capensis*" [*Hyrax*], the "*Aper æthiopicus*" [*Phacochærus*]. These genera (except the Aard Vark) are figured in his 'Spicilegia Zoologica' (1767-1804), especially the 'Novæ species Quadrupedum e Glirinum Ordine,' Erlangæ, 1778.

4. THE PRE-CUVIERIAN EPOCH.

Synopsis.

Renewed reaction against speculation and tradition. The "école des faits." *Description and dissection of mammals without any principles of classification* (*e. g.*, Perrault, Daubenton).

Foundation of comparative anatomy and osteology (*e. g.*, Daubenton, Vicq d'Azyr).

Gradual recognition of natural groups and development of the Linnæan classification (*e. g.*, Vicq d'Azyr, Blumenbach).

Beginnings of "philosophical zoology."

In order to understand the origin of the classifications of the Cuvierian epoch it is necessary to go back to a date (1731) slightly earlier than that of the first edition of Linné's '*Systema Naturæ*,' and to follow the rise of two general lines of investigation, namely comparative anatomy and ordinal classification, which began in France independently of Linné's work. Perrault and Daubenton represent successive stages in the development of comparative anatomy; Brisson's and Pennant's ordinal classifications may be regarded as offshoots of the Raian methods, while the works of Blumenbach, Storr, Vicq d'Azyr and Geoffroy Saint-Hilaire furnish the intermediate stages which connect the Linnæan with the Cuvierian systems. Consequently the above-mentioned authors, down to Cuvier, are here brought together as a transitional group, and the whole movement leading up to Cuvier is called the "pre-Cuvierian epoch."

PERRAULT, 1731.

'*Mémoires pour servir à l'Histoire Naturelle des Animaux.*' La Haye, 2vols., 4to.

The work edited by Perrault is especially noteworthy because it illustrates the status and ideals of natural history in France during the reign of Louis XV. It records the results of a series of dissections performed upon exotic animals from the Jardin du Roi, by a committee of the Royal Academy of Sciences. The work is animated by the spirit of the "école des faits" and illustrates both the search for absolute certainty and the reaction against all theory and generalization,—tendencies which were characteristic of the science of the period. The authors remind us that natural history had long been burdened with error and overgrown with fanciful speculation. They had proposed to themselves the task of accumulating a body of anatomical facts, each of which was to be attested and authenticated by the whole committee. Each detail of their figures likewise was to be attested, after having been drawn by one of their own members, by a hand guided by science as well as by art, "parce que l'importance en ceci n'est pas tant de bien représenter ce que l'on voit, que de bien voir comme il faut ce que l'on veut représenter." And they will not, for example, affirm aught of Bears in general, "nous disons seulement qu'un Ours que nous avons dissequé avoit la conformation tout-à-fait particulière." They profess to hope that upon such a foundation of concrete facts some Aristotle of the future may build a secure philosophy, a veracious Natural History. They do not appear to be aware that such an Aristotle, in the person of John Ray, had in a sense already arisen and that another great genius, Linnæus, was even then arising.

They quote "les grands & magnifiques Ouvrages qu'Aristotle, Pline, Solin & Elian ont composés" chiefly for the purpose of refuting or correcting the opinions of those worthies; and they replace much classical and mediæval rubbish by solid fact.

The plan of the work is very well carried out. The external appearance and anatomy of animals pertaining to 51 genera of vertebrates are figured and described. Of these, 21 genera are mammals, distributed among 15 families and 6 orders, and including various ruminants, carnivores, two genera of monkeys, a beaver, porcupine, hedgehog, seal, etc. Judged by later standards the figures of the animals are of uneven merit, some bordering on the grotesque, but all of evident sincerity. The anatomical drawings, though very wooden and in spite of the committee's efforts not always quite accurate, are at least diagrammatically clear. Special attention is paid to the digestive tract and urinogenital system, and in case of the monkeys the resemblances to and differences from the human anatomy are clearly exhibited.

This work is important because it is a prelude to the more extensive work of Daubenton (in Buffon's 'Histoire Naturelle,') and to comparative anatomy of the Cuvierian type. It also furnishes another example of the application of the methods of one subject to the data of another, since it applies to the anatomy of the vertebrates the already well developed terminology of human anatomy. But this work contained no far-reaching ideas of a general nature, except the very distrust of premature generalizations. Another century was to elapse before comparative anatomy, thus initiated, was to be happily joined to classification by de Blainville.

BUFFON AND DAUBENTON, 1753-1767.

[History of Quadrupeds].

The name of Louis-Jean-Marie Daubenton (1716-1799) has a double claim upon the grateful memory of zoölogists. First, so Cuvier tells us in his 'Recueil des Éloges Historiques....' (tome première, 1819, pp. 37-80), Daubenton was virtually the founder of the Cabinet of Natural History in the Jardin des Plantes. He seems to have been a born 'museum man,' and to have labored incessantly to establish and develop systematic collections of minerals, fruits, woods, shells, etc., and especially to display them to the best advantage. He improved the methods of preserving and mounting mammals and birds, and Cuvier says that "les dépouilles inanimées des quadrupèdes et des oiseaux reprirent les apparences de la vie, et présentèrent à l'observateur les moindres détails de leurs caractères, en même temps

qu'elles firent l'étonnement des curieux par la variété de leurs formes et l'éclat de leur couleurs." He also made for the Cabinet a large number of anatomical preparations, many of which were figured in the work mentioned below.

Daubenton's second great service to mammalogy was his descriptive work on the quadrupeds, prepared in collaboration with Buffon and published as a long series of quarto volumes (iv-xv) of the 'Histoire naturelle' beginning in 1753. Daubenton's methods and ideals were in direct contrast to those of his brilliant but too speculative colleague Buffon. He was a modest follower of the "école des faits" and his work forms a natural development and continuation of that of Perrault. He rejected the classifications of Ray, Klein, and Linnæus as being artificial and tending to encourage superficial knowledge. Cuvier tells us (1819, p. 50) that the 'Histoire des Quadrupèdes' (as it was called in the second edition of the 'Histoire Naturelle,' 1799-1805) comprises the description of the general morphology and internal anatomy of 142 species of quadrupeds, and of the external morphology alone of 26 species. Eighteen entirely new species were described, while the number of new observations and illustrations were "innombrables." Cuvier pronounced the work virtually the foundation of modern comparative anatomy and systematic mammalogy.

Each animal is described more or less as an independent unit and the sequence of forms is without regard to the ordinal classifications which had been proposed by other writers. As the number of forms described is very large, this very fact must have emphasized the need of an ordinal classification, and must have prepared the way for the acceptance of the systems of Vicq d'Azyr, Geoffroy, Cuvier and others, whose knowledge of mammals must also have been based to a considerable extent upon Daubenton's figures and descriptions.

Daubenton refrained as a rule from formal generalizations, and about the only one he ever permitted himself, namely that all mammiferous quadrupeds have seven cervical vertebræ, he lived to see overthrown by the discovery that the Ai, or three toed sloth (*Bradypus tridactylus*), has, in fact, nine (Cuvier, *op. cit.*, p. 52).

BRISSON, 1756, 1762.

'Regnum Animale in Classes IX Distributum sive Synopsis Methodica'.
8vo. Lugduni Batavorum.

The first edition of Brisson's work appeared in 1756, two years before the tenth edition of Linné's 'Systema Naturæ.' The second edition appeared in 1762. The work is essentially pre-Linnæan in method and the classification is a development of certain features of the Raian system.

The animal kingdom is divided into nine classes. The classes include: the Quadrupeds, with hairy body and four feet; the Cetacea, with naked elongate body, fleshy fins and a tail flattened horizontally; the Birds, Reptiles, Cartilaginous Fishes, true Fishes, Crustaceans, Insects and Worms. The Cetacea are thus definitely removed far from the fishes and follow the Quadrupeds which are placed at the head of the list. This step was an important one (even although Ray in 1693 had already gone beyond it) and shows that Brisson understood the essentially mammiferous affinities of the Cetacea.

The quadrupeds are divided dichotomously into 18 orders, based primarily upon the number of the teeth. Brisson selects the kinds of the teeth as criteria of classification, giving them higher rank than the feet and thus reversing Ray's procedure.¹ In laying so much stress upon the number and position of certain parts he may have been influenced by systematic botany.

By dividing the quadrupeds into so many coördinate divisions he escapes some of the most unnatural groupings of Linnæus, but nevertheless makes some new ones that are not much better (*e. g.*, *Elephas* with *Odobænus*, *Prosimia* with *Vespertilio*, *Simia* with *Pteropus*). Brisson did not however, recognize any group of amphibious or web-footed mammals. He places *Phoca* in his fifteenth Order next to *Hyæna*, *Canis*, *Mustela*, etc.

In short, Brisson's classification of the hairy quadrupeds was largely artificial and contained no strikingly original suggestions, and his limitation of the Linnæan genera was the most enduring part of his work. His classification, however, influenced those of certain later French writers, especially Lacépède.

Brisson's Classification of 1762.

Classis I. Quadrupeda.

Horum character est

Corpus pilosum, saltem in aliqua sui parte

Et pedes quatuor.

Classis II. Cetacea.

Horum character est

Corpus nudum, elongatum.

Pinnæ carnosæ:

Cauda horizontaliter plana.

Classis III. Aves.

Classis IV. Reptilia.

Classis V. Pisces Cartilaginei.

Classis VI. Pisces *proprie dicti*.

Classis VII. Crustacea.

Classis VIII. Insecta.

Classis IX. Vermes.

¹ Brisson seems to have been one of the first to emphasize and magnify the importance of the teeth in ordinal classification. F. Cuvier (*cf.* p. 75) developed this idea to the point of almost disregarding all other characters (*cf.* pp. 107, 352).

Tabula Synoptica Quadrupedum.

Much as in the first edition: a dichotomous table, here somewhat condensed and expressed by means of "indentation."

Edentula	Ordo I.	Myrmecophaga, Pholidotus.
Dentibus molaribus tantum	Ordo II.	Tardigradus, Cataphractus.
Dentibus molaribus & caninis	Ordo III.	Elephas, Odobænus.
Dentibus incisoribus, inferiore maxilla tantum, sex	Ordo IV.	Camelus.
octo.	Ordo V.	Giraffa, Hircus, Aries, Bos, Cervus, Tragulus.
Dentibus incisoribus in utraque maxilla:		
Pedibus solidungulis	Ordo VI.	Equus.
Pedibus bisulcis	Ordo VII.	Sus.
Dentibus incisoribus in utraque maxilla:		
Pedibus terungulatis antice & postice	Ordo VIII.	Rhinoceros.
Dentibus incisoribus [etc.]	Ordo IX.	Hydrochærus.
	Ordo X.	Tapirus.
	Ordo XI.	Hippopotamus.
Pedibus unguiculatis, dentibus incisoribus:		
Duobus supra, totidem infra	Ordo XII.	Hystrix, Castor, Lepus, Cuniculus, Sciurus, Glis, Mus.
Caninis nullis		Musaraneus, Erinaceus.
Caninis præsentibus:		
Quatuor supra, totidem infra	Ordo XIII.	Simia, Pteropus.
Quatuor supra, sex infra	Ordo XIV.	Prosimia, Vespertilio.
Sex supra, quatuor infra	Ordo XV.	Phoca.
Sex supra, totidem infra	Ordo XVI.	Hyæna, Canis, Mustela, Meles, Ursus, Felis, Lutra.
Sex supra, octo infra	Ordo XVII.	Talpa.
Decem supra, octo infra	Ordo XVIII.	Philander [Didelphis philander].

BLUMENBACH, 1779.

‘Handbuch der Naturgeschichte.’

Johann Friederick Blumenbach (1752–1840), the father of anthropology, published the first edition of his ‘Handbuch’ in 1779 and 1780. The work rapidly passed through the first four editions in 1782, 1788 and 1791, each one with additions (Sherborn, 1902, p. xv). Of these the ones examined by the writer are the first (1779), the fourth (1791), the French edition (translation of the German edition of 1797), the tenth English edition of 1825, and the twelfth (German) of 1830. The first edition, appearing as it did

in 1779, is almost exactly intermediate in time between the tenth edition of Linné's 'Systema Naturæ' in 1758 and the classification of Geoffroy and Cuvier in 1795. In substance and form also the classification of Blumenbach is likewise intermediate, on the one hand embodying many Linnæan features and on the other distinctly foreshadowing the Cuvierian system.

The features in which it recalls the Linnæan system are as follows:

(1) It is not a dichotomous system and therefore avoids the disadvantages of that method (see pp. 22, 47).

(2) Only monomial names for the orders are used.

(3) The Linnæan terms "Glires," "Feræ," and "Belluæ" are adopted.

(4) The Cetacea are included among the mammals without being given more than ordinal rank.

(5) Man is included in the scheme, which however differs from the Linnæan system in treating the group as a separate order ("Inermis," the "Bimana" of later editions).

(6) In regard to the sequence of the orders the classification is in general harmony with Linné's arrangement.

(7) It does not rely on one or two sets of characters but adopts different criteria in different orders.

The classification is even pre-Linnæan in grouping together the amphibious web-footed mammals of different orders into a single group called "Palmata," an ancient term used in ornithology and suggesting its correlate "Fissipeda" which was used in later editions.

Another old error which survived in various forms well into the present epoch was the assigning of ordinal rank to characters of the integument, as in Blumenbach's order "Sclerodermata," Cuvier's "Pachydermes," and Klein's "Depilata."

On the other hand Blumenbach's classification anticipates the Cuvierian system in the following features:

(1) This is apparently the first classification of the mammals to recognize a group of intermediate rank between the genus and the order, and in so far equivalent to the modern family. This group was given the termination "-ina," which thus historically long precedes the patronymic "-idae" of Kirby (*cf.* p. 102).

(2) Blumenbach's classification is distinctly progressive and "Cuvierian" in freeing the group of Bats from its former association with *Simia* and *Lemur*, and in elevating it to ordinal rank under the new term "Chiroptera." This was a decided advance and must have assisted also in the disentanglement of *Galeopithecus* from the Lemurs.

(3) The Kangaroo, shortly before named *Jaculus giganteus* by Erxleben, is here associated with the rodents, as in Cuvier's scheme (see p. 59).

(4) A further correspondence with the early scheme of Cuvier is apparent in the idea that there is some sort of natural transition between certain adjacent orders, *e. g.*, the Flying Squirrel of the order Glires is placed first, in order to bring it next to the Chiroptera; the opossum (*Didelphis*) of the group "Murina" stands next to "*Jaculus*" (the Kangaroo) of the group "Leporina"; "*Viverra*," the last of the "Mustelina," stands next to "*Ursus*" of the order "Feræ"; "*Sus*" of the "Bisulca" leads to "*Tapir*" of the "Belluæ"; while the water-loving "*Hippopotamus*" leads to the amphibious "Palmata"; and of these in turn "*Manatus*" furnishes the desired transition to the Cetacea "Letzterer macht von hier den schicklichsten Uebergang zur letzten Ordnung (Cetacea)." (Handb. d. Naturg., 12th German ed., 1830.)

Additional features of this classification are:

(1) The correct placing of "*Sus*" with the cloven footed mammals ("Bisulca"), as in Klein's system. (2) The association of "*Tapir*," "*Elephas*," "*Rhinoceros*" and "*Hippopotamus*" under "*Belluæ*," equivalent to Storr's "Multungula" and Cuvier's "Pachydermes".

The work is embellished with excellent figures of the skulls of apes, monkeys and lemurs, and must have formed a good introduction to anthropology as well as to natural history.

In brief, Blumenbach's classification of 1779 represents a conservative development of the work of Ray, Klein and Linnæus. While it breaks up and distributes some of Linné's more unnatural groups ("Bruta," "Bestiæ") it does not escape from forming new unnatural ones ("Sclerodermata," "Palmata"), and it does not get below superficial criteria or enunciate any great new principles. Blumenbach's classification thus furnishes a transitional stage leading from the Linnæan to the Cuvierian system.

Blumenbach's Classification of 1779.

Ord. I.	Inermis.	Homo.
Ord. II.	Pitheci.	Simia troglodytes, <i>S. satyrus</i> , <i>S. longimana</i> [Gibbon], <i>S. cynomolgus</i> , <i>S. sylvanus</i> [and other primates including the Lemurs].
Ord. III.	Bradypoda.	Ignavus (Faulthier), Myrmecophaga.
Ord. IV.	Sclerodermata.	Hystrix, Manis, Tatu.
Ord. V.	Chiroptera.	Vespertilio.
Ord. VI.	Glires.	
	a) Sciurina.	Sciurus volans, <i>S. vulgaris</i> , Glis.
	b) Murina.	Marmota (alpina, cricetus, citellus, lemmus), Mus, Sorex, Talpa, Didelphis.
	c) Leporina.	Jaculus (giganteus [Macropus], jerboa), Lepus, Cavia (porcellus, aguti, paca).
	d) Mustelina.	Mustela, Viverra (including numerous Viverrines and Lotor [Procyon]).

Ord. VII.	Feræ.	Ursus, Canis, Felis.
Ord. VIII.	Solidungula.	Equus.
Ord. IX.	Bisulca.	Camelus, Capra, Bos, Cervus (camelopardalis, alces, dama, etc.), Moschus, Sus.
Ord. X.	Belluæ.	Tapir, Elephas, Rhinoceros, Hippopotamus.
Ord. XI.	Palmata.	Castor, Lutra, Phoca, Trichecus (rosmarus, manatus).
Ord. XII.	Cetacea.	Monodon, Balæna, Physeter, Delphinus.

STORR, 1780.

'Prodromus Methodi Mammalium', 1780.

Gottlieb Conrad Christian Storr's exceedingly rare work, was brought to light in 1874 as a result chiefly of the efforts of Dr. Theodore Gill, who, in the 'Bulletin of the Philosophical Society of Washington' (Vol. II, 1875-1880, appendix v., read Oct. 1874) published a summary of the work with the tables of classification.

Storr divided the "Imperium Naturæ" into successively narrowing groups, and was apparently the first mammalogist to employ groups intermediate between the class and the order. To illustrate his method we may show how he placed the genus *Felis* in the system.

Imperium Naturæ
 Regnum Organicum
 Republica Animalium
 Agmen Rubrisangvium
 Acies Calidorum
 Classis I Mammalium
 Phalanx I Pedatorum
 Cohors I Unguiculatum
 Ordo I Primates
 Missus II Emanuati
 Sectio II [not named]
 Coetus I Unci
 Genus I Felis.

In the high degree of differentiation of groups within groups this classification goes far beyond even that of Ray. The only division that corresponds exactly to one now in use is the class. Some of the orders (*e. g.*, "Pecora") correspond in rank nearly to modern orders; others ("Primates," "Belluæ") are more nearly equivalent in rank, but not content, to super-orders. The genus frequently corresponds, as in Linnæus, to the modern family.

The classification appears to have been built rather by the following of *a priori* principles than by the judicious aggregation of smaller into larger groups as the result of the discovery of more and more elements of simi-

larity. In any scheme of this kind the more inclusive groups must always be less "natural" than the less inclusive groups, since the number of characters that can possibly be predicted of a given group sinks from infinity in the case of the individual to the few fundamental properties of all reality in the case of the "*imperium naturæ*." Even in our own time considerably less than "infinity" is known about each individual and each species, and, higher up in the scale, the number of characters which are assigned to all the Mammalia, for example, will not be above fifty even in that most thorough work, Weber's '*Die Säugetiere*'. Hence it is not surprising that Storr's supergeneric divisions, based as they were in each case upon single characters, should be on the whole very unnatural.

The reliance upon single characters, which is well illustrated in the system under consideration, and which was avoided by the genius of Linné, was fatal to the naturalness of all earlier and of many later classifications; but was a necessary step in the evolution of clearer comprehension and better methods. The consistent application of a single character or set of characters doubtless gave to a classification an appearance of logic and exactitude that must have appealed strongly to scholars trained in classical and scholastic methods and in the construction of dichotomous tables.

In the case of Storr's classification the single set of characters selected as major criteria were those of the extremities, which were given higher diagnostic value even than in Ray's system. And it must be confessed that the results so far justified this choice that Storr's classification of the ungulate orders is on the whole an improvement upon its predecessors and especially far better than that of Brisson (*cf.* p. 43), in which foot-structure was subordinated to the number of incisor teeth.

In directing attention anew to the clear and convenient results of classification by foot-structure, and especially in the invention of the terms "*Manuati*," "*Emanuati*," "*Palmares*," "*Palmoplangtares*," and "*Plantares*," Storr very probably inspired the terms "*Bimanes*," "*Quadrumanes*," "*Pédimanes*," "*Plantigrades*," etc., used by Cuvier and his immediate predecessors, while the work of that school is also strongly suggested both in the arrangement of the plantigrade insectivores and carnivores, and in the general sequence of the genera of mammals.

It is not always easy to demonstrate the exact relations of a particular author to succeeding, contemporary and antecedent thought. As in the case of every other body of doctrines each stage in the history of the classification of mammals is marked by certain principles which seem to be "in the air," as it were, and which in the fertile soil of certain individual minds spring up constantly into combinations of the old and the new. And so it is with Storr. From preceding and contemporary writers he drew the subject

matter and general principles of his classification. He quotes, for example, Marggrav (1684), Catesby (1731), J. D. Meyers (1748), Buffon, Brisson (1756 or 1762), Linnæus (1766), Schreber, Pallas (1766), Erxleben (1777), Blumenbach (1779), and Liske (1779). From Ray, or perhaps Klein, he adopts and improves the group "Verminei," and from Linnæus he takes most of his genera, and the orders "Jumenta," "Pecora," "Belluæ" and "Rosores" (Glires Linn.), as well as the name "Primates" and perhaps "Ungulata" and "Unguiculata," which were, however, the common property of post-Raian naturalists. From Brisson he adopts the genera *Prosimia*, *Meles*, *Hyæna*, *Glis*, *Cataphractus* [*Dasypus*], *Pholidotus* [*Manis*], and *Giraffa*. He follows Linné in admitting Man to the system, but leans toward Blumenbach's idea in giving him the rank of a "Sectio," which is, however, merely a division of the comprehensive "order" Primates. He fails to appreciate Linné's acumen in associating the seals with the terrestrial animals, but in his group "Pinnipedia" including the seals and *Manatus* he follows rather those numerous authors who in bringing animals together were influenced by the nature of the *locus*, or medium.

The best and most original features of Storr's system are the following:

(1) He "greatly improved upon the genera of the 'Systema Mammalium' by their limitation to species naturally and more closely allied" (Gill, p. v). In this process he split off from older genera the new genera *Procebus*, *Tarsius*, *Phalanger*, *Gulo*, *Mellivora*, *Nasua*, *Procyon*, *Lagomys* [Storr non Cuvier], and *Pholidotus* [*Manis*].

(2) He did not adopt the heterogeneous assemblage "Bruta," but correctly grouped the Edentates under the name of "Mutici" (from "muticus," docked, curtailed), probably in allusion to the imperfect development of the teeth. The group was placed next to the "Rosores," or rodents, as a grand division of the Cohort Unguiculata. His arrangement of the Ungulates recalls that of Blumenbach.

(3) He recognized that the Australian mammal described by Brisson and Pallas as *Didelphis orientalis* was generically distinct from the American genus and accordingly he erected the new genus *Phalanger* for its reception.

Storr's tables of classification of the mammals are given below. In the original (as copied by Gill) the relations of the groups are expressed by means of brackets, lines of asterisks and other symbols. Here the same relations are expressed by means of "indentation."

Storr's Classification of 1780.

Tabula Generalior.

Imperii Natvræ

Regni Organici

Reipvblica Animalium

Agminis Rvbrisangvium

Acies Calidorum

Classis I Mammalivm.

Phalanx I Pedatorum.

Cohors I Unguiculatum.

Ordo I Primates.

Ordo II Rosores.

Ordo III Mutici.

Cohors II Ungulatum.

Ordo I Jumenta.

Ordo II Pecora.

Ordo III Belluæ.

Phalanx II Pinnipedum.

Phalanx III Pinnatorum.

Tabula Specialior A.

Mammalium

Pedatorum

Vnguiculatum.

Ordo I Primates.

Missus I Manuati.

Sectio I [Palmares].

Homo.

Sectio II [Palmoplangtares]. Simia, Prosimia, Procebus, Tarsius, Lemur [Galeopithecus].

Sectio III [Plantares].

Didelphis, Phalanger.

Missus II Emanuati.

Sectio I [Nocturni].

Vespertilio, Sorex, Talpa, Erinaceus, Meles, Gulo, Mellivora, Ursus, Nasua.

Sectio II

Coetus I [Olaces].

Procyon, Canis, Hyæna.

Coetus II [Unci].

Felis.

Sectio III [Vermineil].

Viverra, Mustela, Lutra.

Tabula Specialior B.

Mammalium

Pedatorum

Unguiculatum.

Ordo II Rosores

Hystrix, Castor, Mus, Glis, Sciurus, Lagomys, Cauia, Procauia, Lepus.

Ordo III Mutici

Bradypus, Cataphractus, Pholidotus, Myrmecophaga.

Tabula Specialior C.

Mammalium

Pedatorum

Vngulatorum.

Ordo I Jumenta

Equus.

Ordo II Pecora

Camelus, Giraffa, Aries, Antilope, Taurus,
Cervus, Moschus.

Ordo III Belluæ

Sus, Hydrochærus, Rhinoceros, Elephas,
Hippopotamus.

[PHALANX II PINNIPEDIA.]

Mammalia

Pinnipedia.

Phoca, Rosmarus, Trichechus, Manatus.

[PHALANX III PINNATA.]

Mammalia

Pinnata.

Delphinus, Diodon, Physeter, Balæna.

PENNANT, 1781.

'History of Quadrupeds,' Vol. I. 4to. London.

Thomas Pennant, to whom Gilbert White addressed some of his most entertaining letters on the 'Natural History of Selbourne,' was the author of an excellent work of 566 pages on quadrupeds, containing descriptions of over 400 species of mammals and adorned with fifty-two plates of fairly good execution.

In the descriptive part the work was a worthy successor of that of Ray and long remained the standard in England. The classification adopted is merely an adaptation and simplification of Ray's system, with some modern additions. It is what might be called a "common sense" system, very practical and convenient, but bare of new principles, and without appreciation of the essential superiority of some of Linné's best ideas.

This is shown in the author's introduction. After discussing the classifications of Ray, Klein and Brisson, he goes on to speak of Linné's system as follows:

"There are faults in his arrangement of Mammalia¹ that oblige me to separate myself in this one instance from his crowd of votaries. . . . I reject his first division, which he call Primates or Chiefs of Creation; because my vanity will not suffer me to rank mankind with *Apes, Monkeys, Maucaucos* [Lemurs] and *Bats*, the companions LINNÆUS has allotted us even in his last System." He admits that "Whales have in many respects the structure of land animals; but their want of hair and feet, their fish-like form and their

¹ "Or animals which have paps and suckle their young; in which class are comprehended not only all the genuine quadrupeds but even the Cetaceous tribe."

constant residence in the water are arguments for separating them from this class and forming them into another, independent of the rest." Like other naturalists of the time Pennant recognized the artificiality of Linné's orders "Bruta" and "Bestiæ" and correctly removes *Noctilio* from the Glires.

Pennant proceeds to discuss his own classification as a development of that of Ray with modifications from Klein, and, with the separation of the Pinnated and Winged Quadrupeds. "...the first takes in the *Walrus* and the *Seals*, and (in conformity to preceding Writers) the *Manati*. But those that compose this order are very imperfect: Their limbs serve rather the use of fins than legs; and their element being for the greatest part water, they seem as the links between the quadrupeds and the cetaceous animals.

"The Bats are winged quadrupeds, and form the next gradation from this to the class of Birds; and these two orders are the only additions I can boast of adding in this work."

Here again, as in Blumenbach's work, we meet the idea of gradations leading from one order to another. As these supposed annectant forms were usually merely adaptively similar forms, we might say that *the endeavor to find annectant forms was a step leading toward the recognition of parallel and convergent evolution.*

Pennant's Classification of 1781.

Method.

- Div. I. Hoofed Quadrupeds.
- Div. II. Digitated Quadrupeds.
- Div. III. Pinnated Quadrupeds.
- Div. IV. Winged Quadrupeds.
- Div. I. Sect. I. Whole-hoofed.
Genus Horse.
- Sect II. Cloven-hoofed.
Ox, Sheep, Goat, Giraffe, Antelope, Deer, Musk, Camel, Hog, Rhinoceros, Hippopotame, Tapiir, Elephant.
- Div. II. Digitated.
- Sect I. Anthropomorphous frugivorous.
Ape, Maucauco.
- Sect II. With large canine teeth separated from the cutting teeth. Six or more cutting teeth in each jaw. Rapacious, carnivorous.
Dog, Cat, Hyæna, Bear, Badger, Opossum, Weesel, Otter.
- Sect. III. Without canine teeth and with two cutting teeth in each jaw.
Generally herbivorous or frugivorous.
Cavy, Hare, Beaver, Porcupine, Marmot, Squirrel, Jerboa, Rat, Shrew, Mole, Hedgehog.
- Sect IV. Without cutting teeth. Frugivorous, herbivorous. Sloth, Armadillo.
- Sect. V. Without teeth. Insectivorous.
Manis, Anteater.

Div. III. Pinnated. Piscivorous or herbivorous.¹

Walrus, Seal, Manati.

Div. IV. Winged. Insectivorous.

Bats.

BODDAËRT, 1784.

'Elenchus Animalium,' quoted by I. Geoffroy (1826, pp. 67, 68).

The classification of this Dutch naturalist has not been seen by the writer, but according to I. Geoffroy's account (1826) it seems to have contained little that was important so far as regards the major divisions. The Linnæan orders were nearly all adopted but the Primates and Bruta were united into a single order "Unguiculata." Gervais (1837), says that Boddaërt introduced the term "Quadrumanes," which was adopted by Cuvier. The mammals were divided into terrestrial and aquatic sections. In all these respects Boddaërt's classification resembled the contemporary system of Blumenbach.

BLUMENBACH, 1791.

'Handbuch der Naturgeschichte.' Fourth edition.

While Blumenbach's earlier classification was evidently a modification of the Linnæan system, at least in many features, his classification of 1791 apparently reflects the influence of Storr's work and very clearly foreshadows the classification of Geoffroy and Cuvier.

The system under consideration is also notable for the number of new ordinal terms said to originate with Blumenbach, namely "Bimana," "Quadrumana," "Chiroptera" (1779, see p. 44), "Fissipeda" (Digitata), "Fissipeda Glires," "Fissipeda Feræ," "Fissipeda Edentata" (Bruta), "Palmata," "Palmata Glires," "Palmata Feræ," "Palmata Bruta."

The two parallel series of "Glires," "Feræ," "Bruta" under the "Fissipeda" and "Palmata" afford one of the earliest instances where adaptive resemblances between mammals of different orders are recognized, even though imperfectly, in classification. The aquatic animals are evidently thought to be related to each other by virtue of their foot structure which is the prime criterion; but nevertheless *Castor* appears to be conceived as the web-footed representative of the digitate Glires, *Phoca* and *Lutra* of the digitate Feræ, *Ornithorhynchus* and *Trichechus* of the digitate Bruta. This arrangement may have suggested the circular system of Macleay, and the idea of divergent adaptation so clearly implied by de Blainville.

¹ "Their Element chiefly the Water."

The orders Glires, Feræ and Bruta are united under "Digitata," a grouping which recalls Klein's arrangement.

Ornithorhynchus (which was given generic rank by Blumenbach in 1800) now appears for the first time in ordinal classification.

"Les Fissipèdes édentés" (*Bradypus*) are reunited with the other Edentates as in Storr's scheme.

Blumenbach's Classification, as given in the French translation of the Fifth German Edition of the 'Handbuch' (1797).

- Order I. Bimanes.
- II. Quadrumanes.
- III. Chiroptères.
- IV. Fissipèdes ("ou Digités").
 - A. Les Fissipèdes rongeurs [Rodents, except Castor].
 - B. Les Fissipèdes carnassiers (Didelphis, Kangaroo, Viverra, Mustela, Ursus, Canis, Felis).
 - C. Les Fissipèdes édentés (*Bradypus*, *Myrmecophaga*, *Manis*, *Tatu*).
- V. Solipèdes (*Equus*).
- VI. Bisulces [*cf.* *Bisulca* Ray] (*Camelus*, *Capra*, *Antilope*, *Bos*, *Giraffa*, *Cervus*, *Moschus*).
- VII. Multongulés (*Sus*, *Tapirus*, *Elephas*, *Rhinoceros*, *Hippopotamus*).
- VIII. Palmipèdes.
 - A. Les Palmipèdes rongeurs (*Castor*).
 - B. Les Palmipèdes Carnassiers (*Phoca*, *Lutra*).
 - C. Les Palmipèdes Édentés (*Ornithorhynchus*, *Trichechus* [walrus]).
- IX. Cétacés.

VICQ D'AZYR, 1792.

'Système anatomique des Quadrupèdes' (quoted by Gervais, 1836, p. 616).

Vicq d'Azyr's system distinctly foreshadows that of Cuvier, and he also preceded Cuvier in the development of comparative anatomy, "following the line of strict anatomical observation and critical comparison, [he] set forth the correspondence of plan observable in the limbs of the higher vertebrates, and may be considered the founder of the purely scientific higher anatomy," (Huxley, 1894 p. 288).

This classification is the first one entirely in French which we have so far discussed (Brisson's being in French and Latin). Thus, like other French scientists, Vicq d'Azyr used French instead of Latin and tried to popularize science by avoiding all appearance of pedantry, by inventing or adopting common names wherever possible (*e. g.*, "Cheveaux d'eau," "Rongeurs," "Éléphants," etc.), or by gallicising Latin terms (*e. g.*, "Soli-

pèdes," "Ruminans," "Porcini," "Ailepieds"). These names are very well chosen and several of them (Rongeurs = Rodentia, Édentés, Carnivores) were commonly used by later authors.

The sequence of the orders, with some exceptions and improvements, is like that adopted from Linnæus by Blumenbach, namely, beginning with the monkeys and ending with the ungulates. The Cetacea are not discussed and probably, as in Brisson's work, were regarded as a distinct class.

About the only other significant resemblance to Blumenbach's classification of 1779 is shown in the circumstance that the bats are allowed ordinal rank under the name "Ailepieds," a term suggesting Blumenbach's "Chiroptera." More striking is the resemblance to Storr's system seen in the terms "Pédimanes" [recalling Storr's "Manuati," "Palmares," etc.], "Rongeurs" (etymologically related to Storr's "Rosores"), "Empêtrés" (a new term but coextensive with Storr's "Pinnipedia").

According to Isidore Geoffroy (1832) this classification was not original with Vicq d'Azyr but with Daubenton. At any rate Vicq d'Azyr had the advantage of Daubenton's study and dissections of many types of mammals. He is therefore impressed rather with the differences than with the resemblances between mammalian groups and consequently does not attempt the larger groupings given by Storr and Blumenbach. His classification deals only with the Quadrupeds, and so man and the Cetaceans are omitted from the list. The remaining mammals are distributed among 14 orders as against 10 in Blumenbach's system and 7 in Storr's. Several unnatural assemblages of previous authors are thus broken up (*e. g.*, Bestiæ, Belluæ). In certain cases this tendency even results in separating closely allied forms, *e. g.*, the Moles ("Taupens") from the Shrews ("Musaraignes"). On the other hand the old group of amphibious animals here called "Empêtrés" remains undissolved, the Manatees being left in an unnatural alliance with the seals and walruses.

Notwithstanding Vicq d'Azyr's observations on the unity of type in vertebrate limbs he here follows the *école de faits*, neither classifying the mammals according to any *a priori* principles, nor troubling about hidden bonds of affinity, as did Linnæus. Nor did he overemphasize the characters of the feet or of the teeth as ordinal criteria, as did Brisson, Cuvier, and many others. And from a practical point of view the net results are an advance upon all preceding classifications.

Practically every one of the groups recognized, with the exception of the Empêtrés (which indeed only required to be freed from *Manatus* to leave a natural residuum) correspond with families, suborders or orders now in use. And just as Linné's classification of 1735 was less specialized and in many respects less unnatural than his later one of 1758, so the first classifi-

cation of the Cuvierian school is both more simple and in certain respects more natural than Cuvier's more synthetic but overdeveloped systems of 1800 and 1817.

Vicq d'Azyr's Classification of 1792.

1. Pédimanes (Primates, Didelphis, etc.).
2. Rongeurs [*cf.* "Rosores" Storr].
3. Aile-pieds (Chauve souris) [*cf.* "Chiroptera" Blumenbach 1779].
4. Taupens ou Taupes.
5. Soriciens (Musaraignes).
6. Édentés [*cf.* "edentulus" Ray, as an adjective] (Paresseux, Tatous, Fourmiliers, Pangolins).
7. Carnivores [*cf.* "carnivora" Ray, as adjective].
8. Empêtrés [a new term ?] (Phoques, Lamantins, Morses).
9. Cheveaux d'eau (Hippopotame).
10. Éléphants.
11. Tapiriens.
12. Porcini [*cf.* "Porcinum genus" Ray].
13. Ruminans [*cf.* "Ruminantia" Ray].
14. Solipèdes (Equus).

5. THE EPOCH OF CUVIER AND DE BLAINVILLE.

Synopsis.

Enormous expansion of the content of mammalogy:

Description (*e. g.*, by Geoffroy) of many new genera, including pouched and oviparous mammals.

Rise of vertebrate palæontology (Cuvier).

Rise of comparative anatomy and osteology (Cuvier).

Rise of embryology (Von Baer, Agassiz).

Development and great diversity of theories of classification.

Non-inductive, objective monographic work of *école des faits* continued.

Classification by superficial characters (Cuvier, *e. g.*, of the extremities), not by totality of characters.

Classification by "deep seated" characters, especially of the skull and reproductive system (de Blainville).

Return to the Linnæan search for hidden affinities beneath superficial adaptive differences (de Blainville).

Rise of "natur-philosophie," "physiophilosophy," "circularian," "trinitarian," "quinarian," and similar systems (Oken, Macleay, Swainson).

Rise of the idea of "unity of organization" (Goethe, Vicq d'Azyr, Geoffroy Saint-Hilaire) and of the related "archetypal" theory of the vertebrate skeleton (Oken, Owen).

Rise of evolution theories (Lamarck, Erasmus Darwin).

Great net gain in classification, especially:

- Separation of monotremes, marsupials, placentals (de Blainville).
- Breaking up of many unnatural groups, *e. g.*, "Bruta," "Belluæ," "Pachydermes" (de Blainville).
- Recognition of many natural groups, *e. g.*, "Ongulogrades à doigts pairs," "Ongulogrades à doigts impairs" (de Blainville).

É. GEOFFROY SAINT HILAIRE AND G. CUVIER, 1795.

The elder Geoffroy was one of the earliest naturalists to recognize the peculiar characters of the Monotremes and Australian Marsupials, and we owe to him many generic and other terms, including "les Monotrèmes" "Phascolomys," "Dasyurus" "Catarrhini" and "Platyrrhini." He made many observations on the Monotremes, Marsupials; Primates and Chiroptera, his work on the two last named orders being especially referred to by Cuvier in the 'Règne Animal' (ed. I, 1817, p. xxiii). His contributions to philosophical anatomy and to the general development of the idea of evolution have been summarized by Osborn (1899, pp. 196-204). He contributed to the understanding of homological comparisons, especially in his memoir on the bird skull (1803).

Huxley (1894, p. 293) pronounces him "the most brilliant and, at the same time, the soberest representative of the higher or 'philosophical' anatomy."

The circumstances of his first association with G. Cuvier, as related by Flourens (see Alexander, 1861, pp. 164, 165) were as follows:

The elder Geoffroy in 1793, at the age of twenty-one, was appointed professor of zoölogy in the newly organized Jardin des Plantes and in 1794 he opened the first course of zoölogy ever given in France. He had been in charge of the living and preserved animals in the old Jardin du Roi, and so had become an enthusiastic student of the mammals. About that time M. Tessier was sent to him with certain memoirs by a hitherto unknown naturalist G. Cuvier. Struck with enthusiasm on perusing them, Geoffroy immediately invited Cuvier to join him in his work. "Come," he wrote, "and fulfill among us the part of a Linnæus — of another lawgiver of natural history."

"On the arrival of the *new Linnæus* [early in 1795], Geoffroy devoted himself without reserve to his interests. . . . Having a lodge at the Museum, he shared it with Cuvier, and threw open to him all the collection. A mutual devotion to study naturally united their labors, among the first results of which, two may be here noticed. Of one, the object was the *classification of mammifers* — and here the skillfully sustained idea of the *subordination of characters*, which was the great resource of Cuvier, predominates. The other was the history of the *makis*, or apes of Madagascar; and in this we

already discern traces of the *unity of composition*, . . . to which Geoffroy has subjected all comparative anatomy" (*op. cit.*, p. 165).

Within three months after Cuvier's appointment at the 'Jardin' he and Geoffroy published their classification of the mammals (p. 58) in Volume VI of the 'Magasin Encyclopédique,' 1795. From this circumstance and from the fact that after completing his course at Stuttgart, the young Cuvier went to Burgundy where he engaged in tutoring and in the study of shells, and hence apparently had little opportunity for the study of the mammals, Dr. T. S. Palmer inclines to the belief that Cuvier's share in the classification now under consideration was a minor one. Nevertheless it seems not impossible that this brilliant man could, in a short time, acquire sufficient acquaintance with the admirable work of Buffon and Daubenton, of Storr and Blumenbach, to enable him to form his own ideas as to the natural arrangement of the mammals. After this Geoffroy confined himself to monographic work (I. Geoffroy, 1826, p. 68), and the subsequent changes in the classification were introduced by Cuvier alone.

The obligations of this classification are apparently to Blumenbach and Storr, and also to Vicq d'Azyr, whose terms "Carnivores," "Pédimanes," "Rongeurs," "Édentés," "Ruminans" and "Solipèdes" are used. Blumenbach's term "Chiroptera" is also used (in the French form). It thus seems altogether likely (see also pages 47, 48), that Cuvier and Geoffroy were familiar with the works of Blumenbach and Storr; and indeed in the 'Tableau Élémentaire,' Cuvier refers to Blumenbach's system as one of the leading ones of that time, and later, in the 'Ossements fossiles' (Éd. 3, pt. 1, p. 3) he remarks that Storr was the first naturalist to recognize the group of "Pachydermes" ("Multungula" Storr).

The classification under consideration departs from that of Vicq d'Azyr (p. 53) in the following respects:

(1.) Vicq d'Azyr's orders "Taupens" and "Soriciens," including the moles and shrews are united with the arctoid carnivora, as in Storr's system, and are called "Plantigrades."

(2.) The "Verminei" of Storr, after the exclusion of *Viverra*, are separated, under the term "Vermiformes," from "les Carnivores" of Vicq d'Azyr.

(3.) Vicq d'Azyr's term "Pédimanes" which included, besides the monkeys and lemurs, the genera *Didelphis* and *Phalanger*, is restricted to include only the two last named genera and is thus coëxtensive with the "Plantares" of Storr.

(4.) "Les Rongeurs" includes besides the rodents, the Kangaroo, "Kangurus," which had been treated as a gigantic relative of the Jerboa by Erxleben in 1777.

(5.) The sloths, *Bradypus*, are separated from Vicq d'Azyr's "Édentés" as a new order "Tardigrada."

(6.) Vicq d'Azyr's "Empêtrés" are transferred to the "mammifères marines" under the term "Amphibies."

(7.) Vicq d'Azyr's "Cheveau d'eau" (*Hippopotamus*), "Eléphants," "Tapiriens" and "Porcini" are gathered together into the group "Pachydermes," which is exactly coëxtensive with Storr's modification of Linné's "Belluæ" and which long remained in use.

(8.) Finally the ordinal criteria employed are of the same nature as in Cuvier's later classifications; this is illustrated in all the ordinal definitions, one of which *e. g.*, that of the "Plantigrades" may suffice as an example: "Doigts unguiculés; trois sortes de dents; point de pouces séparés; plante entière appuyée."

From these considerations it is evident that this classification is inferior in its ideals, though not in its objective results, to that of Linnæus, since the characters of the feet and front teeth are given higher diagnostic value than the totality of characters drawn from all parts of the anatomy. Nor did any fundamental advance in principles appear in Cuvier's later schemes. This classification is relatively unilluminative in principle and founded upon superficial and adaptive characters. At the same time it was well suited to the age and although scarcely as good as Vicq d'Azyr's was in its objective results much in advance of that of Linnæus.

Geoffroy and Cuvier's classification of 1795.

Mammifères à ongles:

- Ordre I^e. Quadrumanes [Boddaërt].
- Ordre II^e. Chéiroptères [Blumenbach].
- Ordre III^e. Plantigrades [new term? Insectivores, plantigrade carnivora.]
- Ordre IV^e. Vermiformes [*cf.* "Verminei," of Ray and Storr] (Mephitis, Mustela, Lutra).
- Ordre V^e. Carnivores [Vicq d'Azyr] (Civetta, Hyæna, Canis, Felis).
- Ordre VI^e. Pédimanés [Vicq d'Azyr] (Didelphis, Phalangista).
- Ordre VII^e. Rongeurs [Vicq d'Azyr] (Kangurus, Dipus, Glis, Sciurus, Mus, etc.).
- Ordre VIII^e. Édentés [Vicq d'Azyr] (Myrmecophaga, Manis, Dasypus).
- Ordre IX^e. Tardigrades [*cf.* Brisson's "Tardigradus"] (Bradypus).

Mammifères à sabots:

- Ordre X^e. Pachydermes [? new term] (Elephantus, Rhinoceros, Hippopotamus, Tapir, Sus).
- Ordre XI^e. Ruminans [Vicq d'Azyr] (Camelus, Moschus, Cervus, Camelopardalis, Antilope, Capra, Ovis, Bos).
- Ordre XII^e. Solipèdes [Vicq d'Azyr] (Equus).

Mammifères marines:

- Ordre XIII^e. Amphibies [*cf.* "Empêtrés" Vicq d'Azyr] (Phoca, Rosmarus, Manatus, Trichecus [Dugong]).
- Ordre XIV^e. Cétacés.

G. CUVIER, 1798.

Cuvier's first original and independent classification of the mammalia is found in his 'Tableau Élémentaire de l'Histoire Naturelle des Animaux,' published in 1798. In this he unites the "Tardigrades," and "Édentés" under the single heading "Édentés," suppresses "les Vermiformes," and considers "les Cheiroptères," "les Plantigrades," "les Carnivores" et "les Pédimanes" as divisions of a single order "les Carnassiers." In this as we have seen (p. 47), he followed Blumenbach. The main lines of his definitive classification of the 'Règne Animal,' 1817 (*q. v.*), were thus already laid down before the year 1800. The 'Tableau Élémentaire' is also noteworthy because in it Cuvier uses the term "famille" (in the Neuropterous insects) as a division of an order (Palmer, 1902, p. 719). In this he was partly anticipated by Latreille in 1796 (Palmer), and we have already seen the germ of the idea in Blumenbach's "Sciurina," "Murina," etc. of 1779 (p. 45).

Cuvier's Classification of 1798.

(Compiled from the chapter headings of the 'Tableau Élémentaire'.)

Mammifères.

L'homme.

Quadrumanes.

Singes.

Makis.

Carnassiers.

Cheiroptères.

Chauve-Souris.

Galéopithèques.

Plantigrades.

Hérissons.

Musaraignes.

Taupes.

Ours (*Ursus*, *Blaireaux*, *Coati*, etc.)

Carnivores.

Martes.

Chats.

Chiens (*Canis*, "*Canis hyæna*," *C. crocuta*).

Civettes.

Pédimanes.

Didelphes (Marsupials, including the Kangaroo).

Rongeurs.

Porc-épics.

Lièvres.

Damans.

Cabiais.

Castors.

Écureuils (including squirrels and Aye-aye).

Rats.

Édentés.

Fourmiliers (*Myrmecophaga*, *Echidna*, *Manis*).

Orycterope.

Tatous.

Paresseux.

Éléphants.

Pachydermes.

Cochons.

Tapir.

Rhinocéros.

Hippopotame.

Ruminans.

Chameaux.

Chevrotains.

Cerfs.

Giraffe.

Antilopes.

Chèvres.

Brebis.

Bœufs.

Solipèdes.

Amphibies.

Phoques.

Morses.

Cétacés.

Dauphins.

Cachalots.

Baleines.

Narval.

LACÉPÈDE, 1799.

'Tableau des Divisions, Sous-Divisions, Ordres et Genres des Mammifères,'
pp. 1-18. Paris An. VII.

As regards the major divisions Lacépède's classification does not seem to be especially original either in content or in method, except in so far as it combines the features of earlier systems. It agrees with many early systems in grouping together all the "marine mammals." It agrees with Pennant's system in elevating the "Cheiroptères" to the rank of a grand division. In common with the systems of Geoffroy and Cuvier (1795) and Cuvier (1798) it suggests Storr's scheme in several respects, especially in the arrangement of the Ungulates and in interposing several grades of divisions between the class and the order. From Brisson, apparently, is borrowed the general idea of dividing the mammals into many orders on the basis of the number and kind of teeth.

More detailed relations of Lacépède's classification to those of his contemporaries are shown in the subjoined table.

Comparison of early classifications by Cuvier and his contemporaries.

VICQ D' AZR, 1792.	GEOFFROY AND CUVIER, 1795.	G. CUVIER, 1798.	LACÉPÈDE, 1799.	G. CUVIER, 1800.
Pédimanes [Primates plus Didelphis etc.].	<i>Mammifères à ongles</i>	<i>Mammifères à ongles.</i>	<i>Quadrupèdes proprement dis.</i>	<i>Mammifères à ongles.</i>
Rongeurs.	Quadrumanes.	Quadrumanes.	Quadrumanes.	(1) <i>Les trois sortes de dents.</i>
Alle-pieds.	Chéiroptères.	Carnassiers.	Ordre I. [Primates].	Bimanés.
Taupens.	Plantigrades.	Chéiroptères.	Pédimanes.	Quadrumanes.
Sorticéens.	Vermiformes.	Plantigrades.	Ordres II, III. [Marsupials & Aye Aye].	Carnassiers.
Édentés.	Carnivores.	Carnivores.	Plantigrades.	Chéiroptères
Carnivores	Pédimanes	Rongeurs.	Ordre IV. [Ursus, Coati etc. & Insectivores.]	Plantigrades
Empétrés.	Édentés.	Édentés.	Digitigrades.	Carnivores.
Cheveaux d'eau	Tardigrades.	Ordre V. Carnassiers.	Ordre VI. Rongeurs.	Pédimanes.
Éléphants.	<i>Mammifères à sabots</i>	Pachydermes.	Ordre VII. Bradypus.	Rongeurs.
Tapiriens.	Ruminans.	Ruminans.	Ordre VIII. Da syrus, Orycteropus.	Édentés.
Porcini.	Solipèdes.	Solipèdes.	Ordre IX. Myrmecophaga, Echidna, Manis	Tardigrades.
Ruminans.	<i>Mammifères marines</i>	Amphibiles.	Pachydermes	<i>Mammifères à sabots.</i>
Solipèdes	Amphibiles.	Cétacés.	Ordre X. Sus, Tapirus. Hippopotamus.	Pachydermes.
			Ordre XI. Elephas.	Ruminans.
			Ordre XII. Rhinoceros.	Solipèdes.
			Bisulques, ou Ruminans.	<i>Mammifères à pieds en nageoire.</i>
			Ordre XIII. Camelus, Moschus.	Amphibies (Phoques, Morses).
			Ordre XIV. [remaining Pecora].	Cétacés [Sireniens, Cetaceans].
			Solipèdes.	
			Ordre XV. Equus.	
			<i>Mammifères ailés.</i>	
			Chéiroptères.	
			Ordre XVI. [Bats, Galeosmithus].	
			Ordre XVII. Noctilio.	
			<i>Mammifères marines.</i>	
			Empétrés.	
			Ordre XVIII. Phoca, Trichechus.	
			Ordre XIX. Dugong.	
			Ordre XX. Manatus.	
			Cétacés.	
			Ordre XXI. [Odontocetes].	
			Ordre XXII. Balæna.	

Lacépède's Classification of 1799.

(Summarized.)

Division I. Point d'ailes membraneuses ni de nageoires. **QUADRUPÈDES** proprement dis.

Sous-Division I. Les quat e pieds en forme de mains. **QUADRUMANES.**

Ordre I. Dents incisives, laniaires et molaires.

Genres: *Simia*, *Cercopithecus*, *Sapajou*, *Sagouin*, *Alouatta*, *Maccaca*, *Pongo*, *Cynocephalus*, *Lemur*, *Indri*, *Lori*, *Macrotarsus*, *Galago*.

Sous-Division II. Les pieds de derrière en forme de mains. **PÉDIMANES.**

Ordre II. Dents incisives, laniaires et molaires.

Genres: *Didelphis*, *Dasyurus*, *Cœscoes*, *Phalanger*.

Ordre III. Dents incisives et molaires.

Genres: *Kangaroo*, *Aye-aye*.

Sous-Division III. La plante des pieds articulée de manière à s'appuyer sur la terre quand l'animal marche. **PLANTIGRADES.**

Ordre IV. Dents incisives, laniaires et molaires.

Genres: *Ursus*, *Coati*, *Kinkajou*, *Ichneumon*, *Erinaceus*, *Tenrec*, *Sorex*, *Desman*, *Chrysochloris*, *Talpa*.

Sous-Division IV. Les doigts sans sabots. **DIGITIGRADES.**

Ordre V. Dents incisives, laniaires et molaires. **Carnassiers.**

Genres: *Canis*, *Felis*, *Viverra*, *Mustela*.

Ordre VI. Dents incisives et molaires. **Rongeurs.**

Genres: *Lepus*, *Pika*, *Hyrax*, *Cavia*, *Agouti*, *Castor*, *Ondatra* (*O. zibethicus*), *Arctomys*, *Hamster*, *Mus*, *Arvicola*, *Myoxus*, *Talpoïdes* (*T. typhlis*), *Dipus*, *Sciurus*, *Hystrix*, *Coendu*.

Ordre VII. Dents laniaires et molaires.

Genre: *Bradypus*.

Ordre VIII. Dents molaires.

Genres: *Dasyus*, *Orycteropus*.

Ordre IX. Point de dents.

Genres: *Myrmecophaga*, *Echidna*, *Manis*.

Sous-Division V. Les doigts renfermés dans une peau très-épaisse, ou plus de deux sabots. **PACHYDERMES.**

Ordre X. Dents incisives, laniaires et molaires.

Genres: *Sus*, *Tapirus*, *Hippopotamus*.

Ordre XI. Dents incisives et molaires.

Genre: *Elephas*.

Ordre XII. Dents molaires.

Genre: *Rhinoceros*.

Sous-Division VI. Deux sabots. **BISULQUES**, ou **Ruminans.**

Ordre XIII. Dents incisives, laniaires et molaires.

Genres: *Camelus*, *Moschus*.

Ordre XIV. Dents incisives et molaires.

Genres: *Cervus*, *Camelopardalis*, *Antilope*, *Capra*, *Ovis*, *Bos*.

Sous-Division VII. Un seul sabot. **SOLIPÈDES.**

Ordre XV. Dents incisives, laniaires et molaires.

Genre: *Equus*.

Division II. Des ailes membranenses. MAMMIFÈRES AILÉS.

Sous-Division I. Les pieds de devant garnis de membranes en forme d'ailes.
CHEIROPTÈRES.

Ordre XVI. Dents incisives, laniaires et molaires.

Genres: Vespertilio, Spectrum, Rhinolophus, Phyllostomus, Galeopithecus.

Ordre XXII. Dents laniaires et molaires.

Genre: Noctilio.

Division III. De nageoires. MAMMIFÈRES MARINES.

Sous Division I. Les pieds de derrière en forme de nageoires. EMPÊTRÉS.

Ordre XVIII. Dents incisives, laniaires et molaires.

Genres: Phoca, Trichecus (T. rosmarus).

Ordre XIX. Dents laniaires et molaires.

Genre: Dugong.

Ordre XX. Dents molaires.

Genre: Manatus.

Sous-Division II. Point de pieds de derrière. CÉTACÉS.

Ordre XXI. Dents molaires.

Genres: Delphinus, Physeter, Monodon.

Ordre XXII. Point de dents.

Genre: Balæna.

G. CUVIER, 1800.

‘Leçons d’Anatomie Comparée.’

In 1800 the ‘Tableau Elementaire’ was supplemented by the first volume of the ‘Leçons d’Anatomie Comparée’ (Paris An. VIII) which continued to appear at intervals. In this work the osteology, myology, histology and other branches of the morphology of man, the mammals, birds, reptiles, fishes and invertebrates, are very fully treated.

Cuvier was hardly the founder of comparative anatomy to the same degree in which he may be said to be the founder of vertebrate palæontology. He found in Paris an active group of naturalists and anatomists, and the collaboration with his older colleague Geoffroy may be said to have inducted him into the subject. As he himself cheerfully acknowledges in the work now under consideration he was inspired to his own famous investigations by the example of Bloch, Fabricius, Ray, Linnæus, Klein, Buffon, Daubenton, Mertrud, Duvernoy, Vicq d’Azyr, Geoffroy, Lacépède, and Lamarck, as well as of Pallas and other naturalist explorers.

If, however, Cuvier did not create comparative anatomy, he at least organized it. Under his hand both the content and methods of the subject expanded so enormously as to justify the general opinion that he was “practically the creator of comparative anatomy and palæontology in their modern shape” (Huxley, 1894, p. 312).

The classification of the mammals given in the 'Leçons d'Anatomie Comparée,' notwithstanding the favor with which it was generally and long received, reveals no important new principles and reflects relatively little of Cuvier's unrivalled knowledge of comparative anatomy. As Gill (1907, p. 497) has so clearly expressed it: "Cuvier manifestly allowed himself to be influenced by the sentiment prevalent in his time that systematic zoology and comparative anatomy were different provinces. It may, indeed, seem strange to make the charge against the preeminent anatomist, that he failed because he neglected anatomy, but it must become evident to all who carefully analyze his zoological works that such neglect with his prime fault. He, in fact, treated zoology and anatomy as distinct disciplines, or, in other words, he acted on the principle that animals should be considered independently from two points of view, the superficial, or those facts easily observed, and the deep-seated or anatomical characters." And yet this cannot be altogether true in the present instance, or else Cuvier would have left *Hyrax* among the Rodents and *Hydrochaerus* with the Ungulates.

When examined in detail the classification given below exhibits the following features in addition to those already noted:

(1.) The term "ordre" is replaced by "famille," which is really used in a superordinal sense.

(2.) The old three-fold division of the mammals (*cf.*, Linnæus, Storr, Blumenbach and others) into Unguiculates, Ungulates and marine mammals is followed with a change of names.

(3.) The descriptive phrase, last seen in Brisson 1762, here reappears for the larger divisions. In fact, the methods of Brisson, with whose work Cuvier was doubtless familiar, are suggested throughout.

(4.) The Unguiculates are divided into two major groups according to the presence or absence of the three kinds of teeth (*cf.* Brisson's orders I-III, and Lacépède's groups, which were founded on similar considerations).

(5.) The Rodents and Edentates are contrasted with all the higher Unguiculates.

(6.) The relation of digit I to the other fingers is selected as of ordinal importance in "Bimanes," "Quadrumanes," "Plantigrades," "Carnivores" and "Pédimanes." This feature had been more or less foreshadowed by Blumenbach, Storr and Geoffroy.

(7.) The old group "Verminei" is here reduced to a subdivision (corresponding to a family) of "les Carnivores," but is still placed between the plantigrade carnivores and the typical digitigrade carnivores.

(8.) The Linnæan genera have now been split up in many cases and a great number of new genera, described by various authors, appear. In fact the great expansion in the content of mammalogy is very noticeable.

(9.) The genera are grouped under common names of typical forms ("Makis," "Ours," "Civettes," "Chats," etc.), corresponding to the modern suborders or families, which are also named from typical genera.

(10.) Although in this classification there is no hint of the sharp separation between functional analogies and true homologies (so that we find many erroneous associations: *cf.* Aye-Aye in Rodents, Marsupials with Carnivores, "*Kangurus*" with Rodents, *Manatus* with Cetacea, *Echidna* with Edentates, etc.), yet, with the rapidly expanding knowledge of structure, certain old errors (*e. g.*, *Hyrax* with Rodents, *Cercoleptes* with Lemurs, *Hydrochærus* with Ungulates) are corrected.

(11.) The classification as a whole is a conservative development of preceding systems and cannot be compared in originality (even if more effective) with Linné's system. It relies upon a very narrow range of characters, *viz.*: (a) the older criteria of foot structure for the main divisions [equivalent to subclasses]; (b) dental characters for the main subdivisions [equivalent to superorders] of Ungulates; and (c) detailed foot structure for the orders.

Cuvier's Classification of 1800.

Mammifères	A ongles	Les trois sortes de dents.	Fam. I. Les Bimanes. Pouces séparés aux extrémités supérieures seulement.	Homme..... Homo. (Homo)	Pithecus. Callithrix. Cercopithecus. Cynocephalus Papio. Cebus. Lemur. Indris. Loris. Galago. Tarsius. Pteropus. Vespertilio Rhinolophus. Phyllostoma. Noctilio. Galeopithecus.
			F. II. Les Quadrumanes. Pouces séparés aux quatre pieds.	Singes..... (Simia) Makis..... (Lemur)	
			A. Les Cheloptères. Mains alongées: membranes s'étendant du col à l'anus, entre les pieds.	Chauve-souris.. (Vespertilio) Galéopithèques.. (Galeopithecus)	
			F. III. Les Carnassiers. B. Les Plantigrades. Point de pouces séparés: plante entière du pied appuyée sur le sol.	Hérissons..... (Erinaceus) Musaraignes... (Sorex) Taupes..... (Talpa) Ours..... (Ursus)	Erinaceus. Setiger [Centetes]. Sorex. Mygale. Chryso-Chloris. Scalops. Talpa. Ursus. Taxus. Nasua. Procyon. Potos [Cercoleptes]. Ichneumon.

Mammifères.	A ongles	Les trois sortes de dents.	F. III. Les Carnassiers.	C. Les Carnivores. Point de pouces séparés; pieds n'appuyant que sur les doigts.	Martes..... (Mustela)	Mustela.
					Civettes.....	Lutra.
					Chats.....	Mephitis.
					Chiens.....	Viverra.
					(Canis)	Felis.
						Canis.
						Hyaena.
				D. Les Pédimanes. Pouces séparés aux pieds de der- rière seulement.	Didelphes..... (Didelphis)	Didelphis.
						Dasyurus.
						Phalangista.
	Défaut d'une sorte de dents.	F. IV. Les Rongeurs. Défaut de canines seulement.		Kangourous.....	Kangurus [Macropus].	
				Porc-épics.....	Hystrix.	
				Lièvres.....	Lepus.	
				(Lepus)	Lagomys.	
				Cabiais.....	Hydrochoerus.	
					Cavia.	
				Castors.....	Castor.	
				Ecureuils.....	Pteromys.	
					Sciurus.	
				Aye-Aye.....	Cheiromys.	
	A sabots.	F. V. Les Édentés. Défaut d'in- cisives et de canines.		Rats.....	Arctomys.	
				(Mus)	Lemmus.	
					Fiber.	
					Mus.	
					Cricetus.	
					Spalax.	
					Dipus.	
					Myoxus.	
					Myrmecophaga.	
					Echidna.	
	A pieds en nageoire.	F. VI. Les Tardigrades. Défaut d'incisives seulement.		Fourmiliers....	Manis.	
				(Myrmeco- phaga)		
				Oryctéropes.....	Orycteropus.	
				Tatous.....	Dasypus.	
				Paresseux.....	Bradypus.	
					Megatherium.	
			F. VII. Les Pachydermes. Plus de deux doigts: plus de deux sabots.	Éléphants.....	Elephas.	
				Tapirs.....	Tapirus.	
				Cochons.....	Sus.	
				Hippopotame..	Hippopotamus.	
	A pieds en nageoire.	F. VIII. Les Ruminans. Deux doigts: deux sabots.		Daman.....	Hyrax.	
				Rhinocéros....	Rhinoceros.	
				Chameaux.....	Camelus.	
					Lama.	
				Chevrotains....	Moschus.	
				Cerfs.....	Cervus.	
				Giraffe.....	Camelo-Pardalis.	
				Antilopes.....	Antilope.	
				Chèvres.....	Capra.	
				Brebis.....	Ovis.	
	A pieds en nageoire.	F. IX. Les Solipèdes. Un seul doigt: un seul sabot.		Bœufs.....	Bos.	
				Cheval.....	Equus.	
			F. X. Les Amphibies. Quatre pieds.	Phoques.....	Phoca.	
				Morses.....	Trichecus.	
				Lamantins.....	Manatus.	
				Dauphins.....	Delphinus.	
				Cachalots.....	Physeter.	
				Baleines.....	Balæna.	
				Narval.....	Monodon.	
				F. XI. Les Cétacés. Point de pieds de derrière.		

CUVIER AS THE FOUNDER OF VERTEBRATE PALÆONTOLOGY, 1796-1836.

A by-product of Cuvier's early studies in comparative anatomy and mammalogy was his interest in the fossilized remains of animals. As early as January, 1796, he announced to the Institute (Mem. Inst. 1^{re} classe, Math. et Phys., tome II, pp. 20-21) that the fossil elephants which had been known from the earliest times and had formed the subject of a great number of writings were of a species different from the Indian Elephant. This was his first important palæontological discovery.

Cuvier's first independent contribution to mammalogy was his description of the *Megatherium* in the 'Magasin Encyclopédique,' Vol. III, An IV (1796). (Palmer 1904, p. 406.) The year 1796 may consequently be regarded as the date of the founding of Vertebrate Palæontology. This was followed by the first 'Mémoire sur les espèces d'Éléphants vivants et fossiles' (1799), by the memoirs 'Sur le Mégalonix....' (1804), 'Sur le Megatherium....' (1804), 'Sur les elephans vivants et fossiles' (1806), 'Sur le grand mastodonte' (1806); and "Sur différentes dents du genre des mastodontes" (1806); the palæontological researches finally culminating in the famous 'Ossemens fossiles' in 1812, 1821, 1825, and 1834-1836 (Hay, 1902, pp. 72, 73).

DUMÉRIL, 1806.

'Zoologie Analytique ou Méthode Naturelle de Classification des Animaux'.
Paris, 8vo.

Duméril examines in detail the principles of a natural classification. He rejects life-habits as criteria for major classification (contrast Linnæus); he rejects also criteria based solely on the general or external appearance ("superficie"); and finally he rejects classifications based on the variations however slight of a single organ. He declares further that of late it had come to be recognized (*cf.* Daubenton, p. 41 above), that the principal end of natural history being the study of species, instead of building artificial classifications and then proceeding *a priori* to study species (*cf.* Brisson), we should study the latter directly, constantly comparing each with each, and thus gradually recognizing the larger assemblages. From this, he says, springs the natural method of classification, which although "still very imperfect, corrects its own errors each day and tries to fill up the gaps which it sees indicated in advance." Botany (*cf.* Ray, Linnæus) may furnish examples and ideals of method, but these are not to be followed slavishly. Duméril protests against the straining of characters in order to fit some

preconceived scheme, a procedure resulting in the wide separation of genera obviously related.

He protests also against the blind following of the character of one organ or set of organs in the definition of orders and genera, and he cites examples (*l. c.*, p. xv) to prove that animals differing in many essential characters may yet show close resemblances in certain organs; that is, he recognizes that analogical resemblances should not be used to connect otherwise unrelated organisms.

Duméril's classification is based upon that of Cuvier and Geoffroy, with certain modifications "which seemed to help the progression of the system [*i. e.*, in regard to the natural sequence of the genera]," especially in the rodents, marsupials, "Amphibies," and Cetaceans.

The purpose of the section on the mammals, he tells us, is to complete the table of classification given by Cuvier in 1800 (in the '*Leçons d'Anatomie Comparée*') by extending the same methods of analysis and presentation to the genera. As in Brisson's scheme, a series of dichotomous branchings by means of brackets is arranged under each order. In the section on les "Pédimanes ou Marsupiaux" the genera "Sarigue," "Peramèle," "Dasyure," "Wombat," "Coëskoës," and "Phalanger" appear. "Le Kangaroo" furnishes the transition to "les Rongeurs" and appears at the head of that order.

In short, Duméril's work shows that more fundamental principles of classification were being discovered; but his classification is essentially Cuvierian, first, in not recognizing the subclass rank of the Marsupials and their entire independence from the Rodents and Carnivores and, secondly, in endeavoring to find a *natural sequence* of genera leading from order to order.

ILLIGER, 1811.

'Prodromus Mammalium et Avium.'

The work cited above further illustrates the great increase in the content of mammalogy during the half century that had elapsed since the tenth edition of the '*Systema Naturæ*.' Illiger, in contrast with most other naturalists of that time, attempted to cover only a limited territory (mammals and birds in contrast with the Animal Kingdom) in a concise and thorough manner,—an indication of increasing specialization, due to rapidly extending knowledge. The work contains careful generic definitions, an extensive glossary of technical terms, an etymology of generic terms and other commendable lexicographical features and was highly praised by Illiger's contemporaries (*cf.* Latreille, 1825, p. 2).

Illiger's classification appears to be a development of Blumenbach's and Storr's systems, with details from other writers. It contains little that was new in principle, the prime criteria of classification being foot-structure.

In common with most writers of the period Illiger knew nothing of the modern "law of priority," especially as applied to larger groups, and apparently never used a group name of another author if he thought he could invent a more appropriate one. Consequently his classification is chiefly remarkable for the number of new terms, some applied to old groups, some to new orders; and "familie" (*cf.* the "famille" of Cuvier, and the "familia" of Klein). Some of these names of "familie," including "Prosimii," "Duplicidentata," "Proboscidea," "Tylopoda," "Dermoptera," "Pinnipedia" (not of Storr), and "Sirenia," are applied to orders or suborders at the present day. Because he wrote in Latin and used monomial group terms, Illiger is also reckoned as the technical author of "Marsupialia," which had long been used in the French form.

Perhaps the most original feature of Illiger's system is the sequence of the groups. The "Erecta" are followed by the "Pollicata" which end with the Rodent-like *Phascolomys*. This is followed by the order "Salientia" (Kangaroos) which, as in Cuvier's scheme, thus lead to the adaptively similar *Dipus* and *Pedetes* of the "Prensiculantia" (= Rodents). This group in turn ends in the "Subungulata" (including *Cavia* and *Hydrochærus*), which form the transition to the "Multungula," beginning with *Hyrax*. The Ungulate series culminates in the "Bisulca." The Edentates have always been a stumbling-block in any linear arrangement of the orders ever since Ray called them "Quadrupeda anomala"; they had usually been placed ahead of the ungulates, but as they interfered with the sequence described above Illiger placed them after the ungulates. They begin with *Bradypus* (which, as most resembling the Primates, may have been conceived as the "highest") and end with the Scaly Anteater, which affords the desired transition to the Spiny Anteater (*Echidna*) of the "order" "Reptantia." Still another series of orders begins with a Primate-like form (*Galeopithecus*), and is followed by the Chiroptera which thus precede the Insectivores ("Subterranea"). These in turn lead to the "Plantigrada," while the last member of the order is the aquatic *Lutra*, which thus stands next to the Pinnipedia, which in turn lead to the Cetacea.

Illiger's Classification of 1811.

(Summarized).

- Ordo I. Erecta¹ [cf. "Bimana" Blumenbach].
 Fam. Erecta. Homo.
- Ordo II. Pollicata.¹
 Fam. Quadrumana [Blumenbach].
 " Prosimii¹ (cf. Prosimia Storr).
 " Macrotarsi [cf. Macrotarsus Lacépède] (Tarsius, Otolicnus).
 " Leptodactyla¹ (Chiromys).
 " Marsupialia [cf. Geoffroy] (Didelphys, Chironectes, Thylacis [=Perameles Geoff.], Dasyurus Geoff., Amblotis [=Wombat], Balantia [=Phalanger orientalis], Phalangista, Phascolumys).
- Ordo III. Salientia¹ [new order, cf. Jaculus Erxleben].
 Fam. Salientia (Hypsiprymnus Halmaturus).
- Ordo IV. Prensiculantia¹ ["Pfötler," *i. e.*, scratching with the front paws; new term.]
 Fam. Macropoda¹ (Dipus, Pedetes, Meriones).
 " Agilia¹ (Myoxus, Tamias, Sciurus, Pteromys).
 " Murina [Blumenbach] (Arctomys, Cricetus, Mus, Spalax, Bathyergus).
 " Cunicularia¹ (Georychus, Hyudæus [=Lemming], Fiber).
 " Palmipeda¹ [cf. Palmata Blumenbach, applied to a somewhat different assemblage] (Hydromys, Castor).
 " Aculeata¹ (cf. Acanthion Klein) (Hystrix, Loncheres).
 " Duplicidentata¹ (Lepus, Lagomys).
 " Subungulata¹ (Cœlogenys, Dasypsecta, Cavia, Hydrochœrus).
- Ordo V. Multungula [Blumenbach].
 Fam. Lamnungaia¹ (Lipura ["Hyrax hudsonius" Schreber, "Tailless Marmot" Pennant], Hyrax).
 " Proboscidea¹ (Elephas).
 " Nasicornia¹ (Rhinoceros).
 " Obesa¹ (Hippopotamus).
 " Nasuta¹ (Tapirus).
 " Setigera¹ (Sus).
- Ordo VI. Solidungula [Blumenbach].
 Fam. Solidungula¹ (Equus).
- Ordo VII. Bisulca [Blumenbach].
 Fam. Tylopoda¹ (Camelus, Auchenia).
 " Devexa¹ (Camelopardalis).
 " Capreoli¹ (Cervus, Moschus).
 " Cavicornia¹ (Antilope, Capra, Bos).
- Ordo VIII. Tardigrada [Geoff. & Cuvier].
 Fam. Tardigrada (Bradypus, Prochilus [=Melursus]).
- Ordo IX. Effodientia.¹

¹ New term.

- Fam. Cingulata¹ (Tolypeutes, Dasypus).
 " Vermilingua¹ (Orycteropus, Myrmecophaga, Manis).
 Ordo X. Reptantia¹.
 Fam. Reptantia¹ (Tachyglossus, Ornithorhynchus, Pamphractus).
 Ordo XI. Volitantia¹.
 Fam. Dermoptera (Galeopithecus).
 " Chiroptera [Blumenbach] (Pteropus, Harpyia, Vespertilio, Nycteris, Rhinolophus, Phyllostomus, Noctilio, Saccopteryx, Dypsopses).
 Ordo XII. Faculata¹ [cf. "les Carnassiers" Cuvier].
 Fam. Subterranea¹ (Erinaceus, Centetes, Sorex, Mygale, Condylura, Chrysochloris, Scalops, Talpa).
 " Plantigrada¹ (Cercopithecus, Nasua, Procyon, Gulo, Meles, Ursus).
 " Sanguinaria¹ (Megalotis, Canis, Hyæna, Felis, Viverra, Ryzæna [Viverra tetradactyla]).
 " Gracilia¹ (Herpestes Mephitis Mustela, Lutra).
 Ordo XIII. Pinnipedia (cf. Storr).
 Fam. Pinnipedia (Phoca, Trichechus [Walrus]).
 Ordo XIV. Natantia¹ [cf. "les Amphibies" Cuvier].
 Fam. Sirenia (Manatus, Halicore, Rytina).
 " Cete (Balæna, Ceratodon [Narwal], Ancydon [Hyperoödon], Phæseter, Delphinus, Uranodon [Hyperoödon]).

THE "PHILOSOPHICAL ZOÖLOGISTS," CIRCA 1783-1847.

In the work of Cuvier and the majority of his contemporaries the principles of classification adopted were largely such as naturally flowed from a practical acquaintance with zoölogical material; the criteria of classification were for the most part of the convenient but rather superficial kind that had been adopted by the fathers of zoölogy. Ideas as to what constituted the ultimate basis of a natural classification were still confused. *Descent with modification* as the cause both of divergent structure and of homological resemblances remained virtually undiscovered or at best but imperfectly perceived (Goethe). Many partly false explanations of homological resemblances and equally misleading criteria of classification sprang up, ranging in character from the elaborate, purely "metaphysical" and mediæval speculations of Oken to the relatively simple and at least rather fruitful conceptions of the unity of type, held in different forms by Goethe, Geoffroy St. Hilaire, Owen, de Blainville, etc.

The movement has been fully treated in various aspects by Huxley (1894, pp. 283-304), Osborn (1899, pp. 122-127, 181-187) and Gill (1907, pp. 501-502) and therefore here requires notice only in so far as it affected the ordinal classification of the Mammalia.

¹ New term.

Of Goethe's part in this movement Huxley says (1894, p. 291): "I do not think that anyone who studies these works [on the intermaxillary bone of man, on osteology generally and on the metamorphoses of plants], in many ways so remarkable, can doubt that, in the last two decades of the eighteenth century, Goethe arrived, by a generally just, though by no means critical, process of induction, at the leading theses of what were subsequently known as *Natur-philosophie* in Germany, and as *Philosophie anatomique* in France; in other words, that he was the first person to enunciate and conceive as parts of a systematic whole, whatever principles of value are to be met with in the works of Oken, Geoffroy, and Lamarck."

The theory of the "unity of organization" was also developed by Vicq d'Azyr, in its application to the limbs of the higher vertebrates, and especially by the elder Geoffroy (see p. 57), and it influenced profoundly de Blainville's remarkable classification of 1816 (see p. 75), while it also resulted in Owen's elaborate contributions to the "archetypal" theory of the vertebrate skull and of the structure of limbs.

In Oken's hands (1821) these general ideas resulted in a classification of the mammalia in which the primary criteria were certain assumed resemblances in function between the different systems of the human economy and corresponding classes of animals. Isidore Geoffroy (1826, p. 71) has thus summarized this absurd system:

"The celebrated German anatomist tries to establish in this work that the Animal Kingdom is developed in the same order as the organs in the animal body, and that it is these organs which form, characterize and represent the classes; that there are just as many classes of animals as there are organs; and that, in a scientific system, these classes ought to be named from the organs." Oken then applies these ideas to the formation of orders and families, and divides the Mammifers, which he calls "Animals with senses," or "Sensiers," into five orders:

1. "Les Germiers," divided into "Spermiers," "Oviers" and "Fétiers" [Rodents].
- II. "Les Sexiers" [Insectivores and Marsupials].
- III. "Les Entrailleurs" [Monotremes and Edentates].
- IV. "Les Carniers" [Cetacea, Ruminants and Pachyderms].
- V. "Les Sensiers" [Pinnipeds, plantigrades, digitigrades, Chiroptera, Quadrumana and Man]. (I. Geoffroy, 1826, p. 71).

Possibly this system may have been developed from the suggestion of Lamarck that animals could be distributed under three categories: "(1) apathetic animals and (2) sensitive animals among the invertebrates, and (3) intelligent animals, equivalent to the vertebrates" (Gill, 1907, p. 501).

In the 'Allgemeine Naturgeschichte' (1838) Oken proposed another

classification which was even more impracticable and aberrant. The mammals were classified into three groups, lower, middle and higher, each of these divided again into lower, middle and higher stages, the stages again into orders.

In England the "metaphysical" school was represented especially by Macleay and by Swainson.

The "Circular System" of Macleay was proposed in 1819-21 in a rare work called '*Horæ Entomologicæ or Essays on the Annulose Animals.*' According to Swainson (1835, pp. 198-199) the germs of this "natural method" may be found in the work of Herrmann, '*Tabula Affinitatum Animalium,*' 1783, which "contains numerous comparisons, and many valuable observations, on the resemblances which different animals bear to each other. . . . Herrmann seemed to have no clear perception of the difference between analogy and affinity, although, like most others who had gone before him, he did not confound them when treating of very remote resemblances."

Macleay's system was suggested by a study of Lamarck's views of the branching nature of natural series. Macleay conceived the idea that the terminal branches exhibited affinities, and thus the circuit, to use a modern simile, would be completed.

The circular system was developed in the erudite but very "metaphysical" works of William Swainson, especially in his '*Treatise on the Geography and Classification of Animals*' (1836, pp. 224-225). The primary theses finally enunciated by Swainson were as follows:

"I. That every natural series of beings, in its progress from a given point, either actually returns, or evinces a tendency to return, again to that point, thereby forming a circle.

"II. The primary circular divisions of every group are three actually, or five apparently.

"III. The contents of such a circular group are symbolically (or analogically) represented by the contents of all other circles in the animal kingdom.

"IV. That these primary divisions of every group are characterised by definite peculiarities of form, structure, and economy, which, under diversified modifications, are uniform throughout the animal kingdom, and are therefore to be regarded as the PRIMARY TYPES OF NATURE.

"V. That the different ranks or degrees of circular groups exhibited in the animal kingdom are NINE in number, each being involved within the other."

In brief it was held that "creative power delighted in the symmetry of numbers and in circular arrangements" (Gill, 1907, p. 501). These "cir-

cularian" and "trinitarian" principles are maintained by Swainson at great length. The idea of "wheels within wheels" is worked out in such detail that the reader, reminded of the endless cycles and epicycles of the Ptolemaic astronomy, or of the metaphysical arguments used by Copernicus to establish the sphere as the universal figure of the heavenly bodies, becomes lost in the bewildering labyrinth of "affinities" and analogies. Nevertheless, the idea which was dimly adumbrated in Blumenbach's "*Palmata Glires*," "*Palmata Feræ*" etc., namely that similar functional types, such as the "rasorial," "scansorial," "natatorial," "gliriform," "vermiform," occur in different orders, and the related idea of the parallelism of series, as well as the prolonged analysis of "analogies" *vs.* "affinities," all foreshadow the modern discovery of parallel evolution and adaptive radiation; while the whole movement of "philosophical zoölogy" was of great value, not only in stimulating search for the causes of resemblances and differences among animals, but also because, in one of its less extreme forms it guided de Blainville to the remarkable classification which may now be considered.

DE BLAINVILLE, 1816.

'Prodrome d'une nouvelle distribution systématique du règne animale.'

Bull. de la Soc. philom. pour l'année 1816, p. 105.

Journ. de phys., t. 83, p. 244.

The labors of the long series of naturalists from Ray to Cuvier, whose systems have been examined above, had brought to light before 1816 many of the fundamental problems of mammalian taxonomy. The relations of the aquatic mammals to each other and to their terrestrial congeners, the problem of the edentates, the arrangement of the ungulates, the relations of the monotremes and marsupials to other mammals and to the lower vertebrates, the greater problem of the essential nature of "natural" groups,—all these had been formulated, and many contradictory answers had been given. But the net result, in so far as expressed in Cuvier's system, was an ordinal classification still very artificial. The latter was merely a development of the systems of Storr, Blumenbach, Vicq d'Azyr and Geoffroy; and although more brilliant in form and improved in many details, did not withal rise much above these in underlying principles. Cuvier, as remarked by Gill (1907, p. 497) made but little use of his wide knowledge of anatomy in the construction of his ordinal arrangement of the mammals, but followed his predecessors in selecting as prime criteria of classification characters of the kind now regarded as relatively plastic and unstable, such as the number of the three sorts of teeth, the number of the digits, the various modifications of the extremities.

In the meanwhile, the theory of the unity of organization, advocated by Vicq d'Azyr and Geoffroy Saint-Hilaire, and destined to be developed into fantastic extremes by Oken and his school, implied the existence of hidden bonds of affinity between outwardly dissimilar animals, a problem which had evidently engaged the attention of Linnæus. The correlated principle of analogous adaptations in different orders, was being slowly brought to the foreground through the studies of Geoffroy Saint-Hilaire, Lamarck, Frédéric Cuvier, and de Blainville on the monotremes and marsupials, although in the Cuvierian system these perplexing groups still remained mingled with their placental analogues, and the whole problem of parallelism was very imperfectly formulated (see pp. 52, 74). At this juncture Henri Marie Ducrotay de Blainville, guided by his thorough studies of monotreme and marsupial anatomy, and especially by his theory of the continuous approach toward and divergence from ideal prototypes, evolved the remarkable classification given in his '*Prodrome d'une nouvelle distribution systematique du regne animal*,' a classification which was perhaps the most brilliant contribution in the entire history of the subject.

De Blainville was not satisfied with superficial criteria, or with results which recommended themselves either by their appeal to commonly accepted standards or by reason of their mnemonic convenience. He drew his major criteria of classification from the characters of the reproductive system and of the skull, and although his scheme rested in part upon a theory stigmatized as "metaphysical," it was nevertheless more searching in its method and more natural in its results than the Cuvierian system. Cuvier's classification however had gained wide acceptance, because it was clear and practicable and strong in its appeal to common sense. De Blainville's was essentially esoteric, recondite, and repugnant to long accepted opinions and usages and, moreover, as a product of "philosophical zoology," it encountered the powerful and very effective opposition of Cuvier. Accordingly the merit of de Blainville's tripartite division of the Mammals and the reasons for associating in the same "ordre" such widely dissimilar groups as the Proboscidea and Sirenia (see below, p. 407) were but tardily perceived, and we find Frédéric Cuvier in his work of 1825 ('*Des Dents des Mammifères, considérées comme Caractères zoologiques*') still arranging the orders of mammals according to the number and superficial characters of the teeth.

Coming to a nearer examination of de Blainville's classification we first note that it seems permeated with the idea of *adaptation* and the resulting obscurement of affinities. This is seen in the union of assemblages with the normal limb-type of their order with other groups classed as "anomaux" and extremely unlike them in external appearance but supposed nevertheless to represent the same "degree of organization." Thus the Cetacea are

doubtfully bracketed with the Edentates as being "Anomaux pour nager," while the Sirenians are separated from the Cetaceans and bracketed with the "Ongulogrades" as "Anomaux pour nager." These two steps alone (whatever may be said as to their permanent value) indicate a quite Linnaean search for affinities hidden beneath the disguise of divergent adaptations. The Cuvierian system (at least in its early form) may be said to have failed for the most part to discriminate between these two great classes of characters.

Notwithstanding the confusing analogies presented by Marsupials and Monotremes with other orders the two groups are set off in a division ("Didelphes") coördinate with that of all the other mammals ("Monodelphes"); while a foot-note explains that the Monotremes might perhaps form a separate subclass. This great step, perhaps the most important one in the history of the classification of mammals, had (as already noted) been fully prepared for by the discussions of Lamarck, Geoffroy and the brothers Cuvier, which had also brought forward the problem of the value of the reproductive system as a major criterion of classification; but it remained for de Blainville to appreciate fully the taxonomic bearings of these facts.

De Blainville was apparently the first to use the subclass ("sous-classe") in its modern sense. His "ordres" are seen to correspond to superorders or even cohorts (p. 49). They are held together by the deeper characters of the brain and skull, while their subdivisions are defined to a considerable extent by means of limb structure. Osteological characters were evidently given high value in the classification, and a searching analysis leads to some valuable new combinations, such as the "Ongulogrades à doigts pairs" (later called "Artiodactyla" by Owen) and the "Ongulogrades à doigts impairs" (Perissodactyla). This was a great improvement over all previous classifications of the ungulate orders, but zoölogists were slow in accepting the change. The elephants are again freed from the other ungulates (as in several earlier schemes) and now occupy a separate order "les Gravigrades." The largely unnatural assemblages "Ungulata," "Unguiculata," "Natan-tia," etc. of previous authors are thus abandoned.

The Primates are correctly classified. The Anthropoids are sharply separated from the Lemuroids; as in Geoffroy St. Hilaire's scheme, the New World and Old World monkeys form coördinate divisions of "les Singes"; the Aye-Aye (*cf.* Illiger) is correctly allocated. A second grand division ("anomaux") of "les Quadrumanes" is less felicitous (*Galeopithecus* + *Bradypus*), and is retained with misgivings in the later classification after a long but faulty analysis of osteological characters.

The word "Carnassiers" is followed by a question mark as if the naturalness of the assemblage were doubted. The division "anomaux" brings

together "les Cheiroptères," "les Taupes" and "les Phoques," a more or less unnatural arrangement which was greatly improved in the later classification.

The classification under discussion gives up the effort to arrange genera in a linear series forming "natural transitions" (contrast Cuvier, Illiger) especially between orders, and later, in the "Ostéographie," in the discussion of *Palæotherium*, *Anoplotherium*, etc., it is clearly stated that such annectant forms must be sought usually among genera long since extinct. De Blainville's use of the term "ordre ou degré d'organization" implies the recognition of progressive approximation toward a perfect archetype. Like most other naturalists until the time of Huxley, de Blainville began his scheme with the Primates.

Finally one of the most important features of de Blainville's classification is that it represents an effort to get below the adaptive superficies and to seek out relatively non-adaptive or slowly adaptive characters, a conception which even at the present time has not been grasped by all systematists.

De Blainville's Classification of 1816.

Mammifères

Sous-Classe I

Monodelphes

I^{er} degré d'organization ou Ordre.

Quadrumanes.

Normaux.

Singes du continent ancien.

Les Singes.

" " " nouveau.

Les Sapajoux.

Makis

Les Makis.

Les Loris.

L'Aye-Aye.

Anomaux.

Galéopithèques.

Tardigrades.

II^e degré ou

Ordre.

Carnassiers ?

Normaux.

Plantigrades.

Digitigrades.

Insectivores.

Anomaux.

Les Cheiroptères.

Les Taupes.

Les Phoques.

III degré ou Ordre.

Édentés ?

Normaux.

Édentés.

Anomaux pour nager.

Cétacés ?

IV degré

Rongeurs ?

(Celerigrades)

Grimpeurs.

Fouisseurs.

Coureurs.

Marcheurs.

V degré ou Ordre.

Gravigrades.

Éléphants

VI degré ou Ordre.

Ongulograd [es].

Normaux, doigts

Impairs.

Pachydermes.

Solipedes.

Pairs.

Non Ruminans ou Brutes.

Ruminans.

Anomaux, pour nager.

Les Lamantins.

Sous-Classe II.

Didelphes.

Normaux.

Carnassiers [Polyprotodont Marsupials].

Rongeurs [Diprotodont Marsupials].

Anomaux.

pour fuir

L'Echidné.

pour nager

L'Ornithorinques.

"Il se pourrait que les Cétacés dussent former un degré d'organisation séparé."

"On devra peut-être faire des Échidnés, etc., une sous-classe distincte."

G. CUVIER, 1817.

'Le Règne Animal.'

In 1817 Cuvier published the first edition of the 'Règne Animal,' a work which found wide acceptance and was perhaps as popular as Linné's 'Systema Naturæ.' Just as Linné's system had been made familiar to English readers through the works of Kerr (1792) and Shaw, so, under the form of

'Griffith's Cuvier' (1827) and of 'Blyth's Cuvier' (1840, 1849, 1864) Cuvier's 'Règne Animal' became the standard work on natural history in England.

The classification reflects the advances in the subject which had been made since the appearance of the 'Leçons d'Anatomie Comparée,' in the following details:

The arrangement of "les Carnassiers" is considerably improved. The Insectivora (now for the first time called "les Insectivores") are separated from the plantigrade Carnivora ("les Plantigrades"), which are in turn placed with the typical Carnivora, and the term "Carnivores" is expanded to include "les Plantigrades," "les Digitigrades" and "les Amphibies." Thus Linné's reference of the seals to the Feræ was at last accepted by Cuvier. "Les Marsupiaux" in the table of contents, are included as a final division of "les Carnassiers," but on page 169 we find the statement that the Marsupials might almost form an order by themselves, so many are the peculiarities of their economy; and the parallelism of their genera to those of other orders is pointed out (p. 171), thus: "It has been said [by Geoffroy Saint-Hilaire, de Blainville] that the Marsupials form a distinct class parallel to that of the ordinary quadrupeds and divisible into similar orders, in such a way that if the two classes were arranged in two columns, the opossums, dasyures and bandicoots would be opposite the insectivorous carnassiers with long canines, such as the tenrecs and moles, and the phalangiers and kangaroo-rats opposite the hedgehogs and shrews. The true kangaroos cannot well be compared with anything, but the wombats would be opposite the rodents."

In this passage and especially in the discussion of the rodent-like characters of *Phascodomys* (p. 185) the great principle of *analogous adaptations in different orders is recognized but not formulated* (cf. Duméril), but, as shown by the classification as a whole, this principle is not yet taken as a guide.

The Rodents are divided into two sections: (1) those with clavicles, and (2) those without clavicles.

The many anatomical peculiarities of the Monotremes pointed out by Geoffroy are described (p. 225) and their possible connection with Marsupials is also noted (p. 171); but the Monotremes are still left in the Edentates.

The Pachydermes are now divided into "Proboscidiens" [cf. Illiger's term], "Pachydermes ordinaires" and "Solipèdes," but there is no hint of the removal of *Sus*, *Hippopotamus* and *Anoplotherium* to the neighborhood of the Ruminants.

The Camels and Chevrotains are associated in the group of "Ruminans sans cornes."

The Manatees and their allies are now included in the Cetacea [*cf.* Illiger].

The general impression of this classification is that it is *conservative in form but transitional and confused in principle*. Cuvier's former confidence in the worth of the general characters of the extremities as primary ordinal criteria had evidently been shaken as shown by the substitution of "Insectivores" for "Plantigrades," of "Marsupiaux" for "Pédimanes," by the reduction of "les Solipèdes" to subordinal rank, by the association of odd- and even-toed forms under "les Pachydermes," etc. The numerous supposed transitions from Carnivores to Marsupials, from Marsupials to Rodents, and from Edentates to Monotremes and even Ungulates, are stated, but also the opposing views of the total distinctness of the Marsupials and of the Monotremes.

Cuvier's Classification of 1817.

Bimanes.

Quadrumanes.

Carnassiers.

Cheiroptères (Chauve-souris, Galéopithèques).

Insectivores [new term]. (Herissons, Musaraignes [including Myogale, Soricidæ, Scalops, Chrysochloris], Tenrecs, Taupes).

Carnivores.

Plantigrades. [Procyonids, Ursids, Meles, Gulo].

Digitigrades (Martes and various Mustelids, incl. Lutra, Chiens, Civettes, Hyènes, Chats).

Amphibies (Phoques, Morses).

Marsupiaux.

Rongeurs.

À Clavicules (Castors, Rats, Helamys [Pedetes], Marmottes, Ecureuils, Aye-Aye).

Sans clavicules (Porc-épics, Lièvres, Cabiais).

Édentés.

Tardigrades (Paresseux, Megatherium).

Édentés ordinaires (Tatous, Oryctéropes, Fourmiliers, Pangolins).

Monotrèmes (Echidnés, Ornithorhiques).

Pachydermes.

Proboscidiens [*cf.*, Illiger] (Elephants, Mastodontes).

Pachydermes ordinaires (Hippopotames, Cochons, Anoplotherium, Rhinoceros, Daman [Hyrax], "quelque sorte de Rhinoceros en miniature," Palæotherium, Tapirs).

Solipèdes (Chevaux).

Ruminans.

Sans cornes (Chameaux, Chevrotains).

Avec cornes (Cerfs, Giraffes, Antilopes, Chèvres, Moutons, Boeufs).

Cétacés.

Herbivores (Lamantins, Dugongs, Rytines).

Ordinaires.

À petite tête (Dauphins, Narvals).

À grosse tête (Cachalots, Baleines).

GRAY, 1821, 1843 etc.

Noticed below (p. 102) under "Addenda".

BLUMENBACH, 1830.

'Handbuch der Naturgeschichte,' 12th. ed., 1830.

After examining the fairly progressive classifications of Cuvier and the brilliant, prophetic work of de Blainville it is interesting to turn again to the veteran Blumenbach (1752-1840) and find, as late as 1830, a classification which does not differ greatly from his then progressive one of 1791. Blumenbach's successive classifications extend from the Linnæan epoch through the whole pre-Cuvierian epoch and well into the middle of the epoch of Cuvier and de Blainville. His first classification of 1779 (see p. 43) almost falls within the Linnæan epoch, both in time and methods. His classification of 1791 came at the end of the pre-Cuvierian epoch, and together with that of Vicq d'Azyr distinctly foreshadowed the classification of Geoffroy and Cuvier. His final classification of 1830 appeared more than a decade after de Blainville's scheme of 1816, and yet failed to recognize the separation of the Marsupials and Monotremes from their Placental analogues.

Blumenbach's Classification of 1830.

- I. Ordn. Bimanus. Der Mensch.
 - II. Ordn. Quadrumana. Affen, Paviane, Meerkatzen und Makis.
 - III. Ordn. Chiroptera. Die Fledermäuse.
 - IV. Ordn. Digitata. Säugethiere mit freien Zehen an allen vier Füßen. Diese Ordnung zerfällt nach der Verschiedenheit des Gebisses in folgende drey Familien:
 - (A) Glires.
 - (B) Feræ.
 - (C) Bruta. Ohne Gebiss oder wenigstens ohne Vorderzähne &c. Faulthiere, Ameisenbären, Schuppenthier, Panzethiere.
 - V. Ordn. Solidungula. Pferd, &c.
 - VI. Ordn. Bisulca. Die wiederkauenden Thiere mit zerspaltenen Klauen.
 - VII. Multungulata. Schweine, Tapir, Elephanten, Nashörner, Nilpferd.
 - VIII. Ordn. Palmata. Säugethiere mit Schwimmfüßen. Wieder nach ihres Gebisses in obgedachte drei Familien getheilt:
 - (A) Glires. Biber.
 - (B) Feræ. Seehunde &c. Ottern.
 - (C) Bruta. Das Schnabelthier [Ornithorhynchus], Wallross, der Manate.
- Letzterer macht von hier den schicklichsten Uebergang zur letzten Ordnung.
- IX. Ordn. Cetacea. Wallfische, Warmblütige Thiere die mit den kalt blutigen Fischen fast nichts als den unschicklichen Namen gemein haben, und deren natürliche Verbindung mit den übrigen Säugethiern schon Ray vollkommen richtig eingesehen hat.¹

¹ "Cetacea quadrupedum modo pulmonibus respirant, coeunt, vivos foetus pariunt, eosdemque lacte alunt, partium denique omnium internarum structura et usu eum iis conveniunt." Ratus."

DE BLAINVILLE, 1834.

The classification used by de Blainville in his lecture course of 1834 (quoted by Gervais in the 'Dictionnaire pittoresque d'Histoire Naturelle,' Tome IV, 1836, p. 619) is on the whole, far superior to any hitherto met with. As compared with the classification of 1816 (p. 74) it offers the following noteworthy features:

(1) The Monotremes are now definitely separated from the Marsupials and raised to the rank of a subclass, "les Ornithodelphes," so that the completed arrangement is as follows:

I. "Les Ornithodelphes," [Monotremes].

II. "Les Didelphes," [Marsupials].

III. "Les Monodelphes" [Placentals].

(2) The principle of parallelism, *i. e.*, of the existence of analogous members in different orders, is clearly recognized in the subdivisions of the orders into groups adapted either "pour le vol," "pour nager," "pour grimper," "pour sauter," or "pour fouir"; and "teleological" adaptations in the limbs are subordinated to the deeper seated "encephalic" characters and to the totality of resemblances and differences.

(3) The arrangement of "les Carnassiers" is greatly improved, the Bats and Insectivores being set off in a grand division "claviculés," contrasted with the Fissiped and Pinniped carnivora, or "non-claviculés."

(4) The presumed connection between Edentates and Cetacea is again affirmed. New evidence for this connection has been adduced recently by Beddard (1902).

(5) The Rodents are very well grouped, the divisions of Waterhouse and of Brandt being distinctly foreshadowed.

(6) The Sirenia are now definitely associated with the elephants, as the aquatic representatives of the "ordre Gravigrades." This connection is supported by much modern evidence (see p. 407).

(7) The classification of "les Ongulogrades," which is based on an analysis of the skull and skeleton, but in which the divisions are named from the number of digits, is practically in its modern form,

(8) The Marsupials, on the basis of foot structure, are divided into two "degrés," virtually corresponding with the Diadactyla and Syndactyla of later authors. The second "degré" is also well divided.

De Blainville's Classification of 1834.

Sous-classe I. MONODELPHES.

I. *Quadrumanes.*

Normaux,	{	narines {	rapprochées	<i>Pitheci</i> [Catarrhinæ].
			éloignées	<i>Neopitheci</i> [Platyrrhinæ].
				<i>Pseudopitheci</i> [Lemuroidea].

Anomaux, { pour voler *Galeopithec.*
 { pour grimper *Tardigradi* [Sloths].

II. Carnassiers.

Claviculés { anomaux { pour le vol *Cheiropteri.*
 { pour nager *Orycteri* [Taupes etc.].
 { normaux *Insectivori* [Tenrec, *Erinaceus*, etc.].
 Nonclaviculés { normaux { *Plantigradi*, 1° ou omnivores [Plan-
 tigrade carnivores].
 { *Digitigradi*, 2° [Digitigrade car-
 nivores].
 { anomaux pour nager *Pinnigradi*, 3° ou Phoques, auxquels
 on est conduit par les Chiens et
 les Protèles.

III. Édentés.

Claviculés et terrestres, *Brutes* (Tatou, *Oryctérope*, Four-
 millier, Pangolin).
 Nonclaviculés, nageurs, *Cétacés* (Dauphin, etc.).

IV. Rongeurs.

Claviculés { *Grimpeurs*, *Sciurei*.
 { *Fouisseurs* ou *Murini* { 1° dents molaires $\frac{2}{3}$ ou $\frac{3}{3}$.
 { 2° dents molaires $\frac{4}{4}$.
 Subclaviculés, *Coueurs* ou *Lepores*.
 Nonclaviculés, *Marcheurs* ou *Cavia*.

V. Gravigrades.

Normaux terrestres, *Proboscidei*, Éléphants.
 Anomaux pour nager, *Sirenei*, Lamantins.

VI. Ongulogrades.

À doigts { impairs { 3 doigts, *Pachydermes*.
 { 1 doigt, *Solipèdes*: Cheval.
 { pairs, antérieurement au moins { 4 doigts, *Brutæ*: Cochon, etc.
 { 2 doigts, *Ruminantia*.

Sous-classe II. DIDELPHES.

I^{er} degré.

À doigts postérieurs libres { *Pédimanes* [Didelphiidæ].
 [cf., "Diadactyla"] { *Phascogales* [Insectivorous Dasyuridæ].

II^e degré.

Deux des doigts postérieurs réunis. [cf. "Syndactyla"].
 Animaux disposés pour { grimper, *Phalangiers* (Phalanger, *Phascolarctos*).
 { sauter, *Sauteurs* (Potorou, Kangaroo).
 { fouir, *Fouisseurs*, *Phascolome*.

Sous-classe III. ORNITHODELPES.

Disposés pour { fouir, Échidné.
 { nager, Ornithorhynque.

BONAPARTE, 1837.¹

'New Systematic Arrangement of Vertebrated Animals.' Trans. Linn. Soc.
Vol. XVIII, pp. 247.

The classification of Prince Charles Lucien Bonaparte exhibits the following interesting features: (1) The adoption of the Linnæan names for the Cuvierian orders; (2) The influence of de Blainville's classification of 1816, in the grouping together of the Marsupials and Monotremes; (3) The apparent modification and development of de Blainville's idea of classifying the mammals according to the "variations of the encephalic nervous system," namely, the use of brain characters as subclass criteria. The mammals are divided into two series: (1) "Educabilia" (or those with a "bi- or tri-lobed cerebrum") and (2) "Ineducabilia" (or those with a "single lobed cerebrum"). Dr. Gill informs the writer that this idea was suggested to Bonaparte by a friend. At any rate it grouped together animals in similar stages of brain evolution, but otherwise not closely related.

Bonaparte's twofold division of the Placentals is chiefly noteworthy because it was adopted in the subsequent classifications of Gill (1872) and Cope (1880), and may have suggested to Owen his classification of 1868, which was also based on brain characters.

Bonaparte's Classification of 1837.

Mammalia.

Series I. Placentalia [Owen ? *cf.* Placentaria Fleming, 1822].

Subclass Educabilia [Bonaparte]: "Cerebrum bi-(vel tri-) lobum."

Primates ("Quadrumana") [Linn.].

Feræ [Linn.] ("Carnivora").

Pinnipedia [Illiger] ("Amphibia").

Cete [*cf.*, Linn.] ("Natantia" (Sirenia, Cetacea)).

Belluæ [*cf.*, Storr non Linn.] ("Pachydermata"), Tapirus.

Pecora [Linn.] ("Ruminantia").

Subclass Ineducabilia [Bonaparte]. "Cerebrum unilobum."

Bruta [*cf.*, Linn.] ("Edentata").

Cheiroptera [Blumenbach] ("Volitantia").

Bestiæ [*cf.*, Linn.] ("Insectivora").

Glires [Linn.] ("Rosores").

Series 2. Ovovivipara [Owen ? *cf.*, "les Didelphes" de Blainville, 1816].

Marsupialia [*cf.*, Geoffroy] ("Didelphia").

Monotremata [*cf.*, Geoffroy] ("Reptantia").

¹ In his classification of 1831 ('Saggio di una distribuzione metodica degli Animali Vertebrati,' Giorn. Arcad. 49, pp. 3-77) Bonaparte adopted the Linnæan orders but did not introduce the distinctive features which characterized his classification of 1837.

DE BLAINVILLE, 1839-1864.

'Ostéographie ou description iconographique comparée du squelette et du système dentaire des mammifères . . . ,'¹ 4 vols., 4°, with atlas in folio. Paris.

This great work, with its scores of accurate lithographic plates, greatly extends and supplements the osteological studies of Cuvier and continues to be of the greatest service at the present time. It reflects the growing interest in the skeleton of recent mammals, both as yielding the most significant and important characters in ordinal classification and as a means of understanding the remains of past mammalian faunæ. De Blainville regarded the skeleton in a thoroughly modern manner. The skeleton of vertebrates, his biographer Nicard tells us, had been regarded ordinarily as merely the passive part of the locomotive apparatus; but in 1817 de Blainville in the '*Bulletin de la Société Philomathique*' considered it as serving simultaneously: (1) to envelop the central nervous system, (2) to protect the principal part of the eccentric nervous system, and (3) to support the muscular tissue in which it is developed (Ostéographie, p. liii).

In regard to the classification under discussion the chief innovations are the terms "Primatès," "Secundatès" (Insectivora, Carnivora), "Tertiatès" (Rongeurs), "Quaternatès" (Gravigrades, Ongulogrades), and "Maldentès" (Edentata). The process of separating the Insectivora from the Carnivora is now almost completed. The Edentates are contrasted with all the remaining Monodelphians (Biendentés) in a grand division Maldentés.

De Blainville's Classification of 1839-1864.

[Grades of organization].

Monodelphes.

Bien dentés.

Primatès.

Singes. Les Singes, les Sapajous.

Makis. Les Makis, les Indris, Cheiromys.

Bradypus [Incertæ Sedis].

Secundatès.

Insectivores.

Carnassiers [Carnivora].

[Tertiatès.¹ Rongeurs.]

Quaternatès.

Gravigrades. Elephas, Dinotherium, Lamantins [Sirenia].

Ongulogrades.

¹ The Tertiatès are not described in the text of the '*Ostéographie*,' the plates illustrating the rodents having been published posthumously.

A doigts impairs.

Pachydermes [Hyrax, Rhinoceros, Palæotherium and its allies, Tapirus].

Solipèdes. Equus.

A doigts pairs.

Non-Ruminans ou Brutes [Pigs, Hippopotamus, Anoplotherium, etc., Adapis].

Ruminans.

Maldentés.

Maldentés [Edentata].

WAGNER, 1855.

'Schreber's Säugetiere,' Suppl. Bd., Vte Abth., ss. ix-xxvi.

Cuvier's name and influence were so powerful that his system of classification of the mammals, as given in the later editions of the 'Règne Animal,' came into very wide use and was modified only in details. In England "Griffith's Cuvier" long held undisputed sway, as stated above. In Germany, after the classifications of Oken and his school had been found wanting by practical naturalists, the progress of the modern ideas introduced by de Blainville was very slow, as shown in the following classification by Wagner. This classification is mainly Cuvierian with certain features from Blumenbach and Illiger; it constitutes a rather inglorious ending for an epoch in which great ideas had been developed.

Wagner's Classification of 1855.

Simiæ.

I. Fam. Simiæ catarrhinae [Geoffroy].

II. " " platyrrhinae [Geoffroy].

III. " Prosimii [Illiger].

Edentata [*cf.*, Vicq d'Azyr].

Marsupialia [*cf.* Geoffroy, de Blainville].

I. Fam. Dasyurina. (Thylacinus, Dasyurus, Phascologale, Myrmecobius).

II. " Syndactylina. (Perameles, Choeropus).

III. " Pedimana. (Didelphis, Chironectes).

IV. " Edentula. (Tarsipes).

V. " Scandentia. (Phalangista, Petaurus, Phascolarctos, Dendrolagus).

VI. " Macropoda. (Hypsiprymnus, Halmaturus).

VII. " Glirina. (Phascolomys).

Ruminantia

I. Fam. Cervina. (Moschus, Cervus, Camelopardalis).

II. " Cavicornia [Illiger]. (Antilope, Aegoceros, Bos.)]

III. " Tylopoda [Illiger].

Solidungula [Blumenbach]. (Equus).

Pachydermata (Hippopotamus, Sus, etc. Tapirus, Hyrax, Rhinoceros, Elephas.

Insectivora [Cuvier].

- | | | |
|---------------------------|------------------|---|
| I. | Fam. Dermoptera. | (Galeopithecus). |
| II. | “ Scandentia. | (Cladobates (Tupaja), Ptilocercus, Hylomys). |
| III. | “ Soricina. | (Rhynchoeyon, Gymnura, Macroscelides, Sorex, Solenodon, Myogale). |
| IV. | “ Talpina. | |
| V. | “ Aculeata. | (Centetes, etc., Erinaceus). |
| Cheiroptera [Blumenbach]. | | |
| I. | Fam. Frugivora. | (Pteropus, etc.). |
| II. | “ Istiophora. | (Desmodus, etc.). |
| III. | “ Gymnorhina. | (Emballonura, Vespertilio, etc.). |

6. THE EPOCH OF DARWIN AND HUXLEY.

Synopsis.

Key to the confusion of principles of the preceding epoch furnished by the idea of descent with modifications, as the basis of resemblances and differences among animals (Darwin).

Conflict of new and old principles (Huxley, Haeckel, vs. Agassiz, Owen).

The anthropocentric classification, in which man as the measure and standard of all things heads the list of organic beings, gives way to the evolutionary classification, which leads from the more generalized to the more specialized.

Enormous increase in material leads to partial separation of mammalogy proper, comparative anatomy, palæontology.

Monographic work of preceding epoch continued.

Introduction of more exact field and museum methods in palæontology.

Correlation of fossil mammal horizons in different continents and development of the theory of secular migrations and palæogeography (*e. g.*, Cope, Osborn, Depéret, Matthew).

Revision of generic and specific nomenclature on the basis of the “law of priority,” initiated in its modern form by the American Ornithologists Committee on Nomenclature (1886) (*cf.* Scudder, J. A. Allen, Trouessart, Palmer, Hay).

Discovery and development of the principles of evolution of the feet (*e. g.*, Kowalevsky, Cope, Osborn) and of the teeth (*e. g.*, Cope, Osborn).

Reunion and integration of results of mammalogy, comparative anatomy, embryology, palæontology; attempted to a limited degree by Flower and Lydekker, Beddard, more completely by Weber (1904); but still very far from completion.

Descent and phylogenetic classification sought for; but deceptive analogies, existing to an unsuspected extent, deceive all early classifiers of

this epoch (*e. g.*, Haeckel) and even now are only gradually being recognized.

Analysis of the results of parallel, divergent and convergent evolution in their bearing on classification (*e. g.*, Cope, Scott, Osborn, Dollo) and of the principles of adaptive radiation and homology (Osborn).

Search for inconspicuous, slowly changing, "palæotelic" characters as being better indices of affinity than conspicuous superficial, "caenotelic" characters.

GENERAL PROGRESS OF THE ORDINAL CLASSIFICATION OF THE MAMMALIA SINCE 1859.

As already noted the history of mammalogy reveals a continuous interplay between the "école des faits" and the "école de idées." Gesner, Daubenton, Illiger, Flower, Zittel, and Marsh may be taken as types of men whose prime business was the accumulation and orderly presentation of facts with only incidental reference to theories; Ray, Linnæus, Cuvier, de Blainville, Huxley, on the other hand, represent the "école des idées," who in one way or another profoundly influenced the interpretation of facts.

Although Darwin's name is rightly given to the epoch under consideration yet he did not himself apply the doctrine of evolution to the problem of the classification of the mammals. The publication of the 'Origin of Species' did not therefore at once produce its permanent effects upon mammalogy; Haeckel's earlier phylogenetic trees, based too largely upon placental characters, did not stand the test of time; and it was not until 1880 that Huxley made his well known 'Application of the Principles of Evolution to the Arrangement of the Vertebrata and more particularly of the Mammalia,' an analysis which partly formulated the methods for correct phylogenetic conclusions respecting interordinal relationships (see below, p. 94).

Through the discovery of the great fossil faunas of India, North and South America, and more recently of North Africa, mammalogy came into possession of a vast number of new facts which at the present day are still very incompletely assimilated. Several far reaching principles, however, have slowly emerged. Cope (1896 p. 98) and Scott (1891) formulated the theories of parallel and convergent evolution, Osborn has developed the ideas of adaptive radiation, both general and local, and of polyphyletic evolution (1902-10). The general evolution of the teeth and of the feet in the Mammalia has engaged the attention of many investigators. The evolution of the carpus and tarsus was studied by Kowalevsky (1873), Cope (1887), Baur (1885-86) Weithofer (1888), Osborn (1889), Rüttimeyer (1890), Matthew (1895), and the subject is reviewed and extended in the present work (pp. 438-457).

The evolution of the cheek teeth, first sketched by Huxley (1881),

has occasioned an extensive literature, centering around the celebrated 'Theory of Trituberculy' of Cope and Osborn. This subject is very fully dealt with in Osborn's 'Evolution of Mammalian Molar Teeth' (1907), and in the succeeding chapters (pp. 181-194).

In regard to ordinal classification, the chief innovator since Huxley's time was Cope. But Cope's classifications were founded to far too great an extent upon single characters. His theories in regard to the evolution and interrelations of the unguiculate and ungulate orders, and his resulting ordinal classifications, have gradually been crumbling, and recent authors (Weber, 1904, Osborn, 1907) have returned to a more conservative development of the classification adopted by Huxley and developed by Flower. (See below.)

The chief contribution of the present and immediately preceding generation of workers is the long series of monographs on fossil genera and faunas; and here many names in addition to those cited above come to mind, but especially Leidy, Marsh, Kowalevsky, Gaudry, Depéret, Schlosser, Forsyth Major, Lydekker, Andrews, Ameghino, Wortman, Hatcher, Matthew. Nor should we omit the names of those who have devoted many years of unselfish labor to the compilation of such useful works as Trouessart's 'Catalogus Mammalium,' Hay's 'Bibliography and Catalogue of the Fossil Vertebrata of North America,' Palmer's 'Index Generum Mammalium.' Finally, reference may again be made to Weber's great work 'Die Säugetiere', which has joined, to a degree not before attempted, the chief results of palæontology, with the vast, but, it must be confessed, hitherto rather uncoördinated results of comparative anatomy.

This outline history of the ordinal classification of the mammals may be concluded with a brief reference to a few of the more important and most representative systems which have appeared since 1859.¹

OWEN, 1868.

'On the Anatomy of Vertebrates,' Vol. III, Mammals, pp. 839-847.

The first classification among those selected for reproduction is compiled from the zoölogical index of the work cited above and was thus not a formal classification; but nevertheless it serves to reveal the "British Cuvier's" ideas on ordinal relationships. In its general lines the classification appears to be a modification of that proposed by Bonaparte in 1837, which was in turn under obligations to the systems of Linnæus, Cuvier and de Blainville. Bonaparte's "Ineducabilia" and "Educabilia" are represented in Owen's system by the "subclasses" "Gyrencephala" and "Lissancephala," but the "Bimana" are set off in a new subclass "Archencephala." The "Ovovi-

¹ Lack of space forbids the attempt to trace in detail the exact source of each idea noted in these classifications, and it is possible that in some instances ideas which here seem to be credited to a particular author may have been partly borrowed and partly original.

vipara", a term used by Bonaparte but credited by him (1837, p. 248, footnote), to Owen in the present system are called "Implacentalia" and include only the subclass "Lyencephala." The "Mutilata" is the ancient group of Marine Mammals.

The detailed arrangement of the orders contains little that is original. To de Blainville's groups "Ongulogrades à doigts pairs," "Ongulogrades à doigts impairs" Owen's terms "Artiodactyla," "Perissodactyla," of 1847, are applied; but whereas de Blainville had included in the "Ongulogrades à doigts impairs" only the forms now generally recognized as Perissodactyla, Owen includes in that group, in the classification under consideration, such wholly extraneous forms as *Coryphodon*, *Macrauchenia*, *Hyrax* and *Toxodon*.

Owen's Classification of 1868.

Class Mammalia.

Genetic Section Placentalia.

Subclass Archencephala.

Order Bimana. Homo.

Subclass Gyrencephala.

A. Unguiculata.

Order Quadrumana.

Suborder Catarrhina.

" Platyrrhina.

" Strepsirrhina [Lemuroids and Galeopithecus].

Order Carnivora [including seals, etc.]

B. Ungulata.

Order Artiodactyla.

Suborder Ruminantia.

Suborder Omnivora [e. g., Merycopotamus, Dichodon, Xiphodon, Anoplotherium, Microtherium, Entelodon, Hippopotamus, Hexaprotodon, etc. Suidæ, Anthracotherium].

Order Perissodactyla (Coryphodon, Pliolophus, Hyracotherium, Lophiodon, Palæotherium, Paloplotherium, Macrauchenia, Elasmotherium, Rhinoceros, etc., Hyrax, Anchitherium, Hipparion, Tapirus, Toxodon, Nesodon).

Order Proboscidea.

C. Mutilata.

Order Sirenia.

Order Cetacea.

Subclass Lissencephala.

Order Bruta.

Order Cheiroptera.

Order Insectivora.

Order Rodentia.

Genetic Section Implacentalia.

Subclass Lyencephala.

Order Marsupialia.

" Monotremata.

GILL, 1870, 1872.

'On the Relations of the Orders of Mammals.' *Proc. Amer. Assoc.*

Adv. Sci., 1870, 19th meeting, pp. 267-270.

'Arrangement of the Families of Mammals,' *Smithsonian Miscellaneous Collections*, 1872.

The early classifications of the Darwinian epoch revealed an extreme reliance on single characters which Linnæus, Cuvier and de Blainville had wisely avoided. Thus Haeckel, as we have seen, developed the most elaborate phylogenetic classifications on the primary basis of placentation, while Owen, going far beyond de Blainville, had selected brain characters as fundamental, and upon that assumption had erected three "subclasses" within the limits of the Placentalia. In view of these considerations it is interesting to find the present "Dean of American Taxonomy" turning in 1870 to a more normal development of Linnæan methods, and producing an arrangement of the orders which is remarkable for its simplicity, its selection of the best features of preceding classifications and for the lucid statement of guiding principles. The latter are, in fact, so illuminative, that it may be permitted to quote them in full.

"1st, Morphology is the only safe guide to the natural classification of organized beings; teleology, or physiological adaptation, the most unsafe and conducing to the most unnatural approximations.

"2d, The affinities of such organisms are only determinable by the sum of their agreements in morphological characteristics, and not by the modifications of any single organ.

"3d, The animals and plants of the present epoch are the derivatives, with modification of antecedent forms to an unlimited extent.

"4th, An arrangement of organized beings in any single series is, therefore, impossible; and the system of sequences adopted by genealogists may be applied to the sequence of the groups of natural objects.

"5th, In the appreciations of the value of groups, the founder of modern taxonomy (Linnæus) must be followed, subject to such deviations as our increased knowledge of structure necessitates.

"The adoption of such principles compels us to reject such systems as are based solely on modifications of the brain, those of the placenta, and those of the organs of progression, such modifications not being coincident with corresponding modifications of other organs, and therefore not the expressions of the sum of agreements in structure."

Some of the more noteworthy features of the classification are as follows:

(1) The return to de Blainville's three grand divisions; (2) the grouping of

the orders into "series" having the rank of superorders; (3) the recognition of the subordinal rank of the Zeuglodontes and of the relationship of the Cete with the Feræ; (4) the grouping of the Insectivora and Chiroptera, which were regarded as divergent derivatives "from the same primitive stem as the Feræ"; (5) the Ungulata are regarded as "probably the derivatives from the same common stock as the Feræ"; (6) the Sirenia, Hyracoidea and Proboscidea are evidently held to be related orders; (7) the Edentata are regarded as the lowest order of the Monodelphia, "the structure of the skeleton and especially of the skull, the organs of generation, etc., appearing to indicate with sufficient distinctness, that thus degraded are their rank."

In his fuller classification of 1872 ('Arrangement of the Families of Mammals,' Gill adopted Bonaparte's partition of the Placentalia into two subdivisions "Educabilia" (including the Primates, Feræ, "Ungulata," Toxodontia, Hyracoidea, Proboscidea, Sirenia, Cete) and "Ineducabilia" (including the Chiroptera, Insectivora, Glires, Bruta). In the table of contents of the same work the word "Eutheria" is placed in brackets in front of both the terms "Placentalia s. Monodelphia" and "Didelphia," while "Prototheria" is placed in brackets in front of "Ornithodelphia." This implies that Gill recognized that structurally there was a closer relationship between the Monodelphia and the Didelphia than that between the Didelphia and the Ornithodelphia, and his usage of the term Eutheria undoubtedly antedates Huxley's usage of the same word in a different sense (*cf.* p. 230).

Gill's Classification of 1870.

Subclass Monodelphia.



I. Primate Series.

Order Primates.

Suborder Anthropoidea. Suborder Lemuroidea.

II. Feral Series.



Order Feræ.

Suborder Fissipedia.   Suborder Pinnipedia.

Order Cete.

Suborder Zeuglodontes. Suborder Odontocete. Suborder Mysticete.

III. Insectivorous Series.

Order Insectivora.   Order Chiroptera.

IV. Ungulate Series.

Order Ungulata.

Suborder Artiodactyla. Suborder Perissodactyla.

Order Hyracoidea.  Order Proboscidea.  Order Sirenia.

V. Rodent Series.

Order Glires.

Suborder Simplicidentata. Suborder Duplicidentata.

- VI. Edentate Series.
- Order Bruta, or Edentata.
- Subclass Didelphia.
- Order Marsupialia.
- Subclass Ornithodelphia.
- Order Monotremata.

HUXLEY, 1872.

'A Manual of the Anatomy of Vertebrate Animals.

In this classification de Blainville's three-fold division of the Mammalia is followed. Haeckel's division (1866) of the Monodelphia into two series, in accordance with the deciduate or non-deciduate character of the placenta is provisionally accepted as explained in a foot-note. The Hyracoidea had been given separate ordinal rank in Huxley's 'Introduction to the Classification of Animals' in 1869.

Huxley's Classification of 1872.

- I.—ORNITHODELPHIA.
 - 1. Monotremata.
- II.—DIDELPHIA.
 - 2. Marsupialia.
- III.—MONODELPHIA.¹
 - a. Median incisor teeth are never developed in either jaw.
 - 3. Edentata.
 - b. Median incisor teeth are almost always developed in one or both jaws.
 - i. The uterus develops no decidua (Non-deciduata).
 - 4. Ungulata.
 - 5. Toxodontia (?)
 - 6. Sirenia (?)².
 - 7. Cetacea.
 - ii. The uterus develops a decidua (Deciduata).
 - a. The placenta is zonary.
 - 8. Hyracoidea.
 - 9. Proboscidea.
 - 10. Carnivora.
 - β. The placenta is discoidal.
 - 11. Rodentia.
 - 12. Insectivora.
 - 13. Cheiroptera.
 - 14. Primates.

¹ "The manner in which the *Monodelphia* are here subdivided must be regarded as merely provisional."

² "The placentation of the *Toxodontia* and *Sirenia* is unknown."

HUXLEY, 1880.

'On the Application of the Laws of Evolution to the Arrangement of the *Vertebrata*, and more particularly, of the *Mammalia*.' Proc. Zool. Soc., 1880, pp. 649-662.

One of the most important features of this memorable analysis, the general bearings of which have been noted above, is the fact that the main divisions are not founded upon the traditional criteria, such as the number of teeth or of digits, but upon deep-seated anatomical characters having little immediate relations to particular life habits. This method had been initiated by de Blainville, and especially dwelt upon by Gill (see above, p. 91), and the modern development of embryology and comparative anatomy enabled Huxley to apply to the problem of mammalian classification such recondite criteria as the condition of the malleus and the relations of the ureteric apertures. The terms "Hypotheria," "Prototheria," "Metatheria," "Eutheria," being intended to describe *stages of evolution* were employed in a somewhat different sense from that of the purely systematic terms "Prototheria" and "Eutheria," which had been used first by Gill in 1872 (p. 92). The arrangement of the diagram seems to imply that all the orders of Eutheria were derived independently from remote Hypotherian stocks — an extreme form of the "polyphyletic origin" idea. The Primates (Anthropoidea) and Lemuroids seem to be conceived as independent lines both related remotely to the Marsupialia. The Rodents are placed between the Lemuroids and the Proboscidea while the Sirenia are between the Proboscidea and the Ungulata (Perissodactyla + Artiodactyla). The Hyracoidea are placed between the Ungulata and the Insectivora, while the Cetacea lie between the latter group and the Carnivora; the Cheiroptera follow; the Edentata, perhaps regarded as the lowest of the Eutheria are next to the Monotremata, an association regarded as valid by many of Huxley's predecessors.

STAGES OF EVOLUTION	MAMMALIA.	PRIMATES.	RODENTIA.	PROBOSCIDEA.	HYRACODONTA.	INSECTIVORA.	CARNIVORA.	CHEIROPTERA.	EDENTATA.
EUTHERIA....	1. Testes.	deciduate.							
	2. Allantoic placenta.								
	3. Ureteric apertures entocystic.								
	4. Small malleus.								
EUTHERIA....	5. Reduced coracoid.								
	6. Epipubis rudimentary.	Placenta							
	7. Two occipital condyles and an osseous basi-occipital.								
	8. Amnion present.								
EUTHERIA....	9. A corpus callosum.								
	10. No branchiae.	non-deciduate.							
METATHERIA...	1, 3, 4, 5, 7, 8, 9, 10 as above.								
	ii. and vi. as below.								
	7, 8, 9, 10 as above.								
	i. No testis.								
PROTOTHERIA.	ii. No allantoic placenta.								
	iii. Ureteric apertures hypocystic.								
	iv. Large malleus.								
	v. Complete coracoid.								
HYPOTHERIA...	vi. Large epipubes.								
	7, 8, i., ii., iii., iv., v., vi., as above.								
	a. No mammary glands.								
	b. Mandible articulating with quadrate.								
HYPOTHERIA...	c. No corpus callosum.								

"The accompanying Table.... presents, at a glance, the arrangement of the Mammalia in accordance with the views which I have endeavored to express. The sign O marks the places on the scheme which are occupied by known Mammals; while X indicates the groups of which nothing is known, but the formed existence of which is deducible from the law of evolution" (Huxley, *op. cit.*, p. 658).

FLOWER, 1883.

'On the Arrangement of the Orders and Families of existing Mammalia.'
 Proc. Zool. Soc., Apr. 17, 1883, pp. 178-186.

This classification, which deals only with existing orders, may be regarded as a conservative outgrowth of the systems of Cuvier, de Blainville, Owen, Gill, and Huxley, with special modifications after several other authors. Among its noteworthy features are the following: (1.) de Blainville's three grand divisions are recognized, but Huxley's terms are employed. (2.) The Marsupialia are not divided into suborders for the reason that the Peramelidæ were thought to connect the polyprotodont with the diprotodont divisions. (3.) The Edentates are divided as in Flower's work of 1882 (*P. Z. S.*, p. 358). (4.) In regard to the Sirenia it is stated that the known fossil forms "lend no countenance to their association with the Cetacea; and, on the other hand, their supposed affinity with the Ungulata receives no very material support from them." (5.) Of the Cetacea it is stated that there is "nothing known at present to connect the Cetacea with any other order of Mammals; but it is quite as likely that they are offsets of a primitive Ungulate as of a Carnivorous type." (6.) "The remaining Eutherian Mammals are clearly united by the characters of their teeth, being all heterodont and diphyodont, with their dental system traceable to a common formula." (7.) All the ungulate groups are comprised within a single order "Ungulata." (8.) The arrangement of the Insectivora, Chiroptera and Rodentia is after that of Dobson; they are thought to represent "an inferior grade of development in the Mammalian series," and to "occupy a central position, connected, as palæontology seems to show, with the Carnivora on the one hand and the Ungulata on the other" (*cf.* Gill, 1870). These remarks evidently refer only to the Insectivora and Rodentia (9.) The Carnivora are thought to form "a somewhat natural sequence" from the Insectivora (*cf.* Gill). The division of the Fissipedia is based on the work of Flower and of Mivart. (10.) "Whether the Lemuroidea should form part of the Primates (according to the traditional view), or a distinct order altogether removed from it, is as yet an undetermined question, for both sides of which there is much to be said."

Flower's Classification of 1883.

Subclass Prototheria or Ornithodelphia.

Order Monotremata (Ornithorhynchidæ, Echidnidæ).

Subclass Metatheria or Didelphia.

Order Marsupialia (Didelphidæ, Dasyuridæ, Peramelidæ, Macropodidæ, Phalangeridæ, Phascologyidæ).

Subclass Eutheria or Monodelphia.

Order Edentata.

Suborder Pilosa. (Bradypodidæ, Myrmecophagidæ.)

Suborder Loricata. (Dasypodidæ.)

Suborder Squamata. (Manidæ.)

Suborder Tubulidentata. (Orycteropodidæ.)

Order Sirenia. (Manatidæ, Halicoridæ.)

Order Cetacea.

Suborder Mysticoceti. (Balænidæ.)

Suborder Odontoceti. (Physeteridæ, Platanistidæ, Delphinidæ.)

Order Ungulata.

Suborder Artiodactyla.

Suina. (Hippopotamidæ, Phacochoeridæ, Suidæ, Dicotylidæ.)

Tragulina. (Tragulidæ.)

Tylopoda. (Camelidæ.)

Pecora. (Cervidæ, Giraffidæ, Antilocapridæ, Bovidæ.)

Suborder Perissodactyla. (Equidæ, Tapiridæ, Rhinocerotidæ.)

Suborder Hyracoidea. (Hyracidæ.)

Suborder Proboscidea. (Elephantidæ.)

Order Rodentia.

Suborder Simplicidentata (Anomaluridæ, Sciuridæ, Haplodontidæ, Castoridæ, Myoxidæ, Lophiomyidæ, Muridæ, Spalacidæ, Geomyidæ, Dipodidæ, Octodontidæ, Hystericidæ, Chinchillidæ, Dinomyidæ, Caviidæ.)

Suborder Duplicidentata. (Lagomyidæ, Leporidæ.)

Order Chiroptera.

Suborder Megachiroptera. (Pteropodidæ.)

Suborder Microchiroptera. (Vespertilionidæ, Nycteridæ, Rhinolophidæ, Emballonuridæ, Phyllostomidæ.)

Order Insectivora.

Suborder Dermoptera. (Galeopithecidæ.)

Suborder Insectivora Vera. (Tupaiidæ, Macroscelidæ, Erinaceidæ, Soricidæ, Talpidæ, Potamogalidæ, Solenodontidæ, Centetidæ, Chrysochloridæ.)

Order Carnivora.

Suborder Pinnipedia. (Phocidæ, Trichechidæ, Otariidæ.)

Suborder Carnivora Vera or Fissipedia.

Arctoidea. (Ursidæ, Ailuridæ, Procyonidæ, Mustelidæ.)

Cynoidea. (Canidæ.)

Æluroidæ. (Hyænidæ, Protelidæ, Viverridæ, Felidæ.)

Order Primates.

Suborder Lemuroidea. (Chiromyidæ, Tarsiidæ, Lemuridæ.)

Suborder Anthropeidea. (Hapalidæ, Cebidæ, Cercopithecidæ, Simiidæ, Hominidæ.)

COPE, 1891, 1898.

'Syllabus of Lectures on Geology and Paleontology,' Parts III-IV. Publ. Univ. Penn.

This classification was Cope's final attempt to express the taxonomic relationships of all the recent and fossil orders. The chief innovations, as compared with earlier classifications, are the orders "Bunotheria," "Ancylopoda," "Taxeopoda," "Amblypoda," "Diplarthra." These no doubt served at the time to emphasize certain resemblances and differences, but at present it seems probable that, with the exception of the Amblypoda, they are largely unnatural assemblages. The association of the Primates with the Hyracoidea, Litopterna and Condylarthra has not been confirmed by subsequent research, and now it even appears likely (p. 400), that the Perissodactyla and Artiodactyla are by no means so nearly related as to justify their union in a single order. The "Ancylopoda," classed by Cope with the Unguiculata, are very probably only aberrant Perissodactyls (p. 397).

Cope's Classification of 1891 and 1898.

(Abridged from the 'Syllabus'.)

Prototheria [Gill 1872].

Order Protodonta [Osborn].

" Multituberculata [Cope].

" Monotremata [*cf.*, Geoffroy].

Eutheria [Gill 1872].

I. Didelphia [de Blainville] Marsupialia [Illiger].

Suborder Polyprotodontia [Owen].

" Diprotodontia [Owen].

II. Monodelphia [de Blainville].

Mutilata [Owen].

Order Cetacea [auct.].

Suborder Archæoceti [? Flower, *cf.* Zeuglodontes Gill]

" Odontoceti [*cf.* Gray].

" Mystacoceti [*cf.* Gray].

Order Sirenia [Illiger].

Unguiculata [Linnæus].

Order Edentata [Vicq d'Azyr].

" Glires [Linn.].

Suborder Hystricomorpha [Brandt].

" Sciuromorpha [Brandt].

" Myomorpha [Brandt].

" Lagomorpha [Brandt].

Order Chiroptera [Blumenbach].

Suborder Animalivora [Gill].

" Frugivora [Gill].

- Order Bunotheria [Cope].
 - Suborder Pantotheria [Marsh].
 - " Creodonta [Cope].
 - " Insectivora [*cf.* Cuvier].
 - " Tillodonta [Marsh].
 - " Tæniodonta [Cope]¹.
- Order Carnivora [auct.].
 - Suborder Fissipedia [Blumenbach].
 - " Pinnipedia [Storr, Illiger].
- Order Ancylopoda ¹ (Chalicotheria) [Cope].
- Ungulata [Linn.].
 - Order Taxeopoda [Cope].
 - Suborder Condylarthra [Cope].
 - " Litopterna [Ameghino].
 - " Hyracoidea [Huxley].
 - " Daubentonioidea [Chiromys] [Gill]
 - " Quadrumana [Boddaërt].
 - " Anthropomorpha [*cf.* Ray, Linn.].
 - Order Toxodontia [Owen].
 - Suborder Typotheria [Zittel ?].
 - " Barytheria [Cope ?].
 - Order Proboscidea [Illiger].
 - " Amblypoda [Cope].
 - Suborder Taligrada [Cope].
 - " Pantodonta [Cope].
 - " Dinocerata [Marsh].
 - Order Diplarthra [Cope].
 - Suborder Perissodactyla [Owen].
 - " Artiodactyla [Owen].

WEBER, 1904.

'Die Säugetiere,' pp. ix-xi.

The most important features of this classification are as follows: (1) The division of the Insectivora into two suborders for which Haeckel's terms are employed; (2) the elevation of the Galeopithecidae to separate ordinal rank²; (3) the breaking up of the Edentata into entirely independent orders; (4) the recognition of the ordinal independence of many of the ungulate groups, and of the "Prosimiæ" and "Simiæ." All these features indicate that the classifier has endeavored to recognize and discount the misleading effects of parallel and convergent evolution, which in all early classifications caused animals of widely different derivation to be grouped in the same order.

¹ In edition of 1898.

² Following Leche.

Weber's Classification of 1904.

(Summarized and "indented.")

I. UNTERKLASSE MONOTREMATA.

I. Monotremata.

II. UNTERKLASSE MARSUPIALIA.

II. Marsupialia.

Polyprotodontia.

Paucituberculata.

Diprotodontia.

III. UNTERKLASSE MONDELPHIA.

III. Insectivora.

I. Menotyphla (Tupajidæ, Macroscelididæ).

II. Lipotyphla [remaining Insectivores].

IV. Chiroptera.

Megachiroptera.

Microchiroptera.

V. Galeopithecidæ.

Eden-
tata. { VI. Tubulidentata (Orycteropodidæ).
VII. Pholidota (Manidæ).
VIII. Xenarthra [American Edentates].

IX. Rodentia.

I. Duplicidentata.

II. Simplicidentata.

X. Tillodontia.

XI. Carnivora.

I. Carnivora fissipedia.

Herpestoidea (Felidæ, Viverridæ, Hyænidæ), Arctoidea
(Canidæ, Ursidæ, Procyonidæ, Ursidæ, Mustelidæ).

II. Carnivora pinnipedia.

XII. Cetacea.

I. Mystacoceti.

II. Odontoceti.

XIII. Perissodactyla.

XIV. Artiodactyla.

I. Nonruminantia (Suoidea).

II. Tylopoda.

III. Pecora (Cervidæ Bovidæ, Giraffidæ).

IV. Traguloidea.

V. Dichobunoidea.

VI. Anthracotheroidea.

XV. Condylarthra.

XVI. Ancylopoda.

XVII. Litopterna.

XVIII. Amblypoda.

XIX. Toxodontia.

XX. Hyracoidea.

XXI. Proboscidea.

XXII. Sirenia.

Ungulata. {

- Primates. {
- XXIII. Prosimiæ.
 - I. Tarsiidæ.
 - II. Lemuridæ.
 - XXIV. Simiæ.
 - I. Platyrrhina.
 - Hapalidæ.
 - Cebidæ.
 - II. Catarrhina.
 - Cercopithecidæ.
 - Hylobatidæ.
 - Anthropomorphæ.

ADDENDA.

LINNÉ'S CLASSIFICATION OF 1735.

(Given by Gill and Coues, 1877, p. 952.)

QUADRUPELIA.

Anthropomorpha. Homo, Simia, Bradypus.

Feræ. Ursus, Leo, Tigris, Felis, Mustela, Didelphis, Lutra, Odobænus, Phoca,
Hyæna, Canis, Meles, Talpa, Erinaceus, Vespertilio.

Glires. Hystrix, Sciurus, Castor, Mus, Lepus, Sorex.

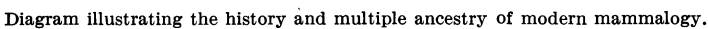
Jumenta. Equus, Hippopotamus, Elephas, Sus.

Pecora. Camelus, Cervus, Capra, Ovis, Bos.

GRAY, 1821, 1843 ETC.

John Edward Gray during the course of his long service (1824–1875) in the British Museum compiled an important series of catalogues of animals, many of them dealing with mammals and containing a large number of new generic names. Dr. Palmer informs the writer that Gray (in the *London Medical Repository*, 1821) was the first to apply to the families of mammals the termination *-idæ*, which had been suggested for the families of insects by Kirby in 1815 (Palmer, 1902, p. 720). Gray divided the Cetacea into two suborders "Denticete" and "Mysticete" and his classification of the Ungulates is noticed below (p. 346).

MODERN MAMMALOLOGY



Appendix B.

TABULAR ANALYSIS OF THE PRESENT CONTENT OF MAMMALOLOGY.

I. Static problems—exact description—the objective data.		II. Kinetic problems—Inferences as to History (subjective).	
<div>1. Morphology</div> <div><div><div>Of recent mammals</div><div>Of fossil mammals</div></div><div><div>1. Systematic mammalogy—Descr. of species and genera—based chiefly on characters of the skin and skull.</div><div>2. Anatomy and Histology.</div><div>3. Osteology.</div></div><div><div>1. Osteology { Skull. Teeth. Limbs. Etc.</div><div>2. Restoration { Of missing parts. Of external form.</div></div></div>	<div>2. Physiology (Adaptation in part.)</div> <div><div>1. Physiology proper. Adaptive significance of tissues and organs—laboratory studies.</div><div>2. Life habits. Adaptation of the organism to its life habits (field studies).</div></div>	<div>1. Morphogeny—tracing the history of a given function.</div> <div><div>A. In its embryology (organogeny).</div><div>B. In its palæontology.</div></div>	<div>2. Physiogeny { tracing the history of a given function. " " Adaptive Radiation to divergent life habits.</div>
<div>3. Embryology</div>	<div>Observing the developmental stages of the individual.</div>	<div>3. Phylogeny—tracing the developmental stages of the race.</div>	
<div>4. Distribution (Of recent and fossil species and faunæ.)</div>	<div><div>In space—involving Geography and Palæogeography.</div><div>In time { 1. General horizon. 2. Exact level (involving Stratigraphy and Correlation.)</div></div>	<div>4. Secular Migration—tracing the wanderings of species and faunæ in response to changing palæogeographical and palæometeorological barriers and openings.</div>	<div>1. Degrees of homological resemblances and divergences.</div>
<div>5. Taxonomy</div>	<div><div>Nomenclature of recent and fossil mammals.</div><div>Classification.—Viewed as a mere systematic tabulation of resemblances and differences.</div></div>	<div>5. Natural Classification, viewed as expressing</div>	<div>2. Ascending grades of specialization and progressive loss of primitive characters.</div> <div>3. Degrees of genetic kinship.</div>