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CONTENTS

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SYSTEMATIC ZOOLOGY: ITS PROGRESS AND PURPOSE *

IT is most fitting that in this year, when the scientific world is commemorating the natal centenaries of two naturalists who have been regarded as the chief systematists of their times, consideration should be given to the subject and object of their old pursuits. Carl Linné, whose bicentenary has been celebrated, was the man who first provided an elaborate code of laws for the nomenclature of all the kingdoms of nature and set an example to others by provision of concise and apt diagnoses of the groups and species he recognized. Louis Agassiz, who was born during the centenary year of Linné, gave a grand impulse to the study of nature in his adopted country, raised it in popular esteem, taught new methods of work and directed to new lines of investigation.

Of all the students of nature from the time of Aristotle to the century of Linné, none requires present notice as a systematic zoologist except John Ray, who was the true scientific father of the Swede. Born in 1627, he flourished in England during the last quarter of the seventeenth century, and died only two years before the birth of Linné.

JOHN RAY

It was long ago truly affirmed by Edwin Lankester that "Ray has been pronounced by Cuvier to be the first true systematist of the animal kingdom, and the principal

* Address before the Section of Systematic Zoology, Seventh International Zoological Congress.

guide of Linné in the department of nature."[1] 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. He, for example, in a dichotomous systematic table of the animal kingdom,[2] first combined the lunged fish-like aquatic and viviparous animals in a special category (Vivipara) in contrast with all the other vertebrates, leaving to Linné only the privilege of giving a name to the class. He recognized a group of lung-bearing animals distinguished by a heart with a single ventricle, including quadrupeds and serpents, and thus appreciated better than Linné the class which the latter named Amphibia. He likewise gave the anatomical characters, based on the heart, blood and lungs, which Linné used for his classes.

THE BEGINNINGS OF SYSTEMATIC ZOOLOGY

Systematic zoology is a vast subject, and any address devoted to it must necessarily be very partial. It need only be partial for such an assemblage of masters in zoology as I have the great honor to address, and I shall confine the present discourse to a review of some of the elements which have made systematic zoology what it now is. I will venture, too, to submit reasons why we may have to take a somewhat different view of the achievements of some men than did our early predecessors. If in doing so I may appear to be dogmatic, I entreat you in advance to insert all the "ifs" and "I thinks" and "perhaps" that you may deem to be necessary. For the present purpose, the work of two who exercised, each for a considerable time, a paramount influence on opinion and procedure, deserves notice, especially because there has been much misapprehension respecting their benefits to natural science. The two were Carl Linné and Georges Cuvier; the one exercised dictatorship from the middle of the eighteenth century till some time after its close; the other was almost equally dominant from the first quarter of the last century to well into the third quarter. No other men approached either of these two in influence on the work of contemporaries or successors. The evil features, as well as the good, were transmitted to and adopted by later authors. Therefore, a notice of those features may help us to a correct judgment of the history of our subject, and may help to show why the disciples of the great Swede, as well as the great Frenchman, complicated many problems they investigated. Sufficient time has elapsed to enable us to judge knowingly and impartially.

[1] Lankester, Edwin, "The Correspondence of John Ray," 1848, p. 485.

[2] "Synopsis Methodica Animalium Quadrupedum et Serpentini Generis," 1693, p. 53.

CARL LINNÉ

Linné needs no eulogy this year, for his praises have resounded over the whole world. Born just two centuries ago (1707), he published the first edition of the "Systema Naturæ" in 1735, and his last (twelfth) in 1766. The various editions mark to some extent the steps of man's progress in the knowledge of nature during the time limited by the respective dates.

Linné's industry was great, his sympathies wide-spread, and his method in large part good. Compare the "Systema Naturæ" and other publications of Linné with works published by earlier authors, and the reason for the active appreciation and esteem which greeted his work will be obvious. The typographical dress and the clearness of expression left no doubt as to what the author meant, and enabled the student to readily grasp his intentions. His boldness in giving expression to new ideas insured success when they deserved

it. Although Ray had already recognized four of the great groups or classes of vertebrates, he had not named them and there were vernacular terms only for the birds and fishes. Linné, for the first time, applied names to the other groups, and admirable ones they were. Mammalia and Amphibia were the coinage of Linné and are still retained; Mammalia or mammals by all; Amphibia or amphibians by the majority for one of the classes now adopted.

A great advance, too—an inspiration of genius, indeed—was the segregation of the animals combined under the class of mammals. 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 naturalists of the present day to appreciate. Linné himself was not reconciled to the idea till 1758, although Ray had more than hinted at it more than threescore years before. At last, however, in no uncertain terms, he promulgated it. It was a triumph of science over popular impressions; of anatomical consideration over superficial views.

But mingled with the great benefactions were many views which long influenced naturalists, but which modern zoology has overthrown.

LINNÆAN CLASSES

After the tentative arrangements published in the original first, second and sixth editions of the "Systema," Linné thoroughly revised his work, and first consistently applied the binomial method of nomenclature to all species in the tenth edition, published in 1758. Six classes were admitted with equal rank, no category being recognized between the class and kingdom. The classes were the Mammalia or Mammals, Aves or Birds, Amphibia, Pisces, Insecta and Vermes. The first four of these classes mainly correspond with the Aves and nameless groups of Ray.

During the Linnæan period of activity the invertebrates were little understood, and his treatment of that enormous host, referred to his two classes Insecta and Vermes, contrasts rather than compares with that at the present time. Naturally, the vertebrates were much better comprehended, and all such then known, with a single exception, were distributed among four classes just named, the Mammalia, Aves, Amphibia and Pisces. The solitary exception of exclusion of a true vertebrate from its fellows was the reference of the genus *Myxine* to the Vermes, next to *Teredo,* the ship-worm. The first two classes were adopted with the same limits they now have, but the Amphibia and Pisces were constituted in a truly remarkable manner. The class of Amphibia was a creation of Linné, and was simply contrasted with his Pisces by having a lung of some kind (*"pulmone arbitrario"*), while the Pisces have exposed branchiæ (*"branchiis externis"*). The Amphibia, thus defined, were made to include as orders: (1) Reptiles or Reptilia, having feet; (2) Serpentes, footless, and (3) Nantes, having fins.

Under the Nantes were first grouped the lampreys, the selachians, the anglers (*Lophius*), and the sturgeons (*Acipenser*). In the twelfth edition were added *Cyclopterus, Balistes, Ostracion, Tetraodon, Diodon, Centriscus, Syngnathus* and *Pegasus.* The Nantes were added to the Amphibia partly because of the assumption that the branchial pouches of the lampreys and the selachians were lungs and partly on the authority of Dr. Alexander Garden,

of Charleston, S. C., who mistook the peculiar transversely expanded and partly double air-bladder of *Diodon* for a lung. With such errors of observation as a basis, Linné apparently assumed that all the associated genera also had lungs. Gmelin, in his edition of the "Systema Naturæ" (generally called the thirteenth), corrected this error, and returned all the Nantes to the class of Pisces, thus reverting to the older view of Linné himself. The Pisces of Linné included only the genera left after the exclusion of those just named and also of *Myxine*, which last was referred to the class of Vermes between the leeches (*Hirudo*) and the ship-worms (*Teredo*).

LINNÆAN GENERA

The genera of Linné were intended and thought by him to be natural,[3] and natural groups some of the so-called genera were, but present opinion assigns to most of them a very different valuation from that given in the "Systema Naturæ." Some of the genera of invertebrates were extremely comprehensive. For example, *Asterias* included all the members of the modern classes of Stelleroidea or Asteroidea and Ophiuroidea; *Echinus* was coequal with the Echinoidea; *Cancer, Scorpio, Aranea, Scolopendra* and *Julus* were essentially coextensive with orders or even higher groups of the zoologists of the present time. Others were so heterogeneous that they can not be compared with modern groups. Thus *Holothuria*, in the last edition of the "Systema," was made to include four holothurians in the modern sense, a worm, a Physaliid, and three tunicates; in other terms, the so-called genus included representatives of four different classes, and even branches of the animal kingdom.

It has been stated by various writers that the genera of Linné were essentially coequal with the families of modern authors, but, as has been indicated, such is by no means the case. Other striking exceptions to the generalization may be shown.

Not a few of the genera of Vertebrates, although not of the superlative rank as several of the Invertebrates, were equivalent to orders of modern zoology; such were, in the main, *Simia, Testudo, Vespertilio* and *Rana*. *Simia* included all the anthropoid Primates or monkeys except man; *Vespertilio* was equivalent to the order *Chiroptera* less the genus *Noctilio; Testudo* was exactly equal to the order Testudinata or Chelonia; *Rana* to the order Salientia or Anura. A number of other genera of one or few species known to Linné were also of ordinal or subordinal value.

In striking contrast with the range of variation of such genera were others, of which several, well represented in northern waters, may be taken as examples. *Scorpæna* was distinguished simply because it had skinny tags on the head;[4] *Labrus* because it had free membranous extensions behind the dorsal spines;[5] and *Cobitis* because it had the caudal peduncle of regular height[6] and scarcely constricted as usual in fishes. These characters are of such slight systematic importance that they have not been used in the diagnoses of the genera by modern ichthyologists. Further, use of them misled even Linné as well as his successors. Some of the consequences may be noticed.

The close affinity of the "Norway haddock" or Swedish Kungsfisk or Rödfisk (*Sebastes marinus*) to the typical *Scorpæna* was unperceived and that species

[3] Classis et ordo est sapientiæ, genus et species Naturæ opus.—Linn. "Syst. Nat.," I., 13.

[4] *Scorpæna.* Caput cirris adspersum.

[5] *Labrus.* Pinna dorsalis ramento post spinas notata.

[6] *Cobitis.* Corpus vix ad caudam angustatum.

referred to *Perca* and even confounded with a *Serranus*.

The typical *Labri* of the northern seas do, indeed, have filiform processes of the fin membrane behind the dorsal spines, but most of the species referred by Linné to *Labrus* do not, and among them is a common sunfish (*auritus* = *Lepomis auritus*) of America.

The genus *Cobitis* was made to include Cyprinodonts of the genera *Anableps* and *Fundulus*, and thus were associated fishes differentiated from the Loaches by characters of immeasurably more importance than the trivial one which was the cause of their juxtaposition.

Another conspicuous instance of a trivial character used as generic, and contrasting with very important differentials of species included under the same genus, is furnished by *Esox*. The essential Linnæan diagnostic character is the protrusion of the lower jaw.[7] Nine species were referred to the genus which represent no less than eight distinct and, mostly, widely separated families of modern systematists.[8] Several of the species do not have the prominent lower jaw, and one of them (*Lepisosteus osseus* of modern ichthyology) is especially distinguished by Linné himself on account of the shorter lower jaw.[9]

But the most marked cases of insignificance of characters used to differentiate by the side of those serving for combination are found in the class Amphibia.

The genus *Lacerta* is made to include all but one of the pedate Lizards and the Crocodilians as well as the salamanders, but the "dragons," or Agamoid lizards with expansible ribs, are set apart in an independent genus.[10]

The genus *Coluber* was intended to embrace all the snakes, except those with a rattle or undivided abdominal and caudal scutes,[11] and hence the vipers and copperheads, so very closely related to the rattlesnakes, were combined with ordinary snakes instead of with their true relations.[12]

Many of the genera of Linné, in fact, were very incongruous, and the great Swede not infrequently failed to interpret and apply their characters in the allocation of species. A few cases furnished by common European or American fishes will illustrate what is meant.

Specimens of the common gunnell or butterfish were received by Linné at different times and once referred to his genus *Ophidion* and at another time to the genus *Blennius*, and the same species stands under both names in the last two editions of his "Systema."

The common toadfish of the Americans (*Opsanus tau*) was placed in the genus *Gadus* (*tau*) and a nearly related species of the Indian Ocean was referred to the genus *Cottus* (*grunniens*).

The common ten-pounder of the American coast served as the type and only species of the genus *Elops*, and also as a second species of the genus *Argentina*, although the characters given were in decided discord with those used for the latter

[7] *Esox*. Mandibula inferior longior, punctata. S. N., '58; '66, 424.

[8] The species are (1) *Sphyræna* (Sphyrænidæ), (2) *osseus* (Lepisosteidæ), (3) *Vulpes* (Albulidæ), (4) *Synodus* (Synodontidæ), (5) *lucius* (Luciidæ), (6) *belone* (Esocidæ), (7) *hepsetus* and (8) *brasiliensis* (Exocœtidæ), and (9) *gymnocephalus* (Chirocentridæ). S. N., '66, 513–517.

[9] Mandibula inferior brevior. S. N., '66, 516.

[10] *Lacerta*. "Corpus (Testa Alisve) nudum, caudatum" contrasting with *Draco*. "Corpus Alis volatile." S. N., '66, 349.

[11] *Coluber*. "Scuta abdominalia; squamæ caudales" contrasting with "*Crotalus*. Scuta abdominalia caudaliaque cum crepitaculo" and "*Boa*. Scuta abdominalia caudaliaque absque crepitaculo." S. N., '66, 349.

[12] As an example of *Coluber* a figure (tab. 3, fig. 2) of a snake with venom fangs is given.

genus, and in perfect harmony with those employed for the distinction of the former genus. Indeed, it might be properly assumed that the ascription of the *Argentina carolina* to *Argentina* was simply a matter of misplacement of a manuscript leaf, and such it may be even now considered, although the error is continued in the twelfth edition, having escaped the notice of Linné.

LINNÆAN NOMENCLATURE

The code of nomenclature devised by Linné was in many respects admirable, but he did not provide sufficiently for the principle of priority in nomenclature. He set the example of changing a name given by himself or by others, when he thought a better one could be substituted; he also felt at liberty to change the intent of a genus. A few examples of many cases may illustrate.

In 1756 the name *Salacia* was given to the Portuguese man-of-war; in 1758 the name *Holothuria* was substituted; in 1766 the latter name was retained, but with a very different diagnosis, and for the first time three holothurians in the modern sense of the word were introduced.

In 1756 the names *Cenchris* and *Crotalophorus* were used for genera, two years later renamed *Boa* and *Crotalus*. In 1756 Artedi's name, *Catodon,* was retained for the sperm whale, and Artedi's *Physeter* mainly for the killers (*Orca*); but in 1758 *Physeter* was taken up for the sperm whale, for which it has been retained ever since, except by a very few naturalists.

In 1756 and 1758 *Ophidion* was used for an acanthopterygian jugular fish—the common northern butterfish, or gunnell, now generally called *Pholis*—but in 1766, under the guise of *Ophidium,* it was transferred to the Apodes and primarily used for what is still known as the genus *Ophidium.*

In 1756 and 1758 *Trichechus* was used for the manatee alone, while the walrus was correctly associated with the seals, but in 1766 the very retrograde step was taken of associating the walrus with the manatee and retaining for the two the name *Trichechus.* Many naturalists persist to the present day in keeping the name for the walrus alone.

The example thus set by the master was naturally followed by his disciples. Many felt at liberty to change names and range of genera as they thought best and great confusion resulted, which has continued more or less down to this year of grace, 1907.

Many of the evils which have been the consequence could have been rectified if the British Association for the Advancement of Science had been logical in the code (often admirable) which it published in 1842. Instead, however, of accepting the edition of the "Systema Naturæ" (tenth) in which Linné first introduced the binomial nomenclature as the starting point, they preferred homage to an individual rather than truth to a principle, and insisted on the twelfth edition as the initial volume of zoological nomenclature. The unfortunate consequences have been manifold. Such consequences are the natural outcome of illogical and ill-considered action and must always sooner or later follow. After these many years almost all naturalists have acceded to the adoption of the tenth edition.

If the vertebrates were so much misunderstood by Linné, it may naturally be supposed that the invertebrates were equally or still less understood. Only one interesting case, however, can be referred to. In the ninth edition of the "Systema Naturæ" Linné had a monotypic genus

Salacia (p. 79) with a species named *Physalis* which was evidently a *Physalia* as long understood. In the tenth edition the name *Holothuria* was substituted for *Salacia* and no holothurians in the modern sense were recognized. In the twelfth edition all the species of the former edition were retained, but the diagnosis was altered and four holothurians of recent authors were added, and thus animals of different subkingdoms or branches were confounded in the genus. Now, if we accept the tenth edition of the "Systema" as the starting of our nomenclature, obviously *Holothuria* can not be used as it has been for these many years, and it must be revived in place of *Physalia,* notwithstanding the laments of those who are distressed by such a change. The echinoderms now called holothurians must be renamed. We can imagine the clamor that will arise when some one attempts the change.

Another fault of less moment—indeed a matter of taste chiefly—was committed by Linné. Very numerous names of plants and animals occur in the writings of various ancient authors and were mostly unidentifiable in the time of Linné. He drew upon this store with utter disregard of the consequences for names of new genera. Most of the ancient names can now be identified and associated with the species to which they were of old applied, and the incongruity of the old and new usage is striking. For example, *Dasypus,* a Greek name of the hare, was perverted to the armadillos; *Trochilus,* a name of an Egyptian plover, was misused for the humming birds; *Amia,* a name for a tunny, was transferred to the bowfin of North America. There was not the slightest justification for such perversion of the names in analogy or fitness of any kind; there was no real excuse for it. At the commencement of Linné's career (1737), the learned Professor Dillenius, of Oxford, strongly protested against such misusage for plant genera, but the sinner persisted in the practise till the end. Naturally his scholars and later nomenclators followed the bad example, and systematic zoology is consequently burdened with an immense number of the grossest and most misleading misapplications of ancient names revolting to the classicist and historian alike.

The influence of Linné continued to be felt and his system to be adopted until a new century had for sometime run its course. Meanwhile, in France, a great zoologist was developing a new system which was published at length in 1817, and anew with many modifications a dozen years later (1829).

GEORGES LÉOPOLD CHRÉTIEN FRÉDÉRIC DAGOBERT CUVIER

Georges Cuvier (born 1769) claimed[13] that before him naturalists distributed all the invertebrates among two classes as by Linné. In 1795 he published an account of memorable anatomical investigations of the invertebrates and ranged them all under six classes: molluscs, crustaceans, insects, worms, echinoderms and zoophytes. This was certainly a great improvement over previous systematic efforts, but from our standpoint crude in many respects. It was, however, necessarily crude, for naturalists had to learn how to look as well as to think.

Cuvier later essayed to do for the animal kingdom alone what Linné did for all the kingdoms of nature. So greatly had the number of known animals increased, however, that he did not attempt to give diagnoses of the species, but merely named them, mostly in foot-notes. His superior knowledge of anatomy enabled him to in-

[13] "Règne Animal," 1817, I., 61.

stitute great improvements in the system. He also first recognized the desirability of combining in major groups classes concerning which a number of general propositions could be postulated.

It was in 1812 that Cuvier presented to the Academy of Sciences[14] his celebrated memoir on a new association of the classes of the animal kingdom, proposing a special category which he called branch (embranchment), and marshaling the classes recognized by him under four primary groups: (1) the Vertebrates or Animaux vertébrés; (2) the Mollusks or Animaux mollusques; (3) the Articulates or Animaux articulés, and (4) the Radiates or Animaux rayonnés. These were adopted in the "Régne Animal." In the first (1817) edition, as in the second (1829–1830), nineteen classes were recognized, and in the latter too little consideration was given to the numerous propositions for the improvement of the system that had been suggested and urged meanwhile.

It has been generally assumed that Cuvier's work was fully up to the high mark of the times of publication, and for many years the classification which he gave was accepted by the majority of naturalists as the standard of right. To such extent was this the case that his classification of fishes and the families then defined was retained to at least the penultimate decade of the last century by the first ichthyologists of France. Nevertheless the work was quite backward in some respects and exercised a retardative influence in that the preeminent regard in which the great Frenchman was held and the proclivity to follow a leader kept many from paying any attention to superior work emanating from Cuvier's contemporaries.

It is by no means always the naturalist who enjoys the greatest reputation for the time being that anticipates future conclusions. A Frenchman who held a small place in the world's regard in comparison with Cuvier advanced far ahead of him in certain ideas. Henri Marie Ducrotay de Blainville was the man. When Cuvier (1817) associated the marsupials in the same order as the true carnivores and the monotremes with the edentates, Blainville (1816) contrasted the marsupials and monotremes as Implacentals ("Didelphes") against the ordinary Placentals ("Monodelphes"). While later (1829) Cuvier still approximated the marsupials to the carnivores, but in a distinct order between the carnivores and the rodents, and still retained the monotremes as a tribe of the edentates, Blainville (1834) recognized the marsupials and monotremes as distinct subclasses of mammals and had proposed the names Monodelphes, Didelphes and Ornithodelphes, still largely used by the most advanced of modern therologists.

Against the action of Cuvier in ranging all the hoofed mammals in two orders, the pachyderms (including the elephants) and the ruminants, may be cited the philosophical ideas of Blainville (1816), who combined the same in two very different orders, the Ongulogrades and the Gravigrades (elephants), and distributed the normal Ongulogrades under two groups, those with unpaired hoofs (Imparidigitates) and those with paired hoofs (Paridigitates), thus anticipating the classification of Owen and recent naturalists by very many years.

Cuvier's treatment of the amphibia of Linné equally contrasted with Blainville's. As late as 1829 the great French naturalist still treated the batrachians as a mere order of reptiles of a single family, and the crocodilians as a simple family of

[14] *Ann. Museum Nat. Hist.*, Paris, 1812, 19, 73–84.

Saurians. On the other hand, as early as 1816 Blainville had given subclass rank to the naked amphibians with four orders, and also ordinal rank to the crocodilians, and a little later (1822) he raised the subclasses to class rank. Still more, Blainville early (1816) recognized that the so-called naked serpents were true amphibians and gave satisfactory reasons for his assumption, though to the last Cuvier (1829) considered them to be merely a family of the ophidians. As Blainville claimed, he based his classification on anatomical facts.[15]

A pupil of Blainville, Ferdinand L'Herminier of the island of Gaudeloupe, at the instance and following the lead of his master (1827), undertook the comparative study of the sternal apparatus of birds and thereby discovered a key to the natural relationship of many types which anticipated by many years the views now current. For instance, L'Herminier first correctly appreciated the differences of the ostriches and penguins from other birds, the difference between the passerines and swifts, the homogeneity of the former, and the affinity of the humming birds and the swifts. Meanwhile Cuvier, like Linné, was content to accept as the basis for his primary classification of birds, superficial modifications of the bill and feet (toes and nails) which led to many unnatural associations as well as separations, but which nevertheless have been persisted in even to our own day by many ornithologists.

Now what could have been the underlying idea which hindered the foremost comparative anatomist of his age from the recognition of what are now considered to be elementary truths and what enabled Blainville to forge so far ahead? 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 was 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. Blainville, on the contrary, almost from the first, considered animals in their entirety and would estimate their relations by a view of the entire organization. Yet the sentiment then prevalent was reflected by one who enjoyed a high reputation for a time as a "philosophical zoologist"—William Swainson. In "A Treatise on the Geography and Classification of Animals" (1836, p. 173), the author complained that "Cuvier rested his distinctions . . . upon characters which, however good, are not always comprehensible, except to the anatomist. The utility of his system, for general use, is consequently much diminished, and it gives the student an impression (certainly an erroneous one) that the internal, and not the external, structure of an animal alone decides its place in nature." It was long before such a mischievous opinion was discarded.

Cuvier was regarded almost universally by his contemporaries, and long afterwards, in the words of his intellectual successor, Louis Agassiz, as "the greatest zoologist of all time."[16] In view of the facts already cited and innumerable others

[15] "Ses bases sont anatomiques et surtout tirées de la consideration du crâne," *Bull. Sc. Soc. Philom.*, 1816, p. 111.

[16] Agassiz, "Essay on Classification," p. 286.

that could be added, however, the contemporary verdict must be somewhat modified. Cuvier was a very great man of most impressive personality, wide versatility, extraordinary industry, vast knowledge of zoological and anatomical details, an excellent historian, a useful critic, and of good judgment in affairs generally, but although a greater all-round man, as a systematic zoologist he was not the equal of a couple of his French contemporaries, Blainville or Latreille. We have either to admit this conclusion or confess that our now universally admitted views are wrong. Nevertheless, Cuvier's work was of great importance, and he first brought to the aid of systematic zoology the new science of vertebrate paleontology.

CUVIER AND PALEONTOLOGY

The animals, and especially the vertebrates, of past ages were practically unknown to the early zoologists, and when they had large collections, as did Volta of the fishes of Mount Bolca, they identified them with modern species, or, with Scheuchzer, might consider a giant salamander as a man witness of the deluge—"Homo diluvii testis"! It was not until Cuvier, with superior knowledge of skeletal details, examined numerous bones unearthed from the Tertiary beds about Paris, that the complete distinction of animals of ancient formations from living species was recognized. Then was afforded the first glimpse of extinct faunas destined to far outnumber the existing one, but so imperfect was the great paleontologist's foresight of what lay in store for the future that he enunciated a dogma which was long accepted as sacrosanct; he called it the law of correlation of structure. A striking and even amusing example of its exposition and its failure I have previously drawn attention to.

Professor Huxley, in his excellent "Introduction to the Classification of Animals" (published in 1869), in his first chapter, "On Classification in General," concluded a consideration of Cuvier's law of the correlation of structure with the following paragraphs:

> Cuvier, the more servile of whose imitators are fond of citing his mistaken doctrines as to the nature of the methods of paleontology against the conclusions of logic and of common sense, has put this so strongly that I can not refrain from quoting his words.[17]
>
> But I doubt if any one would have divined, if untaught by observation, that all ruminants have the foot cleft, and that they alone have it. I doubt if any one would have divined that there are frontal horns only in this class; that those among them which have sharp canines for the most part lack horns.
>
> However, since these relations are constant, they must have some sufficient cause; but since we are ignorant of it, we must make good the defect of the theory by means of observation; it enables us to establish empirical laws, which become almost as certain as rational laws, when they rest on sufficiently repeated observations; so that now, whoso sees merely the print of a cleft foot may conclude that the animal which left this impression ruminated, and this conclusion is as certain as any other in physics or morals. This footprint alone, then, yields to him who observes it, the form of the teeth, the form of the jaws, the form of the vertebræ, the form of all the bones of the legs, of the thighs, of the shoulders, and of the pelvis of the animal which has passed by; it is a surer mark than all those of Zadig.

The first perusal of these remarks would occasion surprise to some and immediately induce a second, more careful reading to ascertain whether they had not been misunderstood. Men much inferior in capacity to Cuvier or Huxley may at once recall living exceptions to the positive statements as to the coordination of the "foot cleft" with the other characteristics specified. One of the most common of domesticated animals—the hog—may come up before the "mind's eye," if not the

[17] "Ossemens fossiles," ed. 4me, tome 1r, p. 184.

actual eye at the moment, to refute any such correlation as was claimed. Nevertheless, notwithstanding the fierce controversial literature centered on Huxley, I have never seen an allusion to the lapse. And yet every one will admit that the hog has the "foot cleft" just as any ruminant, but the "form of the teeth"—and the form of some vertebræ are quite different from those of the ruminants and of course the multiple stomach and adaptation for rumination do not exist in the hog. That any one mammalogist should make such a slip is not very surprising, but that a second equally learned should follow in his steps is a singular psychological curiosity. To make the case clearer to those not well acquainted with mammals, I may add that *because the feet are cleft in the same manner* in the hogs as in the ruminants, both groups have long been associated in the same order under the name Paridigitates or Artiodactyles, contrasting with another (comprising the tapirs, rhinocerotids and horses) called Imparidigitates and Perissodactyles.

I need scarcely add that the law of correlation applied by Cuvier to the structures of ruminants entirely fails in the case of many extinct mammals discovered since Cuvier's days. Zadig would have been completely nonplussed if he could have seen the imprint of an Agriochœrid, a Uintatheriid, a Menodontid or a Chalicotheriid.

The value of this law was long insisted upon by many. Some of the best anatomists, as Blainville, protested against its universality, but one who ranked with Cuvier in skill and knowledge of anatomy, Richard Owen, long upheld Cuvier's view. "You may not be aware," he wrote in 1843, "that Mr. DeBlainville contends that the ground—viz., a single bone or articular facet of a bone—on which Cuvier deemed it possible to reconstruct the entire animal, is inadequate to that end. . . . In this opinion I do not coincide."[18] The many mistakes Owen made in attempting to apply the principle proves how well Blainville's contrary opinion was justified.

The numberless remains of past animals, rescued from the many formations which the animals themselves distinguished, have entailed constant revisions of systems and clearer comprehension of the development of the animal kingdom. Such revision, too, must continue for many generations yet to come.

CUVIER AND ANATOMY

The failure to sufficiently apply anatomy to systematic zoology was especially exemplified in the treatment of the fishes which absorbed so much of Cuvier's attention in later years. He, as well as his associate, gave accounts of the visceral anatomy and was led—often misled—to conclusions respecting relations by his dissections, but he failed to receive enlightenment by examination of the numerous skeletons he had made. Those skeletons, pregnant with significance for the future, had no meaning for Cuvier; he never learned how to utilize them for the fishes as he did those of the mammals. His colleague and successor, Valenciennes, in the great "Histoire Naturelle des Poissons," was equally unappreciative of the importance of comparative osteology for comprehension of the mutual relations of the groups of fishes.

CUVIER'S SUCCESSORS

The same defect in method or logic that characterized Cuvier's work was manifested by his great English successor in range of knowledge of comparative anatomy, Richard Owen. His families, for the most part, were the artificial assemblages brought together by zoologists on account of superficial characters and too often

[18] Owen, *Am. Journ. Sc. and Arts*, XLV., 1843, 185.

without rigorous attention to the applicability of the characters assigned. Much better was the work of the greatest naturalist of all, Johannes Müller, who advanced our knowledge of the systematic relations of all classes of vertebrates as well as invertebrates. But all were unable to free themselves from the incubus of the popular idea that all branchiferous vertebrates formed a unit to be compared with birds and mammals. Several propositions to segregate, as classes, *Amphioxus* and the chondropterygians had been made, and Louis Agassiz deserves the credit of claiming class value for the myzonts or marsipobranchs as well as the selachians. But it was left to Ernst Haeckel, a pupil of Müller, still happily living, to divest himself entirely of ancient prejudices and appreciate the interrelationship of the primary sections of the vertebrate branch. He for the first time (1866) set apart the amphioxids in a group opposed to all other vertebrates, then docked off the marsipobranchs from all the rest, and collected the classes generally recognized in essentially the same manner as is now prevalent. We may differ from Haeckel as to his classes of fishes and dipnoans, but his correctness in the action just noticed will be conceded by most, if not all, systematic zoologists to-day.

EMBRYOLOGY

While Cuvier was still flourishing, a school of investigators into the developmental changes of the individual in different classes, and among them the vertebrates, was accumulating new material which should be of use to the systematic zoologist. Chief of these was Karl Ernst von Baer. In various memoirs (1826 et seq.) he subjected the major classification of animals to a critical review from an embryological point of view, recognized, with Cuvier, the existence of four distinct plans which he called types and characterized them in embryological terms—*Evolutio radiata, Evolutio contorta* (molluscs), *Evolutio gemina* (articulates) and *Evolutio bigemina* (vertebrates). The last were successively differentiated on account of the embryonic changes from the fishes to the mammals. "These Beiträge," Louis Agassiz justly affirmed, "and the papers in which Cuvier characterized for the first time the four great types of the animal kingdom, are among the most important contributions to general zoology ever published."

One of the most notable results, so far as systematic zoology was involved, was the deduction forced on Kowalevsky by his investigation of the embryology of tunicates, that those animals, long associated with acephalous mollusks, were really degenerate and specialized protovertebrates. This view early won general acceptance.

While embryology was very successfully used for the elucidation of systematic zoology its facts were often misunderstood and perverted. For instance, the cetaceans were regarded as low because they had a primitive fish-like form, although it must be obvious to all logical zoologists of the present time that they are derived from a quadruped stock; snakes have been also regarded as inferior in the scale because no legs were developed, although it would be now conceded by every instructed herpetologist that they are descendants of footed or lizard-like reptiles. *Ammocœtes* was considered as higher than *Petromyzon* "inasmuch as the division of the lips indicates a tendency towards a formation of a distinct upper and lower jaw," but we now know that *Ammocœtes* is the larval form of *Petromyzon*. Innumerable still more pertinent examples might be adduced for the inferior systematic grades, orders, families, genera, species, etc. The words high and low were used when generalized

and specialized were really meant and those words, pregnant with mischief, often led their users astray as well as the students to which they were addressed.

PHILOSOPHICAL ZOOLOGY

As knowledge of the various animal groups increased and countless new species were piling up, yearning arose to discover principles underlying the enormous mass of accumulating details, and the excogitations of various naturalists resulted in some curious speculation and expression in classificatory form. They called their outpourings philosophy or philosophical zoology, and philosophers they were called by others.

Some of the philosophers grouped animals according to supposed degrees of nervous sensibility;[19] some according to the relations of parts to a center or an axis;[20] some under groups supposed to correspond with different systems of the body, as the alimentary, the vascular, the respiratory, the skeletal and the muscular,[21] and some would accord to each of the senses definite groups.[22]

Equally, if not more extravagant, views were entertained by many naturalists that creative power delighted in the symmetry of numbers and in circular arrangements. It was contended that all groups of animals represented analogous groups in successively diminishing circles; that in a perfect system there were a definite number of subkingdoms, an equal number of classes in each subkingdom, of orders in each class of suborders, of families, of genera, of subgenera, etc. Some maintained that three was the regnant number, others upheld four, others seven, but the most numerous and influential school contended for five. Exactly what the philosophers thought they meant, or what strange visions they may have conjured up may never be known. But for a time (1822–42) the school of quinarians, as they were called, claimed most of the naturalists of Britain. The most zealous of the school (William Swainson) was especially displeased with the developmental hypothesis of Lamarck and characterized the "speculations" of the great Frenchman "not merely as fanciful, but absolutely absurd."

But it was the much-contemned hypothesis of descent with modifications that was destined at last to relieve biological science of the wild and irrational speculations and

[19] Lamarck (1812) contended for three categories of animals: (1) apathetic animals and (2) sensitive animals among the invertebrates, and (3) intelligent animals, equivalent to the vertebrates.

[20] Blainville (1816) proposed to divide the animal kingdom into three subkingdoms: (1) the Artiomorphes, having a bilateral form, (2) the Actinomorphes, having a radiate form, and (3) the Héteromorphes (mainly sponges and protozoans), having an irregular form.

[21] Oken (1802–47) gave expression to his varying views in several differing classifications. In one scheme (El. Physiophilosophy, 1847, 511 et seq.) he claimed that there were five "circles" corresponding with the "animal systems": (1) Intestinal animals (Protozoa and Radiates); (2) Vascular, sexual animals (Mollusks); (3) Respiratory, cutaneous animals (Articulates); (4) Sarcose animals (Vertebrates except mammals), and (5) Aistheseozoa, or animals "with all . . . organs of sense perfectly developed" (mammals).

[22] Oken maintained (1802–47): "that the animal classes are virtually nothing else than a representation of the sense-organs, and that they must be arranged in accordance with them. Thus, strictly speaking, there are only five animal classes: Dermatozoa (skin or touch animals), or the Invertebrata; Glossozoa (tongue animals), or the fishes . . .; Rhinozoa (nose animals), or the reptiles . . .; Otozoa (ear animals), or the birds; Ophthalmozoa (eye animals), or the Thricozoa (mammals). . . . But since all vegetative systems are subordinate to the tegument or general sense of feeling, the Dermatozoa divide into just as many or corresponding divisions, which on account of the quantity of their contents, may be for the sake of convenience also termed classes." —Oken, El. Physiophilosophy, 1847, p. xi. For the many other assumptions on similar and divergent lines the reader must refer to the "Elements of Physiophilosophy" (1847).

classifications of the nature-philosophers, physiophilosophers, circularians, quinarians, trinitarians, septenarians, and their like that flourished during the first half of the past century.

DEVELOPMENT THEORY

Although there had been previous indications of belief that transmutation of species might have been a cause for the diversity of animal life, Jean Baptiste Pierre Antoine de Monet de Lamarck (1809) first framed a hypothesis that had a logical basis, although weakened by unproved postulates. In view of those weaknesses, it was easy to bring forth many facts that seemed to militate unanswerably against it, and such were well put forward by Cuvier; as the hypothesis, too, was very unpopular, it was for a long time stifled. In the meanwhile geological and paleontological investigation, comparative morphology, physiology and embryology, as well as systematic zoology, were revealing innumerable facts that pointed all in the same direction and were only explicable collectively by the assumption that they were the result of original community of origin and subsequent deviation by gradual changes from time to time. The facts were at length collocated with extreme skill by Charles Darwin (1859) and a rational explanation of their evolution by means of natural selection made the new development theory acceptable to well-informed naturalists and logical thinkers generally.

SEQUENCE OF GROUPS

It had been almost the universal custom from olden time, as well as during the Linnæan era, to commence the enumeration or catalogues of animals with the forms exhibiting most analogy with man and consequently the highest in the scale of organic nature. As long as species were assumed to be individually created this was perhaps the most natural course, and at least had the advantage of proceeding from the comparatively known to the almost unknown. A significant and noteworthy exception to this mode of procedure among the old naturalists was afforded by Lamarck (1809 et seq.), the precursor in this respect as well as in recognition of descent, of the modern school.

When it became generally recognized that there had been always a progression and development from antecedent forms, naturally there was a change in the manner of exposition of a series, and the lowest forms were taken as the initial ones and followed by those successively higher in the scale of beings. Even when old prejudices were administered to and the highest animals put first in a work, it was often done in a reversed series; that is, after the supposed natural ascensive series had been determined on, that series was simply reversed in order that the highest should be the first and the lowest the last. Many of our text-books of zoology still have this characteristic, but are being rapidly replaced by those exhibiting the phyletic series.

HISTOLOGY

One of the most noteworthy modifications of systematic zoology was the fruit of histological research. In 1839 Theodor Schwann, incited by the brilliant results of Matthias Jacob Schleiden's researches (1838) in vegetal histology, and at the suggestion of Johannes Müller, undertook investigations which led him to consider that the animal frame was built up from innumerable cells variously modified to form the different systems and organs of which it is composed. Ultimately the animals thus developed were segregated by Ernst Haeckel, and the animal kingdom was limited to them, while the simple unicellular animals which had been already designated as Protozoa were associated with

unicellular plants under the general term Protista. One of the prominent features of this idea was accepted by Thomas Henry Huxley (1874) with, however, the very important modification of retaining the old name Protozoa as the collective name of the animals and taking a suggested name of Haeckel's (Metazoa) for the multicellular animals.

GRADUAL DELIMITATION OF GENERA

As has been already noted, the animal genera of Linné were mostly extremely comprehensive, answering, when natural groups, to families, superfamilies, and even orders or classes of modern naturalists. Such contrast, however, with others of the Linnæan genera, and when this fact became recognized and it was discovered that the large genera embraced types exhibiting many differences in detail, the latter were subdivided; early in the past century, at first owing especially to French and German naturalists, the subdivision of old genera on approximately present lines was commenced and applied at different times to various classes. It is noteworthy that in some instances the authors of the new genera quite abruptly changed their minds regarding the nature of such groups. For example, Lacépède, in 1798, in the closing lecture of his course at the Museum of Natural History, recognized only 51 genera of mammals, but a few months later (in 1799), in a "tableau," admitted and defined 84 genera.

It seems to be generally supposed that there has been an uninterrupted tendency among zoologists to refinement and increase of number of genera to the present time, but such is by no means the case. Half a century ago and more some ornithologists subdivided old genera and made new ones to an extent to which none of the present time is prepared to go. For example, Charles Bonaparte, Prince of Canino, required eleven genera of gulls to include those now congregated in one. About the same time, some herpetologists were equally radical. Leopold J. F. J. Fitzinger, in 1843, distributed species which are now combined by all in the genus *Anolis* among no less than fifteen genera. The genus *Bufo,* as now understood, was split by some herpetologists into a dozen or more. These are only samples of numberless analogous cases.

THE OLD AND THE NEW

A comparison of systematic zoology at its dawn with that of the present time is rather a contrast of different themes.

The old naturalists believed that all species of animals were created as such by a divine fiat; the modern consider that all animals are derivatives from former ones and that their differences have been acquired during descent and development.

The Linnæans based their systems on superficial characteristics, and the moderns take into consideration the entire animal.

The early systematists assumed that characters drawn from structures or parts most useful to the animals were the best guides to the relationship of the animals; the latest ones have learned to distrust the evidential value of similarity of structures unaccompanied by similarity of all parts. The former were guided mainly by physiological characters; the latter take morphological ones.

The Linnæans confined their generalizations to few categories—genera, orders, classes; the moderns exhibit the manifold modifications and coordinations of all structural parts in many categories—genera, subfamilies, families, superfamilies and various higher groups.

The old naturalists believed more or less in the existence of a regular chain of beings from high to low; the new ones

recognize the boundless ramifications of all animal stocks.

The elders assumed certain forms as highest and ranged their series from high to low; the sons commence their series with the most generalized types and progress from the less generalized to the more specialized.

PROSPECTS AND NEEDS

In numerous old systematic and descriptive works—but in many cases not very old—the skeleton and other anatomical details were noticed in connection with the species described, but not seldom some of those details, if rightly interpreted, would be in contravention of the classification adopted. In fact, the anatomy was to all intents and purposes treated as an offering of curious but useless information. Such conceptions, happily, are mainly—but not entirely—of the past, and we may live to welcome the day when every animal will be treated as whole. Systematic zoology will then be regarded as the expression of our knowledge of the entire structure and as an attempted equation of the results obtained by investigations of all kinds. In fact, systematic zoology is simply an attempt to estimate the relative importance of all structural details and to correlate them so that their relative values shall become most evident. It is the scientific outcome of all anatomical or morphological knowledge and the aim is to arrange the animal groups in such a manner as to show best their genetic relations and the successive steps of divergence from more or less generalized stocks.

One consummation devoutly to be wished for is general acceptance of a standard for comparison and the use of terms with as nearly equal values as the circumstances admit of. There is a great difference in the use of taxonomic names for the different classes of the animal kingdom. The difference is especially great between usage for the birds and that for the fishes. For the former class, genera, families and orders are based on characters of a very trivial kind. For example, the family of Turdidæ, or thrushes, relieved of formal verbiage, has been distinguished from neighboring families solely because the young have spots on the breast, but even this distinction is now known to fail in some instances. Extremely few, if any, of the families of oscine birds are based on characters of a kind which would be regarded as of family value in other classes of vertebrates. On the other hand, many of the families and genera of fishes are made by some excellent authorities to include types separated by striking peculiarities of the skeleton as well as the exterior. The mammals are a class whose treatment has been mostly intermediate between that for the birds and that for the fishes. Its divisions, inferior as well as comprehensive, have been founded on anatomical characters to a greater extent than for any other class. Its students are numerous and qualified. Mammalogy might therefore well be accepted as a standard for taxonomy, and the groups adopted for it be imitated as nearly as the differing conditions will admit. The families of birds would then be much reduced in number and those of fishes increased. All the active herpetologists and ichthyologists of the United States have subordinated their own beliefs and ideas as to what would have been most desirable, to a greater or less extent, to approximate the desirable reduction of the terms admitted by them to a standard uniform with that adopted by mammalogists. If others would likewise sacrifice their own predilections, the lamentable inequality of usage now prevalent would be much less;

such congruity would be to the great advantage of comparative taxonomy.

In these days of extreme specialization one of the greatest needs in our universities is a professor of systematic zoology with whom conference may be held as to the propriety of any systematic modification resulting from special investigation of the anatomy of any organ or part, or of any group of animals. Such conference might prevent the publication of many propositions due to exclusive consideration of an isolated subject. Perhaps the designation of systematic morphology might better indicate the nature of the suggested course. The consummation, however, it must be admitted, is more desirable than probable.

I have intentionally refrained from any consideration of the work of living zoologists. If I had undertaken this, the task of selection would have been very difficult, and at any rate the time demanded for proper consideration would have been much more than that requisite for the reminder of past discoveries. The progress of systematic zoology during recent years has been in accelerated ratio, and not a few of those whose achievements have helped to put zoology at its present level are in Boston to-day. It is from the summit of the elevation they have enabled us to reach that we look back to the deeds of old masters and can determine, better than their contemporaries or immediate successors, their relative merits.

THEO. GILL

SCIENTIFIC BOOKS

Anatomical Terminology with Special Reference to the [BNA]. By PROFESSOR LEWELLYS F. BARKER. Philadelphia, P. Blakiston's Son & Co. 1907.

The necessity for both exactness and simplicity in the nomenclature employed in the descriptive sciences has always been recognized, and in anatomy several attempts have been made to establish a terminology which would be acceptable to the great body of anatomists and eliminate from anatomical nomenclature the ponderous mass of synonyms with which it is burdened. Henle in his classic "Handbook" accomplished much towards the desired end, and since 1880 Professor B. G. Wilder has labored assiduously for the cause. But it was not a matter for accomplishment by a single individual working independently; it required concerted action. And although endeavors had been made to enlist the sympathies of the American Association for the Advancement of Science and the Association of American Anatomists in the work, for one reason or another little definite progress was made.

In 1887 the pressing need of an authoritative revision of anatomical nomenclature was brought to the attention of the German Anatomical Society, then but recently organized, and in 1889 it established a commission to deal with the matter, appointing upon the commission Professors von Kölliker (chairman), O. Hertwig, His, Kollmann, Merkel, Schwalbe, Toldt, Waldeyer and von Bardeleben, Professor Krause being later selected as editor-in-chief and representatives of Great Britain and other countries being also included. For six years the commission labored with the difficulties assigned for its consideration, and in 1895 it presented a report to the society, submitting a list of some 4,500 terms, carefully selected from the 30,000 or more, principally synonyms, which may be collected from the various standard text-books. The society received and adopted the commission's report at its meeting in Basel, a circumstance which has gained for the list the appellation of the Basel Anatomical Nomenclature or, more briefly, the BNA, and the report, drawn up by Professor His, was published as a supplement number of the *Archiv für Anatomie und Physiologie*.

This is neither the time nor the place for a discussion of the work of the commission; suffice it to say that its results have been widely accepted and that a uniformity of an-