

CHAPTER VII.

EVIDENCES OF EVOLUTION.

Systems of Classification.

BEFORE discussing the evidences of Evolution, or examining the arguments advanced in its support, it is advisable to have some idea of the different systems of classification which have obtained in various periods of the history of science, and to learn on what such systems were based. Have naturalists in all ages employed essentially the same systems of classification, or have their systems been widely different, if not contradictory? Are scientific classifications expressions of natural arrangements existing in animated nature, or are they but artificial devices for coördinating our knowledge of nature and facilitating our investigations? Have species, genera, families, orders, classes and branches, a real or an ideal existence? Are they manifestly disclosed in the plan of creation or are they but arbitrary categories hit upon by naturalists as convenient aids in arrangement and research? These are a few of the many questions which present themselves for an answer as we approach the subject of organic Evolution. Others there are also which might be discussed but we have not space for them now.

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The system of classification of Aristotle, and of the naturalists of antiquity generally, was of the most primitive character. It recognized but two groups, *γένος* and *εἶδος*, genus and species. These terms, as a rule, had only a very vague meaning, and were frequently made to embrace groups of animals that we should now refer to orders and classes.¹

This system, however, incomplete and misleading as it was, prevailed for upwards of two thousand years, and no serious attempt was made to improve on it until the time of the great naturalist, Linnæus. He introduced new divisions and distinctions, gave to the study of zoölogy an impetus which it had never received before, and stimulated research in a manner that was simply marvelous. He was the first to introduce classes and orders into the system of zoölogy, in addition to the vague genera and species of the ancient philosophers.² Until the appearance of the "Règne Animal" of Cuvier, in the beginning of the present century, the "Systema Naturæ" of Linnæus, first published in 1735, was the only system of classification which received any recognition. All other attempts at classification were only

¹In the sixth chapter of the first book of his "History of Animals" Aristotle distinguishes between *γένη μέγιστα*, *γένη μεγάλα* and *γένος* simply. This chapter will well repay perusal as illustrating the diversity of meanings given to a word which in modern zoölogy has such a definite and restricted signification. Although *εἶδος* had sometimes a wider meaning than we now give to this term, it must, nevertheless, in justice to the illustrious Stagirite, be said that he usually employed it in the same sense as naturalists now use the word species.

²Linnæus called the class, *genus summum*; the order, *genus intermedium*; the genus, *genus proximum*.

modifications of the system introduced by the Swedish naturalist. But when Cuvier—"the greatest zoölogist of all time," as Agassiz denominates him—began his epoch-making investigations, all was changed. The divisions of Linnæus were based on external resemblances. Cuvier, as the result of an extensive survey of the whole animal kingdom, and more especially in consequence of his marvelous investigations in the domain of comparative anatomy, a science of which he was the founder, demonstrated that classification should be based, not on external resemblance, but on internal structure. He was indeed the first to introduce order into chaos, and to place the science of zoölogy on something like a firm foundation.

Cuvier and His Successors.

Before Cuvier's time no attempt had been made to bring the various groups of animals under a more comprehensive division than that which exhibited the whole animal kingdom as composed of vertebrates and invertebrates; a division which was not materially different from that of Aristotle, who classed all animals as *sanguineous*, ζῷα ἔναιμα, and *asanguineous*, ζῷα ἀναιμα. But, in his memorable communication to the French Academy in 1812, Cuvier declared that his researches had led him to believe "that all animals are constructed upon four different plans, or as it were, cast in four different moulds."¹

¹The words of the French naturalist on this subject are: "Si l'on considère le règne animal d'après les principes que nous venons de poser, en se débarrassant des préjugés établis sur les divisions anciennement admises, en n'ayant égard qu'à l'or-

The names given to the groups—*embranchemens*, or branches, Cuvier calls them—constructed on these four plans are vertebrates, mollusks, articulates and radiates. It will thus be seen that Cuvier introduces divisions above the classes of Linnæus. In addition to this he also interpolates families between orders and genera. And then, again, the various divisions of Cuvier admit of numerous secondary divisions, such as sections, tribes, sub-genera and others besides.

Important as was the "Systema Naturæ" in stimulating research, its influence was almost insignificant in comparison with Cuvier's masterly "Leçons sur l'Anatomie Comparée," and his no less remarkable "Règne Animal," and "Ossemens Fossiles." The publication of these *chefs-d'œuvre* not only gave to the study of natural history a stimulus it had never felt before, but it was likewise the occasion of numerous new systems of zoölogical classification of various degrees of merit.

Naturalists now vied with one another in establishing new divisions, in introducing new classes, orders, genera and species into their systems, and in claiming, each for his own system, some special value or point of superiority not possessed by the others. First came the system of Lamarck, then those of

ganisation et à la nature des animaux, et non pas à leur grandeur, à leur utilité, au plus ou moins de connaissance que nous en avons, ou à toutes les autres circonstances accessoires, on trouvera qu'il existe quatre formes principales, quatre plans généraux, si l'on peut s'exprimer ainsi, d'après lesquels tous les animaux semblent avoir été modelés et dont les divisions ultérieures, de quelque titre que les naturalistes les aient décorés, ne sont que des modifications assez légères, fondées sur le développement ou l'addition de quelques parties qui ne changent rien à l'essence du plan."

De Blainville, Ehrenberg, Burmeister, Von Siebold and Stannius, Leuckart, Milne-Edwards, Kölliker, Vogt, Van Beneden, Owen, Von Baer, Agassiz, Huxley, Hæckel and Ray Lankester, not to mention scores of others of lesser importance.

Points of View.

But what is more striking than the number of zoölogical systems which our century has produced, are the diverse points of view which systematists have chosen in elaborating their systems. The pre-Cuvierian taxonomists, as we have seen, based their schemes of classification on external characteristics. Cuvier insisted that taxonomy should be based on internal structure, and that the structure of the entire animal should be considered. Certain later systematists deemed this unnecessary, and attempted to build systems of classification on the variations of a single organ, or on the structure of the egg alone.

Again, according to Cuvier's classification, the four branches of the animal kingdom are distinguished by four distinct plans of structure. According to Ehrenberg "the type of development of animals is one and the same from man to the monad." According to Cuvier and his school, the four types of structure proceed along four parallel lines. According to the evolutionary school, however, the entire animal kingdom is to be conceived as a genealogical tree, *Stammbaum*, the various branches and twigs, twiglets and leaves of which, are to be regarded as the classes, orders, genera and species of which zoölogists speak.

At first classification was based on only superficial characteristics. Now we must take into account, not only external form and internal structure, not only anatomical and histological characteristics, but we must also incorporate in our classifications the teachings of embryology and cytology. We must study not only bone and muscle, but investigate the nature and structure of the cell, and study the embryo from its earliest to its latest state of development. We can now call no one master, for the days of *magister dixit* have passed. Neither Aristotle, nor Linnæus, nor Cuvier nor any other one person is to be our sole guide, but we must perforce elaborate a system from the combined observations and generalizations of not only the great masters above-mentioned, but also from those of Schwann and Von Baer, Johann and Fritz Müller, Kowalewsky and Darwin. We must discard much, once accepted as true, which more exact research has disproved, and combine into one systematic whole the gleanings of truth which are afforded by the investigations of so many students in the various departments of natural knowledge.

Taxonomic Divisions.

Our brief reference to some of the chief systems of classification conducts us naturally to a more important topic, the nature of the various categories which we have been considering.

Have branches, classes, orders, families, genera and species a real existence in nature, or are they

merely more or less successful devices of scientific men to arrange and correlate the facts and phenomena of nature? Are the divisions which naturalists have introduced into their systems artificial and arbitrary, or have they rather been instituted by the Divine Intelligence as the categories of His mode of thinking? Are they but the inventions of the human mind or have "the relations and proportions which exist throughout the animal and vegetable worlds an intellectual and ideal connection in the mind of the Creator?" "Have we, perhaps," asks the eloquent Agassiz, "thus far been only the unconscious interpreters of a Divine conception, in our attempts to expound nature? And when in the pride of our philosophy we thought that we were inventing systems of science, and classifying creation by the force of our own reason, have we followed only and reproduced in our imperfect expressions, the plan whose foundations were laid in the dawn of creation, and the development of which we are laboriously studying, thinking, as we put together and arrange our fragmentary knowledge, that we are introducing order into chaos anew? Is this order the result of the exertions of human skill and ingenuity; or is it inherent in the objects themselves, so that the intelligent student of natural history is led unconsciously, by the study of the animal kingdom itself, to these conclusions, the great divisions under which he arranges animals being indeed but the headings to the chapter of the great book which he is reading."¹

¹"Essay on Classification," pp. 8, 9.

On a correct answer to this last all-important question depends, in great measure, the truth or falsity of the theory of organic Evolution. It is a shibboleth which cannot be evaded, a crux which must be explained before an intelligent discussion of the evidences of Evolution is even possible.

Plato's "Grand Ideas."

According to Plato, "the world of particular things is somehow determined by preëxisting universal ideas." Species and genera, therefore, are but expressions of the ideas of the Creator; and classifications of animals and plants, according to types, are but translations of the thoughts of God; expressions of grand ideas which from all eternity have been before the Divine mind. Types, then, are but the copy; the Divine ideas, the pattern or archetype. Species, as Plato conceived them, were immutable, and organic Evolution, as now understood, was, accordingly, impossible.

During the Middle Ages, Plato's doctrine of types was accepted without question, and species were looked upon as being as immutable as the rules of dialectics, as unchangeable as truth itself. Thus the great Scotus Erigena, probably the profoundest philosopher of his time, declares that "that art which divides genera into species, and resolves species into genera, which is called dialectics, is not the product of human ingenuity, but has its origin in the nature of things and is due to the Author of all arts which are true arts, and has been

simply discovered by the wise."¹ But this classification, this division into species and genera, which, according to Erigena, is something not artificial and conventional, but something that is real and Divine, applied, in the estimation of most philosophers prior to the time of Darwin, not only to logic and metaphysics but also to the natural sciences as well.

Linnæus held similar views. He tells us explicitly that "the number of species is equal to the number of divers forms which the Infinite Being created in the beginning; which forms, according to the prescribed laws of generation, produced others, but always like unto themselves."²

Cuvier on Species.

But the strongest and most eminent advocate of the creation and fixity of species was Cuvier. In the introduction to his "Règne Animal" he asserts that "there is no proof that all the differences which now distinguish organized beings are such as may have been produced by circumstances. All that has been advanced upon this subject is hypothetical; experience seems to show, on the contrary, that, in the actual state of things, varieties are confined within

¹"Intelligitur quod ars illa, quæ dividet genera in species et species in genera resolvit, quæ *διαλεκτική* dicitur, non ab humanis machinationibus sit facta, sed in natura rerum ab Auctore omnium artium, quæ veræ artes sunt, condita et a sapientibus inventa." "De Divisione Naturæ," IV, 4.

²"Species tot sunt, quot diversas formas ab initio produxit Infinitum Ens; quæ formæ, secundum generationis inditas leges, produxere plures, at sibi semper similes." "Philosophia Botanica," 99, 157.

rather narrow limits, and, so far as we can retrace antiquity, we perceive that these limits were the same as at the present. We are thus obliged to admit of certain forms which, since the origin of things, have been perpetuated, without exceeding these limits; and all the beings appertaining to one of these forms constitute what is termed a *species*. Generation being the only means of ascertaining the limits to which varieties may extend, species should be defined as the reunion of individuals descended from one another, or from common parents, or from such as resemble them as closely as they resemble each other; but although this definition is rigorous, it will be seen that its application to particular individuals may be very different when the necessary experiments have been made."

But not only, according to Cuvier, are existing species fixed and the result of special creative action; the same views must also be held regarding the countless geological species which have so long disappeared from the face of the earth. The great naturalist was a firm believer in the doctrine of successive creations and destructions, of a series of de-populations and repeoplings of the world. As is well known, he was the author of the celebrated Period or Concordistic theory, which attempts to reconcile the statements of the Mosaic narrative of creation with the declarations of geology and paleontology — a theory which has had a great vogue, and which, after the lapse of three-quarters of a century, has even now not a few advocates.

Definition of Species.

We come now to the definition of the term species, the critical point in the controversy between creationists and evolutionists. Aristotle's conception of species was, as we have seen, far from being precise. With his followers, for more than two thousand years, the idea of a physiological species was vague and nebulous in the extreme. It was usually nothing more than a metaphysical concept, and was of little or no value to the working naturalist. Indeed, strange as it may seem, no definition of the term species, as it is now used, was given until the latter part of the seventeenth century. One of the first definitions found is in the "Historia Plantarum" of the noted English botanist Ray, although Yung, of Hamburg, and Tournefort, the distinguished French botanist, contemporaries of Ray, appear to have anticipated the English naturalist in arriving at a true conception of physiological species. According to Ray, "specific characters rested not only on close and constant resemblance in outward form, but also on the likeness of offspring to parent, a considerable measure of variability being, however, recognized." Ray's definition of species and Linnæus' binomial system of nomenclature, which so greatly facilitated classification, contributed immensely towards establishing order where chaos had so long reigned supreme.

It would be a mistake, however, to suppose that, after the labors of Ray, Linnæus, Cuvier, and their collaborators, there was perfect unanimity respect-

ing the nature and signification of species. On the contrary, the divergence of views was rendered greater in proportion to the progress of research and discovery, so that it soon became difficult to find any two persons who could agree on a definition of the term "species."

Everyone who wrote on zoölogy, as we have learned, had his own system of classification. In like manner, everyone who had occasion to treat of questions of natural history found himself compelled to define the little word "species," and the definition given usually differed in important respects from those of previous investigators. Indeed, if we compare the definitions of species which have been given since the time of Ray, we shall find that there has been as great a change of opinion respecting its nature, as there has been displayed in the various systems of classification that have been elaborated since the period of Linnæus. Everywhere there is uncertainty, doubt, nebulosity.

The learned anthropologist, De Quatrefages, in his interesting work, "Darwin et ses Précurseurs Français," gives, besides his own definition of the term, no fewer than twenty definitions of species—he might have given many more—as proposed by as many eminent naturalists.¹ Some, like Ray and Flourens, base their definition on genealogical connection; others like Tournefort and De Candolle regard likeness among individuals as the essential thing in a true definition of species, while others still, and these for

¹Pp. 186, 187.

the nonce are in the majority, aver that both filiation and resemblance must be taken into account in any true definition of the term.

Thus, the illustrious botanist Antoine Laurent de Jussieu, the founder of the "natural system" of botany, which superseded the artificial or sexual system of Linnæus, defines species as "a succession of individuals entirely alike, which are perpetuated by generation."¹ Similar definitions have been given by Lamarck, Cuvier, Johann Müller, Isidore Geoffroy Saint-Hilaire and others. According to De Quatrefages a "species is a collection of individuals, more or less resembling each other, which may be regarded as having descended from a single primitive pair by an uninterrupted and natural succession of families."² Agassiz, however, who, as we have seen, contended that individuals of the same species existing in disconnected geographical areas had independent origins, insisted that we are forced "to remove from the philosophic definition of species the idea of a community of origin, and consequently, also, the idea of a necessary genealogical connection."³

To the foregoing I may add the declarations of our eminent American botanist, Professor Asa Gray, who declares: "We still hold that genealogical connection, rather than mutual resemblance, is the fun-

¹In his great work, "Genera Plantarum," Jussieu says of species: "Nunc rectius definitur perennis individuorum similium successio continuata generatione renascentium."

²"The Human Species," p. 36.

³"Essay on Classification," p. 256.

damental thing—first on the ground of fact, and then from the philosophy of the case. Practically, no botanist can say what amount of dissimilarity is compatible with the unity of species; in wild plants it is sometimes very great, in cultivated races often enormous."¹ What the learned professor here affirms of plants, may likewise, with equal truth, be predicated of animals both wild and domestic.

Difficulties Regarding Species.

What, then, is species? Is it something real, as some have averred, or is it, as others maintain, something which is only ideal? And if it have an existence, real or ideal, how may it be recognized? The definitions given do not, as we have seen, throw much light on the subject. On the contrary, they are all more or less defective, and often quite contradictory.

It is only, however, when we come to consider the practical applications of these or similar definitions, that we find how illusory and unsatisfactory they are. We have but to compare the classifications of different botanists and zoölogists when treating of the same floræ and faunæ, to realize how utterly inadequate are even the best definitions of species as guides in the classificatory work of practical naturalists. No two naturalists, it may safely be asserted, have ever yet agreed on the same classification as to species, even for the animals and plants of restricted geographical areas. Some aug-

¹"Darwiniana," p. 203.