of the same material, a kind of cosmic dust, similar to, if not identical with, that which composes the existing nebulæ. No form of matter has yet been discovered in any of the heavenly bodies which is not found on the earth, and there is every reason to believe that in chemical constitution the visible universe is everywhere identical. And should it eventually be demonstrated that all the known chemical elements are only modifications of one primal form of matter, and this is far from impossible, or even improbable, then will be vindicated the old Greek theory of a primordial matter, πρῶτη ὕλη, a theory ardently championed by St. Gregory of Nyssa and his school, and defended in some form or other by many of the Schoolmen. And then, too, will the theory of Evolution be furnished with a stronger argument than any other single one that has yet been advanced in its support.

Testimony of Biology.

But great as was the influence of discoveries in geology, paleontology, microscopy, chemistry, astronomy and stellar physics, in preparing the minds of scientific men for the acceptance of the theory of organic Evolution, the arguments which had the greatest weight, which finally enlisted in favor of Evolution those who, like Lyell, still hesitated about giving in their adhesion to the doctrine of derivation, were those which were based on data furnished by the sciences of botany, zoölogy, physiology, and by those newer sciences, embryology and comparative osteology.

CHAPTER V.

FROM LORD BACON TO CHARLES DARWIN.

First Materials for the Controversy.

I HAVE spoken of the celebrated dispute between Cuvier and Geoffroy Saint-Hilaire, in which Goethe was so much interested. Materials for this controversy had been rapidly accumulating during the half century preceding the date when it finally broke out in the French Academy. Indeed, it would be truer to say that materials had been accumulating during two centuries prior to the historic debate between Cuvier and Geoffroy Saint-Hilaire. From the time of Bacon, Descartes and Leibnitz, more, far more, had been done towards the development of the Evolution idea than had been effected during all the centuries which had elapsed between the earliest speculations of the Ionian school and the publication of the "Novum Organum."

We have already learned what geology and paleontology contributed towards the establishment of the theory of Evolution. We have seen how the study of fossils and the careful and long-continued examination of the much-vexed question of spontaneous generation shed a flood of light on numerous problems which were before obscure and mysterious in the extreme. But while Da Vinci, Fracostoro, Palissy, Steno, Generelli, Redi, Malpighi, Leeuwenhoek, Schwammerdam and their compeers, were carrying on their

investigations regarding fossils and infusoria, students in other departments of science were not idle. Gesner, Vesalius, Fallopius, Fabricius and Harvey were then conducting their famous researches in zoölogy, anatomy, and embryology, while Cesalpinus, Ray, Tournefort and Linnæus were laying the secure foundations of systematic botany and vegetable anatomy. It was to this period, indeed, that, as has been truthfully observed: "We owe the foundation of microscopic anatomy, enriched and joined to physiology; comparative anatomy studied with care; classification placed on a rational and systematic basis."

Bacon and Kant.

Lord Bacon was not only a firm believer in organic Evolution but was one of the first to suggest that the transmutation of species might be the result of an accumulation of variations. Descartes, too, inclined to Evolution rather than to special creation, and was the first philosopher, after St. Augustine, who specially insisted that the sum of all things is governed by natural laws, and that the physical universe is not the scene of constant miracles and Divine interventions. Leibnitz, like Bacon and Descartes, accepted the doctrine of the mutability of species, and showed in many passages in his works, that no system of cosmic philosophy could be considered complete which was not based on the demonstrated truths of organic Evolution. "All advances by degrees in nature," he tells us, "and nothing by leaps, and this law, as applied to each, is part of my doctrine of continuity."

Immanuel Kant, in common with his illustrious contemporary, Buffon, accepted the ideas that specific mutability results from selection, environment, adaptation and inheritance. Like the great French naturalist, too, he derived all the higher forms of life from lower and simpler forms. He recognized also the law of degeneration from original types, and the principle of the survival of the fittest, which were subsequently to play such important roles in all theories of organic Evolution. Indeed, I do not think Kant has received due recognition for his contributions towards the philosophy of the cosmos. Like Aristotle, he had a faculty for correct generalization which sometimes gave his views almost the semblance of prophecy. Taking up the nebular hypothesis, as it was left by St. Gregory of Nyssa, he adapted it to the science of his time, and in many respects forestalled the conclusions of Laplace and Herschel. Similarly he took up the principles of Evolution as they had been laid down by St. Augustine and the Angel of the Schools, and, by giving them a new dress, he anticipated much of the evolutionary teaching of subsequent investigators. Considering the time in which he wrote, nothing is more remarkable than the following comprehensive *résumé* of his views on Evolution:—

"It is desirable to examine the great domain of organized beings by means of a methodical, comparative anatomy, in order to discover whether we may not find in them something resembling a system, and that, too, in connection with their mode of generation, so that we may not be compelled to stop

short with a mere consideration of forms that are, which gives us no insight into their generation, and need not despair of gaining a full insight into this department of nature. The agreement of so many kinds of animals in a certain common plan of structure, which seems to be visible not only in their skeletons, but also in the arrangement of the other parts—so that a wonderfully simple typical form, by the shortening and lengthening of some parts, and by the suppression and development of others, might be able to produce an immense variety of species—gives us a ray of hope, though feeble, that here, perhaps, some results may be obtained by the application of the principle of the mechanism of nature, without which, in fact, no science can exist. This analogy of forms—in so far as they seem to have been produced in accordance with a common prototype, notwithstanding their great variety—strengthens the supposition that they have an actual blood relationship, due to derivation from a common parent; a supposition which is arrived at by observation of the graduated approximation of one class of animals to another, beginning with the one in which the principle of purposiveness seems to be most conspicuous, namely man, and extending down to polyps, and from these even down to mosses and lichens, and arriving finally at raw matter, the lowest stage of nature observable by us. From this raw matter and its forces, the whole apparatus of nature seems to have been derived according to mechanical laws, such as those which resulted in the production of crystals, yet, this apparatus, as seen in organic beings, is so incomprehensible to us, that we conceive for it a different principle. But it would seem that the archæologist of nature, that is, the paleontologist, is at liberty to regard the great family of creatures—for a family we must conceive it, if the above-mentioned continuous and connected relationship has a real foundation—as having sprung from the immediate results of her earliest revolutions, judging from all the laws of their mechanisms known to, or conjectured by him."[1]

Passing over such speculative evolutionists as De Maillet, Maupertuis, Bonnet, Robinet and Oken, who did little more than revamp the crude notions of the old Ionian speculators, we may scan in hasty review the principal contributions made to the evolutionary movement by the great naturalists who flourished between the time of Linnæus and Cuvier.

Linnæus and Buffon.

Linnæus, who adopted the well-known aphorism of Leibnitz, *natura non facit saltum*, was as much of a special creationist and, consequently, as much opposed to Evolution as was the illustrious Cuvier. But although in the earlier part of his career he contended that there were no such things as new species—*nullæ species novæ*—still, at a later period, he was willing to admit that "all species of one genus constituted at first, that is, at creation, one species"—*ab initio unam constituerint speciem*—but maintained that "they were subsequently multiplied

[1] Quoted in Osborne's useful little work "From the Greeks to Darwin," pp. 101, 102.

by hybrid generation, that is, by intercrossing with other species."[1]

The first one to formulate a working hypothesis respecting the mutation of species was the eminent French naturalist, Buffon. According to Lanessan, he "anticipated not only Lamarck in his conception of the action of environment, but Darwin in the struggle for existence and the survival of the fittest." The questions of heredity, geographical distribution, the extinction of old and the apparition of new species he discussed with rare perspicacity and suggestiveness. He was undoubtedly a believer in the unity of type, and the community of origin of all animal forms, although the diverse views he entertained on these subjects at different periods of his life have led some to minimize the importance of his contributions to the theory of Evolution.[2]

[1] "Suspicio est," he says, "quam diu fovi neque jam pro veritate indubia venditare audeo, sed per modum hypotheseos propono; quod scilicet omnes species ejusdem generis ab initio unam constituerint speciem, sed postea per generationes hybridas propagatæ sint. . . . Num vero hæ species per manum Omnipotentis Creatoris immediate sint exortæ in primordio, an vero per naturam, Creatoris executricem, propagatæ in tempore, non adeo facile demonstrabitur." "Amœnitates Academicæ." Vol. VI., p. 296.

It is interesting to observe that this view found favor with the celebrated Scriptural commentator, Dom Calmet. Only on the supposition that all the species of each genus originally formed but one species, was he able to explain how all the animals could find a place in the ark of Noah.

[2] Speaking of the factors of evolutionary changes he writes: "What cannot nature effect with such means at her disposal? She can do all except either create matter or destroy it. These two extremes of power, the Deity has reserved for Himself alone; creation and destruction are the attributes of His Omnipotence. To alter and undo, to develop and renew—these are powers which He has handed over to the charge of nature."

Buffon, also, was the first to formulate the law of uniformitarianism which was subsequently developed with such care by Lyell and his school. In his "Théorie da la Terre" he tells us that "in order to understand what had taken place in the past, or what will happen in the future, we have but to observe what is going on at present.[1]

Erasmus Darwin and Lamarck.

Erasmus Darwin, a contemporary of Buffon's and the grandfather of the famous naturalist, did much to popularize the idea of Evolution. In his "Zoönomia," "Botanic Garden," and above all in his posthumous "Temple of Nature," he embodies not only the leading evolutionary views of the old Greek philosophers, as well as those of Leibnitz and Buffon, but he likewise introduces and developes new ideas of his own. He is truly a poet of Evolution and in his "Temple of Nature" we find selections of verse that for beauty and force of expression compare favorably with the finest lines of the "De Rerum Natura" of the old Roman evolutionist, Lucretius.

As the founder of the complete modern theory of descent, "Lamarck," justly observes Osgood, "is the most prominent figure between Aristotle and Darwin." He was an accomplished biologist, and a prolific writer on botanical and zoölogical subjects. He laid special stress on the effects of environment, and of use and disuse in the modification of species. He assumed that acquired characters are inherited,

[1] "Pour juger de ce qui est arrivé et même de ce qui arrivera, nous n'avons qu'à examiner ce qui arrive."

but never attempted to demonstrate a postulate which since his time has provoked such widespread discussion.[1]

Among the contemporaries of Lamarck, who did much to develop and corroborate the theory of Evolution, must be mentioned Goethe, who has justly been called the greatest poet of Evolution, and Treviranus. As a morphologist and osteologist, Goethe exhibited talent of the highest order, and, had he devoted his life to science instead of literature, he would have ranked with the most eminent naturalists of modern times. In referring to his essays on comparative anatomy, Cuvier declares that "One finds in them, with astonishment, nearly all the propositions which have been separately advanced in recent times." As to Treviranus, Huxley places him alongside Lamarck as one of the chief founders of the theory of Evolution, although there are many who dissent from this opinion of the great English biologist. The truth is he was rather an

[1] The nature and chief factors of Evolution according to Lamarck, are expressed in the following four laws:—

Première Loi.—La vie, par ses propres forces, tend continuellement à accroitre le volume de tout corps qui la possède, et à étendre les dimensions de ses parties, jusqu' à un terme qu' elle amène elle-même.

Deuxième Loi.—La production d'un nouvel organe dans un corps animal résulte d' un nouveau besoin survenu qui continue de se faire sentir, et d' un nouveau mouvement que ce besoin fait naître et entretient.

Troisième Loi.—Le développement des organes et leur force d'action sont constamment en raison de l'emploi de ces organes.

Quatrième Loi.—Tout ce qui a été acquis, tracé ou changé dans l'organisation des individus pendant le cours de leur vie, est conservé par la génération et transmis aux nouveaux individus qui proviennent de ceux qui ont éprouvé ces changements. Cf. "Histoire Naturelle," and "Philosophie Zoölogique."

exponent of the views of others than an originator of any theory of his own.

Species and Varieties.

The difficulty of distinguishing species from varieties — a difficulty with which all botanists and zoölogists are familiar, and one which augments with the progress of knowledge of the fauna and flora of the world—and the almost perfect gradations characterizing the forms of certain groups of animals and plants, contributed more than anything else towards impelling naturalists from the time of Lamarck to accept the doctrine that species are derived from one another by a process of development.

Observations similar to those made by Lamarck and other naturalists, led the Rev. W. Herbert, of England, to declare, in 1837, that "Horticultural experiments have established, beyond the possibility of refutation, that botanical species are only a higher and more permanent class of varieties." He entertained the same view regarding animals, and believed "that single species of each genus were created in an originally highly plastic condition, and that these by intercrossing and by variation have produced all our existing species."

In 1844 appeared the famous "Vestiges of Creation," an anonymous work by Robert Chambers. This work created a profound sensation at the time, and although lacking in scientific accuracy in many points, and advocating theories that have long since been demolished, it passed through many editions and commanded a wide circle of readers. In Great

Britain the opposition to the views expressed in the work was violent in the extreme, although it seems that most of the adverse criticism was ill-founded. The main proposition of the author, determined on as he himself declares "after much consideration," is, "that the several series of animated beings, from the simplest and oldest up to the highest and most recent, are, under the providence of God, the results, first, of an impulse which has been imparted to the forms of life, advancing them in definite times, by generation, through grades of organization terminating in the highest dicotyledons and vertebrata, these grades being few in number, and generally marked by intervals of organic character which we find to be a practical difficulty in ascertaining affinities; second, of another impulse connected with the vital forces, tending in the course of generations to modify organic structures in accordance with external circumstances, as food, the nature of the habitat and the meteoric agencies, these being the adaptations of the natural theologian."

Prior to this time the distinguished Belgian geologist, D' Omalius d' Halloy, had expressed the opinion that new species are but modified forms of other species from which they are descended. And a short time subsequently the eminent French botanist, M. Charles Naudin, promulgated similar views, and taught that species as well as varieties are but the result of natural and artificial selection. He did not, it is true, employ these words—words which were given such vogue a short time afterwards by Darwin—but his theory implied all they express.

CHAPTER VI.

CONTROVERSY AND PROGRESS.

Darwin's "Origin of Species."

THE culmination of all the tentative efforts which had hitherto been made, towards giving a rational explanation of the mode of production of the divers species of our existing fauna and flora, was in the publication of Darwin's now famous work, "The Origin of Species," which was given to the world in 1859. Simultaneously and independently another naturalist, Mr. Alfred Wallace, who was then far away in the Malay Archipelago, had come to the same conclusions as Darwin. For this reason he is justly called the co-discoverer of the theory which has made Darwin so famous.

The publication of "The Origin of Species" was the signal for a revolution in science such as the world had never before witnessed. The work was violently denounced or ridiculed by the majority of its readers, although it counted from the beginning such staunch defenders as Huxley, Spencer, Lyell, Hooker, Wallace, and Asa Gray. Professor Louis Agassiz, probably the ablest naturalist then living, in his criticism of the book declared: "The arguments presented by Darwin, in favor of a universal derivation from one primary form of all the peculiarities existing now among living beings, have