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OTHNIEL CHARLES MARSH.

THE last of the famous trio of American vertebrate paleontologists has passed into the unknown, and the rich legacy of discovery and advancement in biological knowledge which they have bequeathed to the world will ever stand as an enduring monument to their untiring energy and greatness in the realm of thought. It seems, therefore, especially fitting that the unveiling of this splendid monument and the final pronouncing of judgment upon the labors of these truly great Americans should take place in the closing years of the century, notable alike for the variety and brilliancy of its achievements in almost every department of learning.

At the time when the doctrine of Evolution was finally formulated and brought prominently before the thinking world by the labors of Darwin the direct and positive evidence in favor of such an hypothesis was inconclusive and uncertain. True, it received more or less powerful support from Mr. Darwin's own particular field of research, as well as from the embryological studies which the Germans had brought into especial prominence, but the court of the last resort, the tribunal of final judgment in which the case was to be argued and decided was that of the Geological Record, or, in other words, a direct appeal to the animals and plants themselves, which had inhabited the earth in times

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past, and whose remains lie entombed in the rocks, mute but unimpeachable witnesses of the story of their becoming and development. It was generally agreed and fully admitted by the foremost thinkers of this critical period that these remains not only once formed parts of living animals, but that they furnish safe guides for the determination of the deposits in which they are found, in the general time scale of the earth's history.

Fossils representing the higher forms were not unknown in Europe at the time this discussion arose, but the specimens from which they were known were in general so fragmentary and lacking in consecutiveness as to furnish little evidence for or against the pretensions of the Darwinian hypothesis. To such an extent was this true that Darwin was compelled to add a chapter in his great work on the Origin of Species, on what he was pleased to call the 'Imperfections of the Geological Record.'

It was at this juncture or shortly afterward that the famous American trio appeared upon the scene, and the tremendous weight of their testimony derived from the unrivaled record of the fossil deposits of Western America has served to take the whole question practically out of the realm of discussion and reduce it to the plane of a demonstrated fact. It has been very truly said that if we regard the truth of Evolution from Mr. Darwin's especial point of view, viz.: that of living plants and animals, we shall conclude that it is a possibility; if we look at it from the standpoint of embryology our judgment must be that it is a probability, but if we examine it from the evidence of paleontology it is no longer a possibility or a probability, but a living truth.

Such, in brief, is the basis of the claims to distinction which the works of these men offer. The share which Leidy took in the performance of this great work has already been told; the second chapter, devoted to the brilliant discoveries of Cope, has likewise been written, and it remains now to speak of the work of the man whose scientific labors form the subject of the present sketch.

Othniel Charles Marsh was by nature a student and early gave evidence of what his future career was to be by a love for nature and natural objects. As a boy he collected birds, insects, minerals and fossils. He was born in Lockport, N. Y., October 29, 1831, and in 1852 went to Phillips Andover Academy, where he graduated with honors. He afterwards entered Yale, from which institution he graduated in 1860. While in college he became deeply interested in geology, paleontology and mineralogy, and spent two additional years after his graduation in the Sheffield Scientific School at Yale and three years in Germany in pursuit of these branches. In 1866 a professorship of vertebrate paleontology was established in Yale and he was called to fill it. Between this and the time of his graduation he had published a number of important papers on 'Minerals and Fossils,' many of which appeared in the *American Journal of Science*. In 1868 he began his investigations of the Western fossil deposits, and this he was all the better able to do on account of the inheritance of a considerable fortune from his uncle, George Peabody, the banker. It was largely through his influence that this latter gentleman was induced to make the munificent gifts to the University which led to the establishment of the Peabody Museum at Yale.

The record of his discoveries from the time of his appointment to the professorship is one of almost continual triumph in the bringing to light of new and strange forms of life that had inhabited the western hemisphere in the distant past. Pre-

vious to the publication of any of his Western material he contributed some important papers upon the fossil birds and reptiles from the Cretaceous of the East. In 1869 appeared 'Notice of some New Mosasauroid Reptiles from the Greensand of New Jersey,' 'Description of a New Gigantic Fossil Serpent (*Dinophis grandis*) from the Tertiary of New Jersey' and 'Notice of some Fossil Birds from the Cretaceous and Tertiary Formations of the United States.' In 1871 he gave a description of his trip through the Uinta Mountains and the Discovery of the Uinta Tertiary Formation, the uppermost member of the Eocene series. In May of this year he published a description of some new fossil serpents from the Tertiary deposits of Wyoming, and in June of the same year he gave notice of the discovery of the first remains of Pterodactyles that had ever been found in America. In July of the same year he also published the first notice of Tertiary Mammals from the Western beds. In the following year, 1872, he was very active, and some of the most important discoveries of the long list to his credit followed in rapid succession.

It is quite impossible to give more than a brief list of his remarkable finds published during this and the succeeding years; the more important only must suffice. It appears astonishing, however, in the light of our present knowledge of the subject what a keen insight into their meaning and importance he possessed and of which he gave such distinctive evidence in his descriptions. In this year (1872) he proved beyond all doubt the existence of the Pterodactyles in this country, a group which hitherto had been regarded as entirely wanting in the western hemisphere; he described the first remains of the now famous toothed bird *Hesperornis*, although at this time, May, 1872, he did not know of its having possessed teeth. Among the Mosasauroid Reptiles he determined for the first time the following important points in their structure: (1) position of the quadrate bone, (2) presence of the stapes, (3) presence of the collumella, (4) presence of the quadratoparietal arch, (5) presence of the malar arch, (6) the nature of the pterotic bone, (7) nature of the anterior limbs, (8) presence and nature of the posterior limbs and pelvis and (9) the number of the cervical vertebræ. He also announced in September of this year the discovery of *Ichthyornis*, the curious Cretaceous bird with biconcave vertebræ. Just previous to this came a long list of new genera and species of fossil mammalia from the Bridger Eocene horizon of Wyoming, which, although briefly described, are of the most intense interest and the highest importance in tracing the ancestry of many living mammalian groups. One of the most important of these discoveries among the fossil mammals was the demonstration of the existence of Lemurs, or Primitive Primates, on this continent.

Of scarcely less importance were his contributions of the following year; early in February, 1873, he announced the discovery of teeth, in both jaws, of *Ichthyornis dispar* and established for it, on this account, a sub-class, Odontornithes. This discovery was of far-reaching importance and satisfactorily established the fact that many of the Cretaceous birds are transitional between living birds and reptiles. In this year he devoted much time and space to the consideration of the gigantic mammals of the Eocene, of which the first notices had been given by Leidy from a few fragmentary remains. To Marsh, however, belongs the credit of the final determination of their structure and affinities; he classified them in a separate and distinct order, Dinocerata, a name which has been very widely adopted by naturalists.

In March, 1874, came the discovery which has tended to give Professor Marsh a greater reputation than any other single piece of

work in his entire career. Various futile attempts had been previously made to trace the ancestry of the Modern Horse. Huxley and Kowalewsky in Europe had established the fact that mammals belonging to the equine stem were found in Europe in the early Pliocene and late Miocene, but their attempt to trace the line into any older formations signally failed. Shortly after this Professor Marsh pointed out the equine nature of his Bridger genus *Orohippus*, and was the first to show that the fossil forms of the American Continent furnished every conceivable link between the small polydactyle species of the Eocene and the modern horse. So strong, indeed, is the evidence of this descent that were there no other evidences of evolution to be found among the fossils this would be quite sufficient of itself to establish its truth. In May of this year he published an important paper setting forth these discoveries on the 'Fossil Horses in America.'

In 1875 he published additional discoveries among the Cretaceous birds, and determined for the first time that Hesperornis possessed teeth in both jaws. In the succeeding year a series of important papers appeared, giving the principal characters of the Dinocerata, Tillodontia, Brontotheridæ and Coryphodontia. Of this latter group he was the first to point out that they were very closely allied to a genus that was described by Owen as early as 1846 from a few fragmentary remains found in the Eocene of Europe, thus giving the first secure basis for a comparison of the older Eocene deposits of the two countries. In this year he was elected Vice-President of the American Association for the Advancement of Science, and in the following year succeeded to the Presidency of the body. His address as the Vice-President upon the 'Introduction and Succession of Vertebrate Life in America' is a notable production and shows the wonderful knowledge he possessed of the organization of the Vertebrates.

Some notable discoveries which marked the beginning of his extensive and important contributions to the knowledge of the extinct reptiles of the group Dinosauria from the Rocky Mountain region were published early in 1877. From this time on, almost up to the time of his death, one discovery after another pertaining to these weird gigantic creatures followed in rapid succession. This subject came to engross his attention more and more, and at the time of his death was the one in which he was the most deeply interested. In 1879 the first discovery of fossil Mammals from the Western Mesozoic was announced, and within the next few years a large number of genera and species were added to the list. His contributions to the subject constitute practically all we know of the American Jurassic Mammalia. In 1880 appeared his first important Monograph on the 'Extinct Toothed Birds of North America,' an important and beautifully illustrated volume published by the United States Geological Survey. In 1886 followed his second Monograph on the 'Dinocerata, An Extinct Order of Gigantic Mammals,' which served to bring together and present in extended form his many discoveries on this subject, a work which was likewise published by the Government Survey. In 1889 two discoveries of more than usual importance were made; one was the finding of a very extensive Cretaceous Mammalian fauna in the Laramie Beds of Wyoming, and the other the discovery of those curious horned Dinosaurs, the Ceratopsia, in the same deposits.

It would be impossible to give here even a list of his papers which have contributed so immensely to our knowledge of the extinct Reptilia. It is in this difficult group especially that his splendid knowledge will be so sadly missed, and it will, indeed, be

many years before any of the younger generation of paleontologists who survive him can hope to acquire the information of these various groups which he possessed. It was his intention and special desire to embody this knowledge in separate monographs, to be published by the eological Survey, several of which were in an advanced state of completion at the time of his death. He had also projected extended works upon other groups. The volumes which he had mapped out and already done a considerable amount of work upon were as follows: The Sauropoda, Theropoda and Ornithopoda, to be in three separate volumes representing the three great divisions of the Dinosauria. Last year the Geological Survey issued a preliminary volume from him on the North American Dinosaurs. He also had a volume projected upon the Mesozoic Mammalia and one upon the Brontotheridæ.

The scientific world at large had a just appreciation of his merits, and he was largely rewarded by many marks of distinguished consideration. He was elected a member of nearly every scientific society of note in Europe and America. In 1875 he was elected Vice-President of the American Association for the Advancement of Science, and in the year following he became President. In 1877 he received the Bigsby Medal from the Geological Society of London for the most distinguished researches in geology and paleontology. In 1882 he was chosen President of the National Academy of Sciences, a position which he held for two terms of six years each. In the same year he was chosen Paleontologist of the U. S. Geological Survey, a position which he held for ten years. He was also made honorary Curator of Paleontology in the U. S. National Museum, and held this position at his death. In 1886 the University of Heidelberg conferred on him the degree of Ph.D., and in the same year Harvard gave him an LL.D. Last year he was made a corresponding member of the French Academy, and later he was announced as the winner of the Cuvier prize, one of the most distinguished honors ever conferred upon an American professor.

In his younger days he was a man of tremendous energy and spent much of his time in the field exploring for fossils, frequently far from the outposts of civilization. These expeditions were often attended with many hardships, and at times no small amount of risk to his personal safety, but wherever a new field offered opportunities for adding something novel, calculated to advance the knowledge of his science, no expense, hardship or danger could deter him from undertaking its exploration. The methods of collecting and preparing these fossils for study and exhibition which he has introduced in the course of his long experience forms the basis very largely of all similar work in almost every paleontological laboratory of the world, and it is a matter of common remark that nearly all the noted collectors and preparateurs have received their training under his immediate influence.

The vast collections on this subject which he has brought together are without doubt the finest and most complete of any in the world, and, when properly installed and exhibited, will make a monument in every way worthy of the greatness of the man who dedicated his life and his fortune to its formation. The influence of his work for advancement in this department of knowledge has probably had no equal in any country, and it is to be hoped that his splendid example of unselfish devotion to the cause of education will not be allowed to go unheeded.

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