SCIENCE

VOL. LIX FEBRUARY 22, 1924 No. 1521

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.

New York City: Grand Central Terminal.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 3, 1879.

JOSEPH LEIDY, FOUNDER OF VERTEBRATE PALEONTOLOGY IN AMERICA[1]

THE JOSEPH LEIDY LECTURE IN SCIENCE UNDER THE UNIVERSITY OF PENNSYLVANIA FOUNDATION[2]

I ASK the indulgence of the members of this gathering in honor of Joseph Leidy and fellow-workers in the fields of science if I present what I have to say in an informal manner, and I trust that you will not for a moment imagine that because it is presented informally, I do not appreciate the honor conferred upon me in asking me to speak on this historic occasion in reference to a man for whom I have such great admiration as for Joseph Leidy. I shall not repeat except in a very general way the homage that was paid to Leidy in the series of important and penetrating addresses which we have listened to today, but I shall endeavor to present a summary, especially along the lines of paleontology and comparative anatomy, of some of the distinctive features of his work in comparison with those of the men who accompanied and immediately followed him, and to show what great results have come from his efforts as a pioneer and as a founder of this most interesting and fascinating branch of science in America.

Leidy started with an entirely new world of life; he soon learned that he could not base his study of American fossils on the work of Erench paleontologists, for the life of our western regions was not known in the Old World. Every specimen represented a new species or a new genus or a new family, and in some cases a new order. Never was there a greater opportunity than was offered to Leidy in this virgin field of our then virgin West. Never was a man more ready to grasp it than that quiet, unpretentious, unassuming, wonderfully gifted observer of nature. It is particularly interesting to review his work, which was written in the exact spirit of Cuvier, and to see his long record of direct obser-

[1] Extemporaneous address at the Joseph Leidy Centenary, Philadelphia, December 6, 1923.

[2] Two previous addresses have been given in this series: "Heredity and Microscopical Research," by Professor Edward Beecher Wilson, of Columbia University, April 17, 1913; "The Segregation of Genetic Types," by Professor William Bateson, of the John Innes Horticultural Laboratory, January 24, 1922.

vation of the entire extinct fauna not only of the eastern but, especially, of the great western territories. We find to-day how permanent that work was, how little we have to modify it, how well it stands the test of time, how accurate are his descriptions, how perfect his figures and illustrations, and how even to-day they form admirable standards for all the work that has been done since. After a continuous series of epoch-making papers and contributions which he was in the habit of contributing year after year, in meeting after meeting of the academy, he brought his initial work to a climax in 1869 when he published his great monograph, "Extinct mammalian fauna of Nebraska and Dakota." That work still ranks in breadth and accuracy as the finest single contribution that has been made to vertebrate paleontology in this country, if not in the world.

Whereas in Leidy we had a man of the exact observer type, Cope was a man who loved speculation. If Leidy was the natural successor of Cuvier, Cope was the natural successor of Lamarck. Leidy, in his contributions to the academy, covered the whole world of nature, from the protozoa and infusoria up to man, and he lived as the last great naturalist in the world of the old type who was able by both capacity and training to cover the whole field of nature. Cope, in contrast, mastered—and this mastery in itself was a wonderful achievement—the entire domain of vertebrates from the fishes up. Marsh, with less breadth and less ability, nevertheless was a paleontologist of a very high order and had a genius for appreciating what might be called the most important thing in science. He always knew where to explore, where to seek the transition stages, and he never lost the opportunity to point out at the earliest possible moment the most significant fact to be discovered and disseminated.

It is most interesting to contrast the temperament of these three men, Joseph Leidy, Edward Drinker Cope and Othniel Charles Marsh. They were as different as any three men could possibly be made, both by nature and nurture. As Professor Edward Smith said, in one of his addresses on Leidy, "Scientists are only mortals after all." Your scientific genius may hitch up with a star on the one hand and with an anchor on the other. Whereas Leidy was essentially a man of peace, Cope was what might be called a militant paleontologist. Whereas Leidy's motto was peace at any price, Cope's was war whatever it cost. I do not know that I can find from Shakespeare any characterization of Joseph Leidy, but I think in Henry IV there is a pretty good characterization of my friend Edward D. Cope.

> I am not yet of Percy's mind, the Hotspur of the north; he that kills me some six or seven dozen of Scots at a breakfast, washes his hands, and says to his wife, "Fie upon this quiet life! I want work." "O my sweet Harry," says she, "how many hast thou killed to-day?" "Give my roan horse a drench," says he; and answers, "Some fourteen," an hour after,—"a trifle, a trifle."

Perhaps there was a scientific providence in all this; perhaps such antagonistic spirits were necessary to enliven and disseminate interest in this branch of science throughout the country. This subtle combative quality in a paleontologist is a strange quality; it is a strange inversion, because the more ancient and difficult the study, the more refractory the fossil, the greater the animation of discussion regarding its relationships. From this subtle ferment there arose the famous rivalry which existed not between Leidy and either of the others, because it was impossible to quarrel with Leidy, but between Cope, the descendant of a Quaker family, and Marsh, the nephew of a great philanthropist. When I took up the subject as a young man and first came to the City of Brotherly Love I always expected to learn of some fresh discussion, some recent combat; it was even in the shade of the Academy of Natural Sciences that one found echoes of these convulsive movements. I remember one day coming into the dignified halls of the academy and finding two of the youthful attendants engaged in hot discussion over a dispute they had overheard at a meeting of the academy the night before.

Leidy, after the characterizations that we have heard of his life from Conklin, Jennings, Scott and others, occupied a pivotal position, a very interesting pivotal position. He was in an intellectual environment and more or less in a social environment entirely different from our own. This is very important to keep in mind in estimating his work. In spirit he was, I think, a true pre-Darwinian in the sense of seeking what may be called facts for Darwin and in the breadth and scope of his researches. But he lived in an entirely different intellectual atmosphere from that which surrounds our scientific world of to-day; he was a John the Baptist for Charles Darwin. We must remember that twelve years before Darwin brought forth the "Origin of Species" this young man was beginning to assemble a mass of data which would have been of great value to the great British naturalist. As shown by Professor Scott, he was tracing the ancestral lineage of the horse, the camel, the rhinoceros, the tapir family, the titanotheres, and last, but not least, the anatomical forbears of man, two matters to which I shall return.

Nevertheless, Leidy was an evolutionist *sub rosa;* he was an evolutionist without ever using the word evolution. There is no doubt about that when you read a citation from his writings such as was selected by Professor Jennings:

The study of the earth's crust teaches us that very many species of plants and animals became extinct at successive periods, while other races originated to occupy their places. This probably was the result, in many cases, of a change in exterior conditions incompatible with the life of certain species and favorable to the primitive production of others. . . . Living beings did not exist upon the earth prior to their indispensable conditions of action, but wherever these have been brought into operation concomitantly, the former originated. . . . Of the life, present everywhere with its indispensable conditions, and coeval in its origin with them, what was the immediate cause? It could not have existed upon earth prior to its essential conditions; and is it, therefore, the result of these? There appear to be but trifling steps from the oscillating particles of inorganic matter to a Bacterium; from this to a Vibrio, thence to a Monas, and so gradually up to the highest orders of life! The most ancient rocks containing remains of living beings, indicate the contemporaneous existence of the more complex as well as the simplest of organic forms; but, nevertheless, life may have been ushered upon earth, through oceans of the lowest types, long previously to the deposit of the oldest Palaeozoic rocks as known to us!!

This really is a sketch in 1847 of environment and survival such as we now know to be the actual course of evolution and was truly anticipatory of modern results, substituting modern language as we may do for the quaint phraseology of the period.

On the subject of the evolution of man especially Leidy certainly had very clear and positive ideas. He caught from Goethe the significance of the occasional reversion and the embryonic suture between the premaxillary and maxillary bones—constituting a single bone in the human subject, two bones in the lower order of mammals. He pointed out this suture in 1847 in the skull of a native from one of the Hollander Islands. In 1849 he pointed out the separate embryonic condition of the intermaxillary bones. In both cases, as was his habit, Leidy obviously saw the significance but, always sticking to facts and a presentation of facts, he let the matter rest there. The most pronounced adumbration, however, of the evolution of man from the primates is to be found in a citation of his volume of 1873, a period when the descent of man was still not recognized.

But little change would be necessary to evolve from the jawbone and teeth of *Notharctus* that of the modern monkey. The same condition that would lead to the suppression of a first premolar tooth in continuance would reduce the fangs of the other premolars to a single one. This change with the common teeth shortening and the increase of the depth of the jaw would give the character of the living South American monkey. A further reduction would give rise to the condition of the jaw in the Old World apes and in man.

I do not need to point out that the human jaw, next to the human forehead, is the most significant feature in the transformation from the lower to the higher primates. But some of those here present may not know that a monograph has been written by my successor and colleague Professor William K. Gregory, upon the genus *Notharctus* Leidy. Gregory fifty years after this significant passage was written by Leidy chose *Notharctus* as an ideal intermediate type to place in a theoretic ancestral series leading up to man, and in the beautiful series of preparations which he has recently completed showing the development of the human face in all stages from the most remote ancestral facial type to the modern human face, Gregory uses *Notharctus* as the pivotal point, just as did Leidy fifty years ago.

To return to the matter of Leidy's intellectual environment, how much we owe to-day to our intellectual environment, how much we owe to battles which have been fought and won over insufficient evidence. Not battles of words, but battles of facts. Such evidence as that of *Notharctus* the alert vision of Leidy detected and put in its proper place. In those days "mum" was the word as regards evolution. Neither Cuvier, nor Owen, the British successor of Cuvier, nor Louis Agassiz, great naturalists all, had accepted the theory; theologic influence was still all powerful. Fortunately for Leidy, William Jennings Bryan was still in embryo. Trying to form a historic parallel of William Jennings Bryan, I think it may be found in the figure of King Canute sitting with his court on the shores of Nature, trying to beat back the waves of Truth. If Leidy had lived in the era of Bryan he undoubtedly would have been classified with Professor Conklin and myself—he would have been made with us a type of a new genus, *Anathema maranatha,* in which, according to the zoology of Bryan, are embraced "tall professors coming down out of trees who would push good people not believing in evolution off the sidewalk." Leidy would not have been burned at the stake only because of legal obstacles. Similarly, I think that Professor Conklin and myself owe our lives to the fact that autos da fé in matters of belief are no longer matters of common practice in our civilization!

It is perhaps particularly fitting that Professor Scott and myself were asked to speak at this centenary, for one reason above others. We have been the defendants and supporters of the Leidy tradition. I am not quite sure, but I doubt if you will find in the writings of Professor Cope or Professor Marsh a single allusion to the work of Leidy. I make this statement subject to verification, but I do not recall in their writings a single allusion to the work of Leidy; the rivalry between the two men went to such lengths that in their race with each other Leidy was totally forgotten. Every new animal that was dis-

covered was given a new scientific name by each of them. *Notharctus* Leidy, for example, is exactly the same animal as *Tomitherium* Cope and *Limnotherium* Marsh. Thus arose a trinominal system—three names each for the Eocene and Oligocene animals—the original Leidy name and the Cope and Marsh names. It has been the painful duty of Professor Scott and myself to devote thirty of the best years of our lives trying to straighten out this nomenclatural chaos. Even to this day we are verifying the observations of Leidy; we find that he never made an incorrect observation or published an incorrect figure; his accuracy in these regards is one of his greatest and most permanent claims to immortality as a paleontologist.

I do not know that I altogether agree with my friend Conklin in his address as to the relation of extensive and intensive work. If I understand him aright, he rather implies that intensive work is an inevitable feature of modern scientific progress. I would rather cite Leidy as an example of a man who pursued intensive work and extensive work simultaneously and who had the capacity to pursue intensive work in several branches of science biological and geological, and I would regard the permanence of Leidy's work as largely the result of the state of mind produced by the breadth of his intensive as well as of his extensive work. I would like to leave on your minds my conviction, buttressed by Leidy's life, that it will be necessary even for those of our day to maintain the Leidy attitude, because after all, it is in *the single mind that great hypotheses and theories are generated.* The comparative anatomist, if he dies out, will leave human anatomy impoverished. To-day our students should return to the Leidy attitude, as Professor Scott said, of entering paleontology by way of medicine and base our education in human anatomy as Leidy did on a broad knowledge of comparative anatomy. This is only one instance out of very many that might be given of the legacies of Leidy to us, namely, that throughout his life his mind had continuously the intensive as well as the extensive attitude. He was able to be on the mountain top and then descend into the valleys, and I believe that while some men who pursue one subject intensively all their lives are making great discoveries, for example, such workers as Professor Michelson, whom we all honor, the chances are that few men can make great discoveries unless they approach the subject broadly and work from more than one angle of thought.

Speaking of immortality, I rather share the Leidy view than the view of Cope. I wish it were possible to resurrect Joseph Leidy and to bring him back into the field of modern American paleontology. I wish it were possible to bring him back to life and to have taken him with me, for example, in a motor car across the wastes of Mongolia. I can imagine the joy with which he would have welcomed coming upon the remains of the land dinosaurs, recalling his first description of a dinosaur in America, in the very heart of the great desert of Gobi. And perhaps the still greater joy with which he would have greeted one of his titanotheres, one of the first mammals which he described from Wyoming, out on a great plain on the border of the desert of Gobi.

The desire for this kind of immortality reminds me often of the Greek poet:

> To live like Man and yet like Nature to endure,
> That double gift to Man and Nature both denied
> The Gods alone enjoy.

We are rewriting this beautiful Greek verse in the immortality of Leidy's work and we are holding up his example for the prevailing spirit of truthfulness, which is after all its most characteristic single feature. Would that Leidy and Huxley and Richard Owen and Cuvier and Marsh and Cope could see the heights which have been reached in the branch of science to which they devoted their lives and fortunes. Leidy's infant science, in which it was most hazardous to make predictions, has now reached the stage which I believe is the finest in the history of any science—the stage of prediction—that as astronomers have predicted the existence of unknown and unseen planets, paleontologists can also predict unknown and unseen forms of life and, moreover, can point out where they may be found.

Is our paleontological path reaching its goal? I think not. Its final goal will be reached when paleontologists are able through extensive and intensive methods to join hands with workers in other biological fields and when we are able, pursuing our branch in the Leidy spirit, to bring together into one harmony, the harmony which certainly exists, although at present we do not see it, by bringing together into one harmony the great underlying principle, the multiple aspects of which we can sum up in the word evolution.

HENRY FAIRFIELD OSBORN
AMERICAN MUSEUM
OF NATURAL HISTORY

A GENETIC VIEW OF SEX EXPRESSION IN THE FLOWERING PLANTS[1]

IT seems a conservative statement to say that stud-

[1] Address of the president of the American Society of Naturalists, forty-first annual meeting, Cincinnati, December 29, 1923.

Paper No. 117, Department of Plant Breeding, Cornell University, Ithaca, New York.