SCIENCE

A WEEKLY JOURNAL DEVOTED TO THE ADVANCEMENT OF SCIENCE, PUBLISHING THE OFFICIAL NOTICES AND PROCEEDINGS OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

FRIDAY, FEBRUARY 7, 1908

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MSS. intended for publication and books, etc., intended for review should be sent to the Editor of SCIENCE, Garrison-on-Hudson, N. Y.

STUDIES ON FOSSIL FISHES DURING THE YEAR 1907[1]

SINCE the establishment of a merciful Concilium Bibliographicum it is not necessary for us either to wait for generous authors to donate separates, or to ransack files of literature to find the annual doings in each of our fields of inquiry. In the field in which I am especially interested, that of the lowest groups of fossil vertebrates, the Concilium will give you the full *récolte* of references and spare you my list of them—and titles in plenty there are in all the groups of fishes, from primitive sharks to the most complicated teleosts. There are papers systematic on the fossil fishes of California, on new sticklebacks, surgeon fishes, prosturgeons, conodonts—there are papers on the anatomy of fossil fishes, acanthodians and placoderms, and there are not lacking references to the descent of the fishes and to the philosophy of their evolution, as in Eastman's monograph on the fossil fishes of New York, Smith Woodward's address before the Paleontological Society, Patten's continued studies on *Bothriolepis,* and Jaekel's remarks upon the "nest" of placoderms which he has brought to light in the Upper Devonian of Wildungen.

But from all these references we can for the present review only those which bear upon the greater problems.

Our first inquiry, in considering the advances in paleichthyology, is whether the

[1] A portion of the address of the retiring president of the Society of Vertebrate Paleontologists, New Haven, December 27, 1907.

past year has unravelled the problem of the origin of the vertebrata. And I fear that we can, as usual, report nothing better than progress. To our infinite regret there have been forthcoming no new results on the Silurian fishes of Scotland, the clan of Thelodus, Lanarkia, Lanasius. We recall, however, Dr. Patten's splendid work in unearthing fins, tail and other structures of the lowly *Bothriolepis,* and the beautiful models which he demonstrated before the Zoological Congress in Boston. Nevertheless, he has not established, it seems to me, his thesis as to an arthropodial chordate. But he has given us valuable perspective as to the position of this very early "fish": for his studies show clearly how remote a cousin was this form to any type of our known chordates. On evidence which he adduces, such as the position of the anus between the horizontal postero-ventrolateral plates, curious little separately set jaws, which may have operated laterally instead of vertically, and in other regards, we can only conclude that *Bothriolepis* belonged to a terminal group, as far, at least, as our living fishes are concerned. By no stretch of my morphological imagination can I see how this carapaced, hinge-spined, and thread-tailed anomaly could have given birth to a line of our real backboned animals.

Important in this connection is a summary of Hussakof which shows in how many regards the group to which *Bothriolepis* belongs corresponds, as earlier writers believed and as later writers denied, to the group of Arthrodira containing such forms as *Coccosteus, Dinichthys* and *Titanichthys.*

In short, we may be dealing in these groups collectively, which are popularly known as "placoderms," with a great line, a phylum or subphylum, of chordate creatures which preceded the types of modern chordates and which in spite of lines of heroically developed tribes, families, genera and species, died out as the modern chordates came into competitive being. They were, I suggest, chordates in which there were misdirected, or more accurately, unfortunate, evolutional tendencies, affecting structures or correlated combinations of structures. These may well have carried the placoderms along successfully to a certain point, but beyond this basis their morphological restrictions did not permit them to go. Thus these creatures may have been chordates which were defective in the substratum of a gill arch type of mouth and they had not, therefore, laid the necessary foundation for the endofacial complex of the higher animals: I mean that the mouth region of these ancient forms had not the capability of attaining the strengthening support of endoskeletal elements, the greater mobility which gill muscles provided, the greater vascular and nervous supply, the fuller channel for sensory impressions: instead, in those pioneer forms, the mouth apparatus was fashioned on a simpler, more independent and therefore shorter-lived plan. Their jaws were strictly dermal elements, and operated by dermal muscles—all in all a mouth mechanism non-homologous with that of the higher vertebrates.

In the great group of the placoderms known as Arthrodira, including such puzzles as *Dinichthys, Diplognathus, Mylostoma* and *Coccosteus* these jaws seem to have run a gamut of adaptive changes: then followed a period of extermination, for we know to-day of no placoderm—cephalaspid, pterichthyid, coccosteid—which passed an undisputed boundary line into the Carboniferous. The ancient tree died and its branches dropped off. But before its extinction some of its members developed curiously specialized forms and structures, paralleling the characters of modern fishes, as though in a final and

supreme "effort" to compete successfully with their fundamentally better equipped rivals.

The recent discoveries of Professor Jaekel have confirmed a prediction—suggestion made nearly a score of years ago—that we should yet find how manifold were the forms of arthrodires during their period of maximum prosperity. He has found in Wildungen, in practically a single spot and in a narrow fossiliferous seam, usually but a few inches thick, no less than twelve genera and fifty species of arthrodires, nearly all of which are new! And paleontologists may well look forward to the publication of his extraordinary results. Here, then, in the uppermost Devonian, close before their extinction, these forms assumed the most varied characters, even bilateral narrowness, in which the form of a swift-swimming teleost was paralleled. I hope, however, that my colleagues will leave this case to parallelism and will not make this creature, the latest and most specialized of the placoderms, the progenitor of teleosts! Dr. Jaekel has, up to the present moment, unhappily, published only an abstract of his results. But they show clearly enough that the forms described are typical arthrodires; and they yield, I believe, no good evidence as to the kinship of these forms to true fishes.[2] Dr. Eastman's recent and careful elaboration of the view (of a score of years ago) that arthrodires are of lung-fish derivation and that a primitive form of the Australian lung-fish (*Ceratodus*) was their progenitor I have already commented upon in SCIENCE. On the evidence especially of the flattened dental plates of a late form of arthrodire, *Mylostoma*, he is convinced of a kinship to the modern forms, and he explains the absence of ceratodonts in the pre-Mesozoic on the ground of the fragmentary nature of paleontological evidence. He neglects, however, it seems to me, to take into account what we do know of the Paleozoic lung-fishes, and these documents are both numerous and important, as Dollo, for example, has pointed out. And he has not evaded the morphological pitfall (it seems so to me at least) of attempting to establish homologies between more or less terminal forms of widely different descent. Indeed it is clear that if arthrodires are descended from a primitive ceratodont, their puzzling allies, bothriolepids and cephalaspids must also be closely related to the same ancestor, but this is difficult even to imagine: for who can fancy, as early at least as in the upper silurian, in which all these forms occur, that even then they could be traced back to lung-fishes essentially ceratodont? Furthermore, if I mistake not, Dr. Eastman believes that sharks are the ancestors of lung-fishes, and in this event, how far back into the Urzeit would our paleontological fancy project to find the origin of our modern fishes? The paleontological record is scored, seamed and scanty, we painfully admit, but I am confident that it is not as bad as all this: if the lung-fishes, arthrodira and their anomalous allies came from a ceratodont ancestor we should certainly have found a trace of it somewhere in the stupendously long interval between the upper Silurian and the Mesozoic. We find, on the contrary, that not merely is this creature absent, conspicuously absent, but that its

[2] Thus there is no new light on the presence of fins and girdles: what he regards as the "undoubtedly demonstrable" hip girdle in *Coccosteus* is to certain morphologists, at least, a very doubtful structure; whatever it be, it is rudimentary in Jaekel's new forms. Nor does his explanation carry conviction as to the under jaw of *Pholidosteus* with angular and articular elements. The former is, I believe, the "interlateral" plate well known in the ventral armoring of coccosteids, the latter probably an articular (detached) process of the central plate. The views of Jaekel as to the position of the Arthrodira can not, however, be criticized in detail in the present paper.

kindred, which are present and even abundant, are more and more shark-like in dentition, fins and dermal defenses the further back we go. To maintain in the face of such evidence that a ceratodont existed in the Urzeit would be, it seems to me, as difficult as, for example, to maintain the probable presence of man in the Jurassic.

The puzzles of primitive sharks have been considered several times during the past year, and I think it is quite safe to say on cumulative evidence that "if the earliest true fish could be found, it would almost certainly fall within the subclass Elasmobranchii."[3] From a recent study on the structures of the lowly acanthodians[4] we have reason to believe that they are allied more closely to the more typical sharks. Their dentition was quite shark-like, with (a few) successional rows of teeth, and their fin structures conform more typically to the plan known in cladodonts. In this connection the evolution of their curious finfold type of fin in different members of this group has been indicated lately by Smith Woodward. Of other structural features in acanthodians we know even details, *e. g.*, in sensory canals and ear structures. As vertebrate morphologists some of us wish we could believe that the acanthodians, earliest of sharks, had a great number of gill slits, but for the present we shall have to content ourselves with the typical selachian number, five: we wish also that we could feel assured that the mandibular arch in acanthodians was segmented dorsally after the fashion of a typical gill arch, as Reis and Jaekel have shown in the Permian *Acanthodes bronni,* but unhappily certain earlier genera (the lower Devonian *Ischnacanthus gracilis, Cheiracanthus murchisoni*) do not have this interesting subdivision of the palatoquadrate, and it may well be, therefore, that in later forms the subdivision is due to fossilization, the cartilage subdividing, owing to weakness from nutrient vessels, etc., at certain definite spots.

An up-to-date classification of the selachians by Tate Regan should here be mentioned[5] which gives interesting notes as to the evolution of the sharks and considers the paleontological evidence.

The chimæroids have been made the subject of comparative study during the past year,[6] and from an examination of their fossils, anatomy and embryology the conclusion is reached that they are to be classed not as ancestral sharks, but rather as a group highly divergent from some early shark stem. The few undeniably primitive features which they possess are heirlooms from some Paleozoic selachian ancestor—features which modern sharks have not as well conserved owing, among other causes, to the elaboration of hylostylism. The nearest living kin of the chimæroids are probably cestraciont sharks.

Important in this connection is the discovery that our pre-Permian "chimæroids," *i. e.,* those antedating menaspids, may have to go by the board. Jaekel's discovery of associated remains of *Rhamphodus,* as Dollo points out,[7] makes it probable that all ptyctodonts, hitherto classed as chimæroids, are in reality highly modified arthrodires!

Our knowledge of the descent of lung-fishes has not progressed perceptibly during the past year—*i. e.,* if we admit that the Arthrodira and early lung-fishes are not related, the view which we have main-

[3] Smith Woodward, "Natural Science," Vol. VI., p. 38.

[4] Dean, "Notes on Acanthodian Sharks," *Am. Jour. of Anatomy,* Vol. VII., pp. 209–226.

[5] Regan, *Pro. Zool. Soc. London,* 1906, pp. 722–758.

[6] Dean, "Chimæroid Fishes and their Development," Monograph 34, Carnegie Institution, Washington, D. C.

[7] *Bull. Soc. Belge de Geol.,* 1907, pp. 97–108.

tained above. Nor has the year seen any notable advances in our philosophical knowledge of the ganoids. Their fin structure alone has been considered critically,[8] and in this discussion the evolution of the "effective fins" shows the relations of ganoids and teleosts.

Nor has the great group of Teleosts yielded far-reaching results during the past year. The paper of Woodward above cited recapitulates the teleostean fins and skeleton from the standpoint of evolutional philosophy. And, in a matter of detail, Hussakof has described a form of surgeon fish which serves to connect the balistids with the teuthids. On the purely systematic side work has been active, but this phase of research our time will not permit us to treat.

Finally, as to the evolutional philosophy which the study of fossil fishes has touched upon, we can only say that orthogenesis keeps presenting itself with significant persistency. There has, however, been no attempt up to the present time to collect these results systematically —and herein lies a harvest for the reflective worker. We should, on the other hand, mention the vast materials unearthed by Jaekel at Wildungen, for in them he maintains, rightly or wrongly, the appearance of an "explosive" or mutational origin of species.

BASHFORD DEAN

[8] A. S. Woodward, *op. cit.*, pp. 276–278.

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
SECTION G—BOTANY

SECTION G of the American Association for the Advancement of Science met during the past convocation week at Chicago, all of the sessions, except the vice-presidential address by Dr. D. T. MacDougal, being held in the Botany Building of the University of Chicago. Three sessions were held for the reading of papers, and all meetings were held in conjunction with the Botanical Society of America, so that in no case were two botanical meetings held simultaneously. The attendance varied from one hundred to one hundred and fifty, and over one hundred professional botanists from outside Chicago were present at the meetings. The sessions were presided over by the vice-president of the section, Professor Charles E. Bessey; in the absence of the secretary, Professor Francis E. Lloyd, Dr. Henry C. Cowles acted as secretary *pro tem.*

The following officers were chosen:

Vice-president—Professor H. M. Richards, Columbia University.

Secretary (five years)—Dr. Henry C. Cowles, University of Chicago.

Member of the Council—Dr. F. E. Clements, University of Minnesota.

Member of the Sectional Committee (five years)—Professor R. A. Harper, University of Wisconsin; (one year, vice Professor Charles E. Bessey, resigned)—Dr. J. M. Greenman, Field Museum of Natural History, Chicago.

Member of the General Committee—Professor M. B. Thomas, Wabash College.

The following resolutions were adopted, in memory of Professor Lucien M. Underwood:

WHEREAS: By the lamented death of Dr. Lucien Marcus Underwood, late professor of botany in Columbia University, science has suffered a severe loss and the American Association for the Advancement of Science, particularly the Botanical Section, an active and esteemed member, be it

Resolved, That this society place on record its recognition of his fruitful labors along his chosen lines in the field of scientific research and instruction and its keen appreciation of the stimulating influence of his personal character and scholarly attainments.

The vice-presidential address of Dr. D. T. MacDougal has been published in full in SCIENCE. Abstracts of the technical papers presented follow: