SCIENCE

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THE PROBLEMS OF COMPARATIVE OSTEOLOGY.[1]

OSTEOLOGY is the study of the bones or the skeleton of vertebrates. Comparative osteology is the study of the origin and evolution of the different modifications of the skeleton. It could also be called "morphology of the skeleton" It not only regards the living forms alone, but considers the fossil forms exactly in the same way. As we know nothing but the skeleton of the extinct vertebrates, comparative osteology becomes the real basis of vertebrate phylogeny. All our systems of vertebrates have to be founded on characters derived from the skeleton. It is quite evident, therefore, that comparative osteology is one of the most important branches of vertebrate morphology. It alone enables us to give an exact and scientific explanation of the origin and evolution of vertebrates, and so it is the real foundation of the morphology of these animals.

Comparative osteology may be divided into three branches: 1. Osteology of the living forms; 2. Osteology of the extinct forms; 3. Evolution of the skeleton.

It is the task of the first-named branch—osteology of the living forms—to study the skeleton of the living forms in as complete a manner as possible. A characteristic genus of each family ought to be examined, and the characters of the families given on this basis. It especially regards such groups of animals as are very isolated to-day, and of the origin of which we know very little or nothing through paleontology. Such animals are, for instance, the *Monotremata*, the ostriches, chameleon, *Necturus*, *Hippocampus*. At the same time it aims to study with great care such forms as in former periods must have been abundant, and which are represented to day, perhaps, by a single genus only. Such forms are *Hyrax*, *Apteryx*, *Sphenodon*, *Polypterus*, *Ceratodus*, and many others.

There are different ways to work in this branch. One man may give a most complete osteology of a single form, for instance, the chicken; but this purely descriptive work will be of little scientific value in itself, though it will become valuable for him who gets the philosophy out of it, and who traces the relations and origin of the form described. Notwithstanding, such work is very often important, if forms which are very rare or difficult to get are treated in this way. A pure description, for instance, of the osteology of the peculiar tortoise *Carettochelys* from New Guinea, would be very important, because it would enable us to give the correct systematic position to this form. Of the greatest importance is the study of osteological variations in a genus or a species. Darwin's publications in this direction are known to everybody, and Nehring in Germany has devoted much time to it. Such researches ought to be undertaken oftener, as they are of the greatest value for the explanation of the origin of species. Another man may study all the skulls of the members of a family, or an order, or a class, or even of all living vertebrates, and thus give a complete history of the osteology of the skull; or he may treat the vertebræ, the shoulder-girdle, the pelvis, the limbs, in the same way. Such researches are extremely important; but, by considering one part of the skeleton alone, it may happen that parallel forms may be considered as nearly related which in fact have nothing whatever to do with each other.

[1] Abstract of a lecture given by Dr. G. Baur at Clark University, Worcester, Mass., Oct. 17, 1890.

It is by this method of study that the great homologies of the skeleton have been worked out. Of course, the time of the archetype idea of the skeleton belongs now to the past, or nearly so; but it has been followed by a time which has gone a step too far with its tendency to homologize every thing. In this, great care is necessary. There are elements and formations which have no homologues. I recall the interparietal of mammals. This bone appeared in the mammalian line, doubtless produced by the increase of the brain. It is a new formation in the special branch of mammals which has no homologue among lower vertebrates. When the predentary bone was found in iguanodon, a homologue was eagerly searched for; but this bone is a new formation in the peculiar group of *Orthopoda* to which iguanodon belongs, and has no homologue among lower forms. I could multiply these examples (the tympanic of mammals belongs here, for instance), but I will mention only one other case. There is much said at present about hexa- or hepta-dactylism of the mammalian hand, homologues for the additional digits are looked for among fishes, and we hear about the polydactyl ancestors of mammals; but it is forgotten that mammals came from pentadactyl reptiles, and reptiles from pentadactyl batrachians, and that these rudimentary additional digits in mammals are simply of recent independent origin, and have no homologues. The same is true of the polydactyl forms of ichthyosaurs, of the hexadactyl hind-limb of frogs, and of all higher vertebrates with polyphalangeal digits, as the *Plesiosauria*, *Mosasauridæ*, *Sirenia*, *Cetacea*. It is by studying only one part of the skeleton, without consideration of the others, that such mistakes in homology are made. So it is that the fins of ichthyosaurs were considered for a long time, and by some still to-day, as forming the missing link between fishes and reptiles.

A third man may study the osteology of a group of vertebrates as a whole; for instance, the ungulates, or the parrots, or the crocodiles, or salmons. He will compare all the skulls, the limbs, the vertebræ and so on, of such a group, trying to trace the origin and relation of its members. He will have a big task, but he will get nearest to the truth. But even if he should study the skulls of all living species of vertebrates, or the complete osteology of all living forms, his general results on origin and affinity of the different groups would be very incomplete.

Here paleontology comes in with a helping hand. I mean true morphological vertebrate paleontology, not that old "geological" paleontology. Paleontology of vertebrates, when studied without anatomical knowledge, is of no use: in this case it is generally nothing more than a lumber-room of names of so-called new species or genera, mostly based on insignificant fragments or specimens insufficiently described. That old paleontology should be abolished entirely. A geologist ought to remain in his own domain, geology, and leave paleontology alone, if he is not, what is seldom the case, a thorough anatomist. This is true also of invertebrate paleontology. The splendid publications of Hyatt, Jackson, Beecher, and Clarke, for instance, are written from this standpoint. Vertebrate paleontology is nothing but a branch of comparative osteology, which in itself belongs to vertebrate morphology. It is very remarkable that the museums of natural history are not arranged according to this natural system. Here we find with one exception (the Museum of the Royal College of Surgeons of London) the bones of extinct animals

separated from those of the living ones; not only separated in different rooms or parts of the building, but separated in different departments. The bones of the living animals we generally find with the skins or near them. The bones of the fossil forms we find either in a special department or in the geological department. It is absolutely necessary to exhibit the bones of fossil and living animals together in one section.

The morphologist will not waste his time and that of others in giving new names to every miserable fragment of a skull, or a vertebra, or a limb-bone: he will study the fossil forms exactly as the living ones, with the greatest detail. He will take the utmost care to work the bones out of the rock, not leave them to show people how nicely they were embedded in the matrix. How can a man study the bones of living forms if he does not remove the muscles? By treating the fossil bones exactly as the living ones, it is possible to make a direct comparison with the greatest minuteness; and thus alone can we get satisfactory results. How many important extinct forms exist, of the osteology of which we know but little, simply because they have not been worked out sufficiently! I may mention, that, of the triassic *Aetosauria*, a group of two dozen specimens is preserved in a splendid condition; but about this very remarkable order of reptiles we know very little, simply because it has not been worked sufficiently out of the rock.

I stated above, that a man, if he should study all forms of living animals, would get no clear results without paleontology; but very often we find living forms for which we receive no help even through paleontology, the ancestors of which are not yet found. In this case the third branch of osteology comes in,—embryology, or evolution of the skeleton. Of course, in very rare cases only, we can study the evolution of the skeleton of an extinct form; such a rare case is offered, for instance, by the Permian batrachian *Branchiosaurus*, of which Professor Credner has given the development. The evolution of the skeleton of living forms is of the greatest importance for comparative osteology, and I will demonstrate it by a few examples.

We know little about the ancestors of the *Bovidæ;* but by studying the evolution of their limbs we find that the earliest embryos show four well-developed metapodials, distinct from each other. Gradually the side metapodials become reduced, and the median ones unite. We can safely say that the ancestors of the *Bovidæ* had at a former period four distinct metapodials, which became modified from time to time until the conditions were reached which we see to-day. Another very instructive example is offered by the *Carnivora*, dogs, cats, and so on. In the carpus of the living animals we find that the radial, intermedial, and central are represented by a single bone, but in the embryo we find three distinct cartilages which unite later to form this one bone. This we knew long ago, before we had any idea of these parts in the ancestors of the *Carnivora;* and we could say with confidence that these ancestors must have three distinct bones in the carpus, in the place of one. The limb-bones of some of the *Creodonta*, the ancestors of the *Carnivora*, were discovered subsequently, and showed the three bones.

We know the whole paleontological history of the horse, down to the pentadactyl *Phenacodus* from the lower eocene, but we hardly know any thing about the embryological history of this animal. This, when known, will show the gradual evolution of the peculiar monodactyl foot. Of course, it will not represent the early *Phenacodus* in the earliest embryo (too many generations have gone since the lower eocene, and the embryological history is obscured), but it will doubtless show three well and more equally developed metapodials, and possibly the representative of a fourth one. Here a man could do great service to science by collecting the necessary material in one of the places where the horse has become wild.

But the embryologist has to be sceptical with his conclusions also in osteology. He must never forget that the embryological history is very much abbreviated, and that only the later stages will be indicated in the skeleton of the embryo. But this study is very rewarding, and, in connection with osteology of living and fossil forms, gives splendid views of the origin and evolution of vertebrates. This branch of osteology, I am sorry to say, has not been treated with the interest it deserves. Embryologists generally stop after they have found out about the formation of the germ-layers. Very seldom an animal is studied up to its adult stage. It is true, the late Professor W. K. Parker has published numerous works on the evolution of the skull of different vertebrates, and these we find cited very often as examples of such a kind of study; but these researches suffer very much from the lack of paleontological knowledge, a number of the statements brought forward are unreliable, and the general conclusions are usually too vague. In these numerous papers we miss the true phylogenetic sense, which alone can lead to true results. Had he, with his great diligence, considered more the results of paleontology and taxonomy, he would have done very much more for the phylogeny of vertebrates.

I can only repeat here, what I said eight years ago in my paper on the "Tarsus of Birds and Dinosaurs:" "Palaeontologie und Entwicklungsgeschichte des Skeletsystems müssen Hand in Hand gehen. Wenn wir palaeontologische Reste studiren wollen, so müssen wir die Skeletogenese des Thieres, welches ihm am nächsten verwandt ist, zuvor kennen. Ich halte daher die Genese des Skeletsystems der Wirbelthiere von eben so hoher Bedeutung, wie die ersten Vorgänge am Ei und die Entstehung der Keimblätter."

Osteology of living forms, osteology of fossil forms, evolution of the skeleton, must go hand in hand. No one of these branches is sufficient in itself: it becomes complete only by the assistance of the two others. So osteology of living forms is deficient without paleontology and embryology of the skeleton; so paleontology is deficient without osteology and embryology of the living forms; so embryology is deficient without osteology of living and fossil forms. All three equally and harmoniously united are able to explain and to unriddle that complicated genealogical tree of vertebrates, with its numerous branches and branchlets, and to conceive the origin of man.

REPORT OF THE MARINE BIOLOGICAL LABORATORY AT WOOD'S HOLL.

The trustees have the pleasure of reporting to the corporation another year of prosperity to the laboratory.

During the last summer those working in the laboratory numbered no less than forty-five, and the tuition-fees amounted to $959, as against $845 during 1889, and $363 during 1888.

During the last summer the laboratory offered greater advantages for study and collecting than ever before, and it may be confidently expected that in the future the receipts from tuition-fees will be even larger. The trustees learn with pleasure that the gentlemen in charge of the department of instruction report that the quality of the elementary students and the work done by them is decidedly better than in previous years.

The two Lucretia Crocker scholarships, of fifty dollars each, were held by Miss A. F. Armes and Miss Nellie L Shaw, both teachers in the Boston public schools.

During the summer of 1889 the need of a lecture-room was keenly felt. Every available place in the laboratory being occupied by a work-table, it was impossible for students to gather around the lecturer without completely disarranging the laboratory. Experience had also shown that some more advanced students did not need to attend every lecture given, but could spend the time allotted to certain lectures to greater advantage if allowed to continue their laboratory work. This could not be done conveniently while lectures were in progress. Further, in accordance with the plan adopted by the director, evening lectures of a more advanced character were given from time to time. These were attended by both students and investigators, an aggregate of over forty persons. The interest in and instructiveness of these lectures were much marred by the discomforts of the surroundings. The library had also outgrown the quarters to which it was originally assigned, and during the summer of 1889 the number of rooms for investigators was less than the number of applicants.

In view of remedying these defects, the trustees have added an L to the present building. This addition contains a comfortable and convenient lecture-room, a pleasant library, and six investi-