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I.—On the Genera Dipterus, Sedgw. & Murch., Palædaphus, Van Beneden and De Koninck, Holodus, Pander, and Cheirodus, M'Coy

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THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[FIFTH SERIES.]

“..... per litora spargite muscum,
Naiades, et circum vitreos considite fontes:
Pollice virgineo teneros hic carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas:
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylis succo.”
N. Parthenii Giannettasii Ecl. 1.

No. 7. JULY 1878.

I.—*On the Genera Dipterus, Sedgw. & Murch., Palædaphus, Van Beneden and De Koninck, Holodus, Pander, and Cheirodus, M'Coy.* By R. H. TRAQUAIR, M.D., F.G.S., Keeper of the Natural-History Collections in the Museum of Science and Art, Edinburgh.

[Plate III.]

I. DIPTERUS, Sedgwick and Murchison.

The genus *Dipterus* of Sedgwick and Murchison was classified by Agassiz first in his family of Lépidoides*, and afterwards in that of the Sauroïdes Diptériens †, in which latter it was associated with such rhombic-scaled genera as *Osteolepis*, *Diplopterus*, and *Glyptopomus*. In fact Agassiz himself believed that the scales of *Dipterus* were rhomboidal. The cycloidal shape and imbricating arrangement of its scales, however, were pointed out by M'Coy ‡, who accordingly placed it among the “Cœlacanthi” (*i. e.* cycliferous *Crossopterygii* according to modern ideas), and also doubted the propriety of separating *Glyptolepis* from it, although the very peculiar dentition of *Dipterus* had been already discovered by Hugh Miller §. But the incorrectness of M'Coy's ideas upon this latter point was immediately afterwards

* ‘Poissons Fossiles,’ vol. ii. pt. 1, pp. 3 and 112.

† ‘Poissons Fossiles du vieux Grès Rouge,’ pp. 47, 49, and 58.

‡ ‘British Palæozoic Fossils,’ pp. 590–593.

§ ‘Witness’ Newspaper, Dec. 23, 1848; ‘Footprints of the Creator,’ Edinburgh, 1850.

shown by Pander*, who gave an excellent account of the structure of *Dipterus*, and proposed to institute for it the new family of Ctenodipterini, a term afterwards altered by Sir Philip Grey-Egerton into Ctenododipterini†. This family, in which *Ceratodus*‡ and *Cheirodus* were also provisionally included, was accepted by Prof. Huxley, and placed by him in his suborder Crossopterygidæ§. Moreover, in a remarkable and oft-quoted passage, he drew attention to the singular relations subsisting between the living *Protopterus* and the cycliferous Crossopterygidæ, especially as regards those of the latter which have acutely lobate paired fins. Though Prof. Huxley did not class the Dipnoi as Ganoids, nor *Dipterus* as a Dipnoan, he struck the keynote to its real position in the sentence:—"Furthermore *Lepidosiren* is the only fish whose teeth are comparable in form and arrangement to those of *Dipterus*."

The discovery of *Ceratodus Forsteri* in the rivers of Queensland, and its addition to the catalogue of living Dipnoi, threw a fresh flood of light on the subject; and Dr. Günther was not long in following up the idea suggested in Prof. Huxley's remark quoted above. Guided chiefly by the obvious similarity in *Dipterus* and *Ceratodus* of the bones of the lower aspect of the skull and of the mandible, the dentition, the want of distinct maxillary and præmaxillary elements, the position of the nasal apertures, the notochordal vertebral axis, the acutely lobate condition of the paired fins, and the cycloidal scales, Günther proposed to actually include the Ctenododipterini as a family of Dipnoi, looking upon these Dipnoi, however, not as a distinct order of fishes, but merely as a "suborder" of the Ganoidei. On the other hand the leading differences between *Dipterus* and *Ceratodus*, as indicated by Günther, may be summarized as follows:—the heterocercy of the former genus, its dorsal fin being divided into two, the enamelled surface of its scales, the enamelled scutes of its cranial buckler, its gular plates, the dermal rays of the median fins being joined to the *extremities* of the interneural and interhæmal spines, the latter being branched at their distal ends, and, finally, some unessential differences in the microscopic structure of the dental plates. Yet, "weighing the points of affinity and difference against each other," Dr. Günther observes, "we must come

* 'Ueber die Ctenodipterinen des devonischen Systems,' St. Petersburg, 1858.

† Dec. Geol. Survey, x. 1861, p. 55.

‡ Beyrich had, indeed, previously noticed the resemblance between the dental plates of *Dipterus* and *Ceratodus* ('Zeitschrift der deutschen geolog. Gesellsch.' 1850, p. 154).

§ Dec. Geol. Survey, x. 1861.

to the conclusion that *Dipterus* has a better right to be associated with the living Dipnoi than with *Polypterus**.

Prof. Huxley, however, in his recent and very valuable paper on *Ceratodus*, takes a different view of the matter †. In this paper Prof. Huxley performs the great service to science of pointing out that in their "autostylic" skull the Dipnoi differ essentially from the Ganoidei, which are "hyostylic;" and in reference to Dr. Günther's proposed classification he concludes "that it is better to retain the Müllerian groups of Dipnoi (Sirenoidei, Müller), Ganoidei, Teleostei, Plagiostomi, and Chimæroidei (Holocephali, Müller) as equivalent and distinct natural assemblages." And as regards *Dipterus*, he seems to consider that its place is with the Ganoids, saying concerning it, "But even *Dipterus*, which approaches *Ceratodus* and *Lepidosiren* so closely in its dentition and in the form of its fins, is far more similar to *Polypterus* and *Amia* in other respects; and there is at present no reason to believe that any of the Crossopterygian Ganoids possessed other than a hyostylic skull, or differed from *Polypterus* in those respects in which *Polypterus* differs from the existing Dipnoi. All known Crossopterygians have jugular plates, of which there is no trace in the Dipnoi. And as to the position of the anterior nares, which appear to have been situated on the under face of the broad snout, not only in *Dipterus*, but in *Osteolepis* and *Diplopterus*, I have shown above that, so far from being a diagnostic character of the Dipnoi, it is simply an embryonic feature retained in them, the Selachians, and very probably in many of the earlier Ganoidei."

In a recently published memoir on *Ceratodus* ‡, Mr. L. C. Miall follows Dr. Günther in classifying *Ceratodus* and *Lepidosiren* with the Ganoidei; and as regards the special affinities of the Ctenodipterini, the following statements made by him may be quoted:—

"We do not know for certain that *Dipterus* and *Ctenodus* are hyostylic; but the suggestion has a certain degree of probability." But in a footnote appended to this passage he states, "The fossil suspensorium of *Dipterus*, marked xvi², in the Museum of Practical Geology seems to show that this genus agrees with *Ceratodus* rather than with *Polypterus* in the mode of suspension of the mandible; but a fuller discus-

* "Description of *Ceratodus*," Phil. Trans. 1871.

† Proc. Zool. Soc. London, 1876, p. 57.

‡ "On the Genus *Ceratodus*, with special reference to the fossil teeth found at Maledi, Central India," Palæont. Ind. ser. iv. 2, Calcutta, 1878. See also the same writer's memoir on the "Sirenoïd and Crossopterygian Ganoids," Palæontograph. Society, Lond. 1878.

sion of this point must be reserved for a more suitable occasion. I have seen no specimens of *Ctenodus* which throw light upon the question." However, a little further on he says again, "It is not known whether *Dipterus* and *Ctenodus* are hyostylic or autostylic; but *Polypterus* is hyostylic. It is not known whether *Dipterus* and *Ctenodus* have an archipterygium or an ichthyopterygium; but the outward resemblance of the fins of *Dipterus* to those of *Ceratodus* renders it probable that they have an archipterygium." And in summarizing the arguments for and against the near alliance of the Dipnoi with *Dipterus* and *Ctenodus*, after adducing on one side certain points of agreement, he gives on the other the following as points of difference:—

A. *Lepidosiren*, *Protopterus*, *Ceratodus*. "Autostylic; no gular plates; archipterygium; diphyccercal."

B. *Dipterus*, *Ctenodus*. "Hyostylic?; gular plates; archipterygium?; heterocercal (*Dipterus*)."

Finally, he is "inclined to hold that on the whole A and B are not ordinarily separable, but that they represent two families or suborders of Ganoids, which may continue to be called Sirenoidei (Dipnoi) and Ctenododipterini."

That *Ceratodus* and *Dipterus* represent two perfectly distinct "families" has, however, been already amply shown by Dr. Günther; the real question is whether or not these two families ought to be classed in the same "order" or "suborder." Do we, with Johannes Müller and Prof. Huxley, consider the Dipnoi and Ganoidei independent "orders" of fishes? If so, are *Dipterus* and *Ctenodus* Dipnoans, or are they Ganoids? If, on the other hand, we look upon the Dipnoi as being merely a "suborder" of the Ganoidei, does the Ctenododipterine family belong to that suborder or to the Crossopterygii, or does it likewise constitute an independent "suborder" by itself?

Whatever value may be placed upon the position of the nasal apertures, it appeared to me, at the time Dr. Günther's paper was published, that his reasoning as to the position of *Dipterus* was irresistible, whether we agree with him in considering the Dipnoi a mere suborder of the Ganoidei or not. In view, therefore, of recently expressed doubts, it becomes of some importance to ascertain whether the extraordinary similarity between *Ceratodus* and *Dipterus* in the form and arrangement of the dental plates and palato-ptyergoid bones be not (as might be expected to be the case) accompanied by other important correspondences in the general structure of the head, and more especially whether the skull of *Dipterus* presents that same "autostylic" character, which Prof. Huxley considers, and I think rightly, to be a feature of ordinal

value. Having myself dissected *Ceratodus Forsteri* and also very carefully examined the extensive series of specimens of *Dipterus* contained in the Edinburgh Museum of Science and Art, I may now bring forward a few facts bearing on this question, as well as also point out several errors of detail into which Pander seems to have slipped in his justly celebrated memoir on the Ctenododipterini.

It may be readily seen, on examining a series of skulls of *Dipterus* from the Thurso flagstones (see Pl. III. fig. 1), that the chondrocranium was very much more extensively ossified than that of *Ceratodus*; in fact its side walls were entirely occupied by bone apparently as far as the interorbital region. Posteriorly the bony substance of the occiput shows two openings, one above the other. The lower one (*n.ch*), preserving its neatly rounded contour, is for the entrance of the anterior extremity of the notochord into the base of the skull; while the upper (*f.m*), always more or less distorted by crushing, is the *foramen magnum*, for the exit of the spinal cord. The bony matter surrounding these two openings may be held to represent the exoccipitals; and in front of it on each side the walls of the otic region are distinctly ossified—though, from the abraded condition of this part in all the skulls, it is hardly possible to trace any sutural lines marking off distinct osseous elements. The side walls of the cranium now pass gently outwards into a projecting wing on each side, this wing presenting in front a transverse margin and externally a prominent angle, and, allowing for the vertical flattening to which all the specimens showing the base of the skull have been subjected, it must have passed considerably downwards as well as upwards. Its upper surface, displayed in some specimens, and in them seen to be gently concave, must have been covered by the mandibular muscle, roofed over in turn by the plates of the external cranial buckler. Its anterior margin shows, just within the outer angle, a facet (*x*) for the articulation of the mandible, internal to which the palato-pterygoid plate (*pt*) fits closely on, overlapping also a considerable portion of its under surface. This portion of the skull is clearly to be considered as “quadrate;” and, though it was in all probability ossified from its own centre, no very distinct line of demarcation can be traced between it and the osseous covering of the otic region behind; much less is there any trace of a joint. I have never found it as a detached bone; nor have I seen it wanting in any specimen showing the base of the skull, save in one, evidently long exposed to the action of the sea, and in which, apparently by continued weathering, and not as the fossil was originally entombed,

every thing else has also been removed, save the two palato-ptyergoid plates, which are left still adhering to the under surface of the external buckler. In fact we have here before us as nearly as possible a counterpart in bone of the suspensorial portion of the cranial cartilage of *Ceratodus*; and that the one was as inseparable a part of the skull as the other is evident on the face of things, even although it is naturally impossible to demonstrate any continuity of original cartilage in the fossil skull.

The suspensorium of *Dipterus* is therefore *autostylic*, and closely resembles in form and relations that of *Ceratodus*, from which it mainly differs in being so extensively ossified.

A comparison of Pander's figures 12 and 13 on plate iii. of his work with a series of well-preserved specimens shows that, misled by accidental fractures, he has dismembered the quadrate of *Dipterus* into two parts, which he calls respectively "ptyergoideum externum" and "quadrato-jugale."

In perfect harmony with the condition of the suspensorium we also find that of the palato-ptyergoid plates (*pt*, Pl. III. fig. 1). Their relations to each other and to the base of the skull are precisely the same as in *Ceratodus*; and in their external form they are also very similar to those of that living genus. Their anterior portions, bearing the dental plates, are firmly sutured to each other in the middle line; their hinder portions diverge backwards and outwards, separated by the anterior part of the parasphenoid, with which they are also immovably articulated; their posterior extremities overlap the lower aspect of the quadrate. In the skull represented in fig. 1 a slight twist, which the specimen has undergone through crushing, has dislocated the left palato-ptyergoid a little backwards and inwards from its position with respect to the quadrate; but its connexions with its fellow and with the parasphenoid have remained as firm as ever.

By Pander each palato-ptyergoid is represented as consisting of two portions, "os palatinum" and "os ptyergoideum internum," separated by a longitudinal suture or groove; and this or a similar statement has been frequently made by other writers, who have found in the supposed suture or groove a point in which *Dipterus* differs as well from the Carboniferous *Ctenodus* as from *Ceratodus**. The examination, however, of

* Hancock and Atthey, Ann. & Mag. Nat. Hist. (4) vii. 1871, pp. 190-198; Günther, Phil. Trans. 1871, p. 556; W. J. Barkas "On the Dentary, Articular, and Pterygo-palatine Bones of *Ctenodus*," Proc. Roy. Soc. of New South Wales, 1876; Miall, Quart. Journ. Geol. Soc. Dec. 1874, p. 774.

a large series of specimens reveals the fact that no such suture or groove, indicating an original division of the bone, exists, and that the distinguished Russian palæontologist has again been misled by accidental fractures. This is particularly evident in his figure 13, tab. iii.; and as regards his figure 12 in the same plate, in none of the numerous specimens before me can I see any thing at all resembling the straight deeply indented sutural line which is there represented as dividing the posterior diverging part of the palato-pterygoid into two longitudinal halves. The palato-pterygoid of *Dipterus* consists, then, as in *Ceratodus* and in *Otenodus*, only of one bone; and the peculiarity supposed to be characteristic of the first-named genus therefore falls to the ground. A completely isolated example of this bone is preserved in the Hugh-Miller collection, and is figured in the 'Footprints of the Creator.'

The same remarkable correspondence between *Dipterus* and *Ceratodus* is seen in the structure and configuration of the mandible (Pl. III. figs. 2, 3, and 4); but here also we find that in the Devonian genus ossification is more extensive, and, in addition, a ganoid surface is extensively developed on its outer aspect. The articular element (*ar*), in *Ceratodus* not differentiated from the Meckelian cartilage, is well ossified, and presents posteriorly, and looking upwards and backwards, a deep rounded notch for articulation with the quadrate. Externally and internally the articular is embraced between the posterior extremities of the splenial (*sp*) and of the bone termed in *Ceratodus* "articular" by Dr. Günther, "angular" by Prof. Huxley. The latter element (*ag*) has the same relations as in *Ceratodus*, covering as it does the greater part of the outer surface of the ramus, and passing above and behind into a coronoid process. At the posterior extremity of its lower margin there is, in every specimen I have seen, an appearance as if a small additional piece had fitted on just below the angle of the jaw; but as such an additional piece has not occurred *in situ*, its presence cannot be affirmed. The splenial (*sp*), carrying the mandibular dental plate, is extremely similar in shape, and identical in its relations with that of *Ceratodus*: its anterior extremity, covered up by the matrix in the specimen represented in fig. 2, but visible in other examples, curves inwards and meets its fellow at the symphysis; so close is the union that I have not clearly detected any suture between them. The front of the mandible presents a shovel-shaped aspect, reminding us at once of that of *Ceratodus*; but whereas in *Ceratodus* the labial margin is formed by a shovel-shaped expansion of the coalesced Meckelian cartilages, and the right and left pieces of bone,

considered by Prof. Huxley to represent the *dentary* elements, are small, seen principally on the lower aspect of the jaw, and separated from each other by a median suture, we have in *Dipterus* a single bone (*d*), on whose external smooth and ganoid surface no median suture can be seen, and which, extending upwards and forwards, forms a rounded enamelled lower lip, whose contour, as seen from above (fig. 2), constitutes an arc of more than half a circle. Seen from below (fig. 3) this median "dentary" shows posteriorly a free concave border, continuing the lower margins of the right and left rami uninterruptedly round into each other; in front it passes round into the labial margin already mentioned. The oral aspect of the bone, just within the lip and above the united splenials, is, in one specimen, seen to possess a narrow band of small enamelled denticles, resembling in form those on the ridges of the palatal and splenial dental plates, but irregularly arranged; in fig. 2 these are concealed by the matrix. Now if we look at the jaw from the side (fig. 4)—and the same appearance is also to some extent visible from below (fig. 3)—it will be seen that below the posterior half of the labial margin the bone is suddenly and deeply excavated, so as to form on each side a well-marked hollow (*y*), bounded below by a sharp margin, which, curving sharply round in front, passes then into the posterior part of the lower lip, overhanging and bounding the hollow from above. Posteriorly the floor of this hollow, which is non-ganoid and crossed obliquely by the suture separating the dentary from the angular element, passes uninterruptedly backwards onto the outer surface of the latter. These hollows are important, inasmuch as they afford us an explanation of the real nature of the so-called nasal apertures of *Palædaphus insignis* (figs. 5, 6, 7), as we shall see in considering that remarkable fossil further on.

The large lozenge-shaped *parasphenoid* of *Dipterus* (fig. 1, Pl. III. *pa.sph*) is well known; and its relations to the palatopterygoid plates are precisely as in *Ceratodus*; there is, however, no evidence of its having been prolonged backwards as a narrow process along the under surface of the vertebral axis for a little distance behind the skull as in the latter genus. The "palatal dart-head," figured by Hugh Miller ('Footprints of the Creator') is the anterior part of the parasphenoid broken off.

The upper aspect of the skull differs remarkably from that of *Ceratodus* in being covered by a buckler of thick polygonal ganoid plates, whose arrangement has been well delineated by Hugh Miller and by Pander, though it is difficult to trace any exact correspondence between them and the cranial roof-bones

of ordinary Ganoids and Teleostei. Anteriorly, at the broad depressed snout, sutures cease to be traceable in this bony and ganoid covering, which, becoming reflected round the oral margin, forms a rounded upper lip, overhanging the corresponding mandibular lip when the mouth is closed, as is seen in one specimen in the Hugh-Miller collection. Looking at this lip from the lower aspect of the cranium (Pl. III. fig. 1), the reflected bony covering shows on each side two wide notches, anterior and posterior (n and n'), which certainly indicate the position of the nasal openings and show that these were placed just as in *Ceratodus*, as has been already pointed out by Dr. Günther. There is no distinctly differentiated maxilla or præmaxilla; but the cheek is covered by an arrangement of bony plates, which encircle the orbit and inferiorly continue the upper margin of the mouth for a little distance backwards from the nasal margin of the snout, these plates being represented in *Ceratodus* only by the chain of small suborbital ossicles imbedded in the firm fibrous band below the eye*.

The opercular bones of *Dipterus* correspond in number and position with those of *Ceratodus*, but differ in being of a broader and rounder shape, and, of course, in having ganoid surfaces. There is a large *operculum*, below which there is a much narrower plate corresponding to that bone which in *Ceratodus* is interpreted by Prof. Huxley as *interoperculum*; but I have seen nothing which can be taken to represent a præoperculum, though Pander has figured a plate which he supposed might represent that element. The *jugular plates* are obvious, and seem to have existed as *two pairs*, anterior and posterior; but I have not seen the median plate figured by Pander (*op. cit.* tab. 1. figs. 9a, 23).

The bones of the shoulder-girdle correspond closely with those of *Ceratodus*. There is a broad supraclavicular, proceeding backwards and a little downwards from the posterior part

* With regard to the suborbitals of *Ceratodus*, it may here be appropriate to correct a somewhat serious error which occurs in Mr. L. C. Miall's figure of the skull of *C. Forsteri* (Sirenoid and Crossopt. Ganoids, pl. 1 A. fig. 2). The suborbitals are not figured; nor are they mentioned in the text; but the cheek is represented as covered by a large plate of *cartilage*, in which a circular hole for the orbit is, as it were, punched out; and in the explanation to fig. 3 of the same plate (in which the cartilage is represented as cut away to afford a side view of the palato-pterygoid and its dental plate) it is said that "the lateral cartilages are largely removed." Now this "lateral" circumorbital cartilage (or "cartilages") simply *does not exist*; and I have myself, on the contrary, completely verified Prof. Huxley's statement as to the suborbital fibrous band and osseous chain; only in my specimen I find five such ossicles, instead of three as given by Prof. Huxley.

of the skull and overlapped by the operculum. This is succeeded by a clavicle, whose direction is first downwards and then somewhat forwards. The lower part, forming an obtuse angle with the upper, is formed, as in *Ceratodus*, of a distinct piece, divided off from the upper by a suture which passes just below and in front of the attachment of the pectoral fin, and may be regarded as the equivalent of the *infraclavicular* bone in *Crossopterygii* and *Acipenseroides*.

The points of resemblance between *Dipterus* and *Ceratodus* certainly do not stop when we come to the paired fins, which, so far as their structure is preserved in the former genus, are similarly conformed in both. There is, in *Dipterus*, a central elongated and pointed scaly axis, fringed, both preaxially and postaxially, with a series of delicate fin-rays. In no case is the internal skeleton preserved; hence we may truly infer that, as in *Ceratodus*, it was cartilaginous; and I cannot conceive of any reasonable doubt as to its having been also archipterygial in its nature. Mr. L. C. Miall, who seems to entertain doubts on this point, says that "the presence or absence of scales upon the fin does not mean much," though in another passage already quoted he thinks it "probable" that *Dipterus* and *Ctenodus* have an archipterygium. The question is not, however, one of the presence or absence of scales upon a fin, but of the arrangement of the rays. In many specimens of *Dipterus* the covering of scales upon the axial "lobe" of the pectoral and ventral members is so delicate and thin that the rays stand out boldly defined for their entire length, the pre- and postaxial series enclosing between them an elongated pointed space, which it is as reasonable to conclude was once occupied by a cartilaginous skeleton as that the orbit of a fossil fish once contained an eye with lens and retina. And as in the only recent form (*Ceratodus*) in which the rays have that remarkable arrangement this skeleton is archipterygial, we are scarcely chargeable with rashness in believing that this also was the case in *Dipterus*.

The vertebral axis was in *Dipterus* certainly notochordal, as shown by numerous specimens in the Edinburgh Museum; and from what is seen of its ribs, vertebral apophyses, and interspinous bones or fin-supports, they were conformed and arranged much as in *Ceratodus*. Pander, indeed, described and figured certain detached vertebral bodies which he doubtfully assigned to *Dipterus*; but all the evidence is to the contrary. In many specimens, however, as has been already noted by Pander, there is to be seen in the body-axis, in the region of the caudal fin, a raised line of a somewhat beaded appearance,

which may be explicable by a reference to the condition of the tail in *Protopterus* and at least some specimens of *Ceratodus**. Here the notochord stops short before reaching the extremity of the tail, and the bases of the vertebral arches, which have been proportionately increasing in depth, meet each other from above and fuse together, each neural one with the corresponding hæmal opposite, so as to produce, as Dr. Günther observes, "a distinct vertical segmentation," some amount of ossification in which might, in *Dipterus*, have produced the appearance in question.

The heterocercy of *Dipterus*, and the differentiation from the median fin-system of two dorsals and one anal, distinct from the caudal, are points which can only be looked upon as of "family" importance. Some difference from *Ceratodus* is observable in the structure and arrangement of the median-fin rays, but not to the extent that Dr. Günther has stated. These rays are closely set; but tracing them towards their origins they are seen to converge into small fasciculi, each of which apparently results from the division of an original ray; the rays are also unarticulated up to a certain point, from which they become closely jointed to their terminations. It is quite clear that the unarticulated proximal portions of these rays are what Pander has described as interspinous bones ("Flossenträger"); and, following this interpretation, Dr. Günther has indicated as an important point of distinction between *Ceratodus* and *Dipterus* that the latter has its "interneural and interhæmal spines branched at their distal end, to which the dermal rays are joined." The real fin-ray, however, includes both what is here considered as "ray" and as "interneural" or "interhæmal spines;" and its proximal extremity in reality *overlaps*, as might be expected, the real series of interspinous elements, which, however, are seldom seen, owing to the scaly covering of the body.

As the result of the observations briefly recorded above, I feel myself compelled to differ from Prof. Huxley in his opinion that *Dipterus* is much more similar to *Polypterus* and *Amia* than to the living Dipnoi in other respects than its dentition and the form of its fins—as well as from Mr. Miall, in his statement that "it is not easy to say whether the resemblances or the differences between the Dipnoi and the Ctenododipterini are of greater weight." Agreeing, however, with the last-named author, that "the presence or absence of gular plates is hardly of ordinal value," the correspondence between *Dipterus* and *Ceratodus* in all points of real ordinal

* Günther, *op. cit.* p. 527, pl. xxx. fig. 3.

or subordinal importance is so close as, in my estimation, most fully to justify the step taken eight years ago by Dr. Günther in associating the two genera in one common group (Dipnoi), in which they respectively represent the two distinct *families* of Ctenododipterini and Sirenoidei. In retaining the Dipnoi as a distinct order of fishes I shall continue to follow Prof. Huxley; the discussion of this question is beyond the scope of the present paper.

II. PALÆDAPHUS, Van Beneden and De Koninck, *and* HOLODUS, Pander.

In 1864 a remarkable fossil from a Belgian Palæozoic limestone, formerly supposed to be of Carboniferous age, but now, as I understand from Prof. De Koninck, referred to the Devonian formation, was described and figured by the distinguished palæontologist just named, in conjunction with Prof. Van Beneden, and received from them the name of *Palædaphus insignis**.

The Edinburgh Museum having recently, through the kindness of Prof. De Koninck, acquired a plaster cast of the specimen, I have represented it much reduced in Plate III. figs. 5, 6, and 7. It consists of two rami closely united in front and broken off behind, the left one almost immediately behind the union, the right somewhat further back. The aspect of the fossil shown in fig. 6, considered by its describers to be the *upper* surface of a head, is characterized by them as being "d'une apparence écailleuse et brillante, comme si elle avait été recouverte d'une peau cornée, mais la couche de matière qui lui communique ce brillant est extrêmement mince et assez dure." The other aspect (shown in fig. 5) displays two large dental plates, touching each other in the middle line for some distance in front, and furnished each with four well-marked rounded ridges passing from behind forwards in a slightly radiating manner, there being also a slight appearance of crenulation of these ridges, as seen in the profile view fig. 7. In front of these dental plates, and separated from them by a groove, the anterior margin, gently curved in contour, and thick and rounded, seems formed as if by a folding-over of the opposite surface; on each side the outer extremity of this lip-like margin is abruptly truncated, and presents an excavation (*y*) bounded above, in front, and below by elevated margins, but posteriorly passing uninterruptedly into a shallow groove which proceeds backwards for some distance along the outer aspect of the fossil (fig. 7).

* Bull. Ac. Belg. (2) xvii. 1864, pp. 143-151. The same fossil is also figured in Gervais's 'Zoologie et Paléontologie françaises,' pl. lxxvii. fig. 17.

By Messrs. Van Beneden and De Koninck this fossil was considered to be the anterior part of the head of a fish which belonged "sans contestation à l'ordre des Plagiostomes et au sous-ordre des Squalidiens." The two dental plates they regarded as the two halves of the upper jaw, the anterior rounded ridge as the upper lip; and, lastly, as regards the two lateral fossæ or excavations (*y*), they considered that they "ont probablement correspondu aux fosses nasales de l'animal." No trace of eyes could, however, be discovered; and, in conclusion, they held that this curious fish approached on the one hand the Chimæroids, on the other the Cestracionts and Squatinids.

Some time afterwards another and apparently closely allied fossil was described by Prof. Van Beneden from the Devonian strata of Belgium*. This consists of a large dental plate closely united along nearly its entire length with its fellow of the opposite side, and presenting fine ridges, anteriorly tuberculated or crenulated, and slightly diverging from each other as they pass from behind forwards. To this specimen Prof. Van Beneden gave the name of *Palædaphus devoniensis*, considering it to be the upper jaw of a Plagiostome of the same genus as that previously described by himself and Prof. De Koninck.

Pander had, however, already, in 1858, described, under the name of *Holodus*†, a fragment from the Devonian of Russia, which, though of much smaller size, bears a most unmistakable resemblance to *Palædaphus insignis*, being, in fact, evidently the very same part of the head of a closely allied animal. On comparing Pander's figure of *Holodus* with those of *Palædaphus insignis* it will be seen that, like the latter, the fragment consists also of two united and diverging rami, broken off close behind their union. On one aspect we have a smooth ganoid surface undivided by any median suture, and reflected over in front so as to form a lip-like margin; on the opposite aspect are two dental plates whose outer margins are elevated and bear each at least two conical tooth-like tubercles; these dental plates do not, however, as in *Palædaphus*, touch each other in the middle line, though the bones on which they are carried are united by median symphysis. Seen from the side, the lip-like margin is truncated as in *P. insignis*, and shows here exactly the same right and left depressions or hollows, supposed in the Belgian fossil to be nasal fossæ.

This fossil (*Holodus*) was also considered by Pander to be the snout of a fish; the bones bearing the tooth-plates are compared by him to the palato-pterygoids of *Dipterus*; and into the angle where they diverge posteriorly he conceives an "os

* Bull. A.c. Belg. (2) xxvii. 1869, pp. 378-385.

† 'Ctenodipterinen,' pp. 33-43.

sphenoideum" (parasphenoid) to have been inserted. Finally, though he compares the teeth to those of *Lepidosiren*, he does not seem to consider *Holodus* as a Ctenododipterine, saying that "the remarkable structure of the head, so strikingly different from every thing hitherto known from the older formations, points to a new family, whose dermal coverings, as in the Ctenodipterini, consisted of a bony substance outwardly protected by a kosmine layer."

I have already mentioned that it is clear that *Palædaphus insignis*, v. Ben. and De Kon., and *Holodus Kiprijanowi*, Pander, are closely allied, and represent corresponding parts of the head in the animals to which they respectively belonged; the strongly Ctenododipterine aspect of the dental plates in both cannot fail to strike every observer. But while there is nothing to prevent *Palædaphus devoniensis* from being the palatal tooth-plate of a fish allied to *Dipterus* or *Ctenodus*, the aspect of *P. insignis*, as of *H. Kiprijanowi*, is certainly in many points very unlike that of the snout or "upper jaw" of a fish of that family. So Dr. Günther, in considering what other genera of fossil fishes should accompany *Dipterus* to its new position among the Dipnoi, remarks, "At first I thought that *Holodus*, Pander, was another Dipnoous genus; but I changed this opinion after having compared it with *Palædaphus* of Van Beneden and De Koninck. These two genera are evidently closely allied; and the position of their nostrils (so far as we can judge from the fragmentary remains) appears to have been different from that of the Dipnoi: these openings were more lateral and outside of the mouth. It seems also that there would not have been room for a pair of vomerine teeth, at least not in *Palædaphus*"*.

Prof. J. S. Newberry, however, maintains the Ctenododipterine nature of *Palædaphus devoniensis*, but at the same time considers it to be both generically and ordinally distinct from *P. insignis*. For the former he proposes the generic name *Heliodus*, to include also a new species *H. Lesleyi*, Newb., from the Devonian of North America, retaining the genus *Palædaphus* for *P. insignis*, with whose original describers he agrees in considering it to be probably the head of a large Plagiostome †.

That two forms which in the aspect of their dental plates bear so evident a resemblance to each other and to the Ctenododipterini should be so widely separated as Prof. Newberry supposes, does seem *à priori* a little improbable. A step towards the solution of the problem may, however, be attained by simply asking ourselves the following questions:—Are we

* *Op. cit.* p. 557.

† Palæontology of Ohio, vol. ii. (Columbus, 1875), pp. 62, 63.

quite sure that in *Palædaphus insignis* we have the snout or upper part of a fish-head? that its dental plates belong to the upper jaw? that the lateral excavations are really nasal openings?

The answer to these questions will be found by comparing *Palædaphus insignis* not with the snout, but with the lower jaw of *Dipterus*.

The smooth enamelled surface seen in fig. 6 corresponds obviously with the lower aspect of the united dentaries of *Dipterus* shown in fig. 3; and in the cast there is a distinct trace of a suture in a situation analogous to that which in *Dipterus* separates the dentary from the angular behind. The labial margins are very similar, though that of *Dipterus* is more convex in its contour when seen from above or below (figs. 2, 3). The lateral excavations in *Palædaphus insignis* (y, figs. 5 & 7) correspond exactly with those below the hinder part of the enamelled lower lip of *Dipterus* (figs. 3, 4), as will be at once apparent on comparing the lateral view of the lower jaw of *Dipterus* (fig. 4) with that of *Palædaphus* (fig. 7); these excavations are therefore not nasal openings. The ridged plates supposed to be the halves of the upper jaw of *Palædaphus insignis* represent the splenial dental plates of *Dipterus*, from which they differ in their relatively more anterior position and in coming into contact with each other in front.

There is therefore, in my mind, not the smallest doubt that *Palædaphus insignis* of Van Beneden and De Koninck is the symphysial part of the lower jaw of a gigantic Ctenodipterine fish, and not the snout of a Plagiostome as has been supposed. The same interpretation, size only excepted, must necessarily be accepted for *Holodus Kiprijanowi* of Pander.

Palædaphus devoniensis is evidently the upper or palatal plate of an allied species; there is therefore no necessity for altering its name to *Heliodus*; and if Prof. Newberry's *H. Lesleyi* does belong to the same genus, the name *Heliodus* must drop.

III. CHEIRODUS, M'Coy.

A small dental plate from the Carboniferous Limestone of Derbyshire was described and figured by M'Coy under the name of *Chirodus pes-rancæ**, and considered by him to be a tooth of a Selachian allied to *Ceratodus*, which was at that time still reckoned amongst the sharks.

* Ann. & Mag. Nat. Hist. (2) ii. 1848, pp. 130, 131; 'Palæozoic Fossils,' p. 616, pl. 3g. fig. 9. The name is spelt "*Chirodus*" by M'Coy; but, in common with the majority of authors, I prefer the form "*Cheirodus*."

Other teeth from the Devonian of Russia were subsequently described by Pander as *Cheirodus Jerofejewi*; and from the resemblance which the palatal tooth-plates of this form bore to M'Coy's *Conchodus ostreaformis* from Scat Crag, he proposed to cancel the latter name on the ground that M'Coy had founded it on the palatal tooth-plate of a fish generically identical with that whose mandibular one constituted *Cheirodus pes-ranae*. *Cheirodus* (incl. *Conchodus*), as well as *Ceratodus*, was placed by Pander provisionally among the Ctenodipterini.

On this point Dr. Günther remarks, "Wherever *Dipterus* and *Ceratodus* are placed, thither *Cheirodus* (M'Coy, Pander) or *Conchodus* (M'Coy) must follow. But it is probable that this genus is more nearly allied to *Ceratodus*"*.

Recently, through the kindness of Prof. Hughes of Cambridge, I have been able to examine M'Coy's original specimen of *Cheirodus pes-ranae* preserved in the Woodwardian Museum; and, to my surprise, I found it to be nothing more or less than a mandibular dental plate, not of a Selachian, nor of a Dipnoan, but of the Platsomid fish named by Prof. Young, in 1866, *Amphicentrum*. The conformation of the bone and of its ridges is identical with what we find in the splenial element of Prof. Young's fish, as will be seen on comparing M'Coy's figure with that given by myself of the upper aspect of the splenial of *Amphicentrum granulosum* (Ann. & Mag. Nat. Hist. (4) xvi. 1875, pl. ix. fig. 8), though before I had seen the original of *Cheirodus* I should have hesitated in affirming their identity. There can, however, be no doubt that they belong to the same genus; the species is another question. In M'Coy's specimen it will be observed that the tubercles are quite obsolete; but as regards the number and prominence of these, great differences are found in different specimens of *Amphicentrum granulosum*, in some of which they are very slightly marked. Nevertheless I am, upon the whole, inclined to consider the species as distinct †

Cheirodus, M'Coy, is therefore not = *Cheirodus*, Pander, though the latter is possibly the same as M'Coy's *Conchodus*, which is undoubtedly a Dipnoous genus. As to the name *Chirodus* or *Cheirodus*, I should have preferred to have dropped it altogether, as it was founded on a mere fragment whose nature its describer did not understand; nor should we have understood it to this day but for the discovery of that

* *Op. cit.* p. 557.

† Mr. W. J. Barkas has recorded the occurrence of *Amphicentrum granulosum*, Young, in the Carboniferous Limestone of Richmond, Yorkshire, Geol. Mag. (2) i. 1874, p. 431.

Coal-measure fish of which Prof. Young gave the first description, and which is now so widely known under the name which he applied to it. But as the law of priority is now-a-days considered to be inexorable, I must, though much to my regret, propose the abolition of "*Amphicentrum*," retaining, however, "*pes-ranae*," M'Coy, and "*granulosum*," Young, as distinct species of the genus *Cheirodus*.

EXPLANATION OF PLATE III.

- Fig. 1.* Palatal aspect of a skull of *Dipterus* from Thurso, in the Hugh-Miller collection. *n*, anterior nasal notch; *n'*, posterior nasal notch; *pt*, palatal-pterygoid; *pa.sph*, parasphenoid; *qu*, quadrate; *x*, facet for mandibular articulation; *n.ch*, notochordal opening; *f. m*, foramen magnum; *b*, one of the marginal plates of the external cranial buckler, seen from its inner surface.
- Fig. 2.* Mandible of *Dipterus*, seen from above, a large amount of the matrix being left between the rami. Hugh-Miller collection. *d*, dentary; *ag*, angular; *ar*, articular; *sp*, splenial, with its dental plate.
- Fig. 3.* The same specimen, seen from below. *y, y*, lateral labial fossæ; the other letters as in fig. 2.
- Fig. 4.* The same specimen, seen from the right side. Lettering as in the preceding figures.
- Fig. 5.* *Palædaphus insignis*, Van Ben. & De Kon., seen from above; one fourth natural size, and taken from a plaster cast. Lettering as in the figures of *Dipterus*.
- Fig. 6.* The same, seen from below.
- Fig. 7.* The same, seen from the left side. Compare this figure especially with the similar view of the mandible of *Dipterus*, fig. 4.

II.—*Preliminary Notices of Deep-Sea Fishes collected during the Voyage of H.M.S. 'Challenger.'* By Dr. ALBERT GÜNTHER, F.R.S., Keeper of the Zoological Department, British Museum.

As some time must elapse before the second part of the Ichthyology of H.M.S. 'Challenger' (which will contain an account of the deep-sea and pelagic forms) can be published, it is proposed, with the sanction of the Lords Commissioners of H.M. Treasury, to publish preliminary diagnoses of the genera and species which are new to science. The materials collected have proved to be far more extensive than was at first anticipated; and the author has great pleasure on this occasion to express his gratification at the admirable manner in which the specimens have been preserved by the gentlemen intrusted with their care, and at the clear and simple method in which all necessary particulars connected with their capture have been noted.

