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I.—The Devonian fish- fauna of Spitzbergen

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THE ANNALS
AND
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[SIXTH 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 conchyliis succo."
N. Parthenii Giannettusii Bel. I.

No. 43. JULY 1891.

I.—*The Devonian Fish-Fauna of Spitzbergen.* By A. SMITH
WOODWARD, F.L.S., F.G.S., of the British Museum
(Natural History).

[Plates I.—III.]

DURING a visit to the Royal State Museum at Stockholm two years ago the writer had the privilege of examining the collection of Devonian fish-remains from Spitzbergen obtained by the Swedish expeditions to that country under the direction of Baron Nordenskjöld and Dr. A. G. Nathorst. A selected series of the specimens had already been submitted to Prof. Ray Lankester, who published figures and brief notes upon several of the more striking remains in 1884*; but, from a detailed review of the whole collection, it soon became evident that the materials were worthy of more extended study, and Prof. Gustav Lindström kindly undertook to forward them to the British Museum, where comparisons with known types could be most readily instituted. The opportunity for such comparisons has now been afforded, and palæichthyologists are much indebted to Prof. Lindström for thus rendering possible the discovery of a number of new facts, which it is the object of the following notes to record.

* E. Ray Lankester, "Report on Fragments of Fossil Fishes from the Palæozoic Strata of Spitzbergen," Kongl. Svenska Vetensk.-Akad. Handl. vol. xx. no. 9 (1884).

SPITZBERGEN DEVONIAN FISHES.
Acanthaspis decipiens.

R. Münster del. et lith.

Mintern Bros. imp.

SPITZBERGEN DEVONIAN FISHES.

R. Mintern del. et lith.

Mintern Bros. imp

SPITZBERGEN DEVONIAN FISHES.
Asteroplax scabra.

As already remarked by Prof. Lankester, the fish-remains extend the conclusions of the Swedish geologists*, and prove that two distinct horizons—an Upper and a Lower—are recognizable in the Devonian formation of Spitzbergen. Some of the rocks of the lower division are indistinguishable from certain red sandstones, grey micaceous sandstones, and cornstones occurring in the Lower Old Red Sandstone series of the west of England. The fish-bearing horizon of the upper division is a compact and dark-coloured clayey ironstone.

I. FISH-FAUNA OF THE LOWER DEVONIAN.

Subclass OSTRACODERMI.

Order HETEROSTRACI.

Family Pteraspidae.

Genus PTERASPIS.

Being known only by ventral shields and fragments, the generic determination of the Pteraspicians from Spitzbergen is only provisional. Most probably, however, the remains are referable to the type genus, *Pteraspis*.

Pteraspis Nathorsti (Lankester). (Pl. II. fig. 1.)

1884. *Scaphaspis Nathorsti*, E. R. Lankester, Kongl. Svenska Vetensk.-Akad. Handl. vol. xx. no. 9, p. 5, pl. i. figs. 1-3.

As remarked by Lankester, the ventral shield of this species seems to have been slightly broader and shorter than the typical form met with in the Herefordshire cornstones, and it is readily distinguished from all known species by the feeble beading and crimping of the surface-ridges. As shown by one specimen (Pl. II. fig. 1), the obtusely rounded median extension of the posterior end of the shield is also characteristic. On the visceral aspect the hinder border seems to exhibit a faint thickening, and there is a feebly marked median tubercle immediately in advance.

Form. and Loc. Red Micaceous Sandstone and Cornstones, Dickson Bay; Grey Tilestone, Klaas Billen Bay.

Pteraspis, sp. ind.

Some specimens of the red sandstone from Liefde Bay are

* A. E. Nordenskiöld, "Sketch of the Geology of Ice Sound and Bell Sound, Spitzbergen," Geol. Mag. [2] vol. iii. (1876), pp. 16-23.

filled with fragments of Pteraspidian shields too imperfect for specific determination. So far as the writer has observed, the superficial ridged ornament upon these fossils does not exhibit any crimping, being quite smooth and as even as in the typical species.

Order OSTEOSTRACI.

Family Cephalaspidæ.

A further examination of the supposed evidence of *Cephalaspis* from the Lower Devonian of Spitzbergen (Lankester, *op. cit.* p. 5, pl. i. fig. 4, pl. ii. fig. 5) suggests doubts as to the determination of the larger fossil, and proves that the smaller specimen represents a new species of *Acanthaspis* (see p. 4). It is quite possible that the former may be truly referable to the same category as the triangular spines of *Psammosteus* and *Oracanthus*; but more satisfactory specimens are required for the study of the histology of the fossil.

Order ANTIARCHA.

Family Acanthaspidæ.

Exoskeleton robust, ornamented with tuberculations of ganoine; dorsal and ventral shields of trunk firmly united by the lateral plates, the dorsal comparatively simple, the ventral as in Asterolepidæ. [Head unknown.] A pair of fixed, spine-like, lateral appendages in the pectoral region, encased in a thick plate or plates. [Caudal region unknown.]

The recognition of this family seems to be now rendered possible by the discovery of the specimen described below as *Acanthaspis decipiens*.

Genus ACANTHASPIS.

Head and trunk broad, not much elevated, and the superficial tuberculations distinct, often arranged in regular concentric series. Anterior dorsal armour apparently consisting of a single broad plate, meeting the ventral armour laterally, and in conjunction with this giving rise to a pair of lateral uniform processes, each bearing a simple, backwardly curved, hollow spine-like appendage.

Of this imperfectly definable genus only a single species (*A. armata* *) has hitherto been met with in the Corniferous

* J. S. Newberry, Rep. Geol. Surv. Ohio, vol. ii. pt. ii. (1875), p. 37, pl. lv. figs. 1-6.

Limestone (Lower Devonian) of Ohio. The type specimens comprise a series of detached plates, now in the museum of Columbia College, New York, some of these exhibiting the lateral appendages which suggested to Dr. Newberry the generic and specific name. In the original description the appendages were compared with the cornua of typical Cephalaspidian fishes, and the new genus was thus supposed to pertain to the latter group, differing from all known forms in having a cephalic shield composed of several distinct plates. If, however, the Spitzbergen fossils prove to be correctly interpreted below, *Acanthaspis* is most nearly related to the Asterolepidæ, and its spine-like processes are the homologues of the well-known pectoral paddles of the latter.

Acanthaspis decipiens, sp. n. (Pl. I.)

1884. *Cephalaspis* (cf. *C. Agassizii*), E. R. Lankester, *op. cit.* p. 5, pl. i. fig. 4.

Pectoral appendages comparatively broad and very gently arched, ornamented in the proximal two thirds by closely arranged longitudinal series of fine tuberculations. Median ventral plate relatively large, about as broad as long, occupying more than half the width of the ventral shield at its middle point. Tubercular ornament very fine and closely arranged.

This species is based upon a small slab of red sandstone exhibiting remains of dermal armour that are at first sight somewhat difficult of interpretation. Before the investing matrix was completely removed, one portion of the fossil was briefly noticed and figured by Lankester (*loc. cit.*) as indicating the occurrence of a species of *Cephalaspis* related to the British *C. Agassizii*; but it is now evident that the organism in question is quite distinct from any hitherto satisfactorily determined and cannot be referred even to the family to which *Cephalaspis* belongs.

As shown in the drawing of the natural size the fossil exhibits two distinct portions of armour, each provided on one side with a large, curved, spinous process. As remarked by Lankester, the two spines appear to be essentially identical, and hence it is reasonable to infer that both parts of the fossil pertain at least to the same species, if not to the same individual. The one shield (A) is distinctly convex on the external aspect, for the exposed concave face of the specimen is smooth and has the characteristic appearance of the visceral aspect. The other shield (B) is chiefly shown as an impression; but it is proved to be nearly flat, and some fragments of the

original tissue exhibit an external ornament of fine tuberculations. The first shield, indeed, may be regarded without hesitation as having enveloped the dorsal aspect of a chordate animal, while the second shield can be determined with equal certainty as originally ventral in position.

The dorsal shield is unfortunately much less nearly complete than the ventral, and, so far as preserved, seems to consist of a single continuous piece. As shown by the fractured margin the substance of the shield comprises a thin outer and inner layer, very dense, separated by a thick layer of cancellæ with delicate septa. The section also proves that there was a thickening of the middle layer, producing on the surface a sharp longitudinal keel in the middle of the back (Pl. I. fig. 2). The posterior portion of the shield is obviously broken away, and if any part of its anterior border remains this is confined to the bilaterally symmetrical reentering angle, from which there proceeds backwards on the visceral aspect a feebly marked ridge, and in relation to which a great pair of processes (x) with two pairs of linear impressions are symmetrically disposed. While the downwardly turned border on the right side is well shown, a considerable portion of the left side is thus proved to be missing, and the amount is indicated by the dotted line in fig. 2. The anteriorly and downwardly directed processes (x) are unlike any structure hitherto observed by the present writer in an Ostracoderm dorsal shield; they are bluntly rounded, but apparently not much thickened, and are most suggestive of an arrangement for complex articulation with a shield originally occurring in front. The outer of the two divergent lines extending backwards from the base of each process (m) corresponds with a sharp longitudinal angulation of the shield, as indicated by the transverse section (fig. 2); and this may perhaps represent an obliterated suture, though the evidence is not conclusive. This line is directed outwards, but the inner line, which has more the appearance of a fold than an indentation, trends gradually towards its fellow of the opposite side behind.

The ventral shield is imperfect on all sides except the right, but in general contour it seems to have closely resembled the corresponding armour of the typical *Pterichthys Milleri* from the Old Red Sandstone of northern Scotland. It is, indeed, broadly ovate, tapering behind. The sutures between the component plates are indicated partly by impressions upon the matrix and partly by the arrangement of the fibres in the fragments of the exoskeletal tissue that remain. There are also some traces of the superficial tubercular ornament, fine towards the middle of the shield, somewhat coarser on the

upturned edge of the lateral plates. The median ventral plate (*m.v.*) is remarkably large, almost equilateral, and about as broad as long, and each ventro-lateral plate is distinctly shown to be continued into an upturned lamina at its outer border. The posterior ventro-lateral plate is comparatively long and narrow, with a broad transverse thickening on its visceral aspect, corresponding to the ridge that seems to mark the hinder boundary of the abdominal cavity in the *Asterolepidæ*. The anterior ventro-lateral plate is broader in proportion to its length, but the precise form cannot be ascertained on account of the loss of the front margin.

The two shields thus described correspond so closely in size that they might have formed the dorsal and ventral armour of one and the same individual. That they pertain to two distinct specimens, however, seems to be proved by the circumstance that the appendage preserved in each case is on the right side, while its superior surface is more or less intact in both. The appendage is hollow and thin-walled, at least at its base, as indicated by the transverse sections (Pl. I. figs. 3 *a*, *b*), and the broad basal portion is directly continuous both with the dorsal armour of the trunk above and with the anterior ventro-lateral plate below, there being no interposed suture or movable joint. The dorsal and ventral faces of the appendage are evidently flattened and even, while the lateral borders are sharply rounded; and where the surface or its impression is distinctly preserved, close parallel series of small tuberculations are shown to be arranged longitudinally. The greater portion of the spine-like plate consists of fibrous tissue, of which the fibres are longitudinal in direction; but a fortunate plane of fracture in the appendage attached to the dorsal shield exhibits a sharp line of demarcation between the inner border of the proximal half of this element (*s*) and a broad, triangular, basal area (*b*) in which the structural fibres radiate outwards. It is thus evident that the arrangement agrees precisely with that already noted by Newberry in some of the type specimens of *Acanthaspis* from the Corniferous Limestone, where the suture now indicated by minute structural characters is sometimes open, though quite as often closed.

Form. and Loc. Red Micaceous Sandstone, Dickson Bay.

Acanthaspis minor, sp. n. (Pl. II. figs. 2-5.)

A comparatively small species. Appendages slender, gently arcuated, ornamented with few, conspicuous, rounded longitudinal ribs, which are nodose at distant intervals; prominent lateral denticles at least on the concave border.

Plates of trunk ornamented with numerous fine tubercles, of which the majority are arranged in concentric series.

A second species of *Acanthaspis* from the Lower Devonian of Spitzbergen is indicated by the small slab of remains, partly shown in Pl. II. figs. 2-5. In addition to several portions of the characteristically ornamented plates, the fossil exhibits parts of two or perhaps three lateral appendages. There are also two other plates exposed from the inner aspect, the one having the appearance of the occipital region of the cranial shield, while the other is irregularly quadrate and not readily determinable.

The best-preserved fragment of a lateral appendage is enlarged twice in Pl. II. fig. 3, and displays portions of the sparsely nodose, rounded, longitudinal ridges, with some of the stout, backwardly pointing tubercles on the inner or concave border. Another fragment shows that the plate (either dorsal or ventral) at the base of the appendage is tuberculated like the remainder of the armour and exhibits no arrangement of ridges.

The supposed occipital plate (Pl. II. fig. 2) is thus determined because it is bounded on one side by an attenuated border gently excavated in a symmetrical manner with respect to a short broad process (*p*), which is very suggestive of the median process of the occipital shield in the *Asterolepidæ*. If the element pertains to the same individual as either of the appendages, it is remarkably large; but it may be equivalent to the median occipital and lateral occipitals of the *Asterolepidæ* fused together, and the plates in the fossil under discussion may represent several individuals.

The small quadrate plate, which is shown of twice the natural size in Pl. II. fig. 5, is worthy of note as being unbroken except at the border directed inferiorly in the drawing. Near the upper end of one of the borders placed vertically there occurs a short truncated process; and at the same extremity of the plate there is a broad triangular depression on the exposed inner face, evidently to be interpreted as a surface of overlap. A vertically elongated mesial excavation also extends from the edge of this facette downwards.

Form and Loc. Red Micaceous Sandstone, Dickson Bay.

Incertæ sedis.

Genus LOPHOSTRACON.

Lophostracon spitzbergense (Lankester).

1884. *Lophostracon spitzbergense*, E. R. Lankester, *op. cit.* p. 5, pl. ii. fig. 6.

The ribbed fragment of dermal armour thus named by Lankester still remains *incertæ sedis*; but two new facts may be added to the original notice. In the first place, when light is allowed to fall upon the impression of the superficial ornament in a certain direction the ridges are distinctly shown to have been crimped or tuberculated. The published figure is thus not quite accurate. Secondly, the tissue of the plate is coarsely cancellated, and numerous irregularly arranged bone-lacunæ can be distinguished in microscopical sections.

It must be remarked, however, that the Spitzbergen *Lophostracon* is not unique. So long ago as 1837 Kutorga * described and figured similar fossils from the Lower Devonian of Livonia, erroneously regarding them as referable to a Chelonian under the name of *Trionyx sulcatus*. Twelve years later, also, Hugh Miller † figured another example from the Old Red Sandstone of Thurso, Caithness, as a "shoulder (*i. e.* coracoid?) plate of *Asterolepis*." All these fossils probably pertain to a large Arthrodiran fish; and they occur upon the same horizon as the genera *Homosteus* and *Heterosteus*.

Form. and Loc. The only known specimen was obtained by Dr. Nathorst from the Red Sandstone of Dickson Bay.

Genus POROLEPIS, nov.

Syn. *Gyrolepis*, G. Kade (non Agassiz), Programm k. Realschule zu Meseritz, 1858, p. 17.

An imperfectly recognizable genus, known only by detached rhomboidal scales. Scales moderately imbricating, with a feeble inner ridge, and not united by a peg-and-socket articulation; the exposed surface covered with punctate ganoine and in the antero-superior half marked with oblique wrinkles and ridges.

The distinctness of these scales from those of any known genus was first recognized by Kade, who described examples

* S. Kutorga, Beitr. Geogn. u. Paläont. Dorpat's, pt. ii. (1837), p. 13, pl. ii. figs. 1-4.

† H. Miller, 'Footprints of the Creator' (1849), p. 88, fig. 38.

from boulders in Silesia under the preoccupied name of *Gyrolepis*. The punctate character of the ganoine and the absence of a peg-and-socket articulation suggest that the scales pertain to Crossopterygians allied to *Osteolepis* rather than to any Actinopterygian fish.

Porolepis posnaniensis (Kade).
(Pl. II. figs. 6-10.)

1858. *Gyroptychius posnaniensis*, G. Kade, *op. cit.* p. 16, figs. 6, 7.

1858. *Gyrolepis posnaniensis*, G. Kade, *ibid.* p. 18, figs. 8-10.

There are no satisfactory characters by which the scales from Spitzbergen can be specifically distinguished from those discovered by Kade in the boulders of Silesia, and they must thus at present receive the same name. The scales are rectangular or only slightly rhomboidal in shape, and are rarely broader than deep, but often deeper than broad. The hinder margin is not serrated. The superficial wrinkles are acute, prominent, nearly straight, and approximately parallel, with occasional intercalations, but rarely branching; they are usually confined to a narrow space bordering the superior and anterior margins, and never seem to extend beyond the diagonal connecting the postero-superior and antero-inferior angles. The punctations of the ganoine are very numerous and coarse, arranged in single series between the wrinkles, and occasionally displaying an oblique linear arrangement on the unornamented portion of the scale, though more often disposed in an irregular manner upon the last-named area.

Coarsely tuberculated fragments of bone are associated with the scales in the flagstone of Klaas Billen Bay, and may possibly belong to the same fish.

The specimens named *Gyroptychius posnaniensis* by Kade seem to the present writer to be abraded fragments of scales specifically identical with the nearly complete specimens described as *Gyrolepis posnaniensis* by the same author.

Form. and Loc. Grey Micaceous Flagstone, Klaas Billen Bay (very common); Red Micaceous Sandstone, Dickson Bay (rare).

II. FISH-FAUNA OF THE UPPER DEVONIAN.

Subclass **ELASMOBRANCHII.**

ICHTHYODORULITES.

Genus **PSAMMOSTEUS.**

Psammosteus arenatus, Agassiz. (Pl. II. fig. 11.)

1845. *Psammosteus arenatus*, L. Agassiz, Poiss. Foss. V. G. R. p. 105, pl. xxxi. figs. 7-10.

1884. "Bony fragment," E. R. Lankester, *op. cit.* p. 6, pl. iv. fig. 17.

This species has hitherto been met with only in the Devonian of North-west Russia and Caithness, and in boulders scattered over the plain of Silesia; but several typical though fragmentary plates occur in the collection from the ironstone of Mimers Valley, and the writer has been able to verify their reference to an Elasmobranch exoskeleton by the examination of microscopical sections. Some of the plates are very stout, measuring as much as 0.006 in maximum thickness; but the tissue seems to be everywhere cancellated beneath the external layer.

Unfortunately none of the specimens completely exhibit their original contour; but some portions of the free borders are recognizable, and one small slab of ironstone seems to show two pairs of nearly flat plates in natural juxtaposition. From the absence of ornament along an area bordering the free margin in several instances it is obvious that the plates either mutually overlapped or were covered at the edges with integument; while the slab just mentioned, if rightly interpreted, indicates that the dermal armature was arranged in a bilaterally symmetrical manner. On the slab in question the inner pair of plates is coarsely ornamented except along the borders of a narrow elongated fontanelle which separates them throughout the greater part of their length mesially; and the remains of the outer pair of plates flanking these indicate that they were much more finely tuberculated. Some of the abraded stellate tubercles are shown, enlarged about four times, in Pl. II. fig. 11 *b*.

In addition to the broad flattened plates there is one specimen of much interest, represented in front view and transverse section in Pl. II. figs. 11, 11 *a*. It is part of a long narrow element, bent at its thickened, mesial, longitudinal line, and ornamented by stellate tuberculations, which are ovate rather than round. The modified form of the tubercles is doubtless due to the shape of the plate, which seems to

have been either a long spine or a problematical elongated element such as has been described by Davis* in *Oracanthus*. There is thus no justification for specifically distinguishing the fossil from the typical plates of *P. arenatus*, with which it is associated.

Form. and Loc. Ironstone, Miners Valley.

Subclass **DIPNOI.**

Order **ARTHRODIRA.**

Family (uncertain).

Genus **ASTEROPLAX**, nov.

Dermal armour robust, superficially ornamented with coarse rounded tubercles, more or less fused into radiating and partly reticulated ridges. Head longer than broad; bones of cranial roof few and large, comprising a median occipital, bounded in front by a pair of trapezoidal plates, which meet in the middle line and occupy the entire width of the shield, these immediately succeeded forwards again by a large diamond-shaped median element and a pair of antero-posteriorly elongated lateral plates; [rostral region unknown].

Though known only by the imperfect fossil described below, the reference of this genus to the Arthrodira seems to be justified by the arrangement of the richly ornamented cranial roof-bones. According to existing definitions, however, it cannot be placed in any known family.

Asteroplax scabra, sp. n. (Pl. III.)

Cranial shield nearly flat posteriorly and the tubercular ornament especially coarse. Breadth of median occipital plate about equal to that of one of the posterior paired plates, and the latter much longer than broad; second median plate nearly as broad as the median occipital.

Notwithstanding the difficulties presented by the interpretation of the type and only known specimen of *A. scabra*, it will probably be admitted without hesitation that the aspect of the fossil shown in Pl. III. fig. 1 exhibits part of a cranial shield with remains of an adjoining cheek-plate (*x*). It also seems reasonable to assume that the narrower and more finely ornamented portion of the fossil is the base of the rostral region, the broader end the occipital; and the fortunately

* J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. i. p. 529, pl. lxii. fig. 13, pl. lxx. figs. 3, 4.

good preservation of some of the hinder plates reveals the longitudinal median line of the head. The sutures between the cranial elements are well marked; and these are further rendered conspicuous by the predominant fusion of the superficial tubercles into nodose rounded ridges directed at right angles to the borders of the plates, as in certain species of *Bothriolepis*.

Of the median occipital element only part of the anterior margin remains (o). It is acuminate in front, the two halves of the anterior border meeting in an obtuse angle mesially; but the lateral borders of the bone seem to have been parallel. The posterior lateral plates (1) form a symmetrical pair, meeting in a straight longitudinal suture for a short distance mesially, and expanding outwards to occupy the whole of the space between the antero-lateral boundaries of the median occipital, the postero-lateral border of the second median occipital, and the posterior border of the second pair of lateral plates. Judging from the right side of the fossil, each of these bones is broader behind than in front, but its precise postero-lateral extent cannot be determined. A fracture on the left side reveals the impression of a downwardly (and in part outwardly) descending plate from the external border; while an equally fortunate fracture on the right side in advance of the anterior end of the occipital plate exhibits another vertical lamina of bone, almost transverse to the long axis of the skull, but trending somewhat backwards within. These two robust ossifications may perhaps represent the outer and anterior elements of the otic capsules. The second median plate of the cranial roof (o₁) is about as broad as the occipital and seems to have been regularly diamond-shaped, though its left antero-lateral portion is obscured. The second pair of lateral plates is relatively small and represented only by the element of the right side (2). This, however, is completely preserved. It is $2\frac{1}{2}$ times as long as its maximum breadth, and must have been separated from its fellow of the opposite side by a considerable space, which was doubtless occupied by other plates. The outer border of the bone is nearly straight, but the inner border is much arcuated, with a deep broad notch mesially. An adjoining but separate fragment (z) seems to have originally occupied this notch; but the great overlapping piece of bone immediately on the left must be considerably displaced, as proved by its size and relatively coarse ornamentation. The outer longitudinal border of the last-mentioned element is broken away, but it is shown to be in direct continuity with a large thick lamina of smooth unornamented bone, which extends throughout its

whole length and forms a plane meeting that of the ornamented plate in an acute angle. The long narrow element extending along the right side of the fossil (*x*) is exhibited for the most part as an impression of the inner aspect; but sufficient remains to prove that it was comparatively thin except at the border that is now placed innermost, while it tapers in front to an obtusely rounded extremity, on which the superficial ornament is delicate and composed of longitudinally directed nodose ridges. The bone consists of a single nearly flat lamina, and seems to exhibit the characters of a cheek-plate.

Another problematical bone, of very large dimensions, is preserved on the inferior aspect of the fossil, and is shown of two thirds the natural size in Pl. III. fig. 2. In general form it is very suggestive of a clavicular element, and the face exposed to view is marked only by structural fibres radiating from the centre of ossification. At present, however, this element cannot be assigned to a definite place in the skeleton.

Form. and Loc. Ironstone, Mimers Valley.

Subclass TELEOSTOMI.

Order CROSSOPTERYGII.

Families *Holoptychiidæ* and *Rhizodontidæ*.

Genera non det.

It is somewhat remarkable that in the collection from the Mimers Valley the Holoptychian fishes should be represented exclusively by teeth, while the Rhizodonts are known only by scales and one imperfect clavicle. A microscopical examination of the teeth has confirmed Lankester's surmise (*op. cit.* p. 6) that they are truly Dendrodont in structure, and they are thus excluded from correlation with the numerous *Strepsodus*-like scales which are well figured in the memoir already quoted. The teeth are not improbably referable to two species of *Holoptychius*, and the scales are very suggestive of those of *Sauripterus*; but until the discovery of more satisfactory specimens it seems unwise to attempt generic and specific determinations.

Family Onychodontidæ.

Genus ONYCHODUS.

Onychodus arcticus, A. S. Woodward. (Pl. II. fig. 12.)

1889. *Onychodus arcticus*, A. S. Woodward, Rep. Brit. Assoc. p. 535,
and Geol. Mag. [3] vol. vi. p. 499.

The presymphysial bone thus described still remains unique, but an opportunity is now afforded for publishing the drawing of the specimen given in Pl. II. fig. 12. This figure is of twice the natural size, and exhibits the characters already noted in the original description.

Form. and Loc. Ironstone, Mimers Valley.

Incertæ sedis.

In addition to the dermal plates of *Psammosteus* and the bones of Crossopterygian Ganoids the Ironstone of Mimers Valley also furnishes numerous large and robust plates, which appear as yet to be incapable of determination. A few of these are marked with coarse closely arranged tuberculations, which occasionally pass into ridges (Lankester, *op. cit.* pl. iv. fig. 16); and their tissue, though not well preserved, seems to have been dense. The majority of the plates, however, are of a different character, exhibiting a relatively thick middle layer of polygonal cancellæ, which is traversed by straight closed canals, sometimes few, sometimes numerous, and now filled with mineral matter. The outer and inner surfaces of these plates, so far as can be observed, are smooth, and the borders always become attenuated, as if adjoining elements were originally united by overlap. Most of the plates are nearly flat, only upturned occasionally at some of the borders; but one specimen is very strongly bent and keeled and thickened along the ridge. Some of the elements were distinctly arranged in symmetrical pairs; and one form of plate is especially suggestive of the ventro-lateral of an *Asterolepid* fish.

Microscopical sections of these plates exhibit no bone-lacunæ in the tissue of the middle layer; and it has not been possible to make a satisfactory examination of the external layers. However, the extremely vascular character of the tissue seems to justify the reference of these fossils to an unknown large *Ostracoderm*; and the writer is inclined to suspect that they may eventually prove to represent an ally of the genus *Ceraspis*, which occurs in the Devonian of the

Eifel. There is a large keeled plate of a very similar character from the neighbourhood of Gerolstein in the Museum of Comparative Zoology, Cambridge (Mass.); and evidence is gradually accumulating to prove that certain of the Ostracodermi attained comparatively gigantic proportions.

EXPLANATION OF THE PLATES.

PLATE I.

- Fig. 1.* *Acanthaspis decipiens*, sp. n.; associated dorsal (A) and ventral (B) shields. Lower Devonian, Dickson Bay. *a.v.l.*, anterior ventro-lateral; *b*, basal plate of pectoral appendage; *c*, impression of ridge and constriction on the visceral aspect of the posterior ventro-laterals; *m*, longitudinal lateral ridge (and supposed suture) on the dorsal shield; *m.v.*, median ventral; *p.v.l.*, posterior ventro-lateral; *s*, pectoral appendage; *x*, pair of descending processes on visceral aspect of dorsal shield; *y z*, line of transverse section, *fig. 2*.
- Fig. 2.* Ditto; transverse section of dorsal shield of the same specimen, along *y z*.
- Fig. 3.* Ditto; two transverse sections of the pectoral appendage of the same specimen, one (*a*) nearer the base than the other (*b*).

PLATE II.

- Fig. 1.* *Pteraspis Nathorsti*, Lank.; hinder portion of ventral shield, visceral aspect. Lower Devonian, Dickson Bay.
- Fig. 2.* *Acanthaspis minor*, sp. n.; portion of occipital plate, visceral aspect, twice nat. size. Lower Devonian, Dickson Bay. *p*, median process of hinder border.
- Fig. 3.* Ditto; portion of pectoral appendage, associated with above, twice nat. size.
- Figs. 4, 5.* Ditto; two plates of the same, twice nat. size, outer and inner aspect respectively.
- Figs. 6-10.* *Porolepis posnaniensis* (Kade); scales. Lower Devonian, Klaas Billen Bay. *Fig. 6* is inner aspect, nat. size; the others exhibit the outer aspect, twice or thrice nat. size.
- Fig. 11.* *Psammosteus arenatus*, Ag.; portion of bent plate, front view and transverse section (*a*). *Fig. 11 b*. Abraded tubercles of flat plate of ditto, enlarged. Upper Devonian, Mimms Valley.
- Fig. 12.* *Onychodus arcticus*, A. S. Woodw.; presymphysial bone, twice nat. size. Upper Devonian, Mimms Valley.

PLATE III.

- Fig. 1.* *Asteroplax scabra*, g. et sp. n.; cranial shield. Upper Devonian, Mimms Valley. *o, o₁*, median plates; *1, 2*, posterior and anterior paired plates; *x*, facial plate; *y, z*, undetermined plates.
- Fig. 2.* Ditto; problematical bone exhibited on the inferior aspect of the same specimen, two thirds nat. size.

The specimens are all preserved in the Royal Swedish State Museum, Stockholm, and unless otherwise stated the figures are of the natural size.