4. The Permian Fishes of the Genus *Acentrophorus*.* By
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(Text-figures 1–16.)

Introductory.

As the earliest known members of the family Semionotidae and
the only Paleozoic Actinopterygians of a higher grade than the
Chondrostei, the small fishes named *Acentrophorus* by Traquair
(1877), found in the Permian of the County of Durham, have
frequently been referred to and discussed in paleontological writings.
An examination of the abundant material in the museums at
Newcastle and Sunderland showed that it would be possible to
add considerably to what was hitherto known of the structure
of these fishes, and the main results of such an examination are
here given.

The first species of *Acentrophorus* to be named and described
was *A. glaphyrus*, which Agassiz published (1835) as a species of
*Paleoniscus*. It is found in the Marl Slate, the lowermost bed
of the Permian series in Durham and Northumberland, but as it
is rare and not well preserved it has furnished little information
as to the structure characteristic of the genus. A much more
abundant and better preserved fish is *A. varians* from the Upper
Magnesian Limestone. It was described as *Paleoniscus varians*
by J. W. Kirkby (1862 and 1864), who at the same time described
two much scarcer species occurring in the same beds, "*Paleo-
oniscus*" altus and "*P.* abbsi. Reasons are here given for
doubting whether the species *abbsi* ever had a real existence.
In 1873 Lütken pointed out that these fishes were wrongly
assigned to *Paleoniscus*; and in 1877 Traquair established for
them the genus *Acentrophorus*.

Kirkby's account (1864) includes a careful description of the
general proportions, the squamation, and the fins. Traquair
added many details, especially in regard to the osteology of the
head. In a few minor points, however, the material at his dis-
posal evidently led him astray, and it does not appear to have
shown him anything of the teeth, the axial skeleton, or the bones
supporting the fins. Few figures of the fishes now included
under *Acentrophorus* have been published, and none give a very
clear representation of their structure. The specimens, from
both the Magnesian Limestone and the Marl Slate, seem to have

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been fossilised under quiet conditions; the parts are rarely much disturbed and practically never scattered. On the whole this is a disadvantage. The scales and the few strong bones (frontal and angular for example) are often well preserved, but most of the bones are delicate, and as they are crushed one upon another it is usually very difficult to make out their boundaries. In the case of the palate it is practically impossible. The distal parts of the fin-rays, too, are hardly ever shown satisfactorily. It is only through having abundant material for comparison that it has been possible to make out even so much of the skeleton as is here described.

Description of the Genus.

The descriptions already given by Kirkby, Traquair (1877, pp. 563-4), and Dr. A. Smith Woodward (1895, p. 51), together with the restorations and other figures accompanying this paper, render it unnecessary to go into much detail as to the main external features characterising *Acentrophorus*. The general shape (text-fig. 1), including the excavation of the back along the base of the dorsal fin, is much as in *Lepidodus*, except that the snout is blunter. To judge by the number and appearance of the specimens that have been compressed dorso-ventrally, the body was fairly rounded. The scales, compared with those of most Semionotids, are thin; they overlap deeply, nearly half of each scale being covered by the one in front of it. Their only ornament is a series of concentric lines near the hinder margin; these are presumably annual growth lines, and as many as five can sometimes be counted. The absence of a row of dorsal ridge-scales with projecting points is the character upon which Traquair separated the genus from *Semionotus*; in place of points these scales often even show a concave hind border. But the most striking characteristic of the squamation is the great though perfectly graduated variation in the size of the scales on different regions of the body, and particularly the great depth of the anterior scales of the lateral line. In shape the lateral line scales are not unlike those of *Dapedius*. The lateral line can usually hardly be followed on the outer surface in *A. varians* and *altus*, except by the notching of the scales. In *A. glyphyrus* it is more prominent; and on the inner face of the scales it is marked by a conspicuous groove in all the species. Peg-and-socket articulation is well developed on the inner face of the anterior scales of the upper part of the flanks (text-fig. 2, A); but it is absent in *A. varians* from the smaller scales of the lower flank, and dies out gradually even in the upper scales as they are traced backward towards the tail-shaft (text-fig. 2, B, C, D). In *A. altus* and *A. glyphyrus* the scales have on the inside a low rounded ridge, which is continued above into the peg (text-fig. 2, E), and in these species the peg-and-socket articulation extends almost or quite to the tail. In all the species the scales on the jugular region are very small and rounded (text-fig. 7, etc.). As in many other Semionotids, there
are three or four enlarged scales in the mid-ventral line immediately in front of the anal fin. Enlarged ridge-scales mark the mid-dorsal and mid-ventral line of the tail-shaft. As they near the caudal fin they become pointed posteriorly, and pass without a break into the upper and lower series of tail fulcra.

The massive development of the fin fulcra is a striking characteristic of the genus. In the two later species, *A. varians* and *A. altus*, each fulcrum fits closely to the point over the one next behind it; in the Marl Slate species, *A. glaphyrus*, the points are considerably more drawn out and tend to project more freely.
The smaller fulcra are paired, but the larger ones at the base of each series are single, the transition taking place through the deepening of a median groove. The pectoral fin has only three (possibly sometimes four) fulcra, the distal half of its upper border being unprotected (text-fig. 9).

Of the fins themselves, two features are particularly noteworthy: the situation of the pectoral fin and the degree of heterocercy of the caudal. The pectoral fin is placed rather high on the flank, and (at least in *A. varians* and *A. altus*) its lobe is so formed that the fin can only be spread over or abreast of the lower flank scales. It could not in life be spread below the level of the body as in other fusiform Semionotids, with the pre-axial border turned forwards and downwards. It is occasionally fossilised in this position, but it is then seen to be unnaturally forced down so as to point forward over the jugular region or the branchiostegal rays.

The dorsal body-lobe of the tail is in a particularly interesting stage of reduction. It still extends to the extreme upper tip of the tail, but for about the latter half of the distance it is represented by only a single line of small scales. Towards the tip these scales are so small that but for their slightly different shape they closely resemble the joints of the minute first dermal ray lying beside them. (The appearance suggests the possibility that on the withdrawal of the notochord these little scales might be directly converted into the joints of an additional dermal ray.)

In other respects the fins greatly resemble those of *Lepidotus*. As in that genus, a considerable length of the proximal part of the rays is unjointed. In the best-preserved examples these unjointed lengths and some of the joints immediately following them show a flange-like lateral expansion, which led Kirkby to state that they were covered by an accessory scale. The flanges are especially conspicuous in the anal fin, where the rays are few (only five or six behind the fulcra) and widely spaced.

It is impossible to make out completely the bony structure of the head, since none of the specimens show the elements scattered, and all the more delicate parts are crushed together into a fragile, semi-transparent plate no thicker than fine notepaper. Thus of the chondrocranium it can only be said that in the hinder part it was considerably ossified, and that in one or two examples a pair of exoccipitals are seen, and in another a club-shaped bone in the position of the epiotic. A small bony rod occasionally seen in front of the upper end of the pre-operculum may very probably be the alisphenoid (text-fig. 7, *asp.*).

Other internal bones of the skull are often shown, but never in such a way that they can be completely described. The front of the parasphenoid is very commonly seen as a straight rod crossing the orbit (text-figs. 6 and 13); it has a lateral flange beginning a short distance behind its anterior end, but its hinder portion remains unknown. The vomers are separate, in front
at least, but their connexion with the parasphenoid is not clearly seen. Below the parasphenoid are the crushed remains of the palatal bones, of which it can only be said that a thickened lower border represents the palato-pterygoid bar, and that the shape of the metapterygoid and quadrate can sometimes be roughly made out. The metapterygoid has a central, upwardly directed process (as in Lepidotus, Amia, etc.) for articulation with the otic region of the brain-case. Traquair stated that "a well-marked quadrate is distinct enough," but if he was not mistaken he must have seen some exceptional specimens. A symplectic with a rod-like stiffening lies just inside the lower end of the preoperculum,

**Text-figure 2.**

Outlines of scales of *Acentrophorus* seen from the inside; about twice natural size. All the figures except F include scales of the lateral line. A-D, *Acentrophorus varians*: A, anterior scales (II, sixth lateral line-scale); B, half-way between occiput and dorsal fin; C, between dorsal and anal fins; D, last scales of lateral line, with others above and below. E, *A. altus*, scales above anal fin (na., remains of neural arches and spines). F, *A. glaphyrus*, scales below lateral line between pelvic and anal fins.

its anterior end overlying the quadrate. Projecting from under the upper end of the preoperculum some part of the hyomandibular is often seen; it is well ossified, and in shape closely resembles the hyomandibular of *Lepidotus*. All these bones, so far as they can be made out, are shown in text-fig. 11. Of the hyoid apparatus, the anterior part of the ceratohyal and the small hypohyal are frequently shown. The ceratohyal is deep, especially at its fore end; the hypohyal is knobbed and rather strongly ossified. In one small specimen of *A. varians* from the Kirkby collection the operculars are somewhat displaced, and in the gap thus left three delicate branchial arches are seen.

The membrane bones forming the exterior of the skull are
much more satisfactorily preserved. Those of the cranial roof are shown in outline in text-fig. 3. The pair of parietals together roughly form a square. One well-preserved example of *A. altus* shows two parietal ossifications on each side (text-fig. 4), but as other specimens have only one, this is presumably no more than an occasional aberration. The parietals are flanked by “squamosals” (pterotics, supratemtoporo-intertemporals) which have a rounded expansion of the outer border anteriorly. The frontals are fused into a single plate, the strongest bone in the whole skeleton with the exception of the cleithrum; it is nearly always found either turned outwards clear of the head or folded down beneath it, rarely crushed together from side to side. It is wide behind and much narrowed in front, the very large orbits producing deep excavations of its lateral margins. Three of the circumorbitalts adjoin each of these excavations. The nasals are so delicate that though their extent is seen, their exact shape cannot be made out, chiefly because they are crushed down on the comparatively strong backward processes of the premaxillae. In some specimens there is a suggestion of a small median “ethmoid” and of separate lateral ossifications (either prefrontals or adnasals). The edge of what may be a postfrontal sometimes appears under the anterior border of the squamosal. A pair of very large scale-like post-temporals adjoin the hinder margin of the parietals and squamosals, the suture being overlaid by a transverse pair of supratemporals (extrascapulars). A smaller median plate (text-figs. 3 and 4, *m. tm.*) is wedged in between the post-temporals; it usually overlaps one of them, and is overlapped by the other. It perhaps belongs to the supratemporal series.

The large orbit is surrounded by a chain of about ten circumorbitalts, of which those forming its posterior boundary are much narrower than the rest. Between the circumorbitalts and the preoperculum there were probably thin cheek-plates, but their
presence is suggested only by faint radiating grooves crossing the bones of the palate in a few specimens. One or two examples show a triangular bone which apparently covered the space in front of the orbit between the nasal and the maxilla.

The opening of the mouth is very small. It is bounded above by fairly strong paired premaxillae, each supported by a strong process running backwards beneath the nasals to the frontal (text-fig. 5, r.pmx.). The maxillae are short and delicate; their slender anterior portion passes inward behind the premaxillae; posteriorly they are expanded to overlie the lower jaw about the middle of its length. The lower jaw is remarkable chiefly for the fact that in this early genus it has already acquired in the fullest degree the peculiar shape characteristic of the Mesozoic Semionotids and Macrosemiids. As in these later fishes it is very deep behind and shallow in front, with a downward curve in the region of the symphysis. The agreement extends also to

Text-figure 4.

_Acentrophorus altus_. Skull-roof of a specimen with four parietal plates. In the Kirkby Collection, Hancock Museum. The plates behind the frontal are slightly displaced to the right. About one-and-a-half times natural size. Lettering as in text-fig. 3, with op., operculum.

the shape of the constituent bones, at any rate to those encasing the outer side of the jaw—the angular, coronoid and dentary (text-figs. 1, 5 and 6). An articular ossification was probably present, but though it is sometimes suggested it is not clearly shown. Many specimens show something of the inner side of the jaw, but the splenial was apparently very thin, and its boundaries are lost. The most conspicuous feature exhibited on the inner face of the jaw, as it is actually preserved, is a row of protuberances near the lower margin corresponding to the sensory pits in the outer face of the dentary (text-figs. 5 and 13).

The only mention of teeth in _Acentrophorus_ occurs in Dr. Smith Woodward’s Catalogue (1895, pp. 51 and 52). Traquair states that he found none, and Kirkby’s account makes no mention of any. It is evident, however, that Kirkby had discovered them subsequently, for the fine specimen represented in text-fig. 5 bears
a label in his writing with the word "teeth." As a matter of fact, a considerable proportion of all the specimens exhibit teeth or some trace of teeth when they are examined with sufficient magnification and suitable lighting. Text-figs. 5 and 6 taken together show the dentition fairly completely. Long styliform teeth are borne by the premaxilla, the narrow shaft of the maxilla, and the anterior half of the dentary. The foremost teeth on the dentary are especially long and curved, and it is these that are most frequently found preserved. A single specimen suggests, though not conclusively, that there were minute teeth on the splenial. The vomer is bordered by short, very stout teeth; they usually have the appearance of rounded knobs, but the best examples show them to have had short conical points. In one specimen that seems to show the buccal surface of the vomers, there is a suggestion of inner rows of stud-like tritoral teeth, but they are too obscure to warrant a positive statement. A few specimens, notably the one from the Sunderland Museum represented in text-fig. 6, show that the palatopterygoid also bore small conical teeth.

The opercular apparatus is remarkable in the same way as the jaws, namely in that it is so typically of the Semionotid pattern. Text-fig. 6 and the restorations make its composition clear

Text-figure 5.
without further description. One or two remarks only are necessary. The suture between the opercular and subopercular plates varies considerably in position, but nearly always leaves the suboperculum as the larger bone, except in *A. glaphyrus*. The branchiostegal rays number nine or ten on each side (text-fig. 7). (Traquair thought there were "few, about seven.")) Traquair suspected the presence of a gular; if there was a gular, however, it must have been a very delicate plate, for in the numerous specimens that ought to show it there is no definite trace of it. The only example which does show anything that could well be taken for a gular is Kirkby's type-specimen of

Text-figure 6.

*Acentrophorus alius*. Head showing dentition; Sunderland Museum. *c.h.y.*, ceratohyal; *c.or.*, circumorbitals (three bordering frontal, three more between parasphenoid and lower jaw); *d.n.*, dentary; *f.r.*, frontal; *h.h y.*, hypohyal; *h.m.*, hyomandibular; *i.o.p.*, interoperculum; *m.x.*, maxilla; *o.p.*, operculum; *p.o.p.*, preoperculum; *p.p.t.*, palato-pterigoid with teeth; *p.s.p.*, parasphenoid; *s.o.p.*, suboperculum; *v.r.*, vomerine teeth; *x.*, left premaxilla, or possibly the body of the vomer. About four times natural size.

*A. ali u s*, the head of which is represented in text-fig. 13. The plate marked *x* in this figure is a thin, detached bone, of much the size and shape that the gular would have to possess.

The opercular bones and the roofing bones of the head are ornamented with fine vermicular raised lines. The course of the principal sensory canals of the head can be traced fairly completely. The nasal bones are too thin and badly preserved to show pits or grooves, but the frontal often shows a line of four pits on each side near the orbital margin, and grooves and pits carry the line backwards along the outer side of the squamosal to cross the outer end of the supratemporal and the antero-
external angle of the post-temporal. From thence it crosses the supraclavicle obliquely to the first scale of the lateral line series. The under surface of the frontal is marked by a conspicuous ridge on either side parallel to the curved orbital margin. It underlies the line of sensory pits and may be connected with their canal, or it may only be a boundary wall for the chondrocranium.

Acentrophorus varians. Head crushed obliquely from the left side and from below, showing branchiostegal rays and parts of shoulder-girdle; Kirkby Collection, Hancock Museum. About four times natural size. asp., alisphenoid; c. hy., right ceratohyal; c. or., circumorbitals; fr., frontal, left side from below; h. hy., right hypohyal; i. op., interoperculum; l. br., left branchiostegals; l. cl., part of left cleithrum; l. j., left lower jaw; m. x., maxilla; op., operculum; pal., bones of palate; p. m. x., premaxilla; p. op., preoperculum; r., ribs; r. br., right branchiostegals; r. cl., point of right cleithrum; r. j., right lower jaw; s. c., small scales of jugular region; s. cl., supraclavicle, displaced; s. op., suboperculum.

in this region. As in Amia, one of the pits on the squamosal forms a notch in the margin of the bone at the point where the main canal was joined by the branch traversing the preoperculum. The supratemporals are strongly grooved and pitted by the transverse branch of the canal. The situation of all these pits
and grooves is indicated in text-fig. 3. On the side of the head the sensory canals can be followed even more clearly. Three or four pits are usually conspicuous in the length of the preoperculum, and from the lower end of this bone the line is continued by a groove across the angular, and by a chain of six or seven well-marked pits along the dentary near its lower border (text-figs. 5 and 6). Finally, there are longitudinal grooves on the inferior circumorbital, probably marking the course of a suborbital canal.

The pectoral girdle is rarely seen at all completely, being largely covered as a rule by the operculars and branchiostegal rays. Its general shape, however, can often be seen through these bones (text-figs. 7 and 14), and more or less of the thickened portion of the cleithrum ("clavicle"), ornamented by fine transverse raised lines, appears normally along the lower edge of the suboperculum. Occasional specimens show some portion of the girdle more fully, especially from the inner side, and make possible such a restoration as is given in text-fig. 8. The large scale-like post-temporal has already been referred to. The supraclavicle, which normally appears in part behind the operculum, is of simple, slightly curved form, strengthened along its anterior edge. The cleithrum is massively thickened externally in a boomerang form, pointed at either end, and with a band of fine transverse raised lines marking the portion which sometimes appears at the surface below the suboperculum. Its inner face is expanded and flattened, especially about the middle of its length, but this face also bears a rod-like thickening, bent almost
at a right angle just above the area of attachment of the scapulocoracoid cartilage. This latter cartilage has left a distinct trace of its form in two or three of the specimens (text-fig. 9). Many specimens show the pointed lower ends of the two cleithra meeting (or slightly displaced from their normal contact) in the midventral line, and prove the entire absence of an infracleavicle.

The skeleton of the pectoral fin of *A. varians* is shown in text-fig. 9. The radials are about eight in number. They appear as a single series, though slight cups shown in their outer ends may have lodged minute distal cartilages. The first fin fulcrum, which is large, seems always to be based directly on the scapular cartilage in series with the radials. There is no sign of the presence of a metapterygium. The dermal rays are about twice as numerous as the radials, and where it happens that two adjacent rays are supported by one radial, the bases of these rays are noticeably inclined together. The two first (pre-axial) rays are unbranched, and the three last (post-axial) are both unbranched and unjointed. The remaining rays are all forked twice in the distal third of their length.

The pelvic fins are very short-based, and are remarkable externally for the great length attained by one of the fulcra (text-fig. 10, B). Specimens in which the inner surface of the scales is exposed not infrequently show the supporting bone of the

Text-figure 9.

A. Skeleton of left pectoral fin of *Acentrophorus varians*. Dotted lines show the approximate shape of the scapulocoracoid cartilage and of three postaxial radials which have only been seen as impressions. From a specimen in the Kirkby Collection and one in the Sunderland Museum.

B. Part of preaxial edge of pectoral fin of *Acentrophorus gaphyurus*, showing the long, slender fulcra. From a specimen in the Kirkby Collection, Hancock Museum. Both figures about four times natural size.
pelvic fin. The best example of this kind, showing both supports together, is represented in text-fig. 10; the bones are seen to be of the same general pattern as in *Lepidotus*, but of a stouter form. Nothing is seen of any radials intervening between the supports and the dermal rays, though the parts are so small and difficult to see that no definite statement on the point can safely be made.

Previous investigators do not appear to have noticed any traces of the axial skeleton of the trunk, except that Kirkby refers to the supports of the median fins. The distal ends of these supports fairly often appear, where scales are missing along the bases of the fins. But much more than this can be made out in certain specimens, particularly where, as occasionally happens,

Text-figure 10.

A. Pair of pelvic fin-supports of *Acentrophorus varians*, lying on the inner face of disturbed scales.
B. Part of pelvic fin of *Acentrophorus varians*, showing basal fulcra. Both figures from specimens in the Kirkby Collection, Hancock Museum; about four times natural size.

the splitting of the matrix has cleanly separated a right and a left half, leaving the inner surface of the scales completely exposed. (Such specimens sometimes show by a difference of colour the exact outline of the abdominal cavity, which is precisely as in a herring or similar fish.) If a specimen such as this is examined with a suitable lens and in a strong, very oblique light, any break in the regularity of the scale pattern being carefully scrutinised, it will almost always be found to show more or less extensive traces of the axial skeleton. Kirkby's collection in the Hancock Museum at Newcastle contains three specimens of this nature in which the skeleton is particularly well shown, and the information they give is set out in text-fig. 11, where the unbroken lines represent the parts which are actually seen. The
bones are represented in the fossils by little flattened, semi-transparent pieces of a substance resembling sugar-candy. They were probably not very strongly calcified, and the flattening may have expanded their shape to some extent, but a comparison of different parts does not suggest that much allowance need be made for alteration of this kind.
The number of vertebral segments seems to agree closely with the number of rows of scales—about forty in each case from the head to the middle of the base of the caudal fin—but the longitudinal spacing does not correspond by any means. In the caudal region the segments are so widely spaced as to suggest some sort of foreshadowing of the alternate pleuro- and hypo-centra found in the same region in such fishes, for example, as *Amia*. But there is no sign of actual centra; the notochord evidently persisted complete. The interpretation of what is seen of the vertebral column is not easy. In the segments close behind the head it rather strongly suggests the vertebral column of the sturgeon. It appears as though in the anterior segments the neural spines may have been separate, but further back they were almost certainly fused with the arches. The spines below the dorsal fin-supports are markedly widened from front to back, a peculiar feature, which is confirmed, however, by all the specimens in which these parts are shown. In the anterior caudal region the spines seem to be wide and short; further back they are narrower again and are lengthened to support the dorsal ridge-scales. Their continuation into the tail-lobe is not shown in any of the specimens. Well ossified ribs appear in many specimens in the anterior abdominal region (*cf*. text-fig. 7), extending more than half-way from the level of the lateral line to the ventral border; but in the posterior abdominal region they are very short. They are succeeded by four or five fairly long haemal spines, inclined strongly backwards across the upper ends of the anal fin-supports. In the posterior part of the tail-shaft the haemal spines, like the corresponding neural spines, are lengthened to support the ventral ridge-scales, and the succeeding spines serve to support the caudal fin-rays in the usual way. The supports of the dorsal and anal fins are well shown. There is one to each fin-ray. At the front of the dorsal fin there is also a separate support for each of the fulcra that stand in series with the rays, but the corresponding fulcra of the anal fin, which are more crowded, have only one support for them all. The distal ends of all the supports are notched or forked; in the case of the dorsal fin the two heads so formed appear to share in the support of two adjacent rays. The internal ends are more or less expanded, and seem to come into close contact with the neural or haemal spines, except perhaps in the case of those from the back of the fin. The great proportionate size of the anal fin-supports is a peculiar feature of the internal skeleton of *Acentrophorus*.

The Species of Acentrophorus.

There are known at present three indisputable species of *Acentrophorus*: *A. varius* and *A. altus* (Kirkby sps.) from the Upper Magnesian Limestone, and *A. glaphyris* (Agassiz) from the Marl Slate. A fourth species, *A. abbii* (Kirkby), appears to be

ill-founded. Text-figs. 1, 12, 13, 14, 15 illustrate the differences distinguishing these species, and will be sufficiently supplemented by the following brief notes:

Acentrophorus varians (Kirkby). (Text-fig. 1.) The type-species and very much the most abundant. In spite of its name, not more variable than many modern fishes, e.g., trout, roach. Specimens range in length from 5–11 cm.

Acentrophorus altus (Kirkby). (Text-fig. 12.) Very much scarcer than A. varians but occurring in the same beds. Differs only in its deeper form and, as already stated, in the character of the inner surface and articulation of the scales (text-fig. 2). Length 4–8 cm.

Acentrophorus abssi (Kirkby). Also from the Upper Magnesian Limestone of Co. Durham. Supposed to be distinguished from the other species by its extraordinarily lengthened form. Close examination of the two or three examples in Kirkby’s collection seems to show that they are no more than distorted specimens of

Text-figure 12.

Acentrophorus altus. Restoration.
About natural size.

A. varians. Text-fig. 14 shows the head of the type-specimen. It will be seen that the parts are dragged out to a great degree longitudinally. The opercular apparatus has held together, but is lying far behind its proper position in relation to the squamosal and lower jaw, leaving the hyomandibular region widely exposed. Similarly the squamosal, supratemporal, and post-temporal are dragged apart, and the pectoral fin pulled from its connexion with the shoulder-girdle. A similar distortion is apparent in the whole length of the body, the scales hardly or not at all overlapping and in places separated altogether. Kirkby’s figure (1864, pl. 18. fig. 3) shows the posterior half of the body separately; in the actual specimen the two halves are parted by a very shallow horizontal fault or slip-line which has carried them some distance asunder, with a trail of scales as their only connexion. The condition is difficult to account for, but it is evident that movement took place in the surface layer of limestone before it was quite consolidated but after the fish had
become completely macerated. In the Marl Slate occasional examples of *Palaeoniscus freieslebenti* may be found in precisely the same drawn-out condition. Unless other specimens exist in which the attenuated form can be shown to be that of the living fish the species *A. alleti* should be dropped.

*Acentrophorus glaphyrus* (Agassiz). (Text-fig. 15.) Found in the Marl Slate at the base of the Magnesian Limestone, and

Text-figure 13.

*Acentrophorus altus*. Head of Kirkby's type-specimen (Quart. Journ. Geol. Soc. vol. xx. 1864, pl. 18. fig. 1). About four times natural size. *c.hy.*, ceratohyal; *cl.*, cleithrum; *fr.*, frontal (left side broken away); *h.hy.*, hypohyal; *i.j.*, left lower jaw; *l.pm.*, left premaxilla (part); *m.x.*, maxilla; *pa.*, parietals; *p.tm.*, post-temporal; *r.j.*, right lower jaw, inner surface; *r.pm.*, right premaxilla; *sq.*, squamosal; *s.tm.*, supratemporal; *x.*, possibly a gular plate.

therefore the earliest species. More variable in form than *A. varians*; some examples, the type-specimen among them, deep in the body, others shallower than the form represented in text-fig. 15. The chief diagnostic character hitherto attributed to the species is a pronounced fine denticulation of the free hinder border of the scales. This denticulation is, however, so very
rarely to be detected that it is of little practical use in identification. The only example known to me which shows it clearly is the type-specimen in the Yorkshire Museum (the Yorkshire Philosophical Society's Museum at York); here the finely toothed edge is still preserved on three or four scales which are seen from the inside and are protected by being embedded in the matrix. A few similarly situated scales on specimens at Newcastle also show serration, but less completely. Most specimens of *A. glaphyrys* show no clear trace of it at all. Such thin scales
as those of this fish are not well preserved in the Marl Slate; on the exposed side of a specimen they are nearly always variously splintered at the hinder border, and it is usually impossible to find a perfect scale. A single example in the Hancock Museum retains undamaged scales, and in this example, as in some in the British Museum (Smith Woodward, 1895, p. 54), the scales have the hind margin entire or at the most slightly frilled. It is therefore evident either that the denticulation is an inconstant character or that more than one species is included under the name glaphyrus. Against the latter possibility is the fact that the two examples showing the clearest denticulation—-are respectively among the deepest and the shallowest in body-form. In any case the denticulated scales do not form a reliable or useful specific distinction. Nevertheless, A. glaphyrus is distinguishable from A. varians by several well-marked characters. The caudal fin in A. glaphyrus is considerably longer and more deeply forked (much like that of Palaoniscus in fact, whereas in the later species the tail is shaped as in Lepidotus); the fulcra on all the fins are much longer and slenderer, with freely-projecting needle-like points; the pectoral fin is set a little lower on the body and its basal lobe is so shaped as to permit of its being turned downwards with the preaxial border in front; in the skull the frontal is wider anteriorly than in A. varians, and the maxilla is shorter and stouter; the lateral line is prominent externally; the inner face of the scales is ridged and the articulating pegs are narrow and finely pointed—the inner face of the scales, in fact, resembling that of A. alius, and still more closely that of Palaoniscus.

A note seems called for regarding the puzzling second figure of A. glaphyrus in King's monograph (1850, pl. 22, fig. 4). The original specimen is in the Hancock Museum. Behind the pectoral region it is particularly well preserved, but the head (which appears very large and "Palaoniscid" in the figure) is in reality broken up, part of the area being occupied by a good impression of the skull-roof.

A fish found in the Trias of Chicopee Falls, Mass., was described by Newberry (1888, p. 69, pl. 19, figs. 3, 4) under the

Text-figure 15.

*Acentrophorus glaphyrus.* Restoration.
About natural size.
name of *Acentrophorus chicopesis*. The caudal lobe, which his figures show to be as short as in *Semionotus*, is enough, however, to prove that the fish is not an *Acentrophorus*. In addition, the scales are too uniform in size, and the general outline does not suggest *Acentrophorus* either in head or body. It should also be said that Newberry’s discussion of the genus and of its relationship to “*Ischypterus*” (pp. 67–69) is on the whole misleading, since it is founded only on the obscure figures accompanying Kirkby’s paper of 1864.

Another fish assigned to the genus is *Acentrophorus dispersus* Fritsch (1894, p. 81, pls. 113, 114) from the Lower Permian (Schwartenkohle) of Kounova, Bohemia. Its remains are very imperfect, but Fritsch’s figures show enough of the upper and lower jaws, the opercular apparatus and the pectoral girdle to prove that in all these essential elements of its structure the fish was fundamentally different from any Semionotid. Indeed, at the end of his description of it, Fritsch himself appears to have concluded that it was a Palæoniscid.

Summary.

The propriety of placing *Acentrophorus* in the family Semionotidae was not in doubt, but it is amply confirmed by the additional information now brought forward. In the exact correspondence of the dorsal and anal fin-rays with their endoskeletal supports, in the reduced maxilla, the narrow preoperculum and the whole plan of the opercular apparatus, in the absence of an infra-clavicle as in all the details of the pectoral arch and the pelvic bones, *Acentrophorus* is a characteristic representative of the Protocondyli and of the family Semionotidae.

At the same time, *Acentrophorus* does in certain respects retain primitive characters. It seems, in fact, to provide us with something that is comparatively rarely found among fossil fishes, namely a really early representative of a new group which still shows definite traces of its origin from older types. The most striking character of this kind in *Acentrophorus* is undoubtedly the upper caudal lobe. As compared with the caudal lobe of the contemporary Palæoniscids it is certainly greatly reduced, but the reduction is only in depth; the caudal lobe of *Acentrophorus* is still of the maximum length. It is interesting to find in another contemporary fish, the extraordinary form *Dorypterus hoffmanni*, a caudal lobe in precisely the same stage of reduction, except that, in place of the single line of scales found in *Acentrophorus*, the lobe is marked externally to the very tip by two lines, the scales as they are traced backwards becoming linear and almost microscopic. That a stage such as this—the caudal lobe extremely attenuated in its hinder portion but still more or less of the full length—may have been passed through pretty regularly in the production of a “hemi-heterocercal” tail is suggested not only by the parallelism between *Acentrophorus* and *Dorypterus*, but
also by at least one fact of fossil ontogeny. A young example of *Dapedius*, 9 cm. long and beautifully preserved (text-fig. 16), which has been kindly lent me by Prof. D. M. S. Watson, has a caudal lobe extending just two-thirds the length of the upper border of the tail, instead of only one-third as in the adult; and for some distance towards its apex the lobe is marked by a single line of very small and narrow scales.

The head of *Acentrophorus* also, though in side view almost entirely typical of a Semionotid, shows when seen from above (text-fig. 3) some decided primitive traits. The shape of the

Text-figure 16.

*Dapedius orbis*. Tail of a young example, total length 9 cm., showing extended caudal lobe. Lower Lias; locality uncertain. D. M. S. Watson Collection. About four times natural size.

frontal shield and of the supratemporalis, and the large leaf-shaped post-temporalis, are all strongly reminiscent of *Palaeoniscus*. So also is the internal pattern and articulation of the scales, especially in the earliest species, *A. glaphyurus*.

On the other hand, there are certain points in the structure of *Acentrophorus* which seem to be peculiar to this genus among the Semionotidae. The orbit is very large and encircled by only a single chain of bones; the scales, compared with those of other Semionotids, are thin, deeply overlapping and of unusual range of difference in size, and do not produce the typical "tessellated
pavement” effect; the fin-fulcra in the later species are of particularly massive form; the pectoral fin is placed higher on the flank than in other fusiform Semionotids, and its attachment gives it a peculiarly “modern” appearance. Fused frontals are also unusual in the family; and of the characters of the axial skeleton which are shown clearly enough to be worth discussion, the expanded neural spines under the dorsal fin and the great size of the supports of the anal fin-rays seem to be quite peculiar to Acentrophorus.

In view of all these primitive and individual characters it can no longer be said that Acentrophorus differs from Semionotus only in lacking the median row of acuminate scales in advance of the dorsal fin. It is seen to be very much the most primitive known member of the family Semionotidae, and is therefore difficult to incorporate in any scheme on which the genera may be classified. On the whole, however, it would appear to be nearest to the line of ancestry of Lepidotus. Such a relationship is suggested in many points, in particular in the shape of most of the fins and in other details of their structure, in the excavation of the back along the base of the dorsal fin, and in the tendency towards a tritoral form exhibited by the teeth on the vomers.

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