

XXX.—*The Lower Devonian Fishes of Gemünden.* By R. H. TRAQUAIR, M.D., LL.D., F.R.S., Keeper of the Natural History Collections in the Museum of Science and Art, Edinburgh. (With Seven Plates.)

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Gemünden is situated in Rhenish Prussia, about eighteen miles to the west and slightly also to the south of Bingen, in the district known as the "Hunsrück," and the rock in which the fishes to be described in this memoir occur is called the "Hunsrück Slates."

These Hunsrück slates belong to the Lower Devonian of the Rhenish area, and the position assigned to them by German geologists is as follows:—

Upper Devonian,	{	<i>Olymenia</i> Limestone and <i>Cypridina</i> Slates.
	{	Adorf Goniatite Limestone.
Middle Devonian,	{	<i>Stringocephalus</i> beds.
	{	<i>Calceola</i> beds.
	{	Zone of <i>Spirifer cultrijugatus</i> .
Lower Devonian,	{	Coblenz beds (<i>Spirifer</i> Sandstone).
	{	Hunsrück Slates.
	{	Taunus Quartzite.
	{	Sericitic Phyllite and (?) Gneiss of the Taunus.

The above table is quoted from Kayser and Lake's *Text-book of Comparative Geology*, as is also the following brief statement regarding the Hunsrück slates themselves.

"The Taunus quartzite is succeeded by the Hunsrück slates, a thick series of dark-coloured clay slates, including numerous layers of roofing-slate. They form the monotonous plateaux of Hunsrück and Taunus, but are also repeated in their characteristic form in the Venn and in the Ardennes. In these areas, however, they are for the most part represented by the Grauwacke of Montigny. The fauna of the Hunsrück schists (chief localities, Bundenbach and Gemünden in the Hunsrück, Caub on the Rhine, Alles on the Semois), unlike that of the rest of the Lower Devonian, consists chiefly of trilobites (*Phacops Ferdinandi*, *Homalonotus ornatus*, etc., *Cryphæus*, *Dalmanites* [*Odontochile*]), mailed fish, bivalves, cephalopods (*Orthoceras*, *Goniatites*), crinoids, and beautifully-preserved starfishes, whilst Brachiopods are almost entirely wanting."

The slate is often available for roofing purposes, as at Caub, Bacharach, Gemünden, and Bundenbach, and it is only through quarrying operations that any abundance of fossils has been found. The roofing-slate, or "Dachschiefer," is of a dark blackish-grey

colour, sometimes with a tinge of purple, moderately hard, and splitting very evenly into layers, the surface of which has a certain silky appearance, due apparently to the presence of excessively minute scales of mica. The fossils are entirely converted into hard iron pyrites, and are, when found in the quarry, invariably covered with a layer of matrix, which has to be removed by the expenditure of much time and patience, the instruments used being pointed knives and a brush of fine brass wire, which has the advantage of being harder than the slate, but softer than the pyritised fossils. When properly prepared, these fossils, both invertebrate and vertebrate, form extremely striking and beautiful objects, their drawback being that their pyritised condition renders them quite unavailable for microscopic examination. Occasionally the pyrites is not confined to the substance of the organic remains themselves, but, at places, forms also a layer over their surfaces, which cannot possibly be cleaned off, and by which the appearance of the fossils, as well as their value as specimens, is much impaired.* Hitherto I have only seen this condition in the case of fishes from Gemünden.

Another point to be noticed as regards the condition of the fossils is the *deformation* to which they have mostly been subjected. In this way bilaterally symmetrical organisms, such as Trilobites and fishes, are seen to be almost invariably obliquely disturbed, one side being pushed in advance of the other, as is well shown in the specimens of *Drepanaspis* represented in Plates II., III., and IV.

It is perfectly clear from the contained invertebrate fossils that the Hunsrück slates are of marine origin, and consequently that their "mailed" fishes were inhabitants of the sea. This is, however, not strange when we remember that "mailed" fishes (*Pterichthys*, etc.) also occur in the Middle Devonian Limestones of the Eifel, in company with such purely marine fossils as crinoids and brachiopods. Strange it is, however, that, so far as I can ascertain, it is only in one locality, namely Gemünden, that fish remains have been found in these slates, while, on the other hand, Bundenbach is famed for the variety and beauty of its crinoids and starfishes.

It is also noteworthy that at Gemünden the overwhelming majority of the fish-remains belong to one species, namely, *Drepanaspis Gemündenensis* of Schlüter; the fact being that of the four other species obtained, each is as yet represented only by a single unique specimen. This reminds us of the condition in the Upper Old Red Sandstone at Nairn in the North of Scotland, where almost all the fish-remains (tolerably abundant in certain parts of the rock) belong to one species, namely, *Asterolepis maxima*, Agas., though the proportion of relics of other species is certainly higher than at Gemünden in relation to *Drepanaspis*.

My attention was first drawn to these fishes twelve years ago by Mr STÜRTZ, of Bonn, through whose agency, and also through that of Dr F. KRANTZ, I have succeeded in getting together an excellent collection for the Edinburgh Museum of Science and Art. To Professors BRANCO and JAEKEL I have to express my sincere thanks for permission to

* See Plate I. fig. 1 and Plate V. fig. 2, in which the scales on the side of the tail pedicle of *Drepanaspis* are in this manner concealed.

study the specimens in the Museum of Natural History in Berlin, and also to Professor SCHMEISSER for allowing me to figure three examples belonging to the collection of the Prussian Geological Survey.

Apart from my outline restorations of *Drepanaspis*, I am not aware that any of the vertebrate remains occurring at Gemünden have hitherto been figured.

DESCRIPTION OF SPECIES.

Order HETEROSTRACI, Lankester.

Family DREPANASPIDÆ, Traquair.

Head not externally marked off from body, both enclosed in a carapace of osseous plates, the surfaces of which are ornamented by stellate tubercles. Mouth terminal, unprovided with teeth, or with skeletal parts comparable to jaws. No paired limbs or limb-like appendages. Tail covered with angular sculptured scales, which assume the form of imbricating fulcra along the dorsal and ventral margins. Caudal fin heterocercal, covered with small scales, but without perceptible rays.

Genus *Drepanaspis*, Schlüter, 1887.

Mouth bounded below by a broad median mental plate; a small perforation (sensory?) on each side of the head on the ventral surface just within the margin of the carapace. A large median plate on the dorsal and ventral surfaces respectively, the space between these and the lateral or marginal plates being filled up by a mosaic of small polygonal plates. No dorsal fin, caudal not bilobate.

The only known species is:—

Drepanaspis Gemündenensis, Schlüter. Pl. I. figs. 1-3; Pls. II.-IV.

Drepanaspis Gemündenensis—Schlüter, *Sitzungsb. niederrhein. Ges.*, Bonn, 1887, p. 126.

” ” A. S. Woodward, *Cat. Foss. Fishes Brit. Mus.*, pt. ii., 1891, p. 311.

” ” R. H. Traquair, *Nature*, vol. liv., 1896, p. 263; *Trans. Roy. Soc.*, vol. xxxix., 1899, p. 844; *Geol. Mag.* (4), vol. vii., 1900, p. 153, figs. 1, 2, 3; *ib.*, vol. ix., 1902, p. 289, figs. 1, 2.

As this is the only known species of the genus, no specific diagnosis is necessary.

History.—The name *Drepanaspis Gemündenensis* was given in 1887 by Professor C. SCHLÜTER, of the University of Bonn, to some fragmentary remains from the Gemünden slate, which he apparently considered to indicate a fish allied to *Cephalaspis*. In Dr SMITH WOODWARD'S *Catalogue of the Fossil Fishes in the British Museum* (pt. ii., 1891, p. 311), the fish in question is only mentioned by name along with a number of other imperfectly known forms (*Aspidichthys*, *Anomalichthys*, etc.), which he considered as “perhaps for the most part” referable to the Coccosteidæ. However, in

1896, I briefly expressed the opinion that the affinities of *Drepanaspis* lay rather with the Pteraspidae (*Nature*, vol. liv. p. 263).

To this opinion I adhered in my first detailed account of *Drepanaspis*, which was included in my Report on the Silurian fishes of Scotland published by the Royal Society of Edinburgh in December 1899. In that memoir I instituted the family Drepanaspidæ, and included it in the Heterostraci along with the Cœlolepidæ, Psammosteidæ, and Pteraspidae.

In April 1900 I published in the *Geological Magazine* a paper entitled "Notes on *Drepanaspis Gemündenensis*," illustrated by an amended restoration of the dorsal

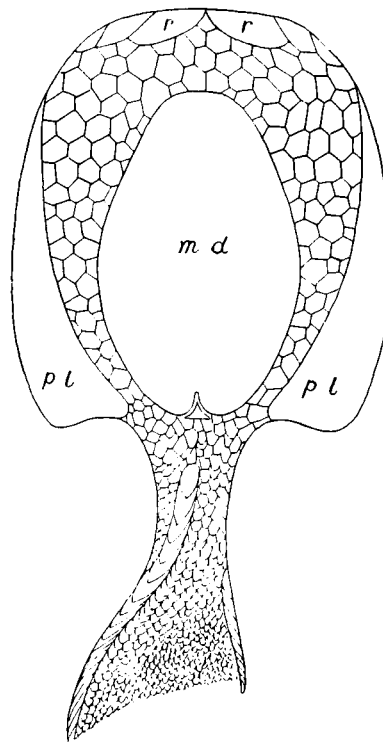


FIG. 1.—*Drepanaspis Gemündenensis*, Schlüter; restored outline of the dorsal aspect; the surface ornament omitted, and the tail twisted round so as to show the caudal fin in profile. *m.d.*, median dorsal plate; *p.l.*, postero-lateral plates; *r.*, rostral plates.

aspect, to which I now added one showing the form and arrangement of the plates on the ventral surface. Fresh material having, however, shown that the position of the sensory openings was still not quite correct, I again in 1902 published in the same journal some "Additional Notes" on the same creature, accompanied by restored figures properly amended as regards the point in question, though the form and arrangement of the scales on the sides of the tail still left something to be desired.

Description.—Nearly entire specimens are shown in Pl. I. fig. 1, Pl. II., and Pl. IV., while in text-figures 1 and 3 I have given restorations of the dorsal and ventral surfaces respectively. The carapace is broad, depressed, very obtusely rounded in front, and

terminating behind in a prominent though rounded angle on each side. There is on the dorsal surface a large median plate (*m.d.*) of an ovate-hexagonal shape, the anterior margin being short and nearly straight, while the still shorter posterior one is acutely notched. The outer tuberculated surface of this plate is well seen in Pl. I. fig. 1 and in Pl. II., while in Pl. IV. it is exhibited from the smooth inner aspect. Each postero-lateral angle of the carapace is formed by a narrow, elongated, somewhat falciform plate (*p.l.*), the postero-lateral or cornual, which, tapering to a sharp point in front, forms most of the external margin of the shield. On the dorsal aspect of the carapace (Pl. I. fig. 1, Pl. II.) the entire contour of this plate is seen, the surface being closely covered with the characteristic stellate tubercles, but on the ventral side (Plates III. and IV.) only a thickened external margin is visible, except in dislocated specimens, which margin is marked with wavy ridges instead of tubercles, and obliquely bevelled off just at the postero-lateral angle. Internal to this peculiar thickened margin the inner surface of the plate is smooth, and in entire examples of the fish it is, of course, covered by the ventral plates (see Pl. III. on the left-hand side of the figure). The rest of the dorsal surface is formed by small polygonal plates, well seen in Pl. II., and not so distinctly in Pl. I. These remind us closely of the polygonal areas on the tessellated surface of many Psammosteian shields, and, as in these, we often find a central tubercle which is larger and more prominent than the others with which the surface is closely covered. Lastly, at the anterior margin of the dorsal aspect of the carapace we find a few large rostral plates, also well marked in the specimen figured in Pl. II.; the form and number of these plates do not, however, appear to be constant in different examples of the fish.

An invariable appearance on the dorsal surface is a rounded pit on one of the plates on each side at the antero-external margin, and close in front of the forwardly-directed apex of the postero-lateral plate. This pit, conspicuously seen on the left side in Pl. II., I first interpreted as an orbit, a view which I had to abandon on finding that it had a non-perforated floor, which was also ornamented by the same tuberculation as the rest of the surface. The explanation of this phenomenon I subsequently ascertained, as will be seen further on.

Proceeding now to the ventral side of the carapace, an admirable view of its construction, though slightly imperfect behind, is afforded by the specimen represented in Pl. III., of which I also give a still more reduced pen-and-ink lettered sketch in fig. 2 in the text, while in the restoration fig. 3 is added the information derived from other specimens, especially that shown in Pl. V. fig. 1.

First we may note the mouth (*o.*), which is terminal, being placed at the anterior margin of the carapace. It is a transverse slit, the upper margin of which is formed by the anterior edges of the rostral plates (*r.*) already mentioned, while at each outer corner there is a small *external labial* plate (*e.l.*), the tubercles on which are rather larger than those elsewhere. The lower boundary of the oral slit is formed by the anterior margin of a broad pentagonal plate (*m.*), which we may call *mental*. Its

anterior or oral margin, which is also the longest, is, however, not quite straight, as it shows a very obtuse angle in the middle; the two lateral margins are shorter and slightly convergent posteriorly; the postero-lateral margins follow, each at an obtuse angle to its respective lateral one, and they meet each other behind, also at an obtuse angle, which fits into the anterior notch or excavation of the plate next to be described. This, the great median ventral plate (*m.v.*), is of a broadly oval form, having a widely open notch or indentation in front, which, as aforesaid, receives the posterior angle of the mental plate. In the specimen shown in Pl. III., and of which text fig. 2 is a sketch, the hinder extremity of this plate is broken off, but in fig. 3 I have restored its contour from other specimens, among others that represented in Pl. V. fig. 1. It will

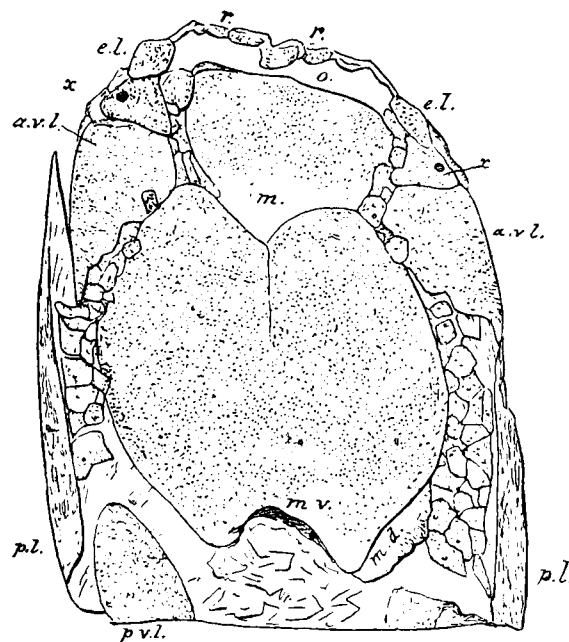


FIG. 2.—Sketch of a specimen of the carapace of *Drepanaspis Gemündenensis*, Schl. One-third natural size. *o.*, mouth; *r.*, rostral or upper labial plates; *e.l.*, external labial plate; *m.*, mental plate; *a.v.l.*, anterior ventro-lateral; *m.v.*, median ventral; *m.d.*, portion of inner surface of median dorsal; *p.v.l.*, posterior ventro-lateral; *p.l.*, postero-lateral or cornual plate.

therefore be seen that the posterior border of this plate presents a narrow bluntly-rounded median notch or indentation, the direction of which is continued for a little way in front by a longitudinal fold-like elevation of the surface. To this indentation I shall again refer in speaking of the scales of the caudal region.

Returning now to the front, we find on each margin of the carapace, immediately behind the small external labial plate, another and rather larger element of a trapezoidal shape (*x.*); transversely placed, with a short external margin, a longer internal one, while the posterior is the largest, and is directed nearly at a right angle to the middle line of the creature. This plate is seen *in situ* on both sides of the carapace in Pl. III., that of the left side in Pl. IV., while in Pl. II. that of the right side is seen detached from its place and turned round so as to show its sculptured surface. In Pl. I.

fig. 2 another detached example of this plate, a right one, is represented, also seen from the sculptured surface.

Closely within the outer narrow margin of this element *x*. is a small round opening which perforates the plate through and through, from the outer to the inner surface. Now, when we get a view of the inner surface as shown in Pl. I. fig. 3, we perceive that on this aspect of the plate the aforesaid opening is surrounded by a prominent thickened ring-like margin. Here we have the explanation of the rounded pit seen in a corresponding situation on the dorsal aspect of the carapace. It results, as is proved

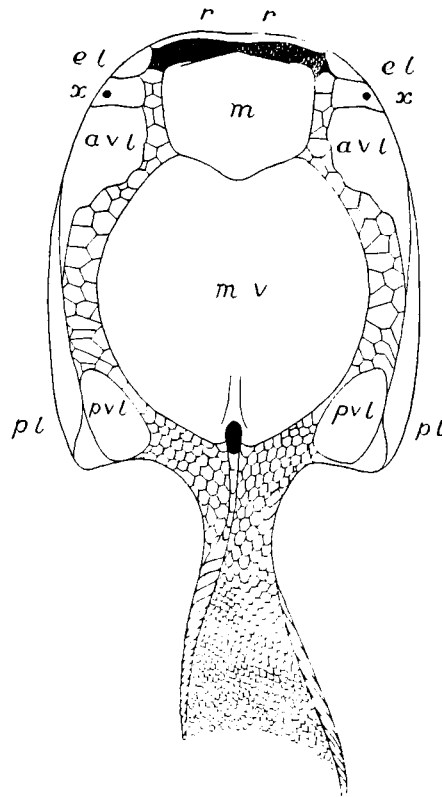


FIG. 3.—Restored outline of the ventral aspect of *Drepanaspis Gemündensis*, Schl. Surface ornament omitted and the tail twisted round so as to appear in profile. Lettering as in Fig. 2, but the mouth in front and the cloacal opening behind are represented in black.

by specimens worked out from both sides, from the dorsal armature above being squeezed down on this ring, which therefore *shows through*, and produces the appearance of a shallow pit with elevated edges as seen on the left side in Pl. II. Why, in this specimen, is no pit seen on the right side? Clearly because the plate *x*. is on this side removed from its place—it is seen turned upside down, lying apart from, though close to, the edge of the carapace—and consequently the ring-like margin of its perforation could not operate, as above indicated, in producing the shallow pit in question.

As to the function of this perforation, it is to be noted that it and the plate which bears it occupy a quite similar position to the ocular plate and the supposed orbit o

Pteraspis,—only in *Drepanaspis* the plate and its round opening, though close to the margin, are nevertheless on the ventral surface of the carapace; a circumstance which rather militates against the idea of an eye having had its place there during life. But as these Hunsrück-slate specimens are all crushed absolutely flat, it is by no means certain that in the original uncompressed condition the opening did not look out to the side. It is, however, perfectly clear that a sense-organ of some sort is here indicated, and so we may safely apply to this plate and its round opening the term *sensory*.

Immediately behind this "sensory" plate is another and larger one (*a.v.l.*) of an approximately triangular form, a long irregularly-scolloped side internally, a gently-convex outer one, and an acutely-pointed posterior angle. The outer margin of this plate, which we may call *anterior ventro-lateral*, fits on below the anterior pointed extremity of the great postero-lateral plate (*p.l.*) so extensively seen on the dorsal surface, but, as already explained, appearing on the ventral aspect only as a thickened margin (see Pl. III. and text-figs. 2 and 3). These lateral elements on the ventral surface are on each side separated from the mental and median ventral plates by a series of small polygonal ones, as seen in figs. 2 and 3, but, just behind, there is an ovate-oblong one of considerable size (*p.v.l.*), which may be called posterior ventro-lateral. The space between this and the posterior external angle of the plate *p.l.* (left empty in the figures) seems in one specimen to be covered by another smaller one; any way, I think that in this region the branchial aperture must have been placed, though its position is as yet not exactly determined.

The tail, springing from the middle of the posterior margin of the carapace, is comparatively short, and terminates in a heterocercal though scarcely bilobed caudal fin, but there is no trace of any other fins or appendages, paired or unpaired. The mode of origin of the tail, as seen from above, is well shown in Pl. II. Here we see that the small polygonal plates behind the median dorsal pass into angular imbricating scales, the outer surface of which is covered by small sharp tubercles, which are longer than they are broad, and are arranged in concentric lines which are parallel with the free margins of the scale. But in the middle line, shortly behind the median dorsal plate, there develops a series of elongated median, acutely-pointed and imbricating fulcral scales, which, becoming in succession longer and more acute in contour, form a row along the dorsal margin of the tail. These dorsal fulcra are seen also in Pl. I. fig. 1, Pl. IV. right-hand side, Pl. V. figs. 1 and 2, but more especially in the latter.

On the ventral aspect the relations of the corresponding inferior row of fulcra are best seen in a specimen belonging to the Prussian Geological Survey, and represented in Pl. V. fig. 1. In this specimen, which I have used in the restoration of the region of the body here concerned (see text-fig. 3), the posterior notch of the median ventral plate seems to form, along with an elevated median scale just behind it, a narrow opening, which I take to be the orifice of the cloaca. This is succeeded in the backward direction by four narrow elevated scales, which pass into the median fulcra of the ventral margin of the tail and caudal fin. It will be seen, on inspecting Pl. V.

figs. 1 and 2, that the ventral fulera are shorter and smaller than those of the dorsal margin.

Both sets exhibit an ornate sculpture, which consists of the tubercles of the ordinary scales, but more lengthened out, so much so in some cases as rather to be described as ridges (Pl. V. fig. 1).

The sides of the tail are clothed with angular imbricating scales, the external sculpture of which has been already noted; but a fact not recorded in my previous descriptions and restorations is, that between the carapace and the origin of the caudal fin there is at least one longitudinal row of scales which are considerably higher than broad.—the cause of my not having noted this before being that this part of the tail is usually more or less covered and obscured by pyritous deposit, as seen to a marked extent in Pl. I. fig. 1, Pl. IV., and Pl. V. figs. 1 and 2. Further on, the scales (Pl. V. fig. 1) become more equilateral and acutely rhombic, and ever smaller as we proceed backwards.

The caudal fin (Pl. I. fig. 1, Pl. IV., Pl. V. fig. 2) is *not bilobate*,—in that respect resembling that of *Cephalaspis* and *Pterichthys*. It is *heterocercal*, inasmuch as the dorsal apex passes further back than the ventral one, and the fulera along that margin are larger than those along the other. There is, however, no definite line of demarcation between the scales of the body-prolongation and those of the fin-membrane, though the latter become gradually smaller.

The plates of the carapace are thin when compared with those of most other armoured fishes; and as they are entirely converted into iron pyrites, it is unfortunately quite impossible to study their microscopic structure. The creature attained a very considerable size, the largest entire specimen which I have seen being that represented in Pl. IV., and which measures $18\frac{1}{4}$ inches in length.

Observations.—I have nothing to add to or to alter in my opinion as to the more immediate affinities of *Drepanaspis* as expressed in my paper on the Silurian Fishes of Scotland. We have here a fish-like creature whose hard parts are entirely dermal; whose endoskeleton must therefore have been quite unossified in any part, as no traces of it can be found; and whose mouth, a simple transverse slit, shows no teeth nor anything which can be called a mandible. These characters assign to *Drepanaspis* a place in the Ostracodermi, and its indubitable resemblance to *Pteraspis* leads us to class it in the Heterostracous subdivision, although evidence from microscopic structure is unfortunately unavailable. But if it be allied to *Pteraspis*, it is also clearly related to *Psammosteus* and to *Thelodus*; and hence, in my "Silurian" memoir, I included in the Heterostraci not merely the Pteraspidae, as formerly, but also the Drepanaspidae, Psammosteidae, and Celolepidae, the last being looked on as the least, and the first as the most specialised member of the group. To enter again into the question of the origin of the Celolepidae does not come into the scope of this paper, which is purely descriptive; but one cannot help remarking that the structure of *Drepanaspis* does not seem to lend much support to the idea of the evolution of the Ostracodermi from a Eurypterid ancestry.

OF UNCERTAIN SUB-CLASS.

ORDER ARTHRODIRA.

Family COCCOSTEIDÆ.

Genus *Coccosteus*, Agassiz.*Coccosteus angustus*, Traquair. Pl. VI. figs. 1 and 2.

Coccosteus angustus, Traquair, *Nature*, vol. liv., 1896, p. 263; *Proc. Brit. Assoc.*, Belfast, 1902, p. 263.

Specific Characters.—Ventral cuirass narrow; median dorsal plate, with a median crest on the second fourth of its length.

Description.—Only one specimen has occurred, which has been worked from both sides by Mr STÜRTZ's assistants.

The ventral side, Pl. VI. fig. 1, is the more perfect, and shows, besides the ventral cuirass, the displaced suborbital and median dorsal plates. The ventral cuirass shows the unmistakable contour of that of *Coccosteus*, but the lines of demarcation between the individual plates cannot be made out, although a good many cracks, the result of crushing, are very distinctly marked. The position of the anterior median ventral plate is covered by a growth of pyrites, and the posterior one is also indistinguishable.

The anterior ventro-laterals are of the form usual in *Coccosteus*, and, as in *C. decipiens*, the tuberculation of the surface is fine in the centre of the plate, coarse along the anterior, inner, and posterior margins. Along the anterior external margin is seen the short, blunt, pectoral spine, which projects just a little outwards beyond the external angle, as it does in *C. decipiens*.

The part of the cuirass occupied by the posterior ventro-laterals is narrow, hence the specific name; but, as in *C. decipiens*, the left one overlaps the right.

Just in front of the cuirass is the displaced left maxilla or suborbital plate, showing the usual sensory groove bifurcating below into an anterior and posterior branch.

Then, lying close to the outer margin of the right posterior ventro-lateral is the median dorsal, torn from its place and turned upside down, so that we see its upper or external surface on the same side of the slab which displays the ventral plates. Its form is narrow-oblong, truncate in front, faintly pointed behind; its length is $1\frac{7}{8}$ and its breadth $\frac{1\frac{3}{4}}{16}$ inch. In the middle line and in the second fourth of its length is a median crest, which gradually rises anteriorly, suddenly ceases posteriorly, and in the present specimen is bent over by crushing to the right side. The surface of the entire plate is ornamented by stellate tubercles, which toward the posterior extremity are arranged in concentric lines.

In fig. 2 of Plate VI. we have a view of the same specimen worked out from the dorsal side, whereby a certain amount is added to our knowledge of the species. In front is seen a portion of the upper surface of the cranial shield, showing very distinctly

the median and external occipital plates. Behind this, the space which ought to have been occupied by the median dorsal is of course blank, but at the sides we have evidence of the lateral plates of the body-cuirass, though hardly in a condition for accurate description. Lastly, on the right side of the hinder part of the cuirass is seen the *inner* surface of the displaced median dorsal plate, which for obvious reasons is not so extensively worked out as on the outer aspect. It shows, however, very distinctly the downwardly-projecting median process, which attains so large a development in *Coccosteus decipiens*, and in *Homosteus* is represented by the "nail"-like process of HUGH MILLER.

Observations.—This is undoubtedly a true *Coccosteus*, and one of the oldest known species of the genus, two other Lower Devonian species being *C. occidentalis*, Newb., from the Corniferous of North America, and *C. hercynius*, H. von Meyer, from the Harz. The genus is therefore of wide geological range, as, besides being abundantly represented in the Middle Old Red Sandstone (Orcaian series) of Scotland, a species (*C. Canadensis*, A. S. Woodw.) has been found in the Upper Devonian of Canada, another (*C. magnus*, Traq.) in the Scottish Upper Old Red, and a third (*C. disjectus*, A. S. Woodw.) in the Upper Old Red of Ireland. The present species is distinguished from all others by the crest on the median dorsal plate.

Genus *Phlyctenaspis*, Traquair.

Phlyctenaspis Germanica, Traquair. Pl. I. fig. 4.

Phlyctenaspis Germanica, Traq., *Proc. Brit. Assoc.*, Belfast, 1902, p. 263.

In fig. 4, Pl. I., we have what appears to me to be the median portion of the cephalic shield of a species of *Phlyctenaspis* from the rostral plate in front to the posterior margin of the median occipital behind, but wanting the lateral portions to which the postorbital, marginal, and external occipital plates so largely contribute. That the lateral parts have been broken away is rendered certain by the fact that a portion of the posterior part of the outer margin of the shield still remains on the right side, and is seen to be joined behind to the occipital region.

No sutures are visible, but there are certain indications of the contour of *rostral* and *pre-orbital* plates similar to those of *Ph. Anglica*, Traq.* The posteriorly directed sensory groove on each *central* plate is also indicated, though the exact demarcation of the plates themselves cannot be deciphered.

The surface, where intact, is covered with stellate tubercles, which in proportion are much smaller than in *Ph. Anglica*, Traq., and not so closely placed as in *Ph. Acadica* (Whiteaves).

* R. H. TRAQUAIR, *Geol. Mag.* (3), vol. vii., 1890, pl. iii. figs. 3, 4. *Ann. and Mag. Nat. Hist.* (6), vol. xiv., 1894 p. 369, woodcut. A. S. WOODWARD, *Cat. Foss. Fishes, Brit. Mus.*, Pt. ii., pl. viii. figs. 5, 6.

INCERTÆ SEDIS.

Family GEMUENDINIDÆ.

Genus *Gemündina*, Traquair.*Gemündina Stürtzi*, Traquair. Pl. VII.

Gemündina Stürtzi, Traq., *Proc. Brit. Assoc.*, Belfast, 1902, p. 263.

This is without doubt a vertebrate organism, but its affinities are so problematical, and the appearances present are so difficult, that it is not without much misgiving that I enter into its description at all.

The specimen is represented in Pl. VII. fig. 1, being what I take to be the ventral surface of the creature, while fig. 2, the same slab worked from the opposite side, shows what in that case must be the dorsal aspect.

The side shown in fig. 1, being the one first exposed and worked out, naturally presents all that remains of the contour of the fossil, as, bearing in mind the thinness and fragility of the remains, it was obviously impossible to lay bare the entire surface on the reverse side. Seen from this presumable ventral aspect, the fish measures eight inches from the tip of the snout to where the tail is cut off by the margin of the stone, and, judging from the rate of attenuation of that part, I should say that at least three inches more would be required to complete the original length.

The general contour is somewhat like that of a ray, there being on the left side (the right is imperfect) a lateral expanse like that of the pectoral fin in *Torpedo*, but there is no trace of a ventral. The distance between the outer convex margin of this expanse and the middle line of the fish is $2\frac{1}{8}$ inches, so that were the contour perfect on the left side the entire breadth would be $4\frac{1}{4}$ inches. The snout is bluntly rounded; the tail gradually narrows till it reaches the edge of the stone, and has still a breadth of $\frac{3}{4}$ inch where there cut off.

On examining the fossil (fig. 1) two sets of appearances are distinguishable:—firstly, clear evidence of dermal hard parts covering the entire or nearly the entire surface; secondly, markings which seem to indicate the presence of endoskeletal structures below the skin. We begin with the latter.

Immediately behind the rounded snout we see what is certainly strongly suggestive of the two rami of a lower jaw, the articular part of which would be $1\frac{1}{8}$ inch from the front. It is possible that this appearance may be deceptive, but whether or not homologous with a true mandible, the parts exhibited seem, in my opinion, to support the mouth. Behind these parts is now seen an area of a strongly convex-concave crescentic form, the convex aspect being anterior, the concave back posterior, each limb of the crescent ending in a right and left backwardly-directed pointed process. Just on the posterior concave margin of this crescent, and somewhat to the left of the

middle line, we see a small ophiurid starfish firmly adherent to the surface of the fish. Within the concavity formed by the two points of the crescent we find other two curved elevations of the surface, concave towards the middle line and meeting behind. In the middle of the oval space thus enclosed is an oblong elevation, which is clearly of an axial nature.

With the exception of the last-mentioned feature, it is extremely hard to put any interpretation on the above-described appearances, which are also very well shown in Pl. VII. fig. 1. The anterior broad crescentic portion may possibly represent a branchiostegal or opercular flap, but what of the two curved elevations behind and within the deep concavity of the horns of that crescent? Have they to do with the shoulder-girdle?

Immediately behind the elliptical space enclosed by the prominent lines last referred to, and continuing the line of the axial elevation in its centre, is a raised band, $\frac{2}{3}$ inch broad in front, which runs straight back in the middle line for the whole remaining length of the fossil. This band is transversely segmented, the segments being very distinct in front, where fourteen may be counted in the extent of $1\frac{1}{2}$ inch; they get, however, more obscure further back, though still evident. The segments in front likewise show a median furrow, which is well exhibited in the plate.

I interpret this band as a vertebral column, consisting of calcified ring-vertebræ, the longitudinal median groove seen in the front segments being, according to this view, due to vertical crushing. But no evidence of apophyses, either neural or hæmal, can be discerned.

As to the *dermal* structures, almost the entire surface is studded with stellate tubercles, which are larger and more distantly placed in the anterior part of the fish, smaller and closer together behind. Indeed, in front, each of these tubercles seems to form the centre of a small polygonal plate, the rest of the area of which is minutely granulated. This appearance of a mosaic of defined polygonal areas gets lost posteriorly, but at the tail, for a couple of inches before it is cut off by the edge of the stone, we find on each side of the vertebral column a row of small, longitudinally-ridged and imbricating scutes. The fact that the segmented body, which I interpret as the vertebral column, is nearer the right than the left row of scutes, seems to me to be due to a slipping over of the skin to the left side, and therefore to prove that it is an endoskeletal structure.

As shown in fig. 2 of Pl. VII., the specimen has also been worked out from the opposite, or, from my point of view, the *dorsal* side; but, of course, in order that the fossil might hold together, the operator has, except in the extreme front, kept well within the margin, so that this aspect does not exhibit nearly such an extent of surface as the other. What we do see is unfortunately quite as problematic as before. Quite in front there certainly is what *appears* to be a wide-open mouth, close behind which are two oval markings, right and left, reminding us of eyes, but I rather suspect that *this*, at all events, is a deceptive appearance. The rest of the head and body part of the

specimen, had best be left without any attempt to decipher it; suffice it to say that we have here abundance of stellate tubercles, smaller and more closely set than on the opposite side; their individuality is, however, in many places obscured by a growth of iron pyrites over their surfaces. And on the tail, as clearly shown in the figure, we have an arrangement of small scutes in longitudinal rows—at least four are shown in the specimen and in the figure—but it must be remembered that on this side of the slab only a small portion of the tail has been uncovered.

Observations.—Little can be said about the affinities of *Gemündina*. The first question which arises is whether or not it may be an Ostracoderm, seeing that the dermal hard parts, especially as seen on the assumed ventral surface, do certainly remind us of the small polygonal plates in *Drepanaspis* and the polygonal areas on many Psammosteian shields, while the general contour of the creature is also suggestive of the Cœlolepidæ. But the presence of what seems to be the axial portion of a vertebral column, and of other indications of internal skeleton as described above, seems decisively to negative the idea of relationship in that direction. There remain only the Elasmobranchii and the Chimæroidii to choose from, as it is certainly not a Teleostome. My own feeling—for the idea rests more on feeling than on anything else—is to look upon *Gemündina* as being possibly a Chimæroid. It is unfortunate that the specimen is as yet unique, but it is to be hoped that additional material will in time be forthcoming to throw more light on the structure and affinities of this singular creature.

Hunsrückia problematica, Traq., n. gen. and sp. Pl. VI. fig. 3.

Undetermined Vertebral Column, Traq.,—*Proc. Brit. Assoc.*, Belfast, 1902, p. 263.

In Pl. VI. fig. 3 is represented, natural size, a series of neural arches and spines belonging to the vertebral column of an otherwise unknown fish.

We first observe a band of pyritous granules, varying from $\frac{1}{4}$ to $\frac{2}{5}$ inch in depth, lying in the position of the vertebral axis, but not showing any distinct signs of segmentation, and over this is the series of arches and spines, forty-eight in number. The spines are slender, elongated, and fused with the arches below so as to form a series of forked rods, which increase in length from the first, which measures $\frac{2}{3}$ inch, to the thirty-first, which attains a length of $1\frac{1}{6}$ inch, after which they again become somewhat shorter. The substance of the arches and spines is granular, as in the calcified cartilage of *Pleuracanthus* and other Selachii, a circumstance which leads one to suppose that the affinities of the creature to whom this vertebral column belonged were with the Elasmobranchs.

In my notice of the Gemünden fishes given to the British Association at Belfast in September 1902 I avoided giving any name to this vertebral column, but since that time I have come to the conclusion that it would be better if it were known by some special designation. I accordingly venture to call it *Hunsrückia problematica*, the

generic name being adapted from the name of the district in which Gemünden is situated, namely, the "Hunsrück" or *Dog Back*.

I am indebted to my friend Professor JAEKEL for his good offices in procuring for me the loan of the above described specimen, which is in the collection of the Prussian Geological Survey, Berlin. In accordance with his request, I append an extract from a letter which I received from him shortly after the specimen arrived in Edinburgh.

"Ueber die Wirbelsäule, die ich Ihnen sandte, ist meines Wissens nichts gedruckt worden. Ich habe einen Vortrag darüber gehalten in dem ich auf Grund dieses Stückes betonte, dass die übliche Vorstellung einer langsamen Heranbildung der Wirbelsäule innerhalb der Fische irrig sei. Die von verschiedenen Typen des Devon vorliegenden Wirbelsäulen erfuhren bei den Fischen zunächst eine Reduction der Verknöcherung, um sich dann innerhalb der Fische neu auszubilden. Die vorliegende dem untersten Devon angehörende Wirbelsäule beweist, dass vor den bekannten Ganoiden, Haien, und andern Fischen, Vertebraten mit echter Wirbelsäule existirten. Diese Thatsache war mir deshalb bedeutungsvoll, weil sie die Wahrscheinlichkeit erhöht, dass jene ältesten Fische von terrestrischen Tetrapoden abstammen. Ich würde Ihnen sehr dankbar sein wenn Sie das in Ihrer Arbeit als meine Ansicht darüber benutzten." (*Letter dated 30th January 1900.*)

The scope of this paper being, as I have explained on a previous page, purely descriptive, I cannot enter into a discussion of the point raised in the above extract. I am however obliged to confess that, though I am sorry to disagree with Professor JAEKEL, I cannot as yet see my way to adopting the view that fishes are descended from terrestrial tetrapod animals, which have found in the water a new direction for their evolution.

EXPLANATION OF THE PLATES.

[All the figures in the following Plates have been reproduced from photographs taken from the specimens themselves, except in the case of fig. 1 Pl. I. and fig. 1 Pl. V., in which the photographs were, for convenience' sake, taken from plaster casts. In both of these cases, however, the original specimens were carefully studied.]

PLATE I.

Fig. 1. A nearly entire specimen of *Drepanaspis Gemündensis*, dorsal view, the extreme front and a part of the right side of the carapace being, however, defective, as is also a portion of the circumference in the anterior part of the left side and the posterior external angle of the left dorso-lateral plate. The scales of the tail are obscured by a covering of pyrites as far as the caudal fin, which is well preserved. The present illustration has been taken from an excellent plaster cast of the original specimen which is contained in the collection of the Prussian Geological Survey in Berlin. Reduced by one-fifth.

Fig. 2. Isolated *sensory* or *ocular* plate of the right side, showing the tuberculation of the external surface, and the rounded perforation or opening close to the outer margin. Natural size.

Fig. 3. Sensory and anterior ventro-lateral plates seen from the inner surface, the former showing the thickened ring surrounding the opening on that aspect of the plate. Some of the small polygonal plates of the carapace are also seen scattered about on the upper part of the figure, one of which, seen from the tuberculated surface, is adherent to the anterior ventro-lateral. Natural size. Specimen in the Museum of Science and Art, Edinburgh.

Fig. 4. Central part of the cranial buckler of *Phlyctauaspis Germanica*, Traq. Natural size; original in the Museum of Science and Art, Edinburgh.

PLATE II.

In this plate is shown a specimen of *Drepanaspis Gemündenensis*, dorsal view, which, with the exception of the caudal fin-membrane and a small portion lost out of the middle of the carapace, is tolerably complete. Note, on the left side, near the front, the rounded pit produced by the compression of some of the small dorsal plates down on the thickened ring around the inner opening of the perforation of the sensory plate. On the right side, as explained in the text, no such pit is to be seen in this specimen, the cause being that the sensory plate has been removed from its place and is seen lying close to the outer margin of the front of the carapace. This specimen also exhibits very well the gradual elevation and expansion of the fulcra of the dorsal margin of the tail as we proceed backwards from the posterior part of the carapace. Reduced by four-thirteenths; specimen belonging to the Museum of Science and Art, Edinburgh.

PLATE III.

This plate shows the greater part of the carapace of *Drepanaspis Gemündenensis* seen from the ventral aspect. A full explanation of the details shown in this specimen is given at p. 727 in the description of text-figure 2, which is a reduced sketch of the original of this plate. Specimen in the Museum of Science and Art, Edinburgh.

PLATE IV.

Here is represented, one-half natural size, the most entire specimen of *Drepanaspis Gemündenensis* with which I am acquainted. The fish lies on its back, the ventral surface being upwards. The mouth, in front, is very distinctly seen, as is also the sensory plate of the left side and its perforation, the left anterior ventro-lateral, and the outer thickened margin of the postero-lateral. The same plates are seen on the right side, but the sensory and anterior ventro-lateral have each a narrow portion cut off by the edge of the stone, and the posterior ventro-lateral is seen displaced over the projecting angle of the postero-lateral. The edge of the mental plate forming the lower margin of the mouth is quite clear, but the rest of the plate is obscured by pyrites, as are also most of the small polygonal plates. The great median ventral plate has, however, fallen out, and in its place is seen the internal smooth surface of the median dorsal, a condition which I have observed in more than one specimen lying in the same position as the present one. The scales of the tail are partly obscured by pyrites, but those on the caudal fin are well shown, as are also the marginal fulcra. The caudal fin is, however, not so complete as in the specimen figured in Pl. I. fig. 1. Specimen in the Edinburgh Museum of Science and Art.

PLATE V.

Fig. 1. Specimen showing the posterior extremity of the median ventral plate and the commencement of the tail of *Drepanaspis Gemündenensis*. The raised median fold on the hinder part of the median ventral plate, and which ends at the marginal notch, is well seen, as is also the position of the supposed cloacal

opening, but the divisions between the four succeeding narrow elevated scales have not come out so well in the plaster cast from which the photograph was taken. In the proximal part of the tail the scales are covered by pyritous deposit, but further back they are well seen, their angular contour and bold sculpture being strongly marked. The commencement of the line of ventral fulcra is clearly exhibited; those of the dorsal set are somewhat disturbed proximally, but their form and sculpture are very sharply defined. The original specimen is in the collection of the Prussian Geological Survey in Berlin.

Fig. 2. This is a tail of the same species, with the caudal fin truncated and the lateral scales covered with a layer of pyrites, except on a small area behind; the fulcra are, however, well seen, and we may note their short, stout form at the commencement of each series, as well as the greater size of those on the dorsal aspect. Specimen in the Edinburgh Museum of Science and Art.

PLATE VI.

Fig. 1. *Cocosteus angustus*, Traquair, seen from the ventral aspect (see text, p. 732). The only known specimen, and preserved in the Edinburgh Museum of Science and Art.

Fig. 2. The same specimen worked out from the dorsal aspect (see text, p. 732).

Fig. 3. *Hansrückia problematica*, Traquair, portion of vertebral column (see text, p. 736). Specimen in the Collection of the Prussian Geological Survey, Berlin.

PLATE VII.

Fig. 1. *Gemündia Stürtzi*, Traquair, ventral aspect (see p. 734). Specimen in the Edinburgh Museum of Science and Art.

Fig. 2. The same specimen worked out from the other side (see p. 737).

DR R. H. TRAQUAIR ON FOSSIL FISHES OF GEMUENDEN—PLATE I.



Fig. 1.
Reduced by One-fifth.

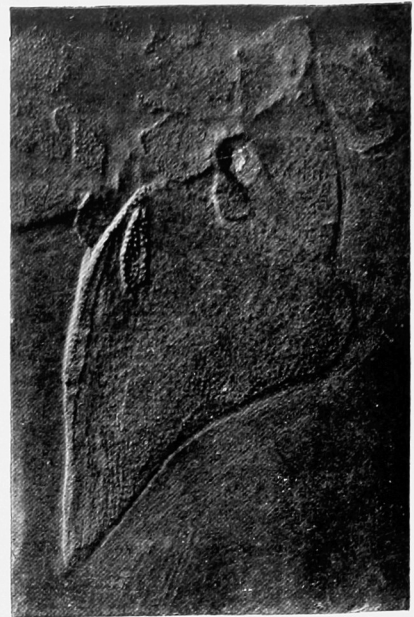


Fig. 3.
Natural Size.

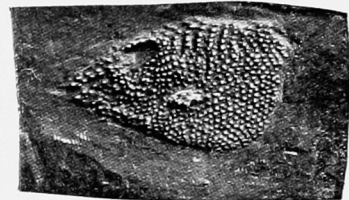


Fig. 2.
Natural Size.

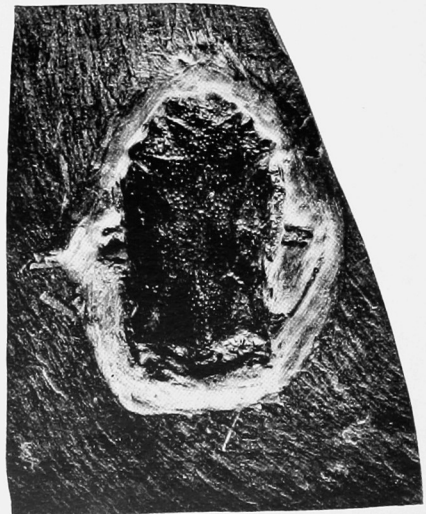


Fig. 4.
Natural Size.

DR R. H. TRAQUAIR ON FOSSIL FISHES OF GEMUENDEN—PLATE II.

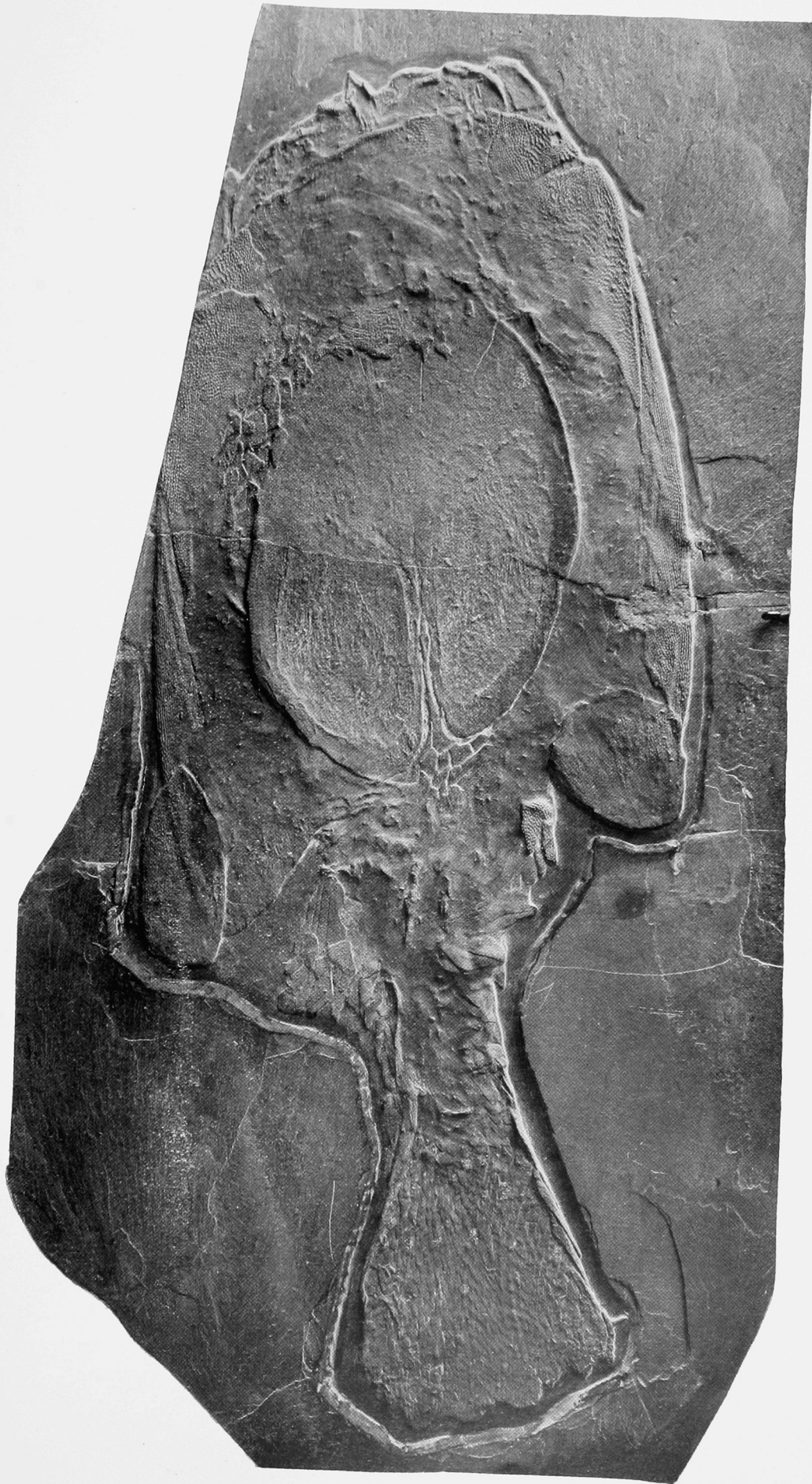


Nine-thirteenths Natural Size.

DR R. H. TRAQUAIR ON FOSSIL FISHES OF GEMUENDEN—PLATE III.



Reduced by One-fifth.



Reduced by One-half.

DR R. H. TRAQUAIR ON FOSSIL FISHES OF GEMUENDEN—PLATE V.



Fig. 1.

Seven-tenths Natural Size.



Fig. 2.

Seven-tenths Natural Size.

DR R. H. TRAQUAIR ON FOSSIL FISHES OF GEMUENDEN—PLATE VI.



Fig. 3.

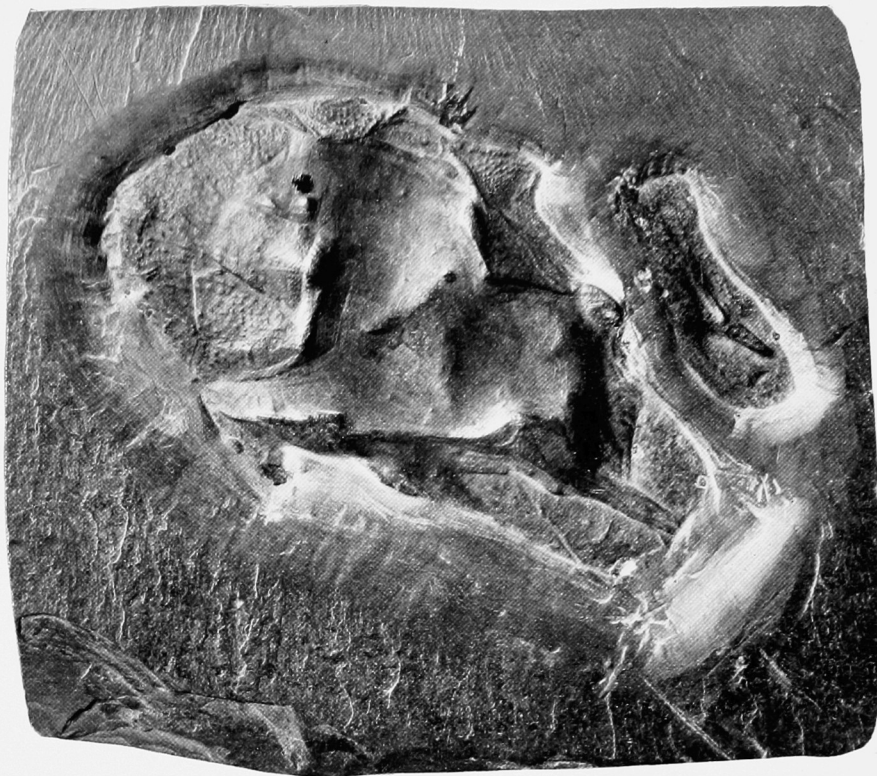


Fig. 2.

Natural Size.



Fig. 1.

DR R. H. TRAQUAIR ON FOSSIL FISHES OF GEMUENDEN—PLATE VII.



Fig. 1.

Natural Size.

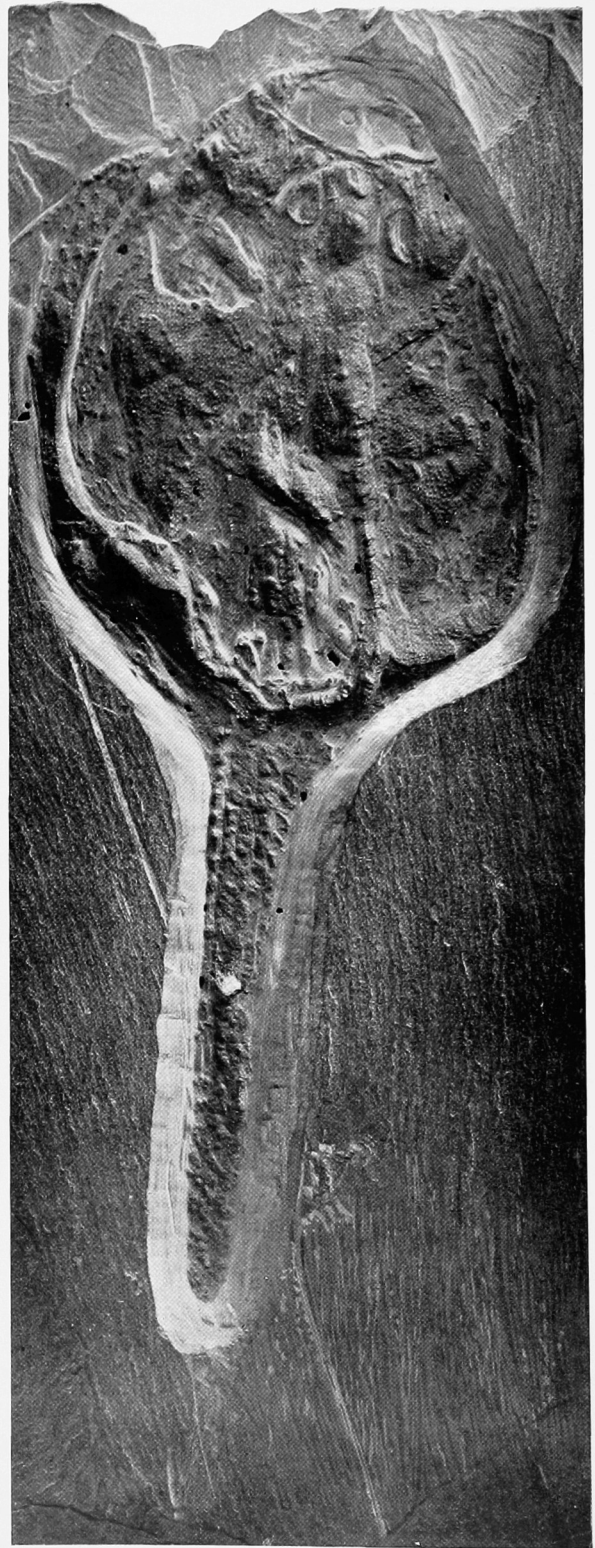


Fig. 2.