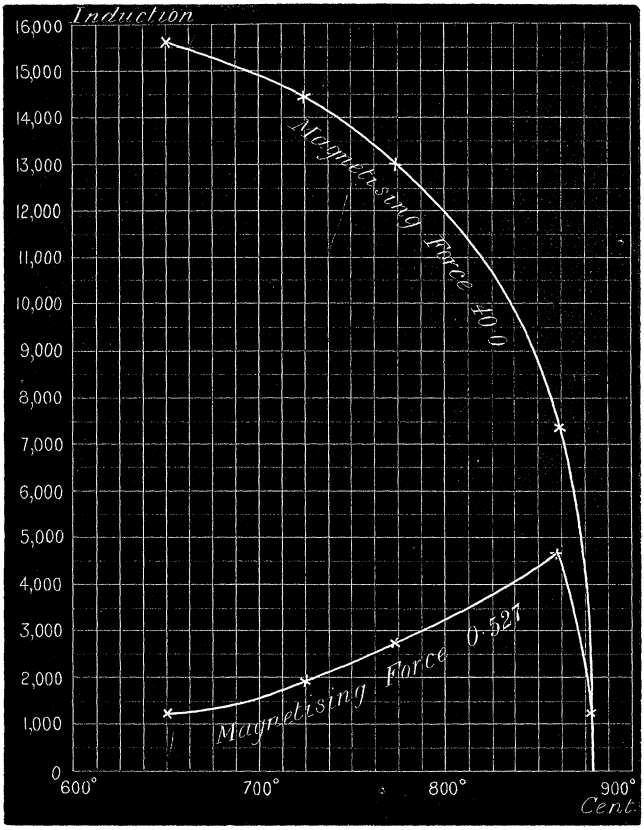
Fig. 7.



"On the Shoulder Girdle in Ichthyosauria and Sauropterygia." By J. W. Hulke, F.R.S. Received April 11,—Read May 12, 1892.

In a paper recently communicated to the Royal Society by Professor H. G. Seeley,* in which is discussed "The Nature of the Shoulder Girdle and Clavicular Arch in Sauropterygia," the author challenges the validity of statements relating to this girdle made by me at the Anniversary Meeting of the Geological Society of London in 1883.† This from so eminent a palæoherpetologist imposed on

* Seeley, Professor H. G., "The Nature of the Shoulder Girdle and the Clavicular Arch in Sauropterygia." Received January 18, 1892. Read February 18, 1892. 'Proc. Roy. Soc.'

† Hulke, J. W., "Presidential Annual Address," 'Geol. Soc., Lond.,' on Feb. 16, 1883; 'Quart. Jl. Geol. Soc.,' vol. 39, 1883, Proc., p. 38.

me the task of re-examining the facts and the considerations on which were based those statements made nine years ago, and now questioned. The outcome of this enquiry I now offer to the judgment of the Royal Society.

In his recent paper, in addition to the known elements recognised by all comparative anatomists (viz., two scapulæ, two coracoids, two clavicles, and an interclavicle), Professor H. G. Seeley (*a*) assigns to the Ichthyosaurian shoulder girdle a *precoracoid*, cartilaginous; (*b*) he regards as non-proven my interpretation of the anterior of the two ventral rays present in the Plesiosaurian girdle, as a *precoracoid;* (*c*) he considers that the process ascending from the body of the scapula in *Plesiosauria* is not homologous with the analogous vertical ray in the Testudinate shoulder girdle; and (*d*) he contends that certain osseous components of the Plesiosaurian girdle are *clavicles* and *interclavicle*, and not *omosternalia*.

It will be convenient to notice these matters serially.

(*a*) The value of the evidence on which a *precoracoid*—cartilaginous—has been assigned to the *Ichthyosaurian* shoulder girdle.

Professor H. G. Seeley conceives the presence of a precoracoid—cartilaginous—in this girdle which "articulated with the part of the scapula anterior to the external articulation of the coracoid, and also with the anterior interior processes of the coracoids, so as to complete the precoracoid foramen anteriorly."

He founds this conception mainly on the supposition that the ventral end of the scapula comprises three several portions:—(1) a posterior portion which contributes to form the *fossa glenoidalis;* (2) a middle portion articulating "with the anterior, articular edge of the coracoid;" and (3) an anterior which does not differ in its cartilaginous, articular aspect or thickness from the middle portion, but which looks inwards without any other bony element of the shoulder girdle to articulate with it.

The conception of a distinct anterior portion of the ventral end of the scapula in front of that part of this end of the scapula which articulates with the coracoid, therefore which is in front of the scapulo-coracoid articulation, is, then, a principal reason for Professor H. G. Seeley's conception of a precoracoid—cartilaginous—in the Ichthyosaurian girdle.

A careful study of many Ichthyosaurian scapulæ disposes me to regard as fallacious the appearance of a tripartite division of the ventral end of the bone; such a division does not appear to me to be supported by the best preserved and most perfect examples.

In a scapula, now before me, obtained by A. Leeds, Esq., from the clay pits (Oxford clay) near Peterborough, which retains its normal figure, texture, and surface markings, as perfectly as a newly mace-

rated bone, I find the ventral end to comprise a stout, posterior part of an approximately semi-ellipsoidal figure, having its major axis, 10·5 cm. long, much nearer the inner border, which does not greatly vary from a straight line. The minor axis, 4·3 cm. long, is distant 4·6 cm. from the posterior vertex of the ellipsoid, towards which the thickness of the bone rapidly diminishes. The reduction of thickness forwards is less rapid, the width across the end, between the inner and the outer surface, being 1·8 cm., at the anterior vertex of the ellipsoid. From this point forwards the thickness of the bone continues to decrease to the anterior border of the bone, with which this part of the ventral end makes an angle. At its anterior termination here the thickness of the ventral end is only 0·8 cm. The surface texture of this end has a granular character suggestive of a former cartilaginous crust. This granulation is coarser in the narrower anterior part.

When this scapula is stood on its ventral end on a flat horizontal surface, as on a table, and viewed perpendicularly to one of its surfaces (preferably the inner surface), the profile of this end of the bone comprises a middle, horizontal segment, from both ends of which the contour rises angularly; its posterior branch includes with the horizontal direction of the middle part (produced) an angle of about 35°; and its anterior branch includes with the same horizontal line an angle of 65°.

This different direction of the parts of the profile apparently has suggested to Professor H. G. Seeley a threefold division, in which each part had a distinct separate office. A critical examination of the surface of the end shows, I think, that the idea of a tripartite division of this end is illusory, and that this end comprises only two parts, one posterior, glenoid, diarthrodial segment; the other, an anterior synchondrosial segment, which articulated with the coracoid.

The outer surface of the scapula near its ventral end is sinuous; convex in its posterior third, where the bone is stoutest; and concave in its anterior two-thirds, where the bone becomes thin, the concavity here being chiefly due to the *outward* trend of the surface towards the anterior border which gives to this part a thin, lip-like, angularly projecting figure where the ventral and anterior borders meet.

In conformity with the ventral end of the scapula, the corresponding outer border of the roughly quadrilateral coracoid exhibits a stout posterior part, its complement of the *fossa glenoidalis;* and a thinner anterior part which encroaches on the anterior border by truncation of the antero-external angle, for synchondrosial union with the scapula.

Bearing in mind that the bones composing the Ichthyosaurian

shoulder girdle are, normally, never synostosed,* but that the scapulæ and coracoids preserve their separate individuality even in skeletons bearing the stamp of maturity, the inference is warrantable that they were in life knit together by a persistent remnant of the cartilaginous "*continuum*," which in Amphibia and upwards is the foundation of these two bones, and also of the precoracoid where this exists.

Further, analogy warrants the inference that the quantity of such persistent cartilage remaining at the ventral end of the scapula, and at the corresponding tract of the coracoid, varied with the age of the individual, and in dependence on this, with the extent to which ossification had advanced; also that the quantity of this remaining cartilage was not throughout its area a bond of uniform width, but it was narrower where the bones it united approached, and wider where they receded from one another. But the recess between the truncated antero-external corner of the coracoid and the adjacent antero-inferior angle of the scapula, both which parts bear, as Professor H. G. Seeley says, the mark of having had cartilage attached to them, is just the situation where a wider band of synchondrosial cartilage might be expected than was present posteriorly where the scapula and coracoid were nearer together.

In support of his conception of a precoracoid—cartilaginous—in Ichthyosauria, Professor H. G. Seeley cites the opinion held by Sir E. Home, Buckland, and Cuvier respecting the position and the relations of the scapula. These opinions are to be gathered chiefly from their figures, since their text gives us little information of their thoughts on the matter.

Sir E. Home, in his third paper on Ichthyosaurian Remains,† says, of the scapula in Mr. Bullock's specimen engraved in his first paper, "it was then mistaken for a portion of a rib accidentally brought there, but it is now found to have been nearly in its natural situation. It bears a resemblance to the clavicular bone in Birds."

Sir E. Home's "reconstruction" of the Ichthyosaurian shoulder girdle (fig. 1) was manifestly based on certain resemblances its component parts showed to those of the "sternum" of *Ornithorhynchus paradoxus*, which latter was brought to his attention by Mr. W. Clift, Conservator of the Museum of the Royal College of Surgeons. Sir E. Home unfortunately misread the Monotreme's pectoral girdle; he mistook its coracoid for a descending process of its scapula, and he identified its epicoracoid with the Ichthyosaurian coracoid.

* I have noticed synostosis of scapula and coracoid in *Ichthyosauria* as a sequel of inflammation, marked by much irregular hyperostosis.

† Home, Sir E., "Additional Facts respecting the Fossil Remains of an Animal," in 'Phil. Trans.,' 1818, p. 25.

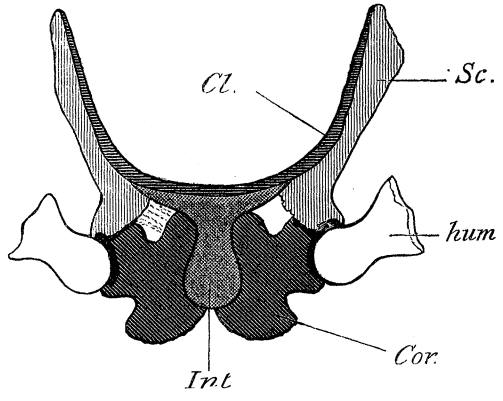


FIG. 1.—Reduced copy of Sir E. Home's restoration of the pectoral arch of *Ichthyosaurus* ('Phil. Trans.,' 1818, Pl. 2, fig. 1). *Cl.*, clavicle; *Sc.*, scapula; *Int.*, interclavicle; *Cor.*, coracoid. (This lettering indicates the identic pieces in all the figures illustrating this paper.) The shading in the vacuity in front of the coracoid has been added to show the position of the precoracoid (Seeley).

The unnatural proportions of the several bones shown in his reconstruction (fig. 1, Pl. 2, 'Phil. Trans.,' Part I, 1818), place it beyond doubt that he derived his ideas from the dissociated bones of more than one individual, and also that he had not at that time seen in a single skeleton all the component elements of this arch in their normal, or in but slightly disordered relation.

Cuvier treats of the scapula very briefly; he says,* "L'omoplate, *d*, est aussi un peu dilatée en éventail vers l'endroit où elle s'unit au coracoïdien; elle se rétrécit, en se courbant, pour remonter vers le dos, et elle a à son bord antérieur une proéminence pour donner appui à l'extrémité de la clavicule."†

Although he added more than any other writer to the exact knowledge of the osteology of *Ichthyosaurus* (and *Plesiosaurus*), and this chiefly from the study of specimens acquired by him in London for the Paris Museum, it is noteworthy that he did not state his own views on the shoulder girdle other than in very general terms; nor did he embody them in a "reconstruction"; but he copied (with proper acknowledgment) the figure of this girdle in Sir E. Home's "plate"; at the same time he also reproduced the restoration given by Conybeare, of the same skeletal part.‡

Now, Sir E. Home's and the Rev. W. D. Conybeare's reconstruc-

* Cuvier, G., 'Ossemens Fossiles.' Edit. 3. Tome 5, Partie 2, p. 470, 1825.

† Cuvier, G., 'Ossemens Fossiles,' *loc. cit.*

‡ Conybeare, W. D. (and De la Beche), A New Fossil Animal, 'Geol. Soc. Trans.,' p. 557, vol. 5, 1821, and Fig. 7, vol. 1, Part 2, 2nd Series.

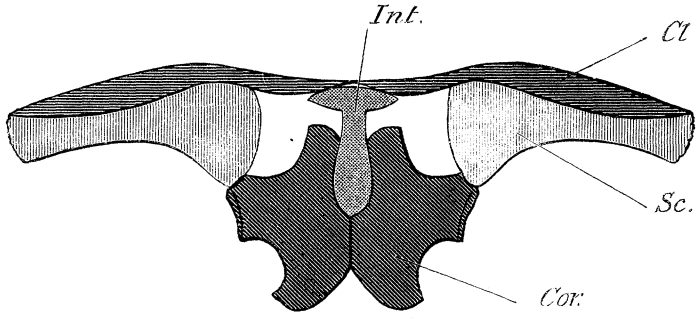


FIG. 2.—Conybeare's reconstruction of pectoral girdle of *Ichthyosaurus* ('Trans. Geol. Soc. Lond.,' vol. 1, Part 2, Series 2, Pl. 49, fig. 7. Copied in 'Oss. Foss.' Edit. 3, Tome 5, Pl. 32, fig. 7).

tions of the Ichthyosaurian shoulder girdle differ greatly, notably so in the positions and the relations of the scapula. As, however, Cuvier copies both, and abstains from expressing his own views on the subject, obviously little weight attaches to his authority in regard to it.

The passage quoted above from the "Ossemens Fossiles," certainly mentions a "*proéminence*" on the anterior border of the scapula for affording support to the end of clavicle; but the passage is not quite free from ambiguity. It does not, however, appear to me to fix the position of the scapula shown in Sir E. Home's reconstruction, and adopted by Professor H. G. Seeley, which represents a non-articular part of the ventral end of this bone in advance of the coraco-scapular articulation; for the reconstruction shows the mesial ends of the clavicles resting on the anterior aspect of the cross-bar of the interclavicle, as we know by numerous examples they certainly do in many *Ichthyosauria*, and not on the antero-ventral angle of the scapula; so that the end of the clavicle here referred to by Cuvier would seem not to be the inner but the outer end. Where this rests on the anterior border of the scapula, I have noticed in some examples a rough, low elevation, as if for a ligamentous attachment, a circumstance confirmatory of the idea that the outer and not the inner end of the clavicle is here intended.

Buckland, another authority cited by Professor H. G. Seeley in support of his view respecting the ventral end of the scapula, reproduces Cuvier's reduction of Sir E. Home's reconstruction given in fig. 1, Pl. 2, 'Phil. Trans.,' 1818; and since in his text he omits all detailed description of the several parts composing the shoulder girdle, he leaves us in ignorance whether he had himself formed a distinct opinion respecting the normal position and relations of the Ichthyosaurian scapula.*

* Buckland, W., 'Geology and Mineralogy considered with Reference to Natural Theology,' p. 181, vol. 1, 1836, and Pl. 12.

Obviously, then, there is small claim to quote Buckland as an authority upon the anatomical details of the pectoral arch.

Amongst other reasons for suggesting the presence of a precoracoid—cartilaginous—in *Ichthyosaurus* assigned by Professor H. G. Seeley, are the following, viz. :—

1. "That it accounts for the structure of the shoulder girdle, and explains its homology."

If by "the structure of the shoulder girdle" the author means, as I imagine, the alleged tripartite division of the ventral end of the scapula, and the marks of attachment of cartilage apparent in the foremost of the supposed three divisions, and also on the antero-internal angle of the coracoid, both are naturally explained in the suggestion I have offered above, and this without the introduction of another skeletal element of which no objective trace remains. As regards the homologies of all the known parts of the Ichthyosaurian shoulder girdle, I had supposed that all comparative anatomists had long been in perfect accord.

2. "It brings the shoulder girdle of *Ichthyosaurus* into harmony with *Nothosaurus*, in which there is a similarly incomplete coracoid foramen, and similar cartilaginous surfaces of coracoid and scapula in close juxtaposition."

The Nothosaurian (osseous) shoulder girdle, for the knowledge of which we are indebted to H. v. Meyer,* comprises three pairs and an azygos piece, viz., two coracoids, two scapulæ, two clavicles, and an interclavicle.

These are precisely the same osseous parts as are present in the Ichthyosaurian shoulder girdle.

Now, Professor H. G. Seeley inferring the existence of a precoracoid in *Ichthyosaurus*, supports this hypothesis by the argument that its presence would bring the Ichthyosaurian girdle into harmony with that of *Nothosaurus*, in which its presence is equally hypothetical.

The form and the relations of its osseous parts are well seen in the annexed figure from Zittel's 'Palæontologie,' which is a reduction of one-fourth of H. v. Meyer's large figure of the shoulder girdle of *Nothos. mirabilis*.†

H. v. Meyer regarded the two angulated long bones composing the principal part of the anterior ventral ray as clavicles, and the small middle piece embraced by their inner ends as "sternum" (interclavicle in the nomenclature of to-day). I formerly thought these precoracoids, but better knowledge of the relation of their inner ends to the interclavicle, and of their outer ends to the scapula, has

* Meyer, H. v., Saurier des Muschelkalks ('Zur Fauna der Vorwelt,' 1845—1857), Fig. 1, Lief. 34, Fig. of Nothos. Shoulder Girdle viewed from above. Natural size.

† Zittel, K. A., 'Handbuch der Palæont.,' vol. 3, Abth. 1; S. 476, fig. 447.

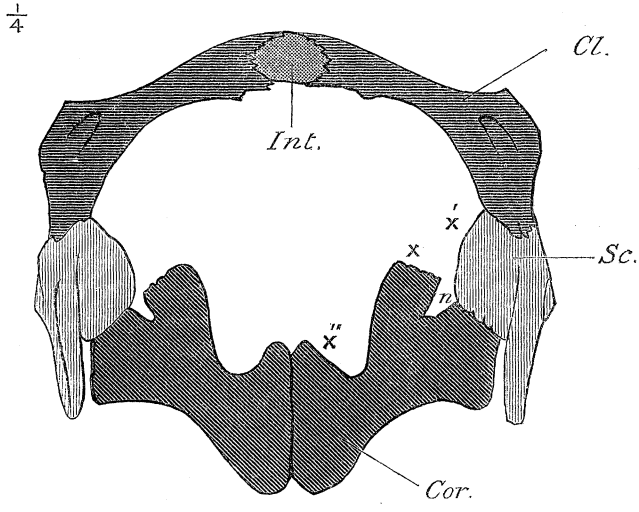


FIG. 3.—Shoulder girdle of *Nothosaurus mirabilis*. ¼ natural size. From Zittel's 'Handbuch der Palæont.,' Bd. 3, Lief. 3, S. 476. (This is a reduced copy of H. v. Meyer's, Fig. 1, Taf. 34, 'Saurier des Muschelkalks.')

long appeared to me conclusive of the correctness of H. v. Meyer's interpretation of their homology; and I am confirmed in this rectification of my earlier view by instances of a similar behaviour of the inner ends of the clavicles and interclavicle in certain *Ichthyosauria* from the Oxford clay obligingly brought under my notice by A. Leeds, Esq., of Peterborough. Such relations obtain in *Ophthalmosaurus icenicus* (Seeley, H. G.) ('Geol. Soc. Quart. Jour.,' p. 396, *et seq.*, vol. 30, 1874).

Whilst in certain *Ichthyosauria* the relations of the inner ends of the clavicles and interclavicle are in close accord with those obtaining in *Nothosaurus*, the relation of the outer ends of the clavicles to the scapulæ is different.

In *Ichthyosauria* the clavicle tapers laterally, not widening, and its outer end creeps up along the anterior border of the blade of the scapula, splint-wise, nearly or quite to the full extent of the latter, with which, as already mentioned, it seems to have been only ligamentously connected. In *Nothosaurus*, however, the outer end of the clavicle is united suturally* to the body of the scapula, and at the root of its ascending process, which most comparative anatomists, I suppose, identify with the blade of the scapula.

* The firmness of the suture (serrated) is shown by the fact that von Meyer found several specimens in which the clavicle had broken off near the suture which still held a fragment of the clavicle firmly knit to the scapula.

Unless I have greatly failed to grasp his meaning, Professor H. G. Seeley grounds his idea of the presence of a cartilaginous precoracoid in *Nothosaurus* on the characters of the terminal border of the process marked x, and on that of the part of the scapula marked x' (fig. 3), and also in the presence of the notch n, at the outer side of the process x, which he identifies with the notch in the anterior border of the Ichthyosaurian coracoid, and so with the *precoracoid* foramen (*cor. for.* of most authors) in *Reptilia squamata*. Were the notch n converted into a foramen by a cartilaginous band joining x and x', such cartilaginous bar with the bony process x would constitute the precoracoid element conceived by Professor H. G. Seeley. This hypothesis is not free from difficulty. In both the primary divisions of Amphibia the cartilaginous precoracoid is more in line with the scapula, forming, as it were, a ventral extension of this, than it is with the precoracoid, and when the precoracoid ossifies (Urodela) in common with either of the other components of the girdle, ossification appears to overrun it from the scapula rather than to extend into it from the coracoid. But in *Nothosaurus*, on the supposition that the process x is part of the precoracoid, obviously, ossification has spread into this from the coracoid and not from the scapula, with which also it has no community of direction. Next, as regards the supposed identity of the notch n, at the outer side of the process x, with the foramen of nerve-passage in the Lacertilian coracoid. This in all lizards I have examined with particular reference to its position is situated behind and usually slightly towards the mesial side of the precoracoid tract or process, so that the homologous notch in the Nothosaurian girdle is to be sought at x'', and not at the outer side of x.

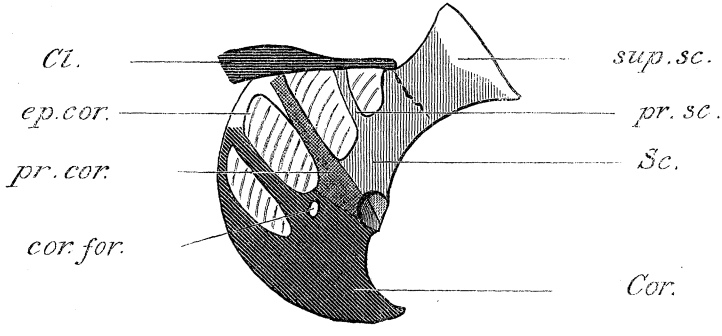


FIG. 4.—Left half of shoulder girdle of *Iguana tuberculata*.

But if we were to concede to Professor H. G. Seeley the presence of a *pre*-coracoid in the Nothosaurian shoulder girdle joining x and x', its relation to the coracoid would be different to that which he assigns

to it in the Ichthyosaurian girdle in which he connects the mesial end of the precoracoid with the antero-internal angle of the coracoid; whereas in *Nothosaurus* its mesial end would be separated from that angle by a wide interval.

That the process *x* was tipped with cartilage, and that the part of the scapula marked *x'* was clothed with cartilage is an inference not drawn by H. v. Meyer himself who, from a study of several specimens, says, the anterior border of the process *x*—"bietet auf seinem Vorderrande Unebenheiten dar, welche auf ein an dieser Stelle angebracht gewesenes Band schliessen lassen;" and of *x'* that the border is—"von einer Beschaffenheit welche vermuthen lässt, dass sie mit einem Band oder Muskel in Berührung gestanden hat."*

From the above I think it will have become evident that the grounds for the supposition of a precoracoid (cartilaginous) in *Nothosaurus* are insufficient to establish this; and if so, that the structure of its shoulder girdle as regards this element fails to support the hypothesis of a precoracoid in Ichthyosauria.

G. Baur has "no doubt that the Ichthyosauria possessed a small *cartilaginous sternum*." He adds "the whole morphology of the shoulder girdle strongly supports this opinion."† I am pleased to find myself in accord with him on this matter, for I have long recognised the great probability of the presence of a cartilaginous sternal plate behind the coracoids. I also have no doubt that the Ichthyosauria had a cartilaginous supra-scapula.

In connexion with the hypothesis of a precoracoid in the shoulder girdle of *Nothosaurus mirabilis*, the small Nothosaurid *Lariosaurus Balsami Curioni* deserves notice. Its shoulder girdle contains the same elements as those in *N. mirabilis*, and their forms and arrangements are similar, the chief difference being the absence of the large process so conspicuous at the anterior margin of the coracoid in the latter. In the more simple form of this bone there is a closer resemblance to Plesiosauria than is shown by *N. mirabilis*. The annexed figure from C. Zittel's 'Pal.' affords the means of comparison of the girdles of *Lariosaurus Balsami* with those of *Plesiosaurus* and *N. mirabilis*. In an upper view of a complete skeleton of *Lariosaurus Balsami* (original in Munich Museum), figured by C. Zittel, 'Pal.,' vol. 3, p. 485, fig. 461, the dorsal process of the scapula is seen in natural position above the glenoid mass, rising with a strong backward slant (*d.pr.*).

In *Anarosaurus pumilio* (W. Dames) another small member of the same family, the coracoid also has a simple form, and its anterior border wants the process characteristic of *N. mirabilis*. Again, in *Neusticosaurus pusillus* (H. G. Seeley), another member of this family,

* Meyer, H. v., *op. cit.*, p. 45.

† Baur, G., 'On the Pelvis of the Testudinata.' Boston, 1891. Reprint from the 'Journal of Morphology,' vol. 4, No. 3, p. 34.

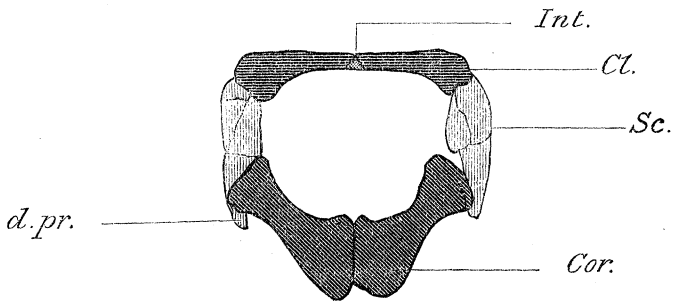


FIG. 5.—Shoulder girdle of *Lariosaurus Balsami Curioni* (ventral view). From Zittel, *op. cit.*, S. 488, fig. 462. *d.pr.*, dorsal process of scapula.

the relations of the anterior ventral ray and scapula are in principle identically the same as in *N. mirabilis;* the anterior ray articulating with the scapula, and not contributing to form the fossa glenoidalis. The coracoid, however, repeats the simpler form seen in *Lariosaurus Balsami* and in *Anarosaurus pumilio.*

Thus if *Macromerosaurus* be only a young example of *Lariosaurus,* and if *Pachypleura* is *Neusticosaurus,* as C. Zittel, W. Dames, and some others suppose, we have the fact that none of the family of Nothosauridæ, unless *N. mirabilis,* lend any support to the idea of the existence of a precoracoid, but rather the contrary; and those points in *N. mirabilis* which have been cited in support of the presence of a precoracoid in this, and so in *Ichthyosaurus,* are, as I have suggested, capable of other and simpler explanation.

Another reason assigned by Professor H. G. Seeley for introducing a cartilaginous precoracoid into the Ichthyosaurian shoulder girdle is "it brings the shoulder girdle of *Ichthyosaurus* into harmony with that of the Anomodontia, because they correspond in the form of the scapulæ, the position and forms of the clavicles, interclavicles, and coracoids; so that if the Anomodont precoracoid were unossified the differences from *Ichthyosaurus* would be small, except that the Anomodonts develop an epiclavicle of Labyrinthodont type."

The principal Anomodont remains available for the comparison are, I take it for granted, those preserved in the British Museum, chiefly from African sources. They include several dissociated more or less imperfect scapulæ and coracoids, of which the more important pieces were figured by R. Owen in his 'Catalogue of S. African Reptilia,' 1876, Pl. 69, figs. 5, 6, 8, 9, and Pl. 70, fig. 1. They comprise also the remains of *Pareiasaurus,* described by Professor H. G. Seeley, 'Phil. Trans.,' B. 1888, p. 59, *et seq.*, Pl. 20, figs. 1, 2; those of *Keirognathus cordylus,* described by this author, 'Phil. Trans.,' B,

1888, Pl. 75, p. 489; and those of *Procolophon*, described by the same author, 'Phil. Trans.,' B. 1889, p. 255, Pl. 9, fig. 9.

Now, the most notable character in the best preserved scapula figured by R. Owen (fig. 1, Pl. 70, *op. s. c.*), is the large process at the ventral termination of its anterior border separated by a deep notch from the coracoid articular margin of the bone (fig. 6). This process, though

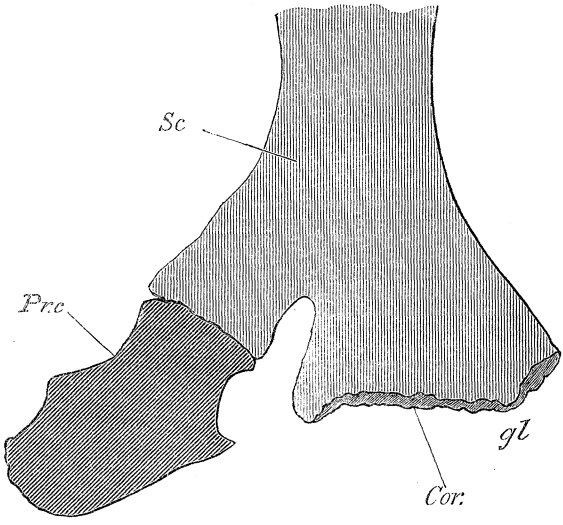


FIG. 6.—Scapula and precoracoid referred to *Dicynodon leoniceps*. Owen, 'S. Afric. Rept.,' Pl. 70, fig. 1. *pre.*, precoracoid; *gl.*, glenoid.

termed acromion by R. Owen and by Professor H. G. Seeley, can hardly be regarded as homologous with the acromion in higher Vertebrata, since in *Dicynodon* it articulates with the precoracoid and not with the clavicle (fig. 7). A similar form of the ventral end of the scapula is not infrequent in Anourous Amphibia, but I am not aware that such has yet been demonstrated in the scapula of any Ichthyosaurian. In *Dicynodon* the clavicles are not known. R. Owen figures (Pl. 49, fig. 8, *op. cit.*) a bone associated with a scapula which he considers interclavicle of *Kistecephalus*. This Professor H. G. Seeley interprets as clavicle. It is dissociated, and the other ventral constituents of the shoulder girdle are missing. I submit, therefore, that no certain information of the clavicle is derivable from this specimen. In *Pareiasaurus*, the interclavicle and the clavicles are known, but not the other ventral elements of the girdle, or, at best, most imperfectly; nor is the form of the scapula known. In *Procolophon*, the interclavicle is well shown in the specimen figured by H. G. Seeley

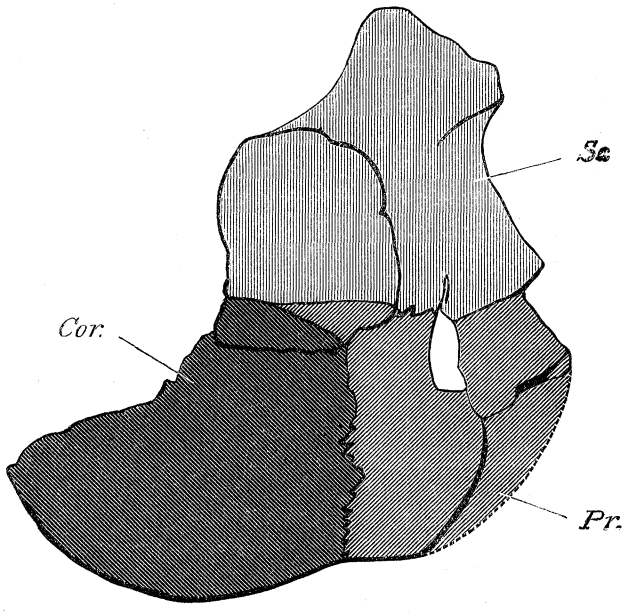


FIG. 7.—Scapula, coracoid, and precoracoid of *Dicynodon* (sp.). Owen, 'S. Afric. Rept.,' Pl. 69, fig. 5.

(fig. 9, Pl. 9, 'Phil. Trans.,' B, 1889). Its form differs notably from that of *Pareiasaurus* in the great length of its sagittal bar, but the clavicle and the scapula are not known. In *Keirognathus cordylus* (figured by Professor H. G. Seeley, 'Phil. Trans.,' B, 1890, Pl. 75), the clavicles are represented by small discontinuous fragments of doubtful interpretation. The bone, with much probability interpreted as interclavicle, is imperfect; its relation to the coracoids, precoracoids, and sternum are unusual. The coracoids and precoracoids are represented only by impressions in the matrix to which but vestiges of bony tissue remain attached: and the scapula is also extremely imperfect.

I submit, then, that our present knowledge of the Anomodont shoulder girdle is too incomplete to serve for any other than a very general comparison with that of *Ichthyosaurus;* and I venture to think that at present it is insufficient to warrant the conclusions of a close agreement in their structural details.

I pass on to the Plesiosaurian shoulder girdle. Since the qualifying prefix *inter-* in interclavicle, and *epi-* in episternum, primarily denote a relation of position and not of genesis, it does not appear to me a matter of great moment which of these names is employed,

and I do not find any fault with those authors who use these names indifferently as synonyms of a certain piece in the secondary shoulder girdle. I prefer, myself, the term interclavicle, since Götte's embryological investigations have appeared to demonstrate that the piece thus denoted is a derivative of the mesial ends of the clavicles. For the analogous part in the Amphibian girdle, since W. K. Parker apparently demonstrated its origin from the epicoracoids (and, if so, it is not the morphological equivalent of the Lacertilian interclavicle), I prefer his name *omosternum*, which has the convenience of implying its essential difference from the interclavicle.

In Plesiosauria the (primary) shoulder girdle, as is well known, consists of a dorsal and of two ventral rays, the *fossa glenoidalis* being seated (approximately) at the spot whence the three rays diverge. In addition to these component parts there are others which, for reasons to be presently stated, I have suggested are omosternalia; if such they are also parts of the primary girdle.

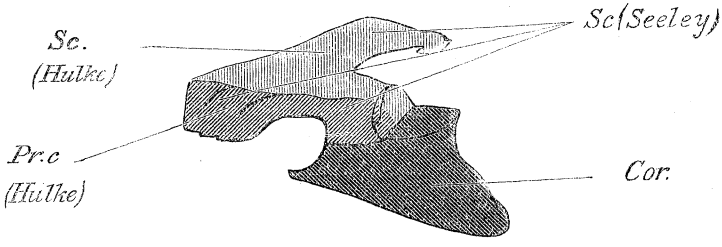


FIG. 8.—Left half of primary shoulder girdle of *Plesiosaurus cliduchus* (Seeley). From photograph of specimen in Woodwardian Museum; taken June, 1869.

Professor H. G. Seeley, however, finds, in these parts, clavicles and interclavicle, a view which, if established, places them in the secondary girdle.*

Concerning the posterior ventral ray, the suggestion that it may include the coracoid and also the precoracoid element has, I think, never been seriously argued, and I believe that all comparative anatomists now agree in regarding it in its entirety solely as coracoid.

After the recognition of "the large flat bone," by Buckland, as the "sternum" in *Ichthyosaurus*, and after its correspondence to the coracoid in Crocodilia had been shown by Conybeare, the latter's identification of the Plesiosaurian coracoid, when soon afterwards this Sauropterygian was discovered by him and De la Beche, almost necessarily followed.†

* C. Gegenbaur denotes by *primary*, that part of the girdle which is preformed in cartilage; and by *secondary*, that which ossifies directly from membrane.

† Conybeare, *op. supra cit.*

The significance of the anterior ventral ray has ever been, and it still is, a "vexed question." I regard it as a precoracoid preserving permanently its original union with the scapula, together with which it shares in forming the *fossa glenoidalis*.

Professor H. G. Seeley considers it part of the scapula. This is plainly shown by the following extracts from his paper:—"The scapula is a stout triradiate bone." "In *Elasmosaurus* the scapular arch has the well-known form with the scapulæ meeting in the median line and continuous posteriorly with the coracoids." "The measurement of the scapula in the median line is $3\frac{3}{4}$ inches." "The scapulæ meet in the usual usual way by a median suture." "The interclavicle was found *in situ* resting in a depression between the anterior margins of the scapulæ." "The interclavicle is wedged in between the scapulæ."

The above passages prove, I submit, that their author rejects the actually dual composition of the bone termed by him, in its entirety, scapula: nor is the significance of these passages weakened by others, as the following, in which the bone is given a compound name, so:—"The scapulo-precoracoid appears to form about two-thirds of the wall of the glenoid cavity." "It is these *precoracoid portions of the scapulæ* which alone meet each other in the median line." That these last quoted passages may not be understood as implying a shade of doubt in the author's mind respecting the genetic oneness of the ray he calls, in its entirety, scapula, appears to be clear from the following passage, on the shoulder girdle in certain Plesiosauroids:—"In *Elasmosaurus, Colymbosaurus, Murœnosaurus*, and their allies, the parts of the bone which meet in the median line, and are in contact with the clavicular arch, are *theoretically precoracoid** elements which connect the scapulæ with the coracoids" (*op. supra cit.*).

It will now be my endeavour to demonstrate that the anterior ventral ray is not only theoretically (whatever precise significance attaches to this term), but that it has an extremely strong claim to be regarded as actually, a precoracoid.

I shall show that in its position in the girdle, in its relations, and presumably in its genesis, it corresponds essentially to the bone that bears the name precoracoid in extant Amphibia and Reptilia.

In discussing the homology of the several parts composing the shoulder girdle, we should ever keep before us the elementary fact that the primitive shoulder girdle is originally one cartilaginous "*continuum*," emitting one dorsal ray and one or two ventral rays. The dorsal ray is, by universal consent, known as the scapula; where there is only one ventral ray this is by nearly all comparative anatomists known as coracoid; and where there are two ventral rays, the anterior is designated precoracoid or clavicle. It is con-

* *Italics* mine.

sidered precoracoid by C. Gegenbaur, Fürbringer, Huxley, W. K. Parker, and others, including myself; and is named clavicle by Götte, Hoffmann, and others, their followers.

The chief argument used in my address, from which Professor H. G. Seeley quotes, that this piece in the Plesiosaurian shoulder girdle is really a precoracoid, is the very close agreement noticeable between the Plesiosaurian and Testudinate girdles, a correspondence not merely general, but also of their respective parts; so that, if the anterior ventral ray in Testudinata is a precoracoid, this affords a very strong presumption that the corresponding ray in Plesiosauria is also precoracoid. This presumption appears to me to amount as nearly to proof as the nature of the comparison of these parts admits; but since Professor H. G. Seeley considers "the evidence insufficient to sustain the interpretation," and since, on re-examination, my former conclusion is confirmed, I shall amplify and re-state it.

In comparing skeletons of fossil with those of extant animals, absolutely complete proof of the essential identity of their several parts is, in particular instances, unattainable, and we have to accept for it presumption so strong as not to allow reasonable doubt. As regards living animals, we have the great aid of embryology to illumine the facts of the mature skeleton; but this valuable aid is, if we except a few very rare instances (*e.g.*, larval, concurrent with adult forms, as in the Batrachial fauna of the Braun-Kohlen formation of Rhenish Prussia), wanting in regard to fossil animal remains, which are so often fragmentary and otherwise imperfect and incomplete.

In Testudinata it is a matter of common elementary knowledge that the primary shoulder girdle (primitively a three-rayed cartilage, having at its centre a hollow for the reception of the caput humeri, the *fossa glenoidalis*) appears, when ossification is completed, to comprise two bones only. Of these, one, the posterior ventral ray, contributes the posterior part of the *fossa glenoidalis*, and sends an expansion inwards towards the mesial line of the body. It is by common consent coracoid, and it requires no further notice.

The other bone has an angulated form, of which one branch ascends to be attached ligamentously at the under surface of the carapace; whilst the other branch bends ventrally inwards, in front of the posterior ray, approaching closely that of the other side, and is mostly attached by its mesial end ligamentously to the entoplastron.

It is respecting the homology of this (anterior) ventral branch that there remains any difference of opinion, since all agree that the dorsally-directed branch is scapula.

As already mentioned, these two branches appear to constitute one bone, which meets the coracoid in the glenoid mass, and with the coracoid forms the glenoid fossa. Of this hollow the apparently

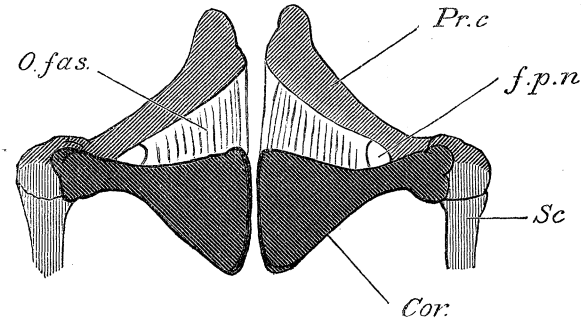


FIG. 9.—Shoulder girdle of *Emys Europæa*. *O. fas.*, obturator fascia; *f.p.n.*, foramen for nerve. From Hoffmann. Bronn's 'Klassen, Rept.,' Bd. 1, Taf. 8, fig. 7.

single, angulated bone forms the upper or the anterior part, the coracoid furnishing the posterior part.

Professor H. G. Seeley says, in his recent paper, "There is no conclusive evidence of the mutual relations of the scapulo-precoracoid to the glenoid cavity in Chelonia." If by this he means that no evidence exists to show whether one only or both of the components of the apparently single bone he thus designates enter into the composition of the glenoid fossa, this statement is, I venture to submit, scarcely justifiable, in view of the embryological investigations of that extremely careful, painstaking observer, H. Rathke, who, writing of the Testudinate shoulder girdle, says: "In the anterior piece (*i.e.*, the united scapula and coracoid), however, I found in the embryo of Chelonia, and in the young of *Chelonia imbricata*, *Trionyx Gangeticus*, and *Terrapene tricarinatus*, that each limb had a particular bony sheath, and that the two sheaths were nowhere confluent, but only at one side of the angle which the two limbs composed they had very closely approached one another; whereas at the outer side of this angle they were still distant from each other, and the entire process projecting from the latter (the angle), and which contained the joint-hollow consisted only of cartilage." "In the young *Sphargis* the two bony sheaths had reached one another at the inner side of the angle formed by the two limbs of the anterior shoulder piece, and had here coalesced, leaving, however, still uncovered the outer side of the angle and the articular process."*

From these observations of H. Rathke, made in different families of *Testudinata*, which are in accord with an observation long previously made by Cuvier in a very young Chelonia, it may very fairly be assumed that in this order generally ossification begins separately

* Rathke, H., 'Ueber die Entwickelung der Schildkröten,' p. 137.

in each of the two branches composing the apparently single bone in the mature girdle, and the apparent oneness of the bone when ossification is complete is due to the coalescence of the two bony masses. Further, as a result of his investigation, H. Rathke knew that the anterior ventral ray enters into the constitution of the glenoid fossa, for, in his discussion of its homology, he says: "Certainly it would be a very peculiar circumstance for Testudinata in connection with this view (viz., that this ray is acromion) that in them the acromion also takes a share in the formation of the hollow of the shoulder joint."*

This places it beyond doubt that H. Rathke found each of the two rays of the "anterior bone" of the Testudinate shoulder girdle entering into the composition of the glenoid fossa.

Now, the separate ossification of each of the branches of the "anterior bone," and the contribution by each to the glenoid fossa, constitutes, I submit, a sufficient warrant for assigning to each equal morphological value, so that if one branch (the dorsal) is scapula, the claim of the other to be precoracoid (clavicular, Götte) cannot be contested.

I repeat, between the Plesiosaurian and the Testudinate girdle there is an extremely close correspondence: each is three-rayed, each has a dorsal ray, each a posterior ventral ray, and each an anterior ventral ray. In Testudinata, each of these three rays contributes to the glenoid fossa; and in the Plesiosaurian girdle no evidence has, so far as I know, been adduced to disprove a similar composition of this fossa.

Without embryological study we had not certainly known whether either, to the exclusion of the other, or both together, of the two branches of the "anterior bone" in Testudinata helped to form the glenoid fossa, since, when ossification is complete, synostosis is so perfect that no trace of earlier separateness remains.

Stannius, indeed, mentions a skeleton of *Emys* in the Berlin Anatomical Museum, in which, on the left side, the anterior ventral limb is suturally united with the ascending limb (scapula). This, however, has been most obligingly re-examined for me by Professor Dr. W. Dames, with the result that he finds the appearance of a suture ambiguous and suggestive rather of an accidental crack, so that this specimen has not the importance previously attached to it.†

In each of the two girdles under consideration the homology of the posterior ventral ray is universally acknowledged to be identic—each is coracoid; and that of the anterior ventral ray cannot, I think,

* Rathke, H., 'Ueber die Entwickelung der Schildkröten,' p. 138.

† I am glad to take this opportunity of expressing my acknowledgment to Professor W. Dames for his assistance kindly rendered me in this matter.—J. W. H.

reasonably be doubted—each is precoracoid (clavicula, Götte). In Testudinata all accept the dorsal ray as representing the blade of the scapula in other Reptilia; but in Plesiosauria the analogous dorsal ray, Professor H. G. Seeley contends, is not an homologous structure. Were it so, then, obviously, the agreement of the two girdles in regard to this element would be seriously compromised.

The ground on which Professor H. G. Seeley rejects the idea that the dorsal process in the Plesiosaurian girdle is homologous with the dorsal ray in the Testudinate girdle, is stated by him in the following passage:—"In Chelonians the ascending process of the scapula extends dorsally towards the vertebræ, while in Sauropterygia it extends backwards above the glenoid articulation for the humerus, and there is no evidence that these structures are homologous" (*cf.* 'Roy. Soc. Proc.,' vol. 51, 1892, p. 122).

It is manifest from this that the backward slant of the Plesiosaurian dorsal scapular process is Professor H. G. Seeley's chief (and only stated) reason for rejecting its homology with the Chelonian shoulder blade. Can this reason be accepted as a sufficient warrant for such rejection? In Birds, does not the long, sword-like shoulder blade slant yet more, bending backwards above and behind the glenoid fossa, in a direction roughly parallel with that of the vertebral column? In his restoration of the Anomodont *Keirognathus cordylus*, has not Professor H. G. Seeley given the shoulder blade a forward inclination so great as to carry its free end so far in advance of the glenoid fossa as to bring it against the centrum of the second vertebra, while a plane laid through the glenoid fossa passes between the seventh and eighth vertebræ? Yet, notwithstanding this excessive forward slant, Professor H. G. Seeley names it scapula. Between these extremes, every degree of slope is observable, so that if the main fact of general dorsal direction above the glenoid fossa be present, this seems to me enough to justify its identification as shoulder blade, and therefore to warrant it and the Chelonian shoulder blade being considered homologous structures.

Should any one still find difficulty in accepting the dorsal *Plesiosaurian* process as shoulder blade, by reason of the somewhat singular position whence it ascends, as homologous with the ascending part of the *Testudinate* scapula, he will find an intermediate step in the Nothosaurian scapula where the corresponding dorsal process* ascends directly from above the glenoid fossa.

In other Nothosauridæ, *e.g.*, in *Lariosaurus*, Cuvier, *Neusticosaurus*, Seeley, to which reference has been already made, the position of the root of the dorsal scapular process corresponds to that in *N. mirabilis*.

Were the part in the Plesiosaurian shoulder girdle, which I call

* The identity of which with that in *Plesiosaurus* has not, so far as I am aware, been doubted.

precoracoid, actually scapula, as Professor H. G. Seeley deems it to be, it must be either *acromion*, or *prescapula*. The former was Conybeare's idea; but Cuvier pointed out this involved an extension of a scapular process mesially inwards towards its fellow of the other side, a construction not known in any Vertebrate; and the same objection lies against a prescapular interpretation.

An objection that might be advanced against homologising the dorsal process in the Plesiosaurian shoulder girdle with the Testudinate shoulder blade, is that it does not ascend so immediately from above the glenoid fossa as does the latter. This is true, but I offer the suggestion (for what it may be worth) that the clue to this difference lies in the dwarfing of this process in *Plesiosaurus;* whilst the growth of the precoracoid has been relatively rapid, with the effect of carrying forward with it the free process of the scapula, which gives to that part of the "anterior bone" somewhat the semblance of a third process. In connection with this it should not be overlooked that in Testudinata before ossification of the shoulder girdle is complete that part of the glenoid mass of cartilage which belongs to the scapula and precoracoid stands off, process-like, from the angle which marks the junction of the two components of the "anterior bone," thus presenting a slight resemblance to that which obtains permanently in *Plesiosauria*.

There remains for discussion the homology of the bony piece or pieces which I have suggested may be omosternal, but which Professor H. G. Seeley contends are clavicles and interclavicle. They lie upon the upper or visceral aspect of the precoracoids (Professor Seeley), therefore within the outer bony frame of the chest; and only to an extent varying in different genera in a ventral view are they visible between the anterior mesial ends of hese bones (precoracoids *mihi*), in advance of the coracoids, above and behind the antero-internal angles of which they are produced backwards to an extent hidden in most skeletons.

In *Plesiosaurus* (type) they form a plate which is more exposed, in a ventral view, than in *Pliosaurus* (R. Owen) in which only a very small part of the omosternum is apparent in the vacuity between the antero-internal angles of the coracoids; whilst in *Colymbosaurus* (H. G. Seeley), the omosternum, if it exist, is completely hidden by the precoracoids (Professor Seeley). Fig. 12, p. 447, 'Geol. Soc. Quart. Journ.,' 1874.

It was this undisputedly deep position of the elements in question, unknown as regards interclavicle and clavicles in any other Vertebrata, that weighed with me against accepting the interclavicular hypothesis held by several previous writers: for I then knew, and I still know, no Vertebrate skeleton in which an interclavicle is thus deeply situated under cover of the other bones of the pectoral frame.

Professor H. G. Seeley certainly has since represented the interclavicle as in part covered by the sternum in *Keirognathus cordylus*,* but I venture to suggest that in the specimen the appearance is not wholly free from ambiguity, and that its damaged condition makes confirmation of so singular a deviation from the usual relation of interclavicle and sternum very desirable.

It was its deep position, together with evidence suggestive of a composite origin, which led me to suggest that this part or parts might be omosternal, since in certain Anoura Professor W. K. Parker had found an omosternum (formed by the fusion of two symmetric halves, each segmented off from the epicoracoid) produced above and behind the anterior border of the precoracoids, and thus occupying a precisely similar position to that occupied by the bone or bones in Plesiosauria. Professor H. G. Seeley's statement that I regarded this bone as indivisible is a misconception, if it is intended to convey that I denied it a dual origin, since in my address I distinctly say, "Some examples show traces of a primitive composition of two similar halves."† I have now before me a drawing of such a Plesiosaurian omosternum (dated June 19, 1869) which I made of a specimen in the Cambridge Museum. In its present form—the postero-external angles are missing—it is an oblong plate, measuring transversely 4·11 ins., and 3 ins. in its antero-posterior extent along the mesial line where are distinct indications of a suture showing its formation by the junction of two halves. That which I regard as the anterior border has the mesial notch seen in some Plesiosauria. The sweep of the posterior border is broken by a projection formed by the backward extension of the postero-internal angle of each of the two halves.

The form of the omosternalia evidently varied in different genera, and it is the opinion of A. Leeds, Esq., who has an excellent knowledge of Enaliosaurian remains, that it varied also with age. An azygos omosternal piece which I saw in his collection at Eyebury, in 1883, was a moderately thin plate, having the outlines of an isosceles triangle, the base of which measured 11·6 cm., and the height 11·3 cm. Its apex was rounded off, and its base slightly incurved. In the direction of a perpendicular from the apex on the base, and also transversely to this direction the figure was slightly curved, which gave a gentle concavity to that surface which I conjectured to be upper.

Two omosternalia, a pair, belonging to another skeleton, had the form of scalene triangles. Of the more perfect of the two the base

* 'Phil. Trans.,' B., 1888, p. 494, Fig. 2. (P. 493, line 3 from bottom, Sternum, the words "so far as to *underlap* the posterior borders of the coracoid," show this "Restoration" to be an inferior, or ventral, view).

† Hulke, J. W., p. 48, 'Proc. Geol. Soc.,' Presidential Address, 1883.

was 6·7 cm. and the height 9 cm. I have not yet found conclusive evidence of the coexistence of such a pair and of an azygos piece in any of the Plesiosaurian remains in the British Museum, and I have thought it probable that the azygos condition was a later stage reached by the fusion of the paired elements as happens in the analogous case of the Anourous omosternum.

Mr. A. Leeds, however, assures me that he possesses one instance of such association of two lateral and a median piece, which he had placed for examination in Professor H. G. Seeley's hands. Such association, if established, would not, however, prove the three pieces to be not *omosternalia* but *clavicular*.

Götte has shown that in Reptilia the interclavicle arises by the coalescence of a piece segmented off from the mesial ends of each clavicle. In Anoura, Parker has shown that the omosternum is formed by the fusion of two pieces segmented off from the anterior extremities of the epicoracoids; in this instance, if a remnant of each lateral segment retained its distinctness, there would be a perfect accord in the principle of the construction of the omosternal and clavicular parts.

By Professor H. G. Seeley the thinness and the surface texture of those pieces is considered decisive of their being originated by the ossification of *membrane* (not of cartilage), an origin which he regards as decisive of their being *clavicular and interclavicular*, and as outweighing the anomaly of their "visceral position." It is possible that they are membrane bones, but this is not yet absolutely certain; whilst their deep position, unknown, if clavicular pieces, in any other Vertebrate skeleton, is not disputed. I submit, then, that the weight of evidence is still in favour of an omosternal homology.

Professor H. G. Seeley argues that these bones cannot be *omosternalia*, because in every existing animal which has an omosternum a sternum also is present, but in no Sauropterygia is there even any trace of a sternum. The usual association of omosternum and sternum may be perfectly true, but since the genesis of these two parts is perfectly distinct, one being a derivative of the epicoracoids, the other a derivative of the costæ, the presence of a sternum is not a necessary antecedent of that of an omosternum. Moreover, though no objective evidence of a sternum in Plesiosauridæ has been preserved, the whole homology of the pectoral girdle, and the high degree of development of the abdominal ribs makes the existence of a cartilaginous sternum a very probable circumstance. Such sternum might not imprint any trace of cartilaginous attachment or other mark of articulation on the postero-internal parts of the coracoids, since their articulation with it might be simply diarthrodial, much as in Lacertilia, in which the border of the coracoid is simply received in a corresponding groove in the sternum.

Professor H. G. Seeley's objection to the importation of the Amphibian plan in explanation of a part of the Plesiosaurian shoulder girdle, of which other parts have been explained by reference to the Chelonian plan of construction, has not, I venture to think, great weight, since, of the early Reptilia, from the time when their remains first began to be studied, it has been a frequent remark that their skeletons comprise structural arrangements which, in existing animals, are now found separately. Moreover, it is thought by some of the ablest comparative anatomists that the Chelonian skeleton shows closer approach to the Amphibian than is to be found elsewhere.

"On Current Curves." By Major R. L. HIPPISLEY, R.E. Communicated by Major MACMAHON, F.R.S. Received May 12,—Read June 2, 1892.

(Abstract.)

1. The object of the present paper is to show how to determine expressions for the current in circuits having iron cores, similar to the well-known equations

$$i = \frac{\mathrm{E}}{\mathrm{R}}(1-e^{-\mathrm{R}t/\mathrm{L}})$$

and

$$i = \frac{\mathrm{E}}{\sqrt{(\mathrm{R}^2+p^2\mathrm{L}^2)}}\sin(pt-\theta)$$

for circuits without iron, which will enable the current curves to be pre-determined by calculation and plotted independently of experiment.

In circuits with iron cores the value of $\frac{d\mathrm{B}}{dt}$ occurring in the original differential equations

$$\mathrm{E}-\frac{d\mathrm{B}}{dt} = \mathrm{R}i \ldots \quad \ldots\ldots\ldots\ldots\ldots \quad (1),$$

$$\mathrm{E}\sin pt-\frac{d\mathrm{B}}{dt} = \mathrm{R}i \ldots \quad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

continually alters as i changes. If we could obtain an expression for $\frac{d\mathrm{B}}{dt}$ in terms of i, the substitution of this expression in (1) and (2) should lead us to the required result. But, though such an expression can be found, its substitution will *generally* lead to differential equations which cannot be solved by known methods.

2. In the case represented by (1), where the applied E.M.F. is constant, we can determine by Lagrange's formula of interpolation

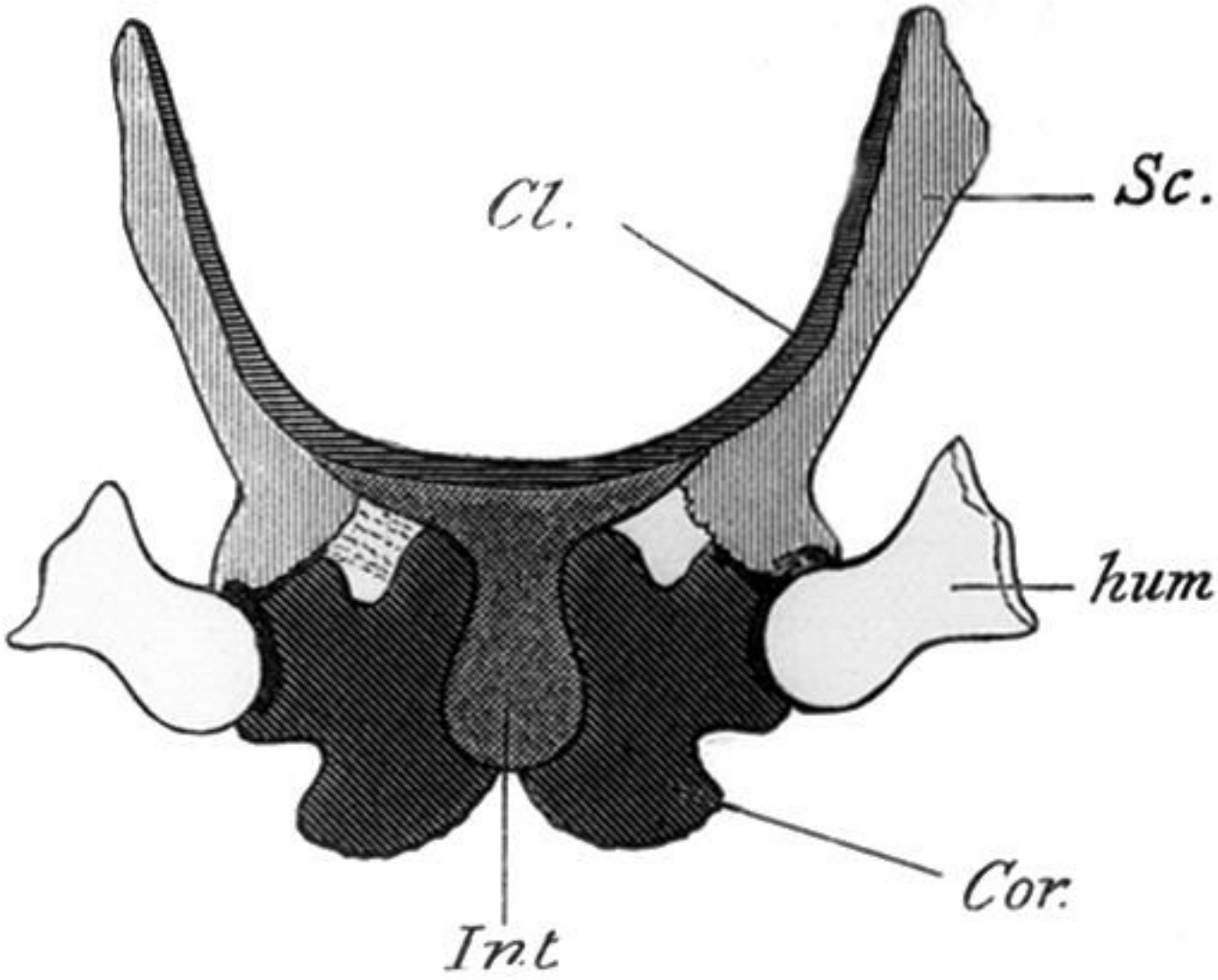


FIG. 1.—Reduced copy of Sir E. Home's restoration of the pectoral arch of *Ichthyosaurus* ('Phil. Trans.,' 1818, Pl. 2, fig. 1). *Cl.*, clavicle; *Sc.*, scapula; *Int.*, interclavicle; *Cor.*, coracoid. (This lettering indicates the identic pieces in all the figures illustrating this paper.) The shading in the vacuity in front of the coracoid has been added to show the position of the precoracoid (Seeley).

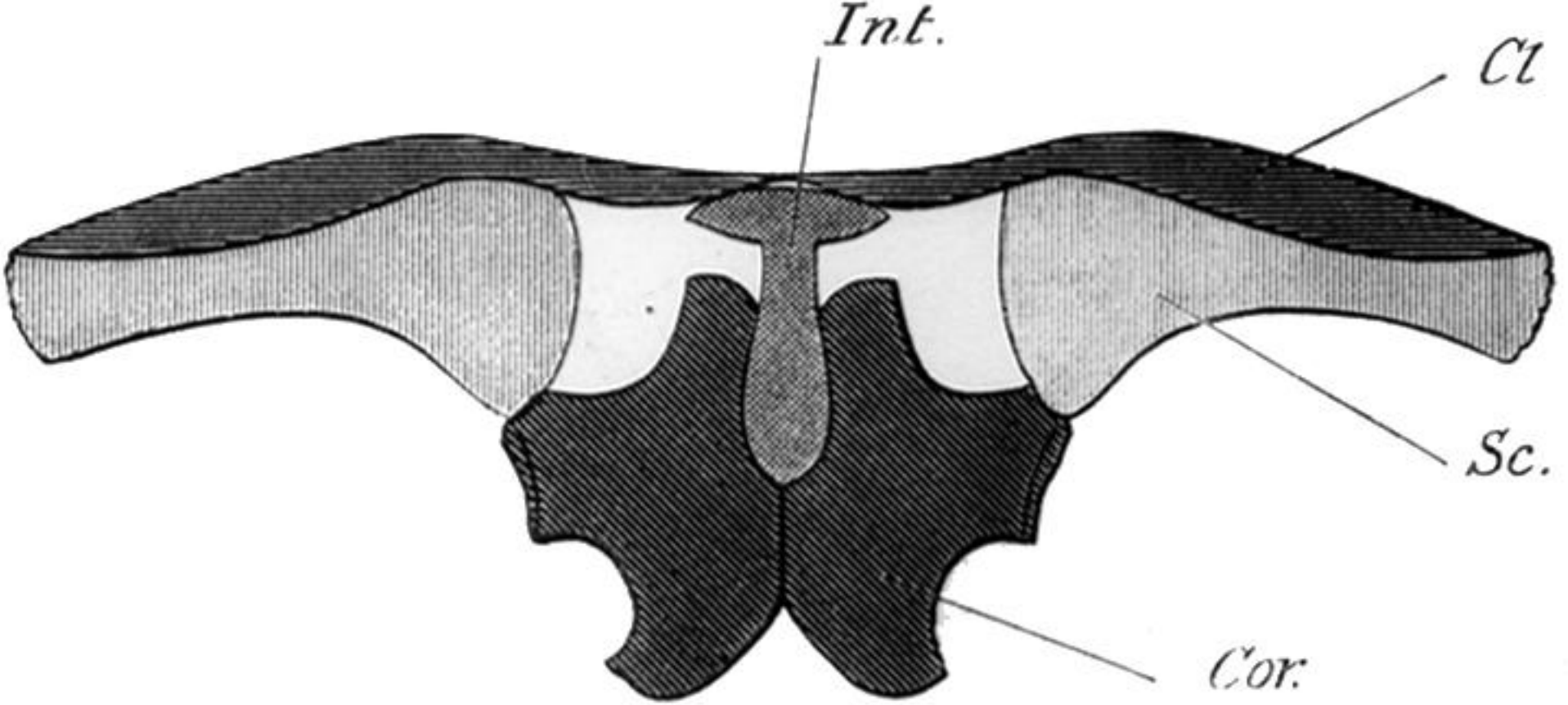


FIG. 2.—Conybeare's reconstruction of pectoral girdle of *Ichthyosaurus* ('Trans. Geol. Soc. Lond.,' vol. 1, Part 2, Series 2, Pl. 49, fig. 7. Copied in 'Oss. Foss.' Edit. 3, Tome 5, Pl. 32, fig. 7).

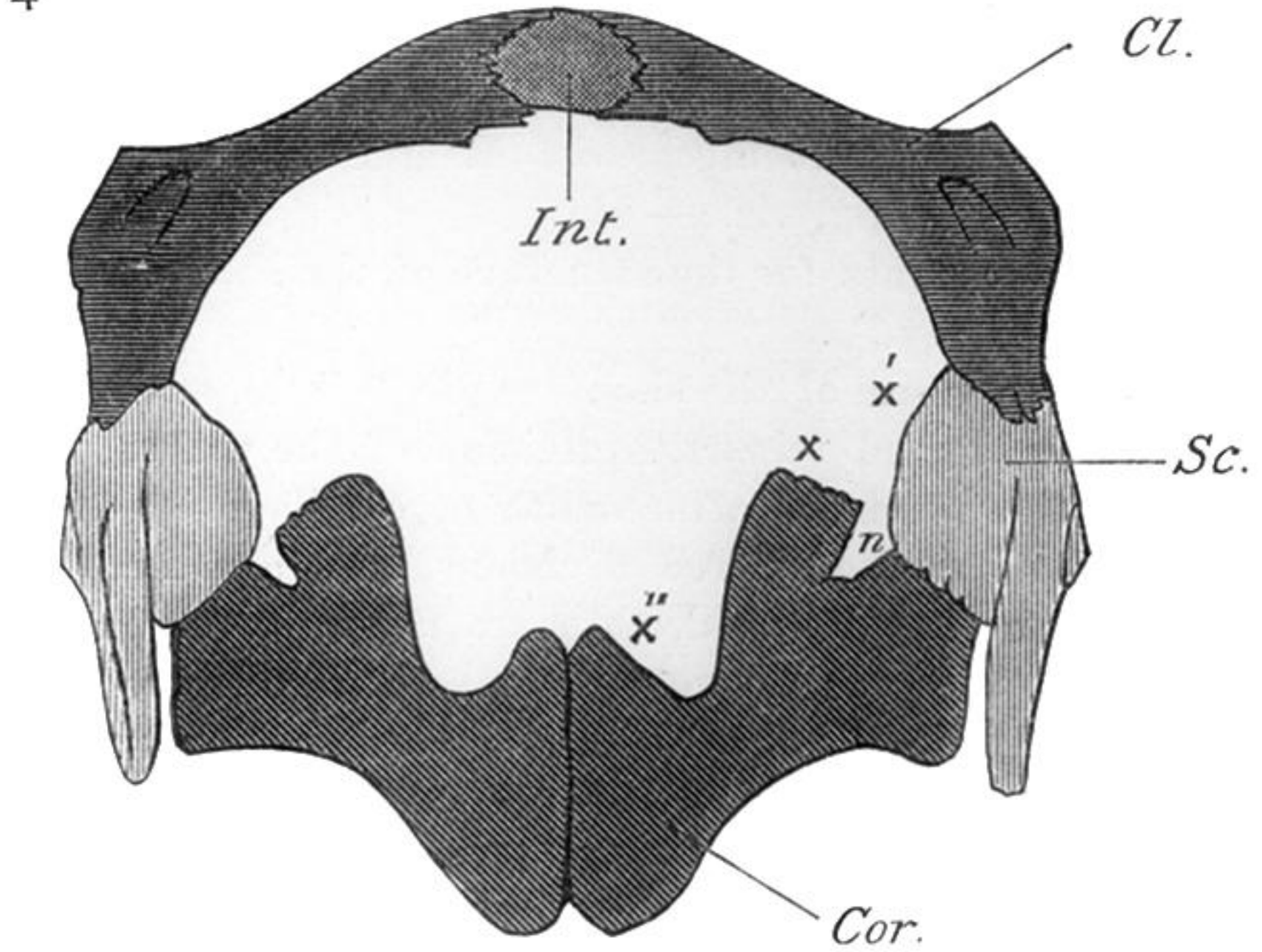


FIG. 3.—Shoulder girdle of *Nothosaurus mirabilis*. $\frac{1}{4}$ natural size. From Zittel's 'Handbuch der Palæont.,' Bd. 3, Lief. 3, S. 476. (This is a reduced copy of H. v. Meyer's, Fig. 1, Taf. 34, 'Saurier des Muschelkalks.')

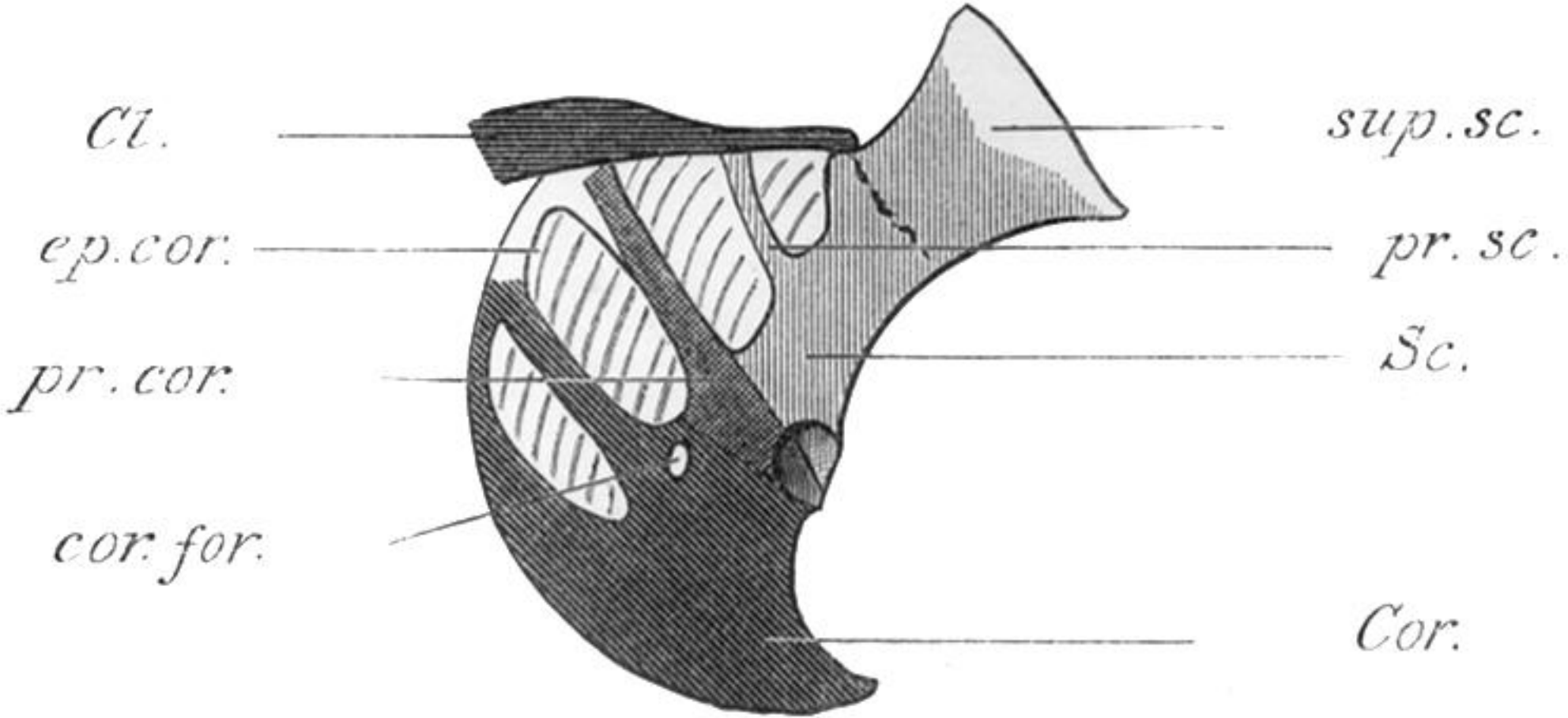


FIG. 4.—Left half of shoulder girdle of *Iguana tuberculata*.

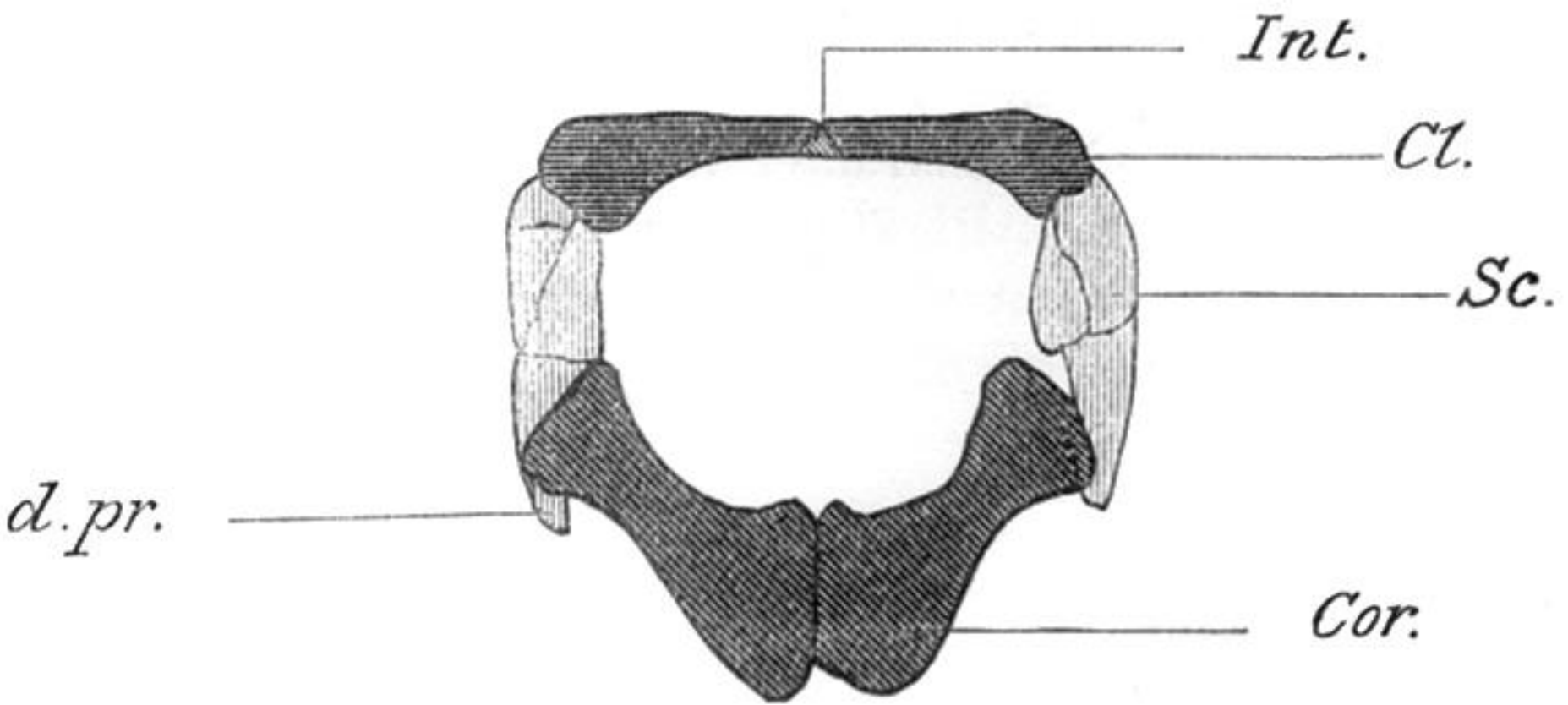


FIG. 5.—Shoulder girdle of *Lariosaurus Balsami Curioni* (ventral view). From Zittel, *op. cit.*, S. 488, fig. 462. *d.pr.*, dorsal process of scapula.

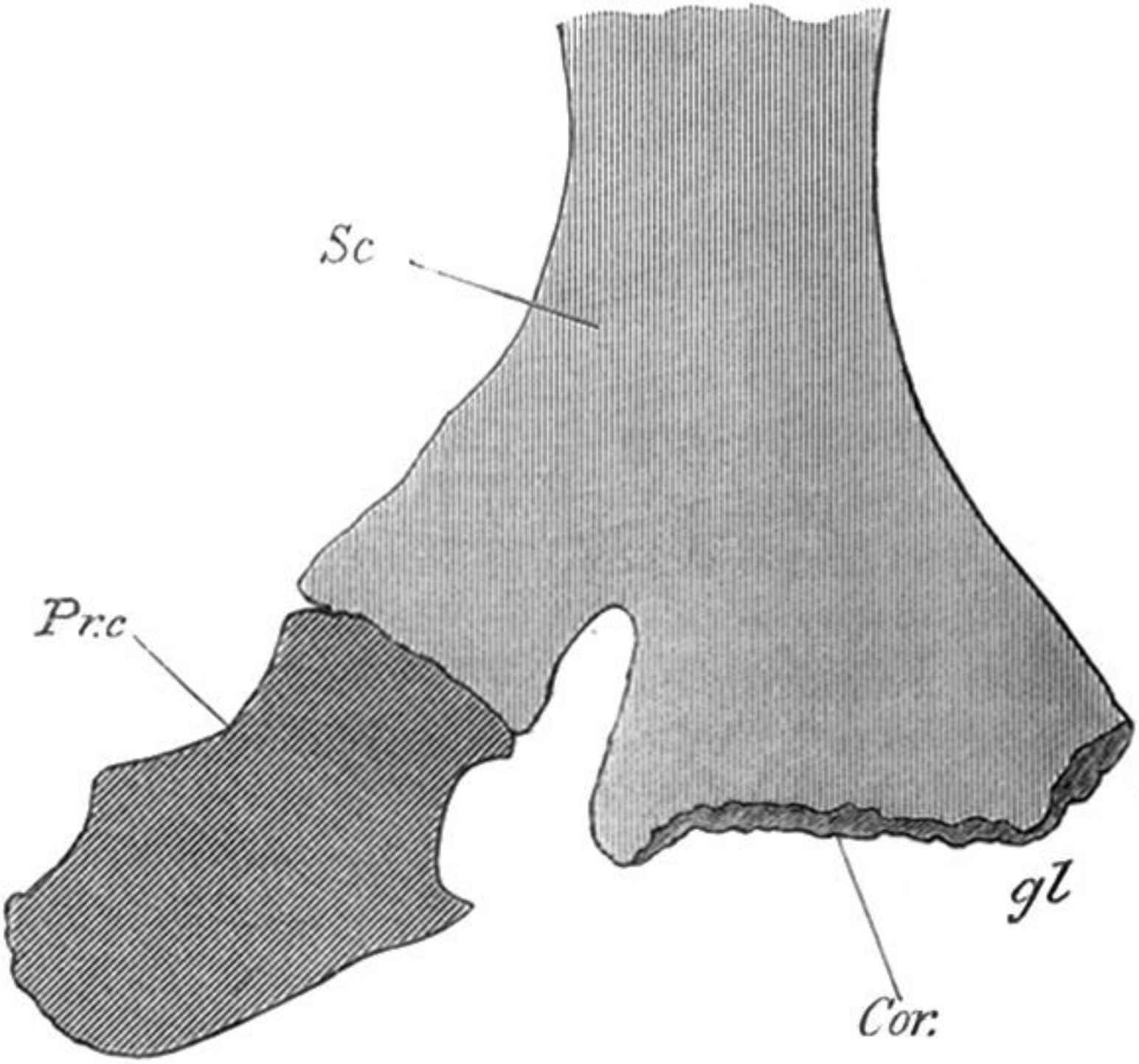


FIG. 6.—Scapula and precoracoid referred to *Dicynodon leoniceps*. Owen, 'S. Afric. Rept.,' Pl. 70, fig. 1. *pre.*, precoracoid; *gl.*, glenoid.

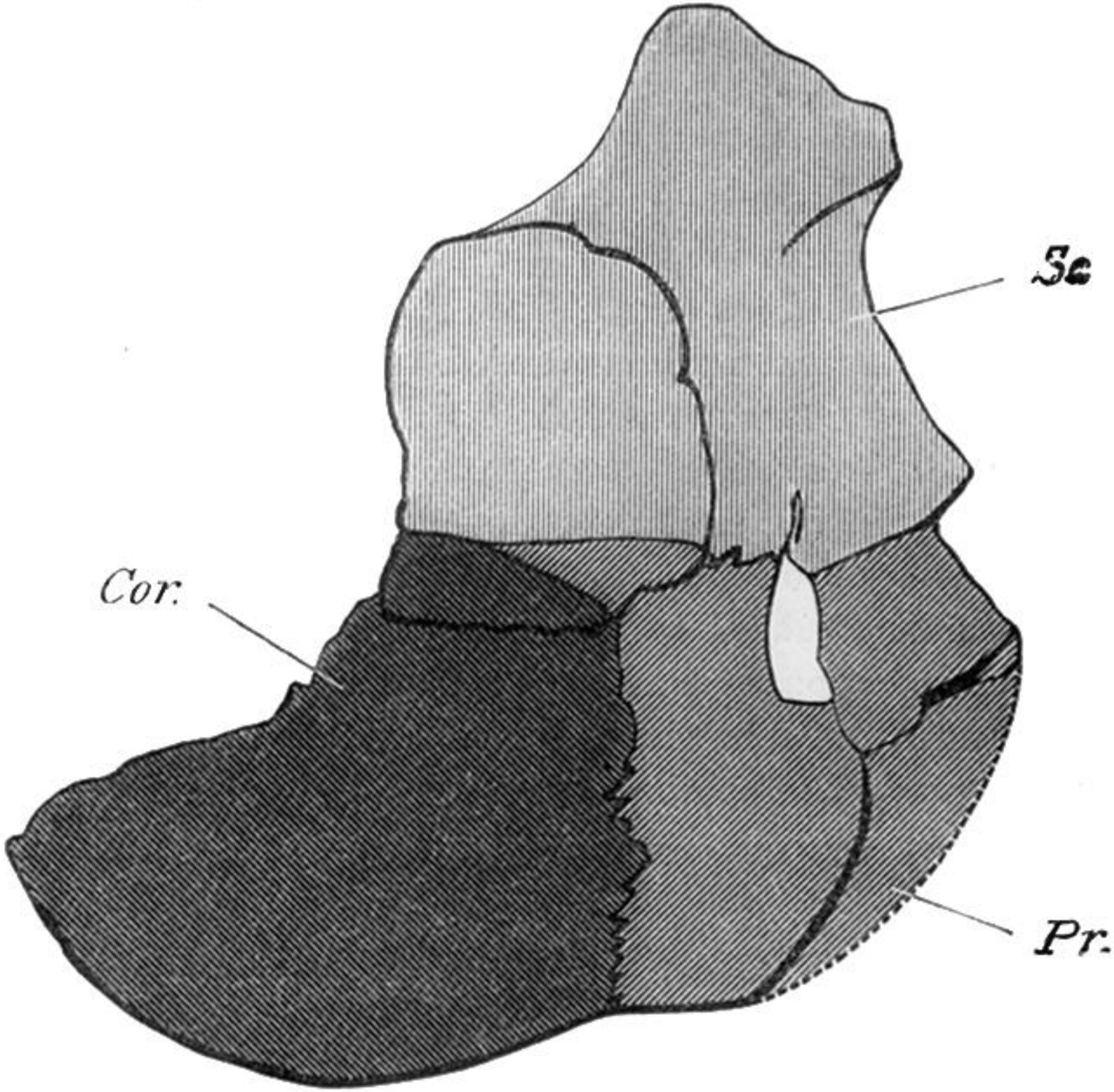


FIG. 7.—Scapula, coracoid, and precoracoid of *Dicynodon* (sp.). Owen, 'S. Afric. Rept.,' Pl. 69, fig. 5.

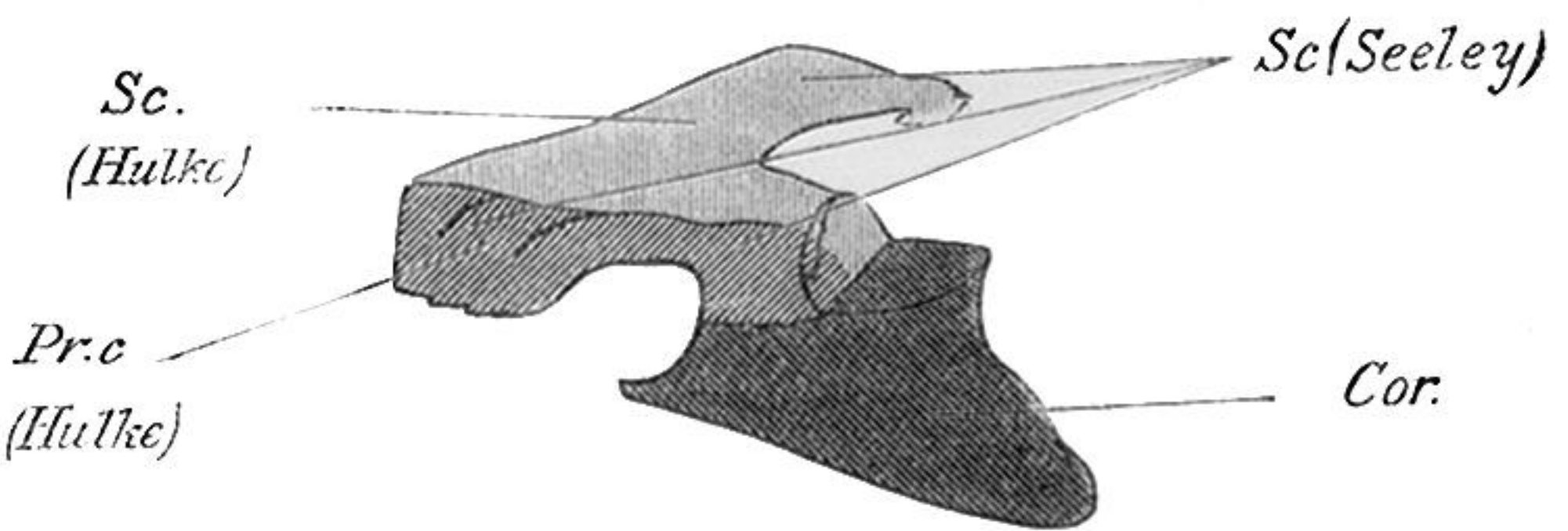


FIG. 8.—Left half of primary shoulder girdle of *Plesiosaurus cliduchus* (Seeley). From photograph of specimen in Woodwardian Museum; taken June, 1869.

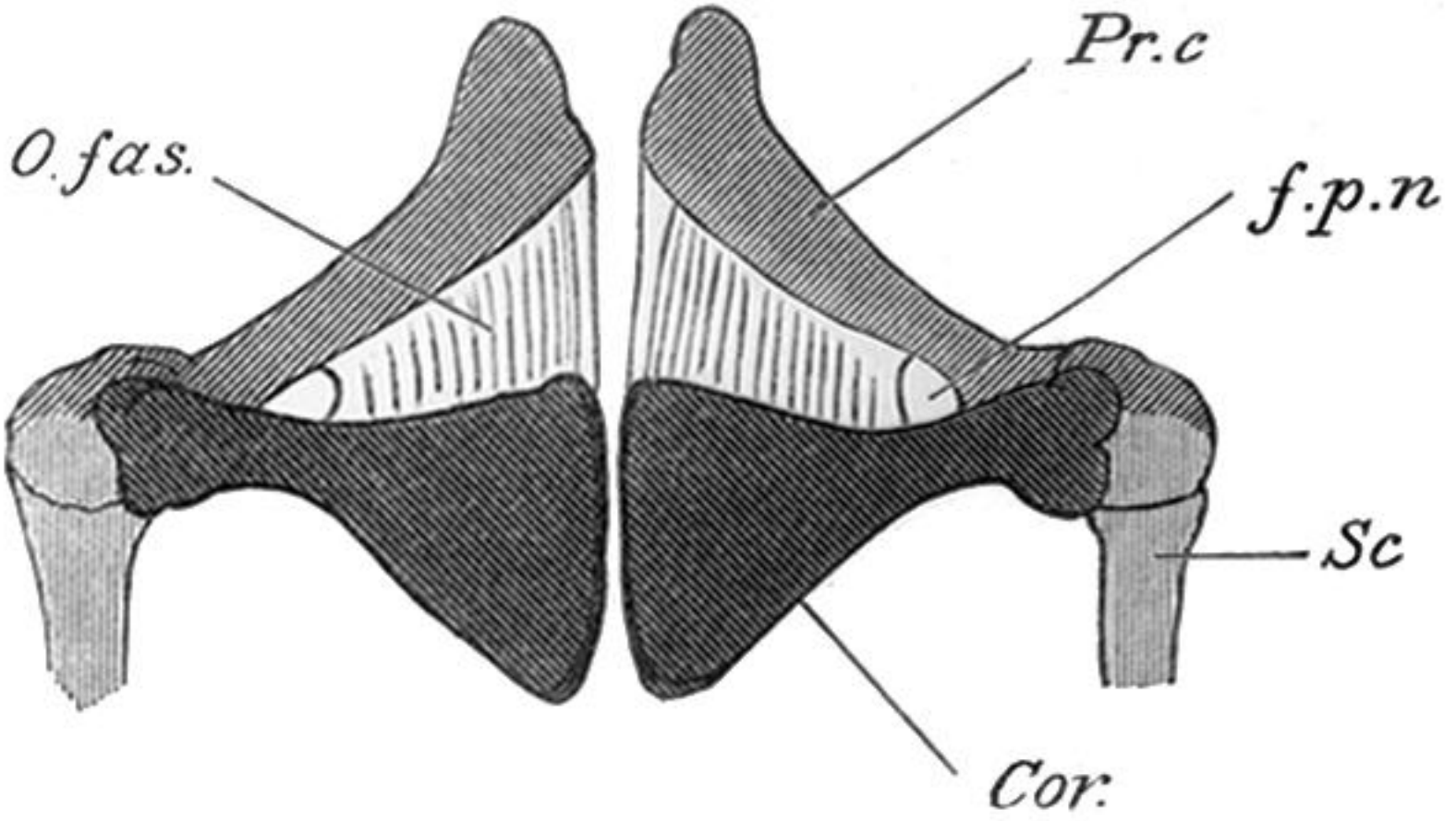


FIG. 9.—Shoulder girdle of *Emys Europæa*. *O. fas.*, obturator fascia; *f.p.n.*, foramen for nerve. From Hoffmann. Bronn's 'Klassen, Rept.,' Bd. 1, Taf. 8, fig. 7.