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On the Skull, Brain, and Auditory Organ of a New Species of Pterosaurian (Scaphognathus Purdoni), from the Upper Lias near Whitby, Yorkshire

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NOTE.—Plate 77, figs. 8, 9, and Plate 78, figs. 10, 11, in Mr. NEWTON'S memoir on "A New Species of Pterosaurian" (pp. 503–537), were copied from a memoir by Dr. GÜNTHER in 'Phil. Trans.,' Vol. 157, Plate 26, figs. 1–5.

XIX. *On the Skull, Brain, and Auditory Organ of a new species of Pterosaurian* (Scaphognathus Purdoni), *from the Upper Lias near Whitby, Yorkshire.*

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[PLATES 77, 78.]

INTRODUCTORY.

THE Rev. D. W. PURDON, of Wolverhampton, obtained some years ago, from the Alum Shale * at Lofthouse, near Whitby, the skull of a Pterodactyl. This was brought to me last autumn, much obscured by the surrounding hard matrix. As the specimen seemed likely to repay a careful study, the owner's permission was obtained to clear away more of the matrix; and to him my best thanks are due for the very courteous manner in which he left the fossil in my hands, to be treated in whatever way was best calculated to develop its structure and add to its scientific value. By careful work with the chisel I succeeded in laying bare much more of the skull, and it has proved to be of unexpected value, and, for several reasons, of exceptional interest. In the first place, no Pterodactyl remains have previously been recorded from the Yorkshire Lias; in the second place, the form is certainly new, and seems nearly related to the Continental Oolitic species, *P. crassirostris*. Again, this skull has undergone little or no compression, and consequently the natural relations of the bones are well preserved, and the structures of the basal portions, including the palate and back of the skull, are better shown than in any Pterosaurian from this side of the Atlantic hitherto described.† And still further, the form of the brain and parts of the auditory organ being preserved, their structure and relation to the entire skull can now be studied in a manner not previously possible.

DESCRIPTION OF SKULL.

This Pterodactyl skull, in its present condition, measures five-and-a-half inches in length (140 mm.); but, as the snout, from just in front of the nasal apertures, is

* My colleague, Mr. BARROW, tells me this must be the Alum Shale of the Upper Lias.

† The skull of *Pteranodon longiceps*, as given by Professor MARSH, seems to be in a very perfect condition; but it has not yet been fully described. See 'Amer. Journ. Sci.,' vol. 27, 1884, p. 423.

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wanting, its proper length is uncertain—probably, when perfect, it was about two inches longer. The extremely thin outer plates of the bones are almost all broken away; this, however, is not altogether a disadvantage, for not only has it exposed several casts of the air cavities, that seem to have occupied the interior of every bone, but the margins of many of the bones are now shown, which, if the external layer had been intact, would probably have been obscured. Both sides of the skull are somewhat broken, but what is wanting on one side is preserved on the other. The supra-occipital region was also broken away when the specimen came into my hands. In a lateral view (Plate 78, figs. 2, 3) there are five distinct apertures. The anterior one is the elongated nasal aperture (*e.n.*); behind this is the somewhat larger ant-orbital fossa (*ant. orb.*) or median aperture; and then comes the orbit (*orb.*), the last named being the largest of the five. Behind the orbit are the infra-temporal fossa (*inf. tem.*) and the supra-temporal fossa (best seen in Plate 77, fig. 1, *sup. tem.*), and these are smaller than any of the other three.

The whole of the snout in front of the nasal apertures seems to be formed by the premaxillæ (*pm.*), which bound these openings anteriorly and above; on the palate (fig. 4) they are firmly united, and form a plate of bone extending from one alveolar margin to the other, these margins standing as a ridge on each side, with a shallow depression running along just within them. Another groove runs along the middle, deepening as it approaches the internal nasal apertures. A slight ridge is seen in the middle of the groove, which passing back, joins what is evidently the vomer (*vo.*). The bony palate extends backwards for some distance on the outer side of the internal nares; but it seems probable that the portion behind the line seen passing obliquely forwards and outwards from each of these apertures may be a palatal portion of the maxilla. If this be so, then some of the teeth probably belonged to the maxilla.

On the middle of the upper surface of the skull (fig. 1) a long tract of bone, which I believe to be an extension of the premaxillæ, runs backwards, and, separating the nasals and pre-frontals, reaches the frontals at about the anterior third of the orbit. On the outer side (fig. 3) the premaxilla, after forming the lower boundary of the external nares for about three-fourths of an inch, seems to overlap and lie external to the maxilla, but how far it extended backwards is uncertain, possibly it may have run some distance below the ant-orbital fossa. On the right side, the alveoli for four flattened teeth may be seen. The first, at the extreme end of the specimen, is small, having a long diameter of 2·5 mm.; after an interval of 5·0 mm., there is a second alveolus, with a long diameter of 5·0 mm. and a short diameter of 3·5 mm. Another interval of 6·0 mm., and a third alveolus of 4·0 mm.; again, a space of 6·5 mm., and then the fourth alveolus, 4·2 mm. in diameter. On the left side traces of similar alveoli are seen, but they are less perfect.

The right maxilla (fig. 3, *mx.*) is better preserved than the left, and its front part appears to be on the inner side of the premaxilla, but the junction of the two bones is very obscure, as it is in Birds. Posteriorly the maxilla has two processes; one extending upwards and backwards forms the hinder two-thirds of the lower boundary of the nasal aperture, and then joins the bone which is believed to be the lachrymal, above the ant-orbital fossa. The second or lower process is narrow and extends backwards to the jugal region. At this point, on the right side, the maxilla is broken away; but the portion here wanting is present on the left side (fig. 2), where it comes below the lower angle of the jugal (*ju.*), and seems to meet the quadrato-jugal (*qu. ju.*). The jugal is a V-shaped bone (fig. 2, *ju.*), forming the lower boundary of the orbit; one limb, passing upwards in front of the orbit, meets the lachrymal; the other limb rises behind the orbit, and has its posterior edge occupied by the quadrato-jugal. On the right side (fig. 4) the lower part of the jugal is seen to be inclined forwards and to lie on the inner side of the maxilla. This V-shaped jugal is quite unlike any of the bones in a Bird's jugal arch; but in *Chamæleo*, *Lacerta agilis*, and other Lizards* the jugal bone has a somewhat similar form, extending backwards from the lachrymal below and then upwards behind the orbit, where it meets the post-orbital. The quadrato-jugal (fig. 2, *qu. ju.*) forms a vertical triangular plate behind the jugal, the base of the triangle being below and the apex extending upwards to meet the post-orbital (*pt.o.*). From the lower and hinder part of the quadrato-jugal a splint of bone runs up the front and outer margin of the quadrate (*qu.*). On the right side (fig. 3) the jugal, quadrato-jugal, and quadrate are much broken. In all Birds the quadrato-jugal is a slender bone and quite unlike this bone in the Pterodactyl, while it is wanting in all Lizards except *Sphenodon*, and in this the lower temporal bar is formed by the jugal bone, while the quadrato-jugal is fixed to the outer side of the quadrate.† The Yorkshire Pterodactyl has the lower temporal bar much reduced in antero-posterior extent, while its distance from the supra-temporal bar is proportionately greater; it is not surprising, therefore, to find the quadrato-jugal, as well as the jugal, with a greater vertical than horizontal extent.

At the hinder end of the external nostril on the left side (fig. 2, *en.*) there is a portion of a bone (*na.*) which, when perfect, probably extended from the premaxillary process above to that of the maxilla below, thus forming the hinder boundary of the nasal aperture, and sending backwards a narrow slip between the lachrymal (*la.*) and pre-frontal (*p.fr.*), terminated just in front of the anterior corner of the orbit. This bone occupies the position of the nasal.

Two elongated convex tracts seen on the upper surface of the skull are thought to indicate the positions of two large pre-frontals‡ (figs. 1, 2, and 3, *p.fr.*), which would thus be separated from each other by the long premaxillary processes; anteriorly and

* PARKER, 'Phil. Trans.,' 1879, Plate 42, fig. 3; and 'Zool. Soc. Trans.,' vol. 11, 1881, Plate 16, fig. 1.

† BAUR, 'Zoologischer Anzeiger,' No. 238, 1886.

‡ Since the above was written I have had the opportunity of showing the specimen to Dr. G. BAUR, of Yale College, who has so carefully studied the skull of *Sphenodon;* and he suggests the possibility of the area, which I have, with some doubt, called pre-frontal, being only part of the bone marked as nasal. It is by no means clear that these two areas can represent a single bone; but, if they do, then there will be no distinct pre-frontal bone.—E. T. NEWTON, *Sept.* 25, 1888.

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externally they are bounded by the nasals, and posteriorly by the frontals (*fr.*), each of which sends forward a slender process separating the pre-frontal from the orbit.

The frontal bones themselves occupy the upper part of the skull between the orbits, of which they form the upper boundary; how far they extended backwards is uncertain, as the parietal and supra-occipital regions have been broken away, but probably they covered the whole of the cerebrum (*cb.*). In the front region of each cerebral lobe the inner and outer tabulæ of the frontal bone, when perfect, evidently met, and, shutting out the air cavity at this point, apparently formed one thin bony plate.

Within the anterior angle of the orbit (figs. 1, 2, and 3) lies the excavated hinder end of a bone (*la.*) which extends forwards, below the nasal bone, to meet the superior process of the maxilla (*mx.*), and downwards along the front border of the jugal, thus forming the upper and hinder boundary of the ant-orbital fossa. This bone has the characters and relations of the lachrymal.

The upper and hinder margin of the orbit is separated from the supra-temporal fossa by a buttress of bone, springing from the hinder frontal region, which occupies the position of post-frontal and post-orbital bones, and may include both these elements, as in *Sphenodon.** Externally this buttress arches downwards, and meets the ascending process of the quadrato-jugal, and possibly that of the jugal also. To what extent the post-orbital enters into the formation of the supra-temporal bar is uncertain, no sutures being seen; but probably the post-orbital and squamosal form about equal parts. In *Sphenodon* the triradiate post-orbital (marked *m.* by Dr. GÜNTHER) meets the squamosal to form this bar; and Professor W. K. PARKER† has shown that the same arrangement occurs in the Chameleon. Moreover, the skulls of *Pterodactylus crassirostris*‡ and *Dimorphodon macronyx*§ both appear to have the supra-temporal bar formed in this same manner.

The supra-temporal fossa is bounded behind by another buttress of bone, the upper part of which arises from the parietal region of the skull (figs. 1 and 5), and the lower part is in close relation with the auditory capsule. Judging from the intimate structure of the skull in *Chamæleo*, *Lacerta*, and other forms of Lacertilia, with which Professor PARKER has made us so fully acquainted,‖ the upper proximal part of the bar will be formed by the parietal, and this, resting upon the auditory capsule, will probably include parts of the otic bones. The external part of the bar is no doubt formed by the squamosal, which gives a point of attachment for the quadrate, and doubtless forms, with the post-orbital, the supra-temporal bar. The squamosal, as we shall presently see, is supported behind by the parotic process, which wraps round the

* See GÜNTHER on *Hatteria*. 'Phil. Trans.,' 1867, pt. 2, Plate 1, fig. 4, bones marked *l.* and *m.* Also, BAUR, 'Zoologischer Anzeiger,' No. 240, 1886.

† 'Zool. Soc. Trans.,' vol. 11, 1881, Plate 16.

‡ GOLDFUSS, 'Nova Acta Leopold.,' vol. 15, 1831, Plates viii. and ix.

§ OWEN, 'Palæontogr. Soc.: Reptiles of the Lias,' Plate 20, 1869.

‖ 'Phil. Trans.,' 1879, p. 595; and 'Zool. Soc. Trans.,' vol. 11, 1881, p. 77.

upper part of the quadrate. The post-temporal fossa (fig. 5, *pt.fos.*), which is so well seen in *Sphenodon* and is extremely large in the common Chameleon, is here very small, being reduced to an oval slit.

The base of the cranium (figs. 4 and 5) is remarkable in that its height is greater than its antero-posterior extent. At the back there is a broad plate of bone, about 13 mm. wide, which extends from the foramen magnum downwards and forwards for about 15 mm. The occipital condyle is wanting; but on each side, and a little below the level of the foramen magnum, there is a large and deep depression; doubtless it is the foramen for the exit of nerves (probably ninth, tenth, and twelfth). Near the middle of each side of the flattened base there is a prominent rounded process. Below this the base narrows somewhat, and from its lower and anterior edge two long rod-like bones or processes (*bp.p.*) pass down to the inner angle of the quadrate. This is very like the base of the Chameleon's skull, except that it is more nearly vertical, and doubtless, like it, includes the basi-occipital and basi-sphenoid, as well as parts of the exoccipitals; but no sutures remain to show the extent of each. The long rods are probably the homologues of the basi-pterygoid processes of the sphenoid, but their great length suggests the possibility of their being separate bones. The front of the basi-sphenoid descends almost vertically, and then curves forwards as it divides into the two basi-pterygoids.

On each side of the foramen magnum there is a large paroccipital process (fig. 5, *op.ot.*), which extends outwards, leaving an oval space between itself and the post-temporal buttress; but towards its distal extremity it expands into a broad fan-like plate, which is applied against the hinder and outer part of this buttress and wraps round the head of the quadrate, holding the latter bone, immovably as it seems, against the squamosal. Precisely similar paroccipital processes are developed in Lizards, and Professor PARKER* has shown that they are mainly formed by the opisthotic bones, the basal portion of each containing the lower and hinder parts of the posterior and horizontal semicircular canals. The exoccipitals only form a small part of the base of these processes. In the fossil the auditory semicircular canals have been traced (see p. 511), and are found to have this same relation to the base of the paroccipital process. At the outer end of each paroccipital process, and forming the hindermost angles of the skull, there seems to have been a small separate bone, which occupies the position of and probably is the supra-temporal, a bone said to be constantly present in Lizards.

The front and side of the brain case have been exposed by clearing away the matrix from the orbit and temporal fossa on the right side, and its relatively small size is shown in fig. 3*a*, where it is represented without the supra-temporal bar, so as to show the parts more clearly.

The sides of the cranium are completely ossified, but in front there is a large rounded aperture. Through the lower part of this opening, no doubt, the optic nerves

* *Loc. cit.*

passed; and it is tolerably certain, therefore, that the pre-sphenoids and orbito-sphenoids were not ossified. A little below the large front opening, and towards the side, is an aperture completely surrounded by bone, through which in all probability the fifth nerve passed out of the cranium (Plate 78, fig. 3*a*, *v.*).

The quadrate forms a broad extent of bone, seen chiefly at the back of the skull (figs. 2, 4, and 5, *qu.*). Its hinder part is convex from side to side, the inner and outer margins being directed forwards; but, although wide, it seems to have been extremely thin, appearing upon the side of the head merely as a slender rod (fig. 2). Its upper part is narrow, and wedged in between the squamosal and the broad end of the opisthotic or paroccipital process. Passing downwards, it rapidly widens, leaving a comparatively small space between its upper part and the base of the skull (fig. 5). The articulation for the lower jaw is wanting, but, judging from other specimens, little more than the rounded surface has been lost. The inner and lower extremity of the quadrate is continued directly into the pterygo-palatine bar (fig. 4), the impressions of the bones at this point showing no indication of a division, the quadrate and pterygoid apparently being firmly attached, if not ankylosed. The basi-pterygoid process meets the quadrate and pterygoid at their point of union, but, being broken at this part, one cannot say whether they were fixed to each other, although the manner in which the basi-pterygoid lies close along the inner edge of the distal part of the quadrate makes it probable that they were immovably attached.

Directly in front of the quadrate the pterygo-palatine bar widens, but the form of the bone at this point is uncertain, as it is somewhat broken; however, it is clear that it formed a thin plate extending forwards to the point marked *pl.* (fig. 4). The inner edge of this plate is thickened, and extends forwards continuously until it meets the triangular plate in the middle line (*vo.*), which there can be little doubt is the vomer. The outer margin of the pterygoid portion of the bar is also thickened, and at a distance of about 15 mm. from the quadrate comes very near to the slender extremity of the maxilla. Some markings on the matrix at this part seem to indicate the former existence of bone, which may have been a transpalatine. GOLDFUSS has described in *P. crassirostris* a portion of bone in this position, which he calls a transverse bone.* The thin plate of the pterygo-palatine bar is nearly horizontal just in front of the quadrate, but, as it passes forwards, the outer edge descends and the inner rises a little towards the roof of the skull, thus tilting the plate; and at a distance of about 25 or 30 mm. from the quadrate it divides into an inner and an outer portion, the slender inner rod extending to the vomer, as already noticed, while the outer portion, becoming more inclined, rapidly assumes a vertical position, and passing forward, evidently joins a palatine plate of the maxilla. The actual junction of these two bones is not seen, but they can be traced to within 6 or 7 mm. of each other, and then a small piece has been broken away. The long aperture (about 35 mm.) enclosed by the palatine behind and the maxilla with the vomer in front is, without doubt, the

* 'Nova Acta Leopold.,' vol. 15, 1831, p. 76.

internal nares (fig 4, *in.*), and anteriorly it is only separated by the vomer from the corresponding aperture of the opposite side. The front of the internal nares is about 32 mm. further back than the front of the external nares.

The absence of any traceable division in what has been called above the pterygo-palatine bar, and the large size of the basi-pterygoid process (*bp.p.*), leads one to question whether the last-named bone may not be the pterygoid, and the bar in front of the quadrate the palatine only. In the first place, it must be remembered that the fixity of all the bones of the Pterodactyl skull, and as a consequence the ankylosis of many of them, makes it probable that the bones of the palate would become soldered together; and this certainly seems to have taken place at the junction of the quadrate with the bones of the palate. The manner in which the front part of the bar bounds the hinder end of the internal nares leaves no doubt as to this portion being the palatine; and as the normal position of the pterygoid is between the palatine and quadrate, the hinder part of the bar is believed to be the pterygoid. It is true the pterygoid bone sometimes extends from the quadrate to the base of the skull, as in many Birds, but even when this is the case it still separates the palatine from the quadrate. I am not aware of any case among Reptiles or Birds where the palatine comes into relation with the quadrate to the exclusion of the pterygoid. That the basi-pterygoid process may be much elongated is seen among Birds in the Emu* and among Lizards in the Chameleon.† In the Emu the relations of the bones are strikingly similar to what is seen in this Pterodactyl, for the long basi-pterygoid abuts upon the hinder end of the pterygoid close to the quadrate, just as in the fossil. The basi-pterygoid of the Chameleon is similarly long, and directed forwards to support the pterygoid, while a backward process of the latter extends to the quadrate. Taking into consideration the arrangement of the bones which we know occurs in Birds and Lizards, it seems much more in accordance with them to regard the bone which, in this Pterodactyl, extends from the base of the skull to the quadrate as an elongated basi-temporal process of the basi-sphenoid, and the bar in front of the quadrate as the combined pterygoid and palatine bones.

Description of the Brain.

When this Pterodactyl skull was first brought to me, the fracture of the parietal and frontal bones had exposed a part of the cast of the cranial cavity in the cerebral region, and it seemed likely that a cast of the whole interior of the skull had been preserved. The small relative size of the cranium made it highly probable that the brain had originally filled the cavity, and, if so, the cast would give the form of the brain. To expose this cast on one side, I obtained Mr. Purdon's permission to remove a portion of the bone, and having raised the greater part of the left frontal in

* Huxley, 'Zool. Soc. Proc.,' 1867, p. 422.

† Parker, 'Zool. Soc. Trans.,' vol. 11, 1881, Plate 19, fig. 2.

one piece, little by little other parts were cleared away, until I had succeeded in exposing not only the cast of the left half of the brain, but also a large part of the auditory organ. The form of the cast exposed leaves no doubt but that it represents the form of the Pterodactyl's brain, just as much as would a cast taken from the skull of a Bird or Mammal; and such casts show the natural external form of the brain even better than a brain itself, which, being very soft, is apt to be distorted and shrunken by the means adopted for its preservation. Taking the cast, therefore, as representing the brain (figs. 1, 6, and 7), it will be seen to be relatively small, its greatest length, from the edge of the occipital foramen to the front of the cerebral lobes, being 25 mm., and its greatest width—that is, across the optic lobes—17 mm.; it is therefore about one-sixth or one-seventh the length of the entire skull. Each cerebral lobe is a somewhat depressed egg-shaped mass, wide behind, narrow in front, and separated from its fellow by a deep groove, which is naturally occupied by the inner edges of the frontals; anteriorly, it is continued into a small triangular olfactory lobe, which can be traced for about 5 mm. in front of the cerebrum. The thickness of each cerebral lobe is not quite as great as its width (fig. 6), and below, at about its hinder third, there is a depression or fissure. A large optic lobe is placed directly behind the cerebral hemisphere, and is separated from it by a well-marked groove, which is seen on the side of the brain running upwards and backwards, and then over the upper surface to within 5 mm. of the middle line (fig. 7); the optic lobe itself extends a little further inwards, and is then broken away, its height being a little greater than that of the cerebrum. A second and shallower depression, seen on the upper surface of the brain, running round the back of the cerebral lobe, marks off a triangular space.

Unfortunately, the cerebellum is almost wholly wanting, and this is much to be regretted, as it is the relation of this to the optic lobes which is of so much interest when the possible relations between Birds and Pterodactyls are discussed. However, we are not without some indications of its position, for on the right side, at the point marked *cbl.* (figs. 1, 6, and 7), a fragment of the cerebellum marks its hinder boundary to very nearly the middle line; on the left side, the optic lobe is preserved to within 4 mm. of the middle line; and between the hinder part of the cerebral lobes there is a small triangular rising, occupying the position of a pineal lobe. The hinder boundary of the cerebellum is fixed, and it is also certain that it cannot have extended beyond the other points just noticed, and may not have extended quite so far. The greatest length of the cerebellum could not have been more than 10 mm. or its width more than 7 mm. It is tolerably clear, however, that the cerebellum extended between the optic lobes, somewhat as in Birds, and that the optic lobes did not separate the cerebrum from the cerebellum, as they do in all Reptiles.

Being anxious to corroborate this extension of the cerebellum between the optic lobes, I examined the Pterodactyl skulls in the British Museum, but without success. Mr. R. LYDEKKER, however, showed me a specimen in the Fox collection which included a cranium; and Dr. H. Woodward, with his usual courtesy, had the specimen cut through longitudinally in the middle line. This section exhibits the brain cavity under a considerable thickness of open cancellous bone. The upper part of the cavity forms a double arch, one curve extending from the foramen magnum upwards and forwards for nearly half the length of the cavity, while the second and rather longer curve continues from this to the front. The section being in the middle line, the anterior of these curves will be between the cerebral lobes, and consequently does not give their proper convexity, although showing their antero-posterior extent. The hinder curve, as I understand it, is that of the cerebellum; for if the optic lobes in any part came between the cerebrum and the cerebellum, some slight indication of them ought to be seen by a break in the curve where the cerebellum ended. No such mark is seen, and I conclude, therefore, that the cerebellum reached to the cerebrum in this Wealden specimen, and probably also in that from the Yorkshire Lias.

A little behind the optic lobe, and separated from it by a definite space, there is a large pyriform flocculus (figs. 1, 6, and 7, *fl.*). This body, which is somewhat flattened from above downwards, is attached by its broad end to the side of the hind brain just below the cerebellum, and is directed outwards and backwards. Until exposed by the chisel the flocculus was contained in a cavity of the bone situated in the base of the hinder supra-temporal buttress at its junction with the opisthotic, and, consequently, immediately on the inner side of the post-temporal fossa (fig. 5), from which it was separated only by a thin plate of bone. The lower and outer edge of the flocculus is marked by a depression or groove, which divides it into a larger proximal and a smaller distal portion. The finding of this flocculus was as advantageous as it was unexpected, for although not seen in Lizards, it is present in Birds, and has served as a landmark in exploring the auditory region.

Sensory Organs.

If the interior of a Bird's skull be examined, such as that of a Goose, there will be found on each side, in the region of the auditory organs, a large recess hollowed out of the bony periotic capsule. (A similar cavity is found in some Mammals, such as the Rabbit.) This recess, as is well-known, is occupied by a lobule given off from the side of the hind brain, called the flocculus; and around it the various parts of the internal ear are arranged. Just below the entrance to this cavity are the foramina for the auditory nerves passing to the vestibule, which lies just below the inner part of the flocculus. The anterior vertical semicircular canal arches over the entrance to the recess, close to the inner side of the skull, and the posterior vertical canal forms an arch just behind it; while in a plane a little below and underneath it, the horizontal canal forms a segment of a circle, with the convexity turned outwards.

In clearing away the bone of the fossil surrounding the flocculus of the left side, a small tube filled with black matrix was found, arching over the pedicle of the flocculus and dipping down between it and the optic lobe. This canal was removed from the left side, but its fellow is still seen in place on the right (figs. 1 and 7), and its position is precisely that of the anterior vertical semicircular canal of a Bird. By carefully tracing this tube backwards and downwards another was uncovered, joining it and forming an arch behind the flocculus corresponding in position with the posterior semicircular canal of a Bird. Having thus uncovered two of the canals, it seemed very probable that the third would be found under the flocculus. The exploration here was more troublesome, as it was necessary to dig somewhat under the flocculus; but a portion of a horizontal tube was at length discovered, which, although seemingly larger than the two placed vertically, is believed to be part of the horizontal semicircular canal. The front limb of the anterior canal seems to be enlarged at its lower part, but of this one cannot speak with certainty; and a similar enlargement is seen at the lower end of the hinder limb of the posterior canal. These enlargements, it will be noticed, are in the same positions as the ampullæ in Birds; and indeed the close resemblance, in all essential particulars, which these canals in the fossil bear to those of the auditory apparatus of Birds, leaves no room for doubting that they had a similar function.

With regard to the fenestra ovalis we can now speak with confidence. The quadrate and base of the skull being so similar in the Pterodactyl and in the Chameleon led one to expect that the fenestra ovalis would have a similar position in both; and when the matrix was cleared away from the right side of the base of the fossil skull, within the temporal fossa, this aperture was found in a deep hollow just in front of the lower part of the paroccipital process (fig. 3*a*, *fo.*). GOLDFUSS in his description of *Pterodactylus crassirostris** noticed an aperture in this position which he thought might be the opening of the ear.

In Lizards which have an ear-drum the quadrate is curved over and forms an attachment for it; but in the Chameleon, which has no external drum, the quadrate is straight and the outer end of the stapes abuts upon its inner side. In the Pterodactyl the quadrate is similarly straight, and the fenestra ovalis is, in like manner, partly hidden behind it, and, from this resemblance in structure, it seems fair to infer that this Pterodactyl, like the Chameleon, had no ear-drum.

The sense of vision seems to have been keen in the Pterodactyl, for the orbits are wide, and the large size of the optic lobes may probably be taken as an indication that the eyes were well-supplied with nerves. No sclerotic plates were found in this specimen, although careful watch was kept for them when clearing the matrix from the orbit.

The large size of the external nares might be thought to indicate a corresponding development of the sense of smell; but the olfactory lobes are too small to justify such a conclusion.

* 'Nova Acta Leopold.,' vol. 15, p. 72, Plate viii.

SYSTEMATIC POSITION OF THE YORKSHIRE PTERODACTYL.

In considering the relation which this Pterodactyl bears to other Pterosauria, we may at once dismiss all the Cretaceous species, for the American forms are characterised by the absence of teeth, as well as by other peculiarities of the skull, while the British species which are represented by portions of the skull, so far as they are known, have a ridge along the palate, and the anterior premaxillary teeth directed forwards. The anterior part of the snout being lost in the Yorkshire specimen, we do not know whether there were teeth in front or whether it terminated in an edentulous beak, as in *Rhamphorhynchus;* but the large size of the external nares and ant-orbital fossæ prevents a reference to that genus. Nearly all the forms which are generally placed in the genus *Pterodactylus* have the nasal aperture larger than the ant-orbital fossa, the latter being very small, and in most cases the two spaces are not separated by bone. Our fossil, therefore, will not agree with any of these.

There are two forms to which the Yorkshire fossil bears a closer resemblance, and these are *Dimorphodon macronyx* and *Pterodactylus crassirostris.* The former, being from the Lias, may be first considered. *Dimorphodon* * is characterised by the presence of two forms of teeth in the lower jaw, a few larger ones in front, and numerous small ones just within the edge of the hinder part of the jaw. Whether the Yorkshire specimen had these two kinds of teeth or not we do not know, and in the absence of this character, on which the generic distinction of *Dimorphodon* largely rests, one could hardly refer it to that genus, even if their resemblances were greater than they are; but it will be seen that the proportions of the skulls are quite different, as well as the relative sizes of the lateral apertures. In *Dimorphodon* the nasal aperture is larger than the ant-orbital fossa, while the orbit is smaller than either of them. In the Yorkshire skull the proportions are reversed, the nasal aperture being the smallest and the orbit the largest of the three. The great height of the skull of *Dimorphodon,* in proportion to its length, and the slenderness of all the bones are quite unlike the Yorkshire fossil. Although these characters by themselves might not be deemed sufficient for generic distinction, yet, seeing that the form next to be noticed makes a still nearer approach in the structure of its skull, one cannot but give the preference to that genus.

Pterodactylus crassirostris from the Lithographic Slates, as figured by GOLDFUSS,† VON MEYER,‡ and OWEN,§ certainly makes a nearer approach to our fossil than does any other form yet described, and a comparison of the figures just referred to with those here given (figs. 1–5) will show the close resemblance between them. The general form is very similar, and the relative proportions of the lateral apertures are

* OWEN, 'Palæontogr. Soc.: Reptiles of the Lias,' 1869 and 1874.

† 'Nova Acta Leopold.,' vol. 15, part 1, p. 63, Plate 7.

‡ 'Fauna d. Vorwelt,' p. 40, Plate 5.

§ 'Palæontogr. Soc.: Cret. Rept.,' 1851, Plate 27, figs. 2, 3, 4.

the same in both; indeed, so close is the agreement that the two cannot be generically separated, although there are points of difference which militate against their belonging to the same species.

The somewhat crushed condition of the skull of *P. crassirostris* makes its true form a little uncertain, yet it seems tolerably evident that it was originally more depressed than in our fossil; it has a median ridge extending, apparently, from the snout to the parietal region; and the ant-orbital fossa is somewhat triangular. The Yorkshire specimen, on the other hand, has the ant-orbital fossa more oval, and there is a definite channel along the middle of the upper surface of the skull, between the large pre-frontals and continued over the frontals as far as they are preserved; the teeth also seem to have been more numerous than in *P. crassirostris.*

These differences prevent the two specimens being placed in the same species, and their wide separation in time makes it still more certain that they are distinct forms.

Pterodactylus crassirostris, GOLDFUSS, has been thought by several writers on the Pterosauria to exhibit characters of the skull and other parts of the skeleton justifying its generic separation; and in the year 1843 Professor FITZINGER* proposed for it the name of *Pachyrhamphus*, while in 1861 Professor WAGNER† suggested that of *Scaphognathus*. Mr. R. LYDEKKER has pointed out to me that Professor FITZINGER'S name, having already been used for a genus of Birds, is preoccupied and cannot be adopted, although it has the priority, and Professor WAGNER'S name, *Scaphognathus*, must therefore be used.

I purpose naming the Yorkshire Pterodactyl after the gentleman to whom it belongs, as an acknowledgment of his patient kindness, which has permitted me to keep it sufficiently long to work out its points of interest, and to lay the results before the Royal Society; its name, therefore, will be *Scaphognathus Purdoni.*

COMPARISON OF SCAPHOGNATHUS PURDONI WITH OTHER PTEROSAURIANS.

The skulls of Pterosauria, hitherto described, are for the most part in a condition which renders a close comparison with *S. Purdoni* of little value; but still there are two or three forms which may with advantage be so compared. Taking, in the first place, *Dimorphodon macronyx*, one can fully appreciate Sir R. OWEN'S difficulty as to the extent of the maxilla, the terminations of which are so much obscured by the overlapping of the neighbouring bones. If my interpretation of the bones of *S. Purdoni* be correct, then the bone marked by Sir R. OWEN, No. 15 (nasal)‡ may possibly include also the pre-frontal, and the element marked No. 14 (pre-frontal) may be the lachrymal. The region in *D. macronyx* between the numbers 21 and 26 is so

* 'Systema Reptilium,' p. 35.

† 'München, Bayer. Akad. Sitzber,' Jahrg. 1861, vol. 1, p. 518.

‡ 'Palæont. Soc.: Lias Rept.,' 1874, Plate 20.

like the corresponding part of *S. Purdoni* that it will probably be found to include parts of both jugal and quadrato-jugal. The supra-temporal bar of *D. macronyx* was probably formed of two parts, as restored by Sir R. OWEN (*loc. cit.*); but it is not easy to distinguish these elements in the specimens themselves, and it seems most probable, as already stated (p. 506), that the hinder of these two bones is the squamosal. The rod marked No. 27 (squamosal) in Sir R. OWEN'S restoration occupies the position of the bone which in *S. Purdoni* I have called the basi-pterygoid, and that numbered 28 (tympanic) is what we now commonly call the quadrate.

Not having seen the original specimen of *S. crassirostris,* I am only able to make comparison with the figures and restorations published by GOLDFUSS.* There is in this specimen the same uncertainty as in *D. macronyx* as to the extent of the nasal and pre-frontal bones, and also of the premaxilla and maxilla. There can be no doubt that the bar of bone separating the nasal aperture from the ant-orbital fossa is formed by the maxilla and not by the premaxilla, and it seems probable that the hinder bar of bone† is also a part of the maxilla; but, as we have seen in *S. Purdoni*, it is quite possible that the premaxilla may extend backwards for some distance on the outside of the maxilla. The oblique line seen below the ant-orbital fossa is, I think, correctly interpreted by GOLDFUSS as the junction of the maxilla and jugal bones, the last-named bone being marked *m* by GOLDFUSS and 21 by OWEN. If this region of the skull is formed as in *S. Purdoni*, and the general resemblance makes this almost certain, then the bone marked *g* by GOLDFUSS and 27 by OWEN in his figure 3 will be a portion of the quadrato-jugal. GOLDFUSS described the jugal arch as consisting of two parts. The inner angle of the quadrate is seen to meet the long process from the basi-sphenoid, as described by GOLDFUSS,‡ which process I should interpret as the basi-pterygoid process; at this point also it meets the hinder part of the bar of bone seen in the orbit and crossing the ant-orbital fossa. GOLDFUSS fully described this bar as including pterygoid, palatine, and transverse bones, an interpretation fully borne out by the study of *S. Purdoni*. The slender rods of bone, one of which projects below the angle of the jaw, are no doubt correctly described as parts of the hyoid.

In Professor QUENSTEDT'S account of *Pterodactylus Suevicus*,§ the skull was fully described, and in 1871 Professor H. G. SEELEY‖ gave a translation of this description and suggested some modification in the interpretation of the bones. It is acknowledged that the skull of this specimen is much pressed and twisted, and consequently the parts are somewhat out of place. *P. Suevicus* evidently had a long skull, the snout being proportionately more slender than in *S. Purdoni*, and more resembling that of

* 'Nova Acta Leopold.,' vol. 15, Part I., Plates 7, 8, 9, 1831. Reproduced by OWEN, 'Palæont. Soc.,' 1851, Plate 27, figs. 2, 3, 4.

† OWEN, *loc. cit.*, fig. 3, No. 22.

‡ *Loc. cit.*, Plate 7, *i*.

§ 'Ueber *Pterodactylus Suevicus*,' 4to, 1855.

‖ 'Ann. Mag. Nat. Hist.,' ser. 4, vol. 7, p. 20.

*P. longirostris.** Not having the original specimen for comparison, I may, perhaps, be mistaken, but I cannot understand why the lateral apertures of the skull should be differently interpreted from what they are in *P. longirostris.* There is the same large anterior, or nasal, aperture (through which the bones numbered 16 are seen), and the hinder rounded aperture or orbit; between these are two processes projecting from the upper margin, which it is difficult to understand, if they are not the same as those which in other Pterodactyls mark the front and back of the ant-orbital fossa, or "middle hole" of the skull. The so-called nasal slits on the upper surface of the premaxillary region may be due to crushing, they are certainly very small for the anterior nares and are not seen in another specimen of the species noticed below. The bone numbered 3 by Professor QUENSTEDT is surely the premaxillary process, and not the nasal bone; the latter being in all probability the bone marked 2. According to this interpretation, number 19 will mark the process of the maxilla which separates the nasal aperture from the ant-orbital fossa. Number 26 is no doubt correctly named the quadrate, and the bone extending forward from this, and numbered 16, is the pterygo-palatine bar. I cannot think that either of the bones marked 25 can be a pterygoid, for it would then be more out of place than the palatine and quadrate, between which the pterygoid properly lies; and, moreover, the hinder end of the bone, number 16, is already in the place of a pterygoid. The hinder part of the head is much broken, and the bones numbered 25 may, perhaps, be parts of the jugal or supra-temporal bars.

Another specimen, referred to *P. Suevicus*, has been described by Dr. OSCAR FRAAS,† and this shows nothing of the slits which, in Professor QUENSTEDT'S specimen, were thought to be the nasal apertures. The brain case seems to be entire, and shows the supraoccipital region extending backwards, but not so much as it seems to do in the type specimen. The bones in the middle region are distinct, but so much out of place as to make their interpretation very uncertain. The lower of the two bones marked *fr.* is, I believe, the lower temporal bar, and apparently indicates also the presence of a supra-temporal bar in this species, as in *P. crassirostris.*

The remarkable toothless Ornithosaurians, described by Professor MARSH, from American Cretaceous beds, may be noticed here, although very unlike *S. Purdoni* in the details of their structure. The most striking peculiarity of these skulls, besides the absence of teeth, is their enormous crest-like extension backwards from the occipital region; a structure reminding one forcibly of the skull of the Chameleon,‡ where the supra-temporal fossæ are greatly enlarged by the extension backwards of the supra-temporal bar and the middle region of the skull; but in *Chamæleo pumilus*, while there is a similar development of occipital crest, the supra-temporal fossæ are covered over above by bone, and this is the condition which is found in *Pteranodon;*

* See GOLDFUSS, 'Nova Acta Leopold.,' vol. 15, Plate 10; and OWEN, 'Palæont. Soc.,' 1851, Plate 27.

† 'Palæontographica,' vol. 25, 1878, p. 163.

‡ Professor W. K. PARKER, 'Zool. Soc. Trans.,' vol. 11, 1881, p. 77.

but in the latter the crest is much larger, and the supra-temporal fossæ are so completely covered in by bone that only a small post-temporal fossa can be seen in the published figures.*

Professor SEELEY, in his work on Ornithosauria,† described two portions of skulls and the cast of a portion of a brain cavity, from the Cambridge Greensand, as remains of Pterodactyl, giving evidence of the form of the brain. These specimens, with the addition of a frontal bone, were further described in 1871, and from this evidence, restored figures of the brain were given.‡ In another communication on the same subject§ one of these specimens was omitted, as it was thought to be part of a Bird; and as such was described with other Avian remains.|| The second portion of skull¶ still referred to Pterodactyl, I have carefully compared with the Yorkshire specimen, and am inclined to agree with Professor SEELEY's identification; but its fragmentary condition prevents, as it seems to me, a definite determination, and possibly it may be Avian. The cast figured on the same plate (figs. 10, 11, and 12) represents a pair of cerebral lobes, and perhaps a part of the cerebellum behind and between them, and in form agrees fairly well with the form of the cerebral lobes in *S. Purdoni*.

The indications of the form of the brain, shown by the portion of skull,** are not sufficient to allow of comparison with *S. Purdoni*; the rounded bodies seen at the sides are doubtless a pair of optic lobes, but unfortunately we cannot see how far they extended up the sides of the brain; they seem, however, to be more definitely marked off from the cerebral lobes than these bodies are in the Yorkshire specimen.

COMPARISON OF THE PTERODACTYL SKULL WITH THOSE OF BIRDS AND LIZARDS.

The resemblances between Pterodactyls and Birds and Lizards have often been dwelt upon by writers on the Pterosauria; and it has been very generally agreed that these aberrant fossil creatures showed striking affinities to both these groups of living animals; but Professor SEELEY would assign them a position much nearer to Birds than most naturalists have been willing to allow, and in doing this he has laid great stress upon the characters of the brain deducible from the specimens alluded to above. The clearer light which *S. Purdoni* throws upon the structure of the Pterosaurian skull and brain lends a fresh interest to a renewed comparison with the two groups of the Sauropsida, and in some points strengthens Professor SEELEY's position.

When the skulls of Birds and Lizards are compared they are found to have many

* 'Amer. Journ. Sci.,' vol. 27, 1884, p. 423; and 'Geol. Mag.,' vol. 1, 1884, p. 345.

† 'Ornithosauria,' 1870, p. 77.

‡ 'Ann. Mag. Nat. Hist.' ser. 4, vol. 7, p. 20.

§ 'Linn. Soc. Journ.,' vol. 13, 1876, p. 84.

|| 'Geol. Soc. Quart. Journ,' vol. 32, 1876, p. 496.

¶ 'Ornithosauria,' Plate 11, figs. 1 and 2.

** *Loc. cit.*, Plate 11, figs. 1 and 2.

structures in common, and we are not surprised therefore to find that several of the characters presented by the Pterodactyl skull are found in both these groups; but it is obvious that, while such characters may be evidence of near affinity to the Sauropsida, they do not show to which of the two groups the Pterodactyls are most nearly related. It is the characters which serve to distinguish between the skulls of Birds and Lizards which in the present instance will be of most service, and the more important of these will now be noticed.

1. The large size of the brain case, in proportion to the rest of the skull, in Birds, is one of their most marked characters when compared with Lizards.

2. The quadrate, pterygoid, and palatine bones are moveable on the skull in Birds, but more or less fixed in Lizards.

3. In Birds the hinder end of the palatine and front end of the pterygoid are brought into close relation with the rostrum of the sphenoid, and, in all but struthious Birds, are distinctly articulated with the rostrum. This is not the case with Lizards.

4. The orbit is rarely completed by bone in Birds, and when it is so completed it is not by the jugal bone. In Lizards the orbit is surrounded by bone, and the jugal forms part of it.

5. In Birds there is no pre-frontal bone, while it is always present in Lizards; but it may be noted that in some Birds, such as the Goose, the upper part of the nasal bone, where divided across by the "hinge," has much the appearance and occupies the position of a pre-frontal.

6. No Bird has the supra-temporal bar, which is always developed in Lizards.

7. The back of the skull in Lizards is characterised by a pair of large paroccipital processes, developed from the opisthotic bones, which run outwards and meet the post-temporal buttress and quadrate. In Birds there is no such bar, the paroccipital being short and formed chiefly by the exoccipital.

8. In Birds the bones of the cranium are early ankylosed, while in Lizards they nearly always remain separate.

9. In Birds the premaxillæ are large and united to form one bone, which sends backwards a long process (sometimes divided), nearly, if not quite, reaching the frontals. Lizards usually have the premaxillæ small, and there may be but one.

10. The ant-orbital fossa, which is present in Birds, is only occasionally indicated in Lizards (*Lyriocephalus, fide* OWEN), and is absent in some Pterodactyls.

11. In Birds there is a lower temporal bar of bone extending from the maxilla to the quadrate. This bar is not completed by bone in any Lizard except *Sphenodon*. However, other Reptiles have this lower bar as strongly developed as in Pterodactyls.

In the first seven of the above characters the skull of *Scaphognathus Purdoni* agrees with Lizards, and not with Birds.

In the characters numbered 8 and 9 *S. Purdoni* agrees with Birds, and not with Lizards.

The last two characters, numbered 10 and 11, being variable, afford no evidence of the affinities of Pterodactyls.

Comparison of the Pterodactyl Brain with those of Birds and Lizards.

In an upper or in a side view of the brain of a Reptile one sees behind the cerebral hemispheres a pair of more or less rounded optic lobes, and behind these again the single rounded cerebellum. This separation of the cerebrum from the cerebellum by the optic lobes occurs in all Reptiles, although the form and proportions of the parts may vary; thus in Chelonians the cerebrum is elongated, while in Alligators it is rounded and globose.

The most striking characteristic of a Bird's brain as compared with that of any Reptile is its much larger size in proportion to the bulk of the skull. The brain of a Bird seen from above seems, at first sight, to have no optic lobes, for directly behind the inflated cerebrum there is the cerebellum; the latter has, in fact, increased in size, and grown forwards between the optic lobes, which have thus been pressed outwards and downwards. At the same time the cerebrum has also enlarged, and, pressing backwards, has overlapped the optic lobes and shut them out from forming any part of the upper surface of the brain. In a side view, however, the optic lobe is seen as a rounded body quite at the lower part of the brain, and almost hidden by the cerebrum. Another peculiarity of the Bird's brain is the process from each side of the medulla, which occupies the fossa on the inner side of the periotic capsule, and is called the flocculus. I am not aware of this having been observed in Reptiles.

The brain of *Scaphognathus Purdoni*, it will be seen, agrees with that of the Reptile in its small size in proportion to the skull, in the relatively large size of the optic lobes, and in those bodies being placed behind the cerebrum on the upper surface of the brain. It is tolerably certain that the cerebellum intervened between the two optic lobes, and in this particular, therefore, the brain resembled that of the Bird and differed from that of the Reptile. At the side of this fossil brain the optic lobe extends from the upper to the lower surface; its presence on the upper surface is, as we have seen, a Reptilian character; and its presence as a rounded mass on the lower surface is an Avian character. The most important characters in which this Pterodactyl brain resembles that of a Bird is in the extension of the cerebellum between the optic lobes, in the possession of flocculi, and in the optic lobes forming rounded masses at the base of the brain.

The relations of these brains will, perhaps, be best appreciated by placing the characters in a tabular form, thus:—

Bird brain.	*S. Purdoni* brain.	Reptile brain.
1. Brain relatively large	1. Brain relatively small	1. Brain relatively small
2. Cerebellum between optic lobes	2. Cerebellum between optic lobes	2. Cerebellum *not* between optic lobes, but behind them
3. Optic lobes at base	3. Optic lobes at base	3. Optic lobes *not* at base
4. Optic lobes *not* at top	4. Optic lobes at top	4. Optic lobes at top
5. Flocculi present	5. Flocculi present	5. Flocculi *not* present

The Pterodactyl brain described by Professor SEELEY has already been alluded to, and I am not aware of any other fossil Reptile brain with which that of *S. Purdoni* could be profitably compared.

No comparison of the skull and brain of a Pterodactyl would be complete which did not take into account those remarkably Reptilian Birds the Archæopteryx and the toothed Birds of North America.

The skull of *Archæopteryx* has been described by Professor W. DAMES,* and Dr. H. WOODWARD has reproduced the enlarged figure of it.† The presence of teeth in the front of the jaw, and the distinct ant-orbital fossa completely separated from the orbit by a bony bar give to this skull a strong resemblance to that of a Pterosaurian. Unfortunately, the back of the head is broken; but, in so far as one can judge from the figures, it and the brain which it protected were relatively as large as in ordinary Birds. On the slab containing the remains of *Archæopteryx*, in the British Museum, there is a "bilobed projection," which Dr. J. EVANS, no doubt correctly, described as a cast of part of the interior of the brain cavity;‡ but this is not sufficiently well preserved to allow of a comparison being made.

The skulls of *Hesperornis* and *Ichthyornis*, described by Professor MARSH,§ depart from the ordinary Avian type and approach Reptiles in the relatively small size of the brain case and in the possession of teeth; in these particulars they also resemble Pterosaurians; but in other particulars they conform to ordinary Bird characters.

Casts of the brain cavities of both *Hesperornis* and *Ichthyornis* have been described,‖ and these indicate a brain more like that of *S. Purdoni* than is that of any other Bird or Reptile with which I am acquainted. The two forms of toothed Birds have such similar brains that it will only be necessary here to speak of one of them. The relatively small size of the cranial cavity of *Hesperornis* is well shown by Professor MARSH's figures,¶ where the brain and skull of a Loon (*Colymbus torquatus*) are compared with

* 'Berlin, Palaeont. Abhandl.,' vol. 2, part 3, 1884, p. 119.

† 'Geol. Mag.,' vol. 1, 1884, pl. 14, and 'Geol. Assoc. Proc.,' vol. 9, 1886, p. 360.

‡ 'Nat. Hist. Rev.,' vol. 5, 1865, p. 415; reprinted with further remarks as a separate pamphlet, 8vo., London, 1881.

§ 'U.S. Geol. Expl. 40th Parallel Report,' vol. 7, 1880, p. 9.

‖ *Loc. cit.*, pp. 9 and 122.

¶ *Loc. cit.*, p. 9.

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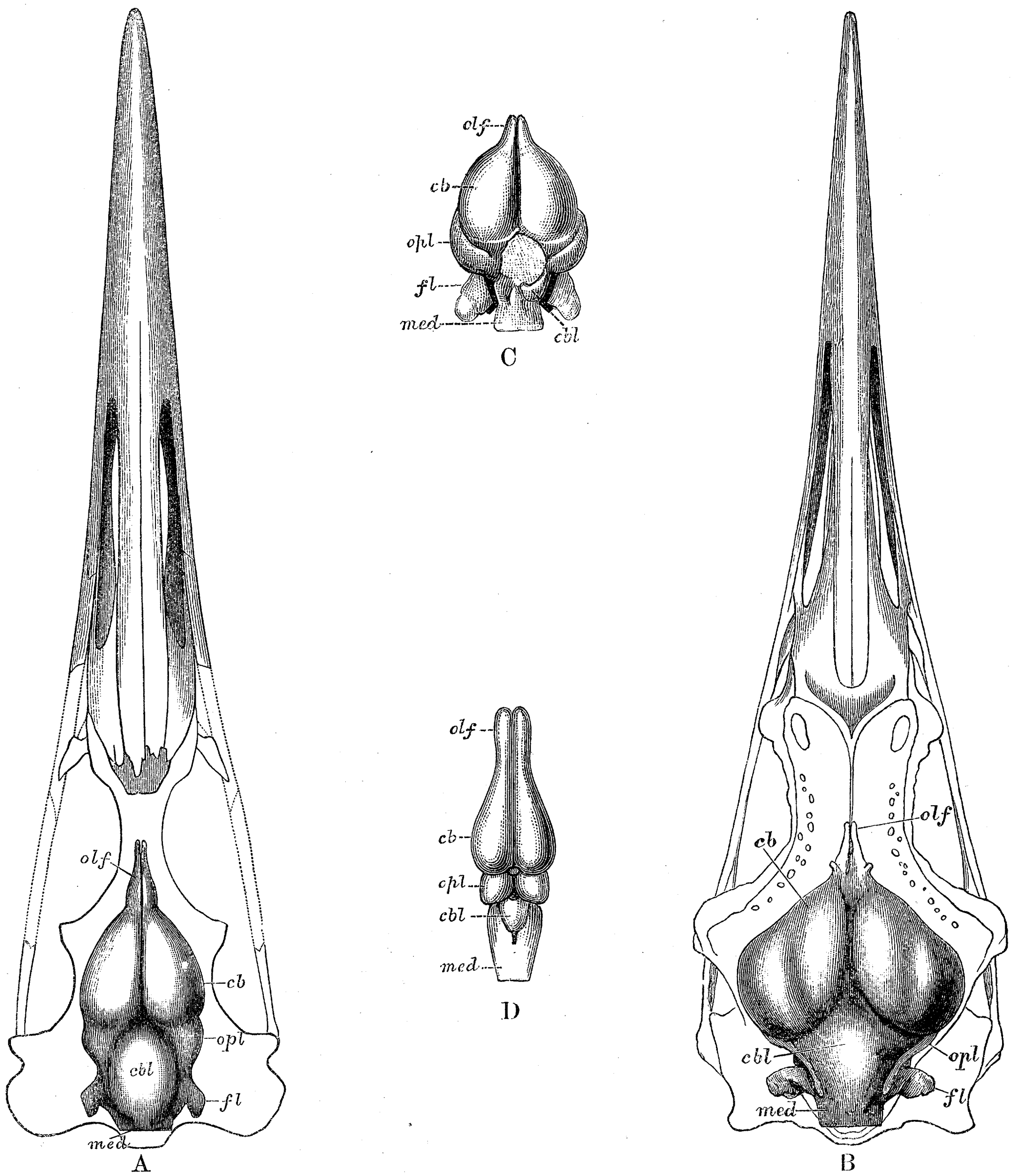
those of *Hesperornis*, the great difference between them being the small size of the cerebrum in the latter, and as a consequence more of the optic lobes are seen on the upper surface, but at the same time the cerebellum extends forwards between the optic lobes, and reaches to the cerebrum.



A. Skull and Brain of *Hesperornis*, three-fifths natural size (after MARSH).
B. Skull and Brain of *Colymbus torquatus*, natural size (after MARSH).
C. Brain of *Scaphognathus Purdoni*, natural size.
D. Brain of Lizard, enlarged.

A comparison of the figures will show more clearly than any words the close agreement between the brains of *Hesperornis* and *S. Purdoni*, but there are certain points of difference which must not be overlooked. In *Hesperornis* the brain is relatively larger, being about one-fifth of the length of the head, while in *S. Purdoni* it is only about one-eighth. In the latter, also, the cerebellum is smaller, and the optic lobes larger, than in *Hesperornis*. Although the optic lobes of *Hesperornis* are well seen from above, yet they do not seem to reach the upper surface of the brain; while in *S. Purdoni* they form no inconsiderable part of the upper surface, and are as high as, if not higher than, the cerebrum itself.

Conclusion.

The endeavour to trace the affinities of fossil animals is constantly leading us into unexpected difficulties and seeming incongruities. These difficulties, no doubt, arise sometimes from our want of knowledge, but often also from our inability to rightly interpret the known facts, which are only too frequently few in number, and serve rather to indicate the wide fields of knowledge yet to be searched than to furnish materials from which to draw definite conclusions. The organisation of the Pterosauria presents us with some of these difficulties.

The comparisons which have been made will, I think, make it clear that the Pterosaurian skull, as shown in *Scaphognathus Purdoni*, has a very close affinity to the skulls of Lacertilia in important points of structure, while the resemblances to the Avian skull are only superficial. On the other hand, the brain of *S. Purdoni* departs from the Reptilian type, and makes an approach towards the brain of Birds, and more especially to the form found in the fossil *Hesperornis* and its allies. Accepting these facts, about which there can be no doubt, the Pterosauria show close affinities with both Birds and Reptiles. From an evolutionist's point of view, this seems to be just what would be expected; and one is inclined to say at once, Here is the link connecting the two Sauropsidan groups. If Birds are modified and more highly developed Reptiles, the Pterodactyl was surely the intermediate stage, or, in other words, the Pterodactyl was the direct ancestor of the Bird. Is this really the case? I think not. The brain of *S. Purdoni* might, indeed, be taken as intermediate between that of Birds and of Reptiles, and it certainly makes such a near approach to the brain of *Hesperornis* that one cannot but recognise their close affinity.

With regard to the skull of *S. Purdoni*, however, it seems to me, it is as truly Reptilian as that of any Lizard living at the present day, and cannot therefore be said to be intermediate between Reptiles and Birds. It may be argued that all parts of an animal's organization would not necessarily change at the same time; but one modification would give rise to another. This is no doubt true, and it may be that the new development of the brain seen in the Pterodactyl subsequently caused modifications of the skull; but it must be remembered that, while the brain of *Hesperornis* is only a little more advanced than that of *S. Purdoni*, the skull would seem, from Professor Marsh's description, to be that of a true Bird; and surely we ought to find the skull of the Pterodactyl more modified in the Avian direction if it were indeed an ancestor in the direct line of any Bird. The facts, as we at present know them, seem to point to Birds, Pterosauria, and Lizards having been derived from a common ancestor, possessing the general characters of all three, but with none of their specialisations.

If we take two or three of the characters of each of these forms as examples, the relationship may be put thus :—

Lizard.	Pterodactyl.	Bird.
Small cerebellum, optic lobes meeting, paroccipital formed by opisthotic.	Cerebellum large and separating optic lobes, paroccipital formed by opisthotic.	Cerebellum large and separating optic lobes, paroccipital formed by exoccipitals.

Possible Ancestral Type.
Small cerebellum, optic lobes meeting, paroccipitals small and formed by both exoccipitals and opisthotics.

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EXPLANATION OF PLATES 77 AND 78.

(All the figures natural size except No. 12.)

Fig. 1 (Plate 77). *Scaphognathus Purdoni*, skull seen from above.
Fig. 2 (Plate 78). ,, ,, ,, left side.
Fig. 3 (Plate 78). ,, ,, ,, right side.
Fig. 3*a* (Plate 78). ,, ,, ,, side view of base and cranium.
Fig. 4 (Plate 77). ,, ,, ,, palatal view.
Fig. 5 (Plate 78). ,, ,, ,, viewed from behind.
Fig. 6 (Plate 78). ,, ,, brain cast seen from left side.
Fig. 7 (Plate 78). ,, ,, ,, from above and behind. The right side is only partly exposed in the fossil.
Fig. 8 (Plate 77). Skull of *Sphenodon punctata*, from above.
Fig. 9 (Plate 77). ,, ,, ,, from below.
Fig. 10 (Plate 78). ,, ,, ,, back view.
Fig. 11 (Plate 78). ,, ,, ,, from right side.
Fig. 12 (Plate 78). Skull of young Fowl, back view (after PARKER).
Fig. 13 (Plate 77). ,, *Dromæus Novæ Hollandiæ*, palatal view.

ant.orb.	Ant-orbital fossa.
ant.sc.	Anterior vertical semicircular canal.
b.o.	Basi-occipital.
b.p.p.	Basi-pterygoid process.
b.s.	Basi-sphenoid.
bt.	Basi-temporal.
cb.	Cerebrum.
cbl.	Cerebellum.
en.	External nares.
ex.o.	Ex-occipital.
fr.	Frontal bone.
fl.	Flocculus.
f.o.	Fenestra ovalis.
in.	Internal nares.
inf.tem.	Infra-temporal fossa.
ju.	Jugal.
la.	Lachrymal.
med.	Medulla oblongata.
mx.	Maxilla.
na.	Nasal bone.
olf.	Olfactory lobe of brain.
op.l.	Optic lobe.
op.ot.	Opisthotic.
orb.	Orbit.
pa.	Parietal.
p.fr.	Pre-frontal.
pl.	Palatine.
pmx.	Premaxilla.
pt.	Pterygoid.
pt.fos.	Post-temporal fossa.
pt.fr.	Post-frontal.
pt.o.	Post-orbital bone.
pt.sc.	Posterior vertical semicircular canal.
qu.	Quadrate.
qu.ju.	Quadrato-jugal.
so.	Supra-occipital.
sq.	Squamosal.
st.	Supra-temporal bone.
stp.	Stapes.
sup.tem.	Supra-temporal fossa.
vo.	Vomer.

APPENDIX I.

Catalogue of the Genera and Species of Ornithosauria.

In bringing together all the generic and specific names that have been given to Ornithosaurians, I have been able to consult with Mr. R. Lydekker, F.G.S., so that the synonymy here given may agree with the 'Catalogue of Fossil Reptiles in the British Museum,' which is now passing through the press.

Full synonymy of the species previous to the year 1860 will be found in Professor Hermann von Meyer's 'Fauna der Vorwelt.'

Brachytrachelus, Giebel	See Scaphognathus.
Cimoliornis diomedeus, Owen	See Ornithocheirus.
Coloborhynchus, Owen	See Ornithocheirus.
Cretornis, Fritsch	See Ornithocheirus.
Criorhynchus, Owen	See Ornithocheirus.
Cycnorhamphus Suevicus, Quenstedt	(Lithographic Slate, Nusplingen, Würtemberg.)
1854. *Pterodactylus Württembergicus*	Quenstedt. Neues Jahrb. Mineral., p. 570. (This was not intended as a specific name. See 'Der Jura,' p. 812.)
1855. *Pterodactylus Suevicus*	Quenstedt. 'Ueber Pterodactylus Suevicus, &c.' Tübingen, 1855.
1860. ,, *Württembergicus*	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 50.
1861. ,, *Suevicus*, subsp. *eurycheirus*	Wagner, München, Bayer. Akad. Sitzber., vol. 1, p. 532. (Wagner also includes *P. grandipelvis* as a subspecies.)
1870. *Cycnorhamphus* ,,	Seeley, 'Ornithosauria,' p. 111 (8vo., Cambridge).
1871. ,, ,,	Seeley, Ann. Mag. Nat. Hist., ser. 4, vol. 7, p. 20.
1878. *Pterodactylus* ,,	Fraas, Palæontographica, vol. 25, p. 163.
1882. ,, ,,	Zittel, *ibid.*, vol. 29, p. 80.
Dermodactylus Montanus, Marsh	(Jurassic, Wyoming.)
1878. *Pterodactylus Montanus*	Marsh, Amer. Journ. Sci., ser. 3, vol. 16, p. 233.
1881. *Dermodactylus* ,,	Marsh, *ibid.*, vol. 21, p. 342.
Dimorphodon Banthensis, Theodori	See Dorygnathus.
Dimorphodon macronyx, Buckland	(Lias, Lyme Regis.)
1829. *Pterodactylus macronyx*	Buckland, Geol. Soc. Proc., Feb. 6, vol. 1, p. 96.
1835. ,, ,,	Buckland, Geol. Soc. Trans., ser. 2, vol. 3, p. 217.
1836. ,, ,,	Buckland, Bridgewater Treatise, pp. 221, 226.
1858. *Dimorphodon* ,,	Owen, Brit. Assoc. Rep., 1858 (*Sect.*), p. 97.
1859. ,, ,,	Owen, Phil. Trans., vol. 149, p. 161.
1860. *Rhamphorhynchus* ,,	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 85.
1870. *Dimorphodon* ,,	Owen, Pal. Soc. for 1869, Lias Rept.
1870. ,, ,,	Seeley, Ann. Mag. Nat. Hist., ser. 4, vol. 6, p. 129.
1874. ,, ,,	Owen, Pal. Soc., Lias Rept., p. 13.
1874. ? *Pterodactylus Marderi*	Owen, Pal. Soc., Mesoz. Rept., p. 37.

Diopecephalus, Seeley		See PTERODACTYLUS.
		(Professor Seeley included in DIOPECEPHALUS *P. longicollum*, *P. rhamphastinus*, and *P. Kochi*; Ann. Mag. Nat. Hist., vol. 7, 1871, p. 35, foot-note.)
Dolichorhamphus, Seeley		See RHAMPHOCEPHALUS PRESTWICHI.
Doratorhynchus validus, Seeley		See ORNITHOCHEIRUS.
DORYGNATHUS BANTHENSIS, Theodori		(Lias, Banz, near Boll, Würtemberg.)
1830.	*Ornithocephalus Banthensis*	Theodori, Froriep's Notizen, No. 623, and Isis, 1831, col. 276.
1831.	*Pterodactylus macronyx*	v. Meyer, Nova Acta Leopold., vol. 15, pt. 2, p. 198.
1852.	*Rhamphorhynchus Banthensis*	Theodori, Bamberg Naturf. Ver. Bericht, p. 17.
1858.	,, ,,	Wagner, München, Bayer. Akad. Sitzber., vol. 8, pt. 2, p. 502.
1860.	,, *macronyx*	v. Meyer (in part), 'Fauna d. Vorw., Rept. Lith. Schief.,' p. 85.
1860.	*Dorygnathus Banthensis*	Wagner, München, Bayer. Akad. Sitzber., p. 48.
1861.	,, ,,	Wagner, *ibid.*, vol. 1, p. 520.
1882.	,,	Zittel, Palæontographica, vol. 29, p. 64.
	? *Pterodactylus Goldfussi*	Theodori, 1830 (*fide* Bronn, 'Index Palæont.,' p. 1082).
Macrotrachelus, Giebel		See PTERODACTYLUS.
NYCTODACTYLUS GRACILIS, Marsh		(Cretaceous, Kansas.)
1876.	*Pteranodon gracilis*	Marsh, Amer. Journ. Sci., ser. 3, vol. 11, p. 508.
1876.	*Nyctosaurus gracilis*	Marsh, *ibid.*, vol. 12, p. 479.
1881.	*Nyctodactylus gracilis*	Marsh, *ibid.*, vol. 21, p. 342, note.
Nyctosaurus, Marsh		See NYCTODACTYLUS.
Ornithocephalus, Soemmerring		See PTERODACTYLUS and RHAMPHORHYNCHUS.
ORNITHOCHEIRUS BRACHYRHINUS, Seeley		(Cambridge Greensand.)
1870.	*Ornithocheirus brachyrhinus*	Seeley, 'Ornithosauria,' p. 123.
ORNITHOCHEIRUS BÜNZELI, Seeley		(? Upper Greensand, Gosau, near Vienna.)
1881.	*Ornithocheirus Bünzeli*	Seeley, Geol. Soc. Quart. Journ., vol. 37, p. 701.
1882.	,, ,,	Sauvage, Soc. Géol. France Mém., ser. 3, vol. 2, p. 1.
ORNITHOCHEIRUS CAPITO, Seeley		(Cambridge Greensand.)
1870.	*Ornithocheirus capito*	Seeley, 'Ornithosauria,' p. 126.
ORNITHOCHEIRUS CARTERI, Seeley		(Cambridge Greensand.)
1870.	*Ornithocheirus Carteri*	Seeley, 'Ornithosauria,' p. 128.
ORNITHOCHEIRUS CLAVIROSTRIS, Owen		(Wealden, St. Leonards.)
1874.	*Coloborhynchus clavirostris*	Owen, Pal. Soc., Mesoz. Rept., p. 6.
ORNITHOCHEIRUS CLIFTI, Mantell		(Wealden, Hastings.)
1827.	Bones of Birds	Mantell, 'Fossils of Tilgate Forest,' p. 81.
1840.	,, ,,	Mantell, Geol. Soc. Trans., ser. 2, vol. 5, p. 175.
1844.	*Palæornis Clifti*	Mantell, 'Medals of Creation,' p. 806.
1846.	*Pterodactylus*	Owen, Geol. Soc. Quart. Journ., vol. 2, p. 96.
1846.	Fossil Remains of Birds	Mantell, *ibid.*, p. 104.
1848.	*Pterodactylus Clifti*	Bronn, 'Index Palæont.,' p. 895.
1854.	,,	Morris, 'Cat. Brit. Foss.,' p. 353.
ORNITHOCHEIRUS COLORHINUS, Seeley		(Cambridge Greensand.)
1870.	*Ornithocheirus colorhinus*	Seeley, 'Ornithosauria,' p. 124.

ORNITHOCHEIRUS COMPRESSIROSTRIS, Owen . (Lower Chalk, Burham; Greensand, Maidstone; Wealden, Tilgate, and Portland, Solothurn, Switzerland.)

1851.	*Pterodactylus compressirostris*	Owen, Zool. Soc. Proc., 1851, p. 32.
1851.	,, ,,	Owen, Pal. Soc., Cret. Rept., pp. 95, 98.
1858.	,, ,,	Wagner, München, Bayer. Akad. Abhandl., vol. 8, pt. 2, p. 497.
1878.	,, ,,	Owen, Dixon's 'Foss. Sussex,' edit. 2, p. 428.

ORNITHOCHEIRUS CRASSIDENS, Seeley . . . (Cambridge Greensand.)

1870.	*Ornithocheirus crassidens*	Seeley, 'Ornithosauria,' p. 122.

ORNITHOCHEIRUS ? CURTUS, Owen . . . . (Wealden, Sussex.)

1870.	*Pterodactylus curtus*	Owen, Pal. Soc., Lias Rept., pt. 2, pl. 19, figs. 8, 9.

ORNITHOCHEIRUS CUVIERI, Bowerbank . . (Lower Chalk, Burham; Cambridge Greensand.)

1840.	Remains of Bird	Owen, Geol. Soc. Proc., vol. 3, p. 298.
1842.	,, ,,	Owen, Geol. Soc. Trans., ser. 2, vol. 6, pt. 2, p. 411.
1851.	*Pterodactylus Cuvieri*	Bowerbank, Zool. Soc. Proc., p. 14.
1851.	,, ,,	Owen, Pal. Soc., Cret. Rept., pp. 88, 97.
1858.	,, ,,	Wagner, München, Bayer. Akad. Abhandl., vol. 8, pt. 2, p. 497.
1861.	,, ,,	Owen, Pal. Soc., Cret. Rept., suppl. iii., pl. 3, figs. 1–3.
1870.	*Ornithocheirus* ,,	Seeley, 'Ornithosauria,' p. 113.
1874.	*Coloborhynchus* ,,	Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 6.
1878.	*Pterodactylus* ,,	Owen, Dixon's 'Foss. Sussex,' p. 428.

ORNITHOCHEIRUS DAVIESI, Owen . . . . (Gault, Folkestone.)

1874.	*Pterodactylus Daviesi*	Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 2.

ORNITHOCHEIRUS DENTATUS, Seeley . . . . (Cambridge Greensand.)

1870.	*Ornithocheirus dentatus*	Seeley, 'Ornithosauria,' p. 119.

ORNITHOCHEIRUS DENTICULATUS, Seeley . . (Cambridge Greensand.)

1870.	*Ornithocheirus denticulatus*	Seeley, 'Ornithosauria,' p. 122.

ORNITHOCHEIRUS DIOMEDEUS, Owen . . . . (Chalk, Kent.)

1840.	Bird allied to Albatross	Owen, Geol. Soc. Trans., ser. 2, vol. 6, p. 411.
1846.	*Cimoliornis diomedeus*	Owen, 'Brit. Foss. Mam. and Birds,' p. 545.
1851.	*Pterodactylus* ,,	Owen, Zool. Soc. Proc., p. 28.
1851.	Large Pterodactyle	Owen, Pal. Soc., Cret. Rept., p. 192, pl. 32, figs. 4, 5.
1854.	*Pterodactylus giganteus*	Morris, 'Cat. Brit. Foss.,' p. 353.

(All the above refer to the same specimen, which may be identical with *O. giganteus.*)

ORNITHOCHEIRUS ENCHORHYNCHUS, Seeley . . (Cambridge Greensand.)

1870.	*Ornithocheirus enchorhynchus*	Seeley, 'Ornithosauria,' p. 123.

ORNITHOCHEIRUS EURYGNATHUS, Seeley . . . (Cambridge Greensand.)

1870.	*Ornithocheirus eurygnathus*	Seeley, 'Ornithosauria,' p. 123.

ORNITHOCHEIRUS FITTONI, Owen . . . . (Cambridge Greensand.)

1858.	*Pterodactylus Fittoni*	Owen, Brit. Assoc. Rep., 1858 (*Sect.*), p. 98.
1859.	,, ,,	Owen, Pal. Soc., Cret. Rept. sup. 1, p. 4.
1859.	,, ,,	Owen, Phil. Trans., vol. 149, p. 161.
1870.	*Ornithocheirus Fittoni*	Seeley, 'Ornithosauria,' p. 118.

ORNITHOCHEIRUS GIGANTEUS, Bowerbank . . (Upper Chalk, Kent.)

1846.	*Pterodactylus giganteus*	Bowerbank, Geol. Soc. Quart. Journ., vol. 2, p. 7. (Paper read May 14, 1845; species named in note dated December, 1845.)
1848.	,, ,,	Bowerbank, *ibid.*, vol. 4, p. 2.

1850. *Pterodactylus conirostris* . . . Owen, Dixon's 'Foss. Sussex,' 1st edit., p. 401.
1851. ,, *giganteus* . . . Bowerbank, Zool. Soc. Proc., p. 14.
1851. ,, ,, . . . Owen, Pal. Soc., Cret. Rept. p. 91.
1858. ,, *conirostris* . . . Wagner, München, Bayer. Akad. Abhandl., vol. 8, pt. 2, p. 497.
1878. ,, *giganteus* . . . Owen, Dixon's 'Foss. Sussex,' edit. 2, p. 427.

Ornithocheirus harpyia, Cope . . . . See PTERANODON OCCIDENTALIS.

ORNITHOCHEIRUS HILSENSIS, Koken . . . (Neocomian, Hils, Hanover.)
1883. *Ornithocheirus Hilsensis* . . . Deutsch. Geol. Gesell. Zeitschr., vol. 35, p. 824, and vol. 37, 1885, p. 214.

(Referred to *Dinosaur* by Otto Meyer, Deutsch. Geol. Gesell. Zeitschr., vol. 36, 1884, p. 664, and by S. W. Williston, Zool. Anzeig., vol. 8, 1885, p. 628.)

ORNITHOCHEIRUS HLAVATSCHI, Fritsch . . . (Upper Chalk, Bohemia.)
1881. *Cretornis Hlavatschi* . . . . . Fritsch, Prag, Böhm. Gesell. Sitzber., 1880, p. 276.
1888. *Ornithocheirus* ,, ... Lydekker, 'Cat. Foss. Rept. Brit. Mus.,' p. 14.

ORNITHOCHEIRUS HUXLEYI, Seeley . . . . (Cambridge Greensand.)
1870. *Ornithocheirus Huxleyi* . . . . Seeley, 'Ornithosauria,' p. 116.

ORNITHOCHEIRUS MACHÆRORHYNCHUS, Seeley . (Cambridge Greensand.)
1870. *Ornithocheirus machærorhynchus* Seeley, 'Ornithosauria,' p. 113.

ORNITHOCHEIRUS MICRODON, Seeley . . . . (Cambridge Greensand.)
1870. *Ornithocheirus microdon* . . . Seeley, 'Ornithosauria,' p. 116.

ORNITHOCHEIRUS NASUTUS, Seeley . . . . (Cambridge Greensand.)
1870. *Ornithocheirus nasutus* . . . . Seeley, 'Ornithosauria,' p. 120.

ORNITHOCHEIRUS NOBILIS, Owen . . . . . (Wealden, Isle of Wight.)
1870. *Pterodactylus nobilis* . . . . Owen, Pal. Soc., Lias Rept., pt. 2, pl. 19, fig. 10.

ORNITHOCHEIRUS OWENI, Seeley . . . . . (Cambridge Greensand.)
1870. *Ornithocheirus Oweni* . . . . Seeley, 'Ornithosauria,' p. 115.

ORNITHOCHEIRUS OXYRHINUS, Seeley . . . (Cambridge Greensand.)
1870. *Ornithocheirus oxyrhinus* . . . Seeley, 'Ornithosauria,' p. 117.

ORNITHOCHEIRUS PLATYRHINUS, Seeley . . . (Cambridge Greensand.)
1870. *Ornithocheirus platyrhinus* . . Seeley, 'Ornithosauria,' p. 128.

ORNITHOCHEIRUS PLATYSOMUS, Seeley . . . (Cambridge Greensand.)
1870. *Ornithocheirus platysomus* . . Seeley, 'Ornithosauria,' p. 120.

ORNITHOCHEIRUS POLYODON, Seeley . . . . (Cambridge Greensand.)
1870. *Ornithocheirus polyodon* . . . Seeley, 'Ornithosauria,' p. 121.

ORNITHOCHEIRUS REEDII, Seeley . . . . (Cambridge Greensand.)
1870. *Ornithocheirus Reedii* . . . . Seeley, 'Ornithosauria,' p. 126.
1881. ,, ,, ... Seeley, Geol. Mag., Dec. 2, vol. 8, p. 3.

ORNITHOCHEIRUS SAGITTIROSTRIS, Owen . . (Wealden, St. Leonards.)
1874. *Pterodactylus sagittirostris* . . Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 3.

ORNITHOCHEIRUS SCAPHORHYNCHUS, Seeley . (Cambridge Greensand.)
1870. *Ornithocheirus scaphorhynchus* . Seeley, 'Ornithosauria,' p. 119.

ORNITHOCHEIRUS SEDGWICKII, Owen . . . . (Cambridge Greensand.)
1858. *Pterodactylus Sedgwickii* . . . Owen, Brit. Assoc. Rep., 1858 (*Sect.*), p. 98.
1859. ,, ,, . . . Owen, Pal. Soc., Cret. Rept., suppl. 1, p. 2.
1859. ,, ,, . . . Owen, Phil. Trans., vol. 149, p. 161.

1860. *Pterodactylus Sedgwickii* . . . Owen, 'Palæontology,' p. 427.
1870. *Ornithocheirus* ,, . . Seeley, 'Ornithosauria,' p. 112.
1874. *Coloborhynchus* ,, . . . Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 6.
1882. ? *Ornithocheirus* . . . . Sauvage, Soc. Géol. France Mém., ser. 3, vol. 2, pt. 4, p. 6.

ORNITHOCHEIRUS SIMUS, Owen . . . . . . (Cambridge Greensand.)
1861. *Pterodactylus simus* . . . . . Owen, Pal. Soc., Cret. Rept., suppl. 3, p. 2.
1870. *Ornithocheirus* ,, ... Seeley, 'Ornithosauria,' p. 127.
1874. *Criorhynchus* ,, ... Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 7.
(*Pterodactylus Woodwardi*, Owen, may belong to this species.)

ORNITHOCHEIRUS TENUIROSTRIS, Seeley . . (Cambridge Greensand.)
1870. *Ornithocheirus tenuirostris* . . Seeley, 'Ornithosauria,' p. 114.

Ornithocheirus umbrosus, Cope . . . . . . See PTERANODON INGENS.

ORNITHOCHEIRUS ? VALIDUS, Owen . . . . (Purbeck, Swanage.)
1869. *Pterodactylus macrurus* . . . Seeley, 'Index to Aves, Ornithosauria, &c.,' Cambridge, p. 89.
1870. ,, *validus* . . . . Owen, Pal. Soc., Lias Rept., pt. 2, pl. 19, fig. 7.
1875. *Doratorhynchus validus* . . . Seeley, Geol. Soc. Quart. Journ., vol. 31, p. 465.

ORNITHOCHEIRUS WOODWARDI, Owen . . . (Cambridge Greensand.)
1861. *Pterodactylus Woodwardi* . . . Owen, Pal. Soc., Cret. Rept., suppl. 3, p. 4.
1870. *Ornithocheirus* ,, . . Seeley, 'Ornithosauria,' p. 125.
(This species may be identical with *O. simus*.)

ORNITHOCHEIRUS XYPHORHYNCHUS, Seeley . . (Cambridge Greensand.)
1870. *Ornithocheirus xyphorhynchus* . Seeley, 'Ornithosauria,' p. 117.
1881. ,, ,, . Seeley, Geol. Mag., Dec. 2, vol. 8, p. 18.

ORNITHOPTERUS LAVATERI, v. Meyer . . . (Lithographic Slate, Bavaria.)
1837. *Pterodactylus* . . . . v. Meyer, Neues Jahrb. Mineral., p. 558.
1838. ,, *Lavateri* . . . . v. Meyer, *ibid.*, p. 415.
1860. *Ornithopterus* ,, ... v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 25.

ORNITHOSTOMA, Seeley . . . . (Cambridge Greensand.)
1871. *Ornithostoma* . . . . Ann. Mag. Nat. Hist., ser. 4, vol. 7, p. 35, note.
(The portions of jaws thus named may perhaps belong to *Ornithocheirus*.)

Palæornis, Mantell . . . . See ORNITHOCHEIRUS CLIFTI.

Pachyrhamphus, Fitzinger . . . . See SCAPHOGNATHUS.

Ptenodactylus, Seeley . . . . See ORNITHOCHEIRUS.
(See 'Index to the Fossil Remains of Aves, Ornithosauria, &c., in the Woodwardian Museum,' 8vo., Cambridge, 1869, p. xvi.)

PTENODRACON BREVIROSTRIS, Soemmerring . (Lithographic Slate, Eichstätt, Bavaria.)
1816–17. *Ornithocephalus brevirostris* . Soemmerring, München, Bayer. Akad. Denksch., vol. 6, p. 89.
1826. *Pterodactylus nettecephaloides* . Ritgen, Nova Acta Leopold., vol. 13, pt. 1, p. 338.
1842. ,, *Meyeri* . . . . Münster, Neues Jahrb. Mineral., p. 35.
1860. ,, *brevirostris* . . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 55.
1860. ,, *Meyeri* . . . . v. Meyer, *ibid.*, p. 56.
1861. ,, *brevirostris* . . . Wagner, München, Bayer. Akad. Sitzber., vol. 1, p. 533.
1861. ,, *Meyeri* . . . . Wagner, *ibid.*, p. 533.
1870. *Ornithocephalus brevirostris* . . Seeley, 'Ornithosauria,' p. 111.
1882. *Pterodactylus* ,, . . Zittel, Palæontographica, vol. 29, p. 78.
1888. *Ptenodracon* ,, . . Lydekker, 'Cat. Foss. Rept. Brit. Mus.,' p. 3.

PTERANODON COMPTUS, Marsh . . . . . (Cretaceous, Kansas.)
1876. *Pteranodon comptus* . . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 11, p. 509.
1876. „ „ . . . . Marsh, *ibid.*, vol. 12, p. 479.

Pteranodon gracilis, Marsh . . . . See NYCTODACTYLUS.

PTERANODON INGENS, Marsh . . . . (Cretaceous, Kansas.)
1872. *Pterodactylus ingens*. . . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 3, p. 246.
1872. *Ornithocheirus umbrosus* . . . Cope, Amer. Phil. Soc. Proc., vol. 12, p. 421.
1875. „ „ . . . Cope, U.S. Geol. Surv. Terr., vol. 2, pp. 65 and 249.
1876. *Pteranodon ingens* . . . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 11, p. 507; vol. 12, p. 479; also vol. 27, 1884, p. 423; and Geol. Mag., vol. 1, 1884, p. 345.

PTERANODON LONGICEPS, Marsh . . . . . (Cretaceous, Kansas.)
1876. *Pteranodon longiceps* . . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 11, p. 508; vol. 12, 1876, p. 479; vol. 27, 1884, p. 423; and Geol. Mag., vol. 1, 1884, p. 345

PTERANODON NANUS, Marsh . . . . (Cretaceous, Kansas.)
1881. *Pteranodon nanus* . . . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 21, p. 343.

PTERANODON OCCIDENTALIS, Marsh . . . . (Cretaceous, Kansas.)
1871. *Pterodactylus Oweni* . . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 1, p. 472.
1872. „ *occidentalis*. . . Marsh, *ibid.*, vol. 3, p. 241.
1872. *Ornithocheirus harpyia* . . . Cope, Amer. Phil. Soc. Proc., vol. 12, p. 421.
1875. *Pterodactylus occidentalis*. . . Cope, U.S. Geol. Surv. Terr., vol. 2, pp. 66 and 249.
1876. *Pteranodon* „ . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 12, p. 479; also Amer. Journ. Sci., ser. 3, vol. 27, 1884, p. 423; and Geol. Mag., vol. 1, 1884, p. 345.
Non *Ornithocheirus Oweni* . Seeley.

PTERANODON VELOX, Marsh . . . . (Cretaceous, Kansas.)
1872. *Pterodactylus velox* . . . . . Marsh, Amer. Journ. Sci., ser. 3, vol. 3, p. 247.
1875. „ „ . . . . . . Cope, U.S. Geol. Surv. Terr., vol. 2, p. 250.
1876. *Pteranodon* „ . . . . . . Marsh, Amer. Journ. Sci., vol. 11, p. 507; and vol. 12, p. 479.

Pterodactylus Aclandi, Owen . . . . See RHAMPHOCEPHALUS DEPRESSIROSTRIS.

PTERODACTYLUS ANTIQUUS, Soemmerring . . (Lithographic Slate, Pappenheim, Bavaria.)
1784. "Un genre particulier" . . . Collini, Mannheim, Acad. Theod. Palat. Acta, vol. 5, p. 58.
1812. *Ornithocephalus antiquus* . . . Soemmerring, München, Bayer. Akad. Denksch., vol. 3, p. 126.
1824. *Pterodactylus longirostris* . . . Cuvier, Oss. Foss., vol. 5, pt. 2, p. 359.
1826. „ *crocodilocephaloides* Ritgen, Nova Acta Leopold., vol. 13, pt. 1, p. 344.
1860. „ *longirostris* . . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 26.
1861. „ „ . . . Wagner, München, Bayer. Akad. Sitzber., vol. 1, p. 532.
(Wagner also includes *P. scolopaciceps* as a subspecies of *P. longirostris.*)

Pterodactylus Banthensis, Theodori . . . . See DORYGNATHUS.

Pterodactylus brevirostris, Soemmerring . . See PTENODRACON.

Pterodactylus Bucklandi, v. Meyer . . . . See RHAMPHOCEPHALUS.

PTERODACTYLUS CIRINENSIS, v. Meyer . . . (Lithographic Slate, Cirin, E. France.)
1852. *Pterodactylus* . . . . . . v. Meyer, Neues Jahrb. Mineral., p. 832.
1860. „ *Cirinensis* . . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 66.
1861. „ „ . . . Wagner, München, Bayer. Akad. Sitzber., vol. 1, p. 525.

Pterodactylus Clifti, Owen . . . . See Ornithocheirus.

Pterodactylus compressirostris, Owen . . . See Ornithocheirus.

Pterodactylus conirostris, Owen . . . . . . See Ornithocheirus giganteus.

Pterodactylus crassipes, Meyer . . . . (Lithographic Slate, Eichstätt, Bavaria.)
1857. *P. (Rhamphorhynchus) crassipes* v. Meyer, Neues Jahrb. Mineral., p. 535.
1860. *Pterodactylus* „ v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 64.
1861. *Scaphognathus* „ Wagner, as var. of *S. crassirostris*, München, Bayer. Akad. Sitzber., vol. 1, p. 524.

Pterodactylus crassirostris, Goldfuss . . . See Scaphognathus.

Pterodactylus crocodilocephaloides, Ritgen . See Pterodactylus antiquus.

Pterodactylus curtus, Owen . . . . See Ornithocheirus.

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1843. *Pterodactylus dubius*, Münster . v. Meyer, Neues Jahrb. Mineral., p. 584.
1851. *Ornithocephalus dubius* . . . Wagner, München, Bayer. Akad. Abhandl., vol. 6, pt. 1, p. 148.
1860. *Pterodactylus* „ . . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 52.
1861. „ „ . . . Wagner, as sub-species of *P. rhamphastinus*, München, Bayer. Akad. Sitzber., vol. 1, p. 531.

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Pterodactylus elegans, Wagner . . . . (Lithographic Slate.)
1860. *Pterodactylus longirostris* . . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' pl. 1, fig. 1.
1861. „ *pulchellus* . . . v. Meyer, Neues Jahrb. Mineral., p. 470.
1861. „ „ . . . v. Meyer, Palæontographica, vol. 10, p. 9.
1861. „ *elegans* . . . . Wagner, München, Bayer. Akad. Sitzber., vol. 1, pp. 363, 533.
1882. „ „ . . . . Zittel, Palæontographica, vol. 29, pp. 50, 73.

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Pterodactylus Goldfussi, Theodori . . . . See Dorygnathus Banthensis.

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1852. *Pterodactylus gracilis* . . . . Theodori (*fide* v. Meyer).
1860. „ „ . . . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief,' p. 7.

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1860. *Pterodactylus grandipelvis* . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief,' p. 53.
1865. „ „ . . v. Meyer, Neues Jahrb. Mineral., p. 845.
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Pterodactylus grandis, Cuvier . . . . . See Rhamphorhynchus.

Pterodactylus hirundinaceus, Wagner . . . See Rhamphorhynchus Münsteri.

Pterodactylus Hopkinsi, Seeley

(This name, with others, was given for specimens from the Cambridge Greensand, Brit. Assoc. Rep., 1864 (*Sect.*), p. 69, but has not since been used.)

Pterodactylus ingens, Marsh	See PTERANODON.
Pterodactylus intermedius, Goldfuss . . .	See PTERODACTYLUS MEDIUS.
Pterodactylus Kiddi, Owen	See RHAMPHOCEPHALUS BUCKLANDI.
PTERODACTYLUS KOCHI, Wagner	(Lithographic Slate, Kelheim and Eichstätt, Bavaria.)
1831–6. *Ornithocephalus Kochi* . . .	Wagner, München, Bayer. Akad. Abhandl., vol. 2, p. 168.
1850. *Pterodactylus scolopaciceps* . .	v. Meyer, Neues Jahrb. Mineral., p. 199.
1860. „ *Kochi*	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 35.
1860. „ *scolopaciceps* . .	v. Meyer, *ibid.*, p. 33.
1861. „ „ . .	Wagner, München, Bayer. Akad. Sitzber., vol. 1, pp. 522 and 532.
1861. „ *Kochi*	Wagner, *ibid.*, vol. 1, p. 533.
1871. *Diopecephalus* „	Seeley, Ann. Mag. Nat. Hist., ser. 4, vol. 7, p. 35, note.
1882. *Pterodactylus* „	Zittel, Palæontographica, vol. 29, p. 64.
Non *P. Kochi*	Winkler, Mus. Teyler Archives, vol. 3, 1874, p. 377.
Pterodactylus Lavateri, v. Meyer	See ORNITHOPTERUS.
PTERODACTYLUS LIASICUS, Quenstedt . . .	(Upper Lias, Lower Lias, and Upper Keuper, Würtemberg.)
1858. *Pterodactylus*	Quenstedt, 'Der Jura,' p. vi.
1858. „ *Liasicus* . . .	Quenstedt, Jahresheft. Naturk. Württemb., vol. 14, p. 299.
1860. „ „	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 66.
Pterodactylus longicaudus, Münster . . .	See RHAMPHORHYNCHUS.
PTERODACTYLUS LONGICOLLUM, v. Meyer . .	(Lithographic Slate, Eichstätt, Bavaria.)
1854. *Pterodactylus longicollum* . . .	v. Meyer, Neues Jahrb. Mineral., p. 52.
1858. „ *longicollis* . . .	Wagner, München, Bayer. Akad. Abhandl., vol. 8, pt. 2, p. 456.
1860. „ *longicollum* . . .	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 45.
1861. „ *longicollis* . . .	Wagner, München, Bayer. Akad. Sitzber., p. 532.
1871. *Diopecephalus longicollum* . . .	Seeley, Ann. Mag. Nat. Hist., ser. 4, vol. 7, p. 35, note.
PTERODACTYLUS LONGIPES, Münster	(Lithographic Slate, Solenhofen, Bavaria.)
1836. *Pterodactylus longipes*	Münster, Neues Jahrb. Mineral., p. 580.
1860. „ „	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 48.
1861. „ „	Wagner, as subspecies of *P. longicollis*, München, Bayer. Akad. Sitzber., vol. 1, p. 532.
Pterodactylus longirostris, Cuvier	See PTERODACTYLUS ANTIQUUS.
Pterodactylus macronyx, Buckland	See DIMORPHODON.
PTERODACTYLUS MANSELI, Owen	(Kimeridge Clay, Dorsetshire.)
1874. *Pterodactylus Manseli*	Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 8, pl. 1.
PTERODACTYLUS MARDERI, Owen	(Lias, Lyme Regis.)
1874. *Pterodactylus Marderi*	Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 12.
PTERODACTYLUS MEDIUS, Münster	(Lithographic Slate, Daiting, Monheim, Bavaria.)
1831. *Pterodactylus medius*	Münster, Nova Acta Leopold., vol. 15, pt. 1, p. 49.
1831. „ *intermedius* . . .	Goldfuss (in error), *ibid.*, p. 68.
1860. „ *medius*	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 39.
1861. „ „	Wagner, as subspecies of *P. propinquus*, München, Bayer. Akad. Sitzber., p. 532.
Pterodactylus Meyeri, Münster	See PTENODRACON BREVIROSTRIS.
Pterodactylus micronyx, Meyer	See PTERODACTYLUS REDENBACHERI.
Pterodactylus Montanus, Marsh	See DERMODACTYLUS.
Pterodactylus Münsteri, Goldfuss	See RHAMPHORHYNCHUS.

Pterodactylus nettecephaloides, Ritgen . . . See PTENODRACON BREVIROSTRIS.

Pterodactylus nobilis, Owen . . . . See ORNITHOCHEIRUS.

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1840. Bones of Birds . . . . Mantell, Geol. Soc. Trans., ser. 2, vol. 5, p. 175.
1846. *Pterodactylus* . . . . v. Meyer, Palæontographica, vol. 1, p. 2.
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1874. *Pterodactylus Pleydelli*, Owen . . Pal. Soc., Mesoz. Rept., pt. 1, p. 9.

PTERODACTYLUS PROPINQUUS, Wagner . . . (Lithographic Slate, Bavaria.)
1857. *P.* (*Ornithocephalus*) *propinquus* . Wagner, München, Bayer. Akad. Anzeig., 17th August, 1857, p. 171.
1858. *Pterodactylus propinquus* . . . Wagner, München, Bayer. Akad. Abhandl., vol. 8, pt. 2, p. 451.
1860. ,, ,, . . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 40.
1861. ,, ,, . . . Wagner, München, Bayer. Akad. Sitzber., vol. 1, p. 532. (Wagner includes *P. medius* as a subspecies.)

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1851. *Ornithocephalus Redenbacheri* . Wagner, München, Bayer. Akad. Anzeig., No. 35, p. 270.
1856. *Pterodactylus micronyx* . . . . v. Meyer, Neues Jahrb. Mineral., p. 826.
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1851. *Ornithocephalus rhamphastinus* . Wagner, München, Bayer. Akad. Sitzber., vol. 6, pt. 1, p. 132.
1860. *Pterodactylus rhamphastinus* . . v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 54.
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1874. *Diopecephalus* ,, . . Seeley, Ann. Mag. Nat. Hist., ser. 4, vol. 7, p. 35, note.

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1843. *Pterodactylus secundarius* . . . v. Meyer, Neues Jahrb. Mineral., p. 583.
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Pterodactylus Sedgwickii, Owen . . . . . See ORNITHOCHEIRUS.

Pterodactylus simus, Owen	See ORNITHOCHEIRUS.
PTERODACTYLUS SPECTABILIS, v. Meyer . . .	(Lithographic Slate, Bavaria.)
1861. *Pterodactylus spectabilis* . . .	v. Meyer, Neues Jahrb. Mineral., p. 467.
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1882. ,, ,, . . .	Zittel, Palæontographica, vol. 29, p. 77.
Pterodactylus Suevicus, Quenstedt	See CYCNORHAMPHUS.
PTERODACTYLUS SUPRAJURENSIS, Sauvage . .	(Kimeridgian, Boulogne.)
1873. *Pterodactylus Suprajurensis* . .	Sauvage, Soc. Géol. France Bull., ser. 3, vol. 1, p. 365.
Pterodactylus umbrosus, Cope	See PTERANODON INGENS.
Pterodactylus validus, Owen	See ORNITHOCHEIRUS.
Pterodactylus velox, Marsh	See PTERANODON.
PTERODACTYLUS VULTURINUS, Wagner . . .	(Lithographic Slate, Daiting, Monheim, Bavaria.)
1857. *P.* (*Ornithocephalus*) *vulturinus*	Wagner, München, Bayer. Akad. Anzeig., No. 21, p. 174.
1860. *Pterodactylus* ,,	v. Meyer, 'Fauna d. Vorwelt, Rept. Lithog. Schief.,' p. 62.
1861. ,, ,,	Wagner, München, Bayer. Akad. Sitzber., vol. 1, p. 531.
Pterodactylus Woodwardi, Owen	See ORNITHOCHEIRUS.
Pterodactylus Württembergicus, Quenstedt .	See CYCNORHAMPHUS SUEVICUS.
Pycnorhamphus, Zittel	In error for PACHYRHAMPHUS. (See Palæontographica, vol. 29, 1882, p. 80.)
RHAMPHOCEPHALUS BUCKLANDI, v. Meyer . .	(Stonesfield Slate.)
1832. *Pterodactylus Bucklandi* . . .	v. Meyer, 'Palæologica,' pp. 117 and 252.
1859. ,, ,, . . .	Huxley, Geol. Soc. Quart. Journ., vol. 15, p. 658.
1860. ,, ,, . . .	v. Meyer, 'Fauna d. Vorwelt, Lithog. Schief.,' p. 10.
1874. ? ,, *Duncani*. . . .	Owen, Pal. Soc., Mesoz. Rept., pt. 1, p. 11, pl. 1, fig. 18.
1874. ? ,, *Kiddi*	Owen, *ibid.*, pl. 1, fig. 17.
1888. *Rhamphocephalus Bucklandi* .	Lydekker, 'Cat. Foss. Rept. Brit. Mus.,' p. 34.
RHAMPHOCEPHALUS DEPRESSIROSTRIS, Huxley	(Stonesfield Slate.)
1859. *Rhamphorhynchus depressirostris*	Huxley, Geol. Soc. Quart. Journ., vol. 15, p. 663.
1874. ? *Pterodactylus Aclandi* . . .	Owen, Pal. Soc. Mesoz. Rept., pt. 1, p. 11.
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RHAMPHOCEPHALUS PRESTWICHI, Seeley . .	(Stonesfield Slate, Kineton, Warwick.)
1880. *Rhamphocephalus Prestwichi* .	Seeley, Geol. Soc. Quart. Journ., vol. 36, p. 27.
1885. *Dolichorhamphus* (in error) . .	Seeley, Phillips' Geology, edit. 2, p. 518.
Rhamphorhynchus Banthensis, Theodori . .	See DORYGNATHUS.
Rhamphorhynchus Bucklandi, v. Meyer . .	See RHAMPHOCEPHALUS.
Rhamphorhynchus crassirostris, Goldfuss . .	See SCAPHOGNATHUS.
Rhamphorhynchus curtimanus, Wagner . .	See RHAMPHORHYNCHUS MÜNSTERI.
Rhamphorhynchus depressirostris, Huxley .	See RHAMPHOCEPHALUS.
Rhamphorhynchus ensirostris, Theodori . .	See DORYGNATHUS BANTHENSIS.
RHAMPHORHYNCHUS GEMMINGI, v. Meyer . .	(Lithographic Slate, Solenhofen, Bavaria.)
1846. *P.* (*Rhamphorhynchus*) *Gemmingi*	v. Meyer, Palæontographica, vol. 1, p. 1, and Neues Jahrb. Mineral., p. 463.
1851. *Ornithocephalus* ,,	Wagner, München, Bayer. Akad. Abhandl., vol. 6, pt. 1, p. 190.
1855. *Rhamphorhynchus* ,,	v. Meyer, Neues Jahrb. Mineral., pp. 333 and 809.
1858. ,, *longimanus* .	Wagner, München, Bayer. Akad. Abhandl., vol. 8, pt. 2, p. 491.

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1884. „ „ . . Ammon, Regensburg, Nat. Ver. Corr. Blatt, vol. 38, p. 130.

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1831. *Ornithocephalus Münsteri* . . Goldfuss, Nova Acta Leopold., vol. 15, pt. 1, p. 112.
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1846. *P. (Rhamphorhynchus) Münsteri* v. Meyer, Palæontographica, vol. 1, p. 20.
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1882. *Pachyrhamphus* „ . . Zittel, Palæontographica, vol. 29, p. 17.
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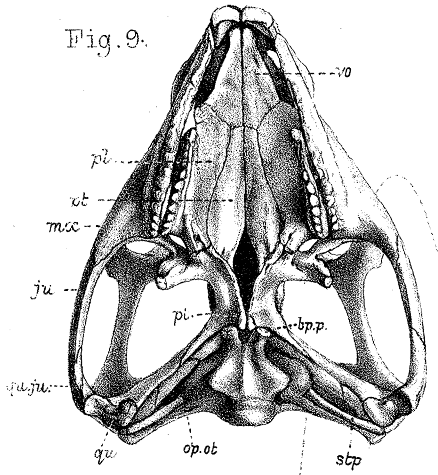
Fig. 9.



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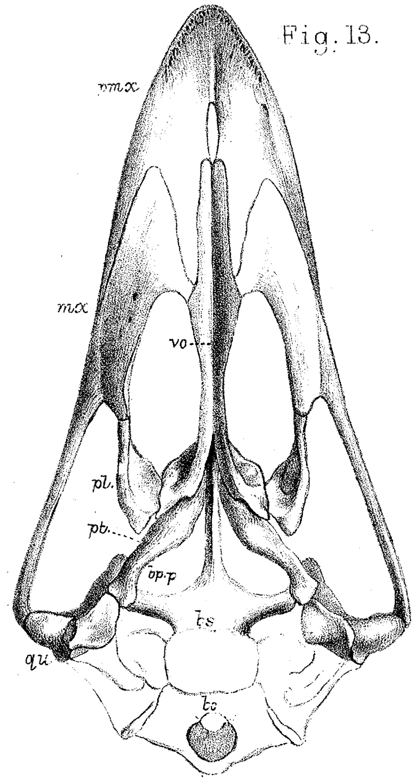

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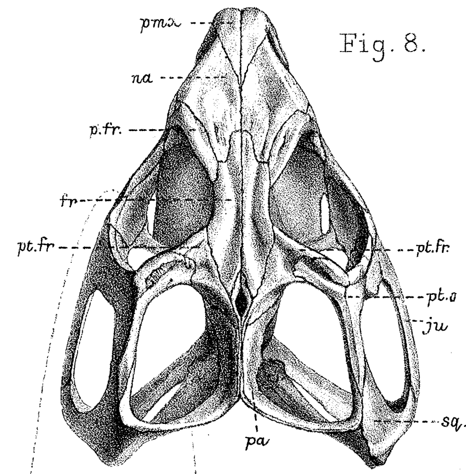

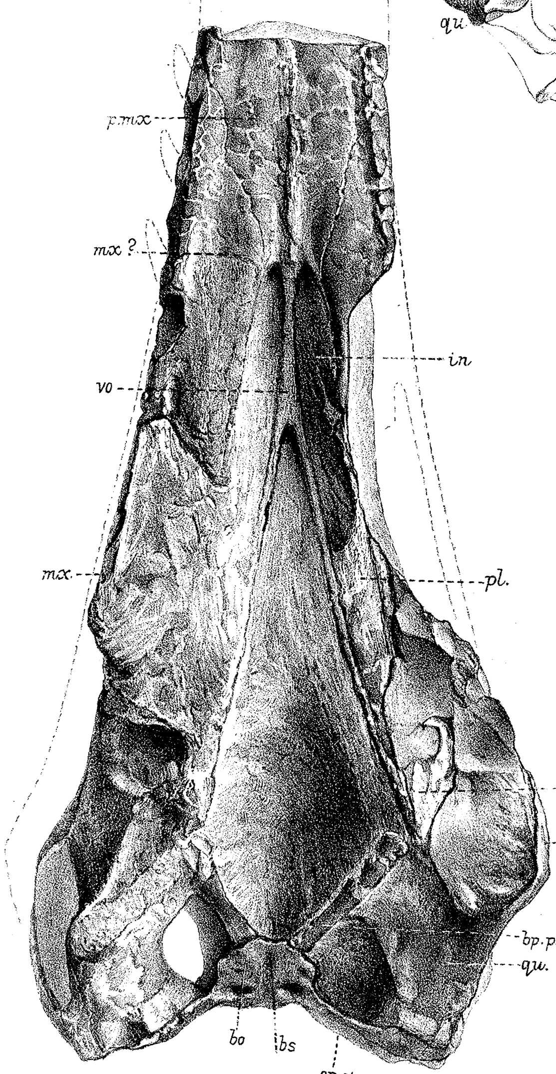

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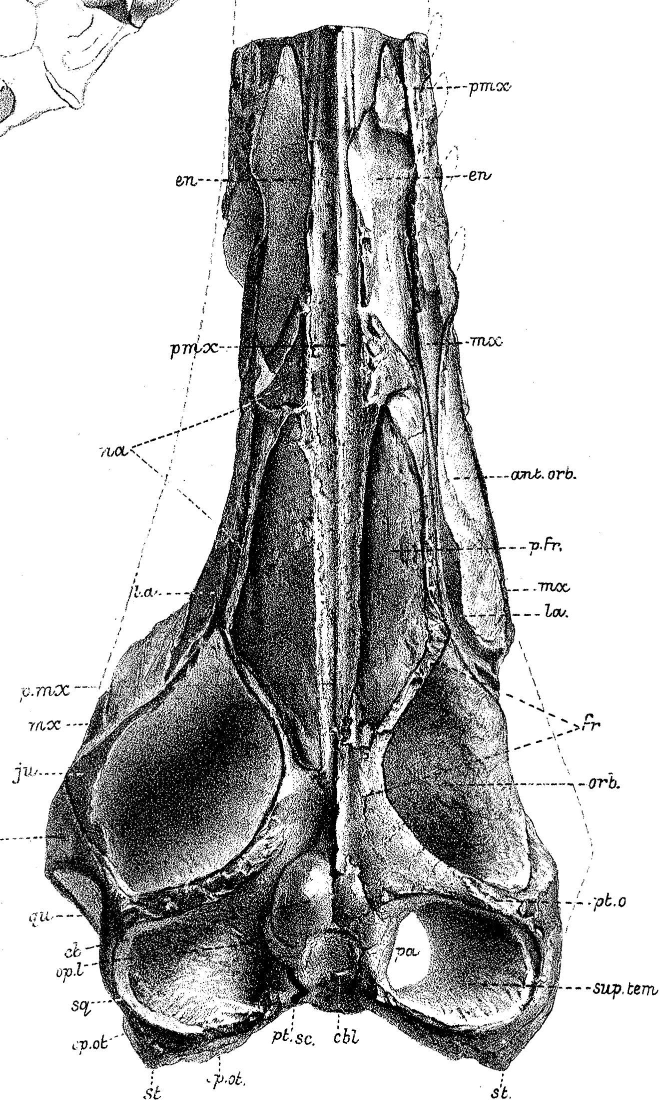

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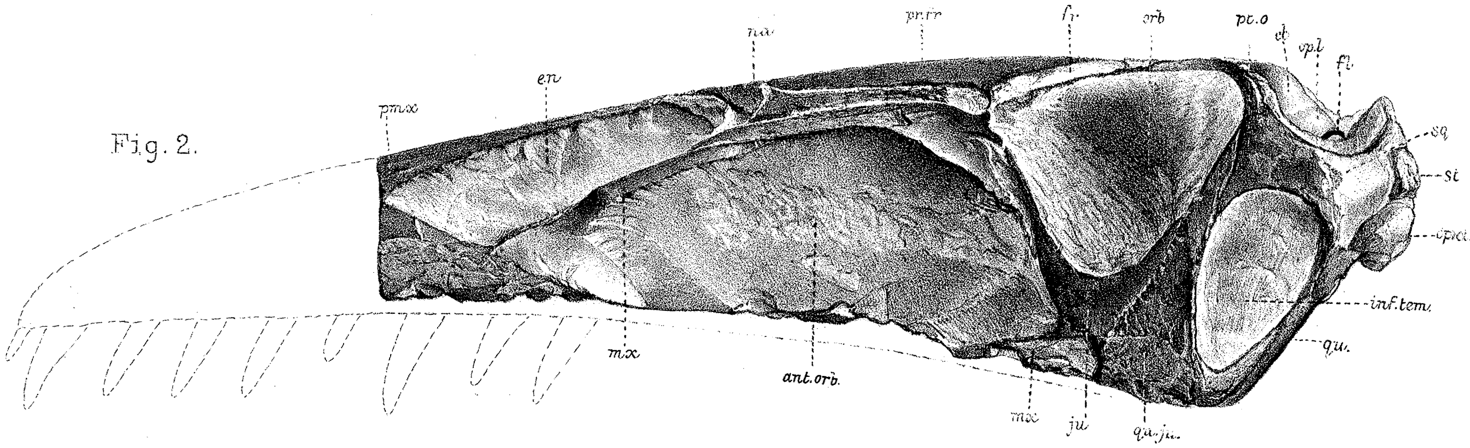

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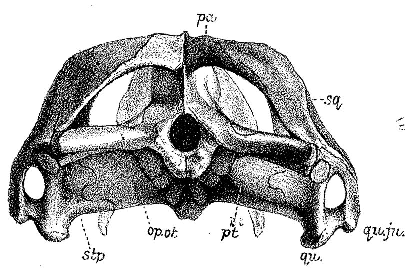


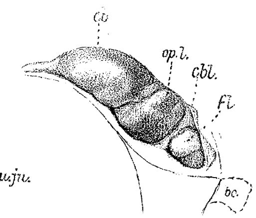
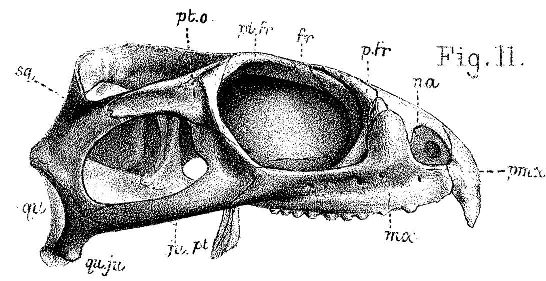


Fig. 6.

Fig. 11.



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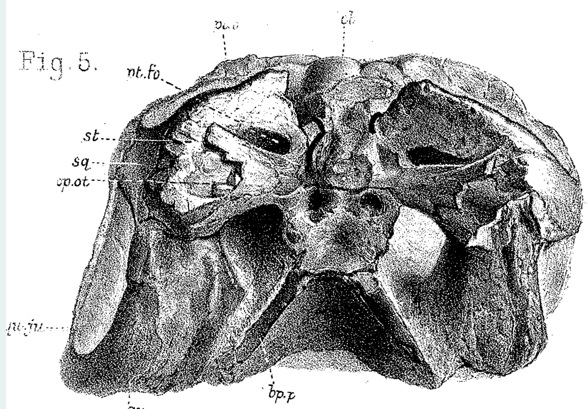

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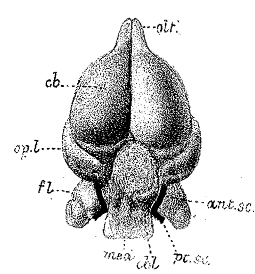

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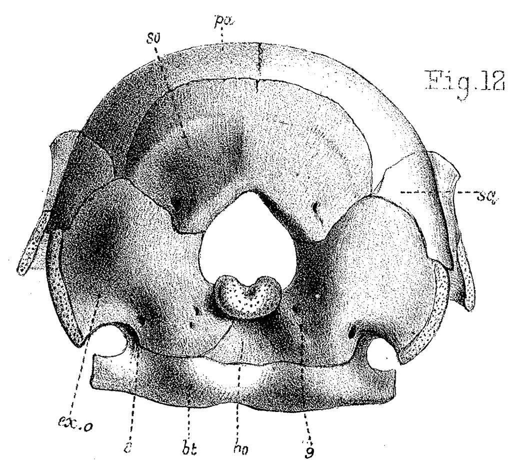

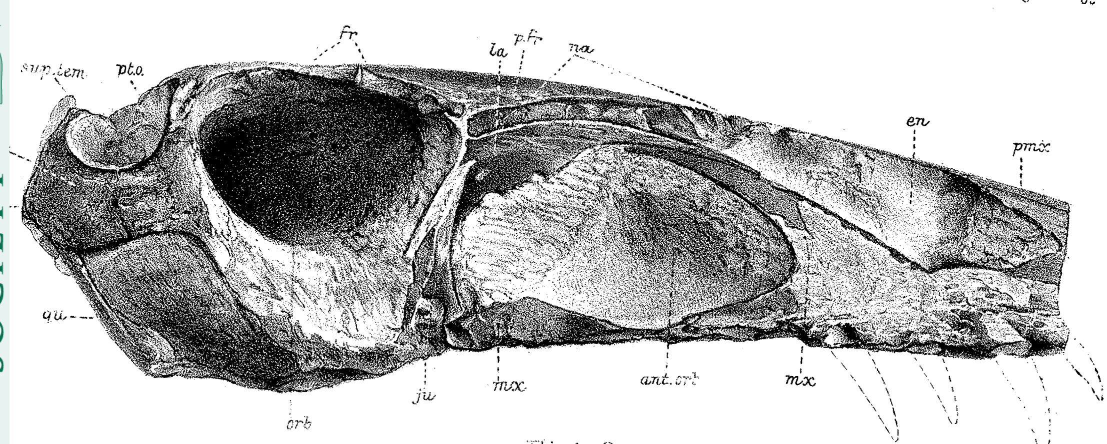

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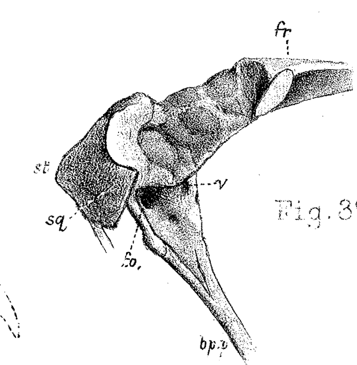
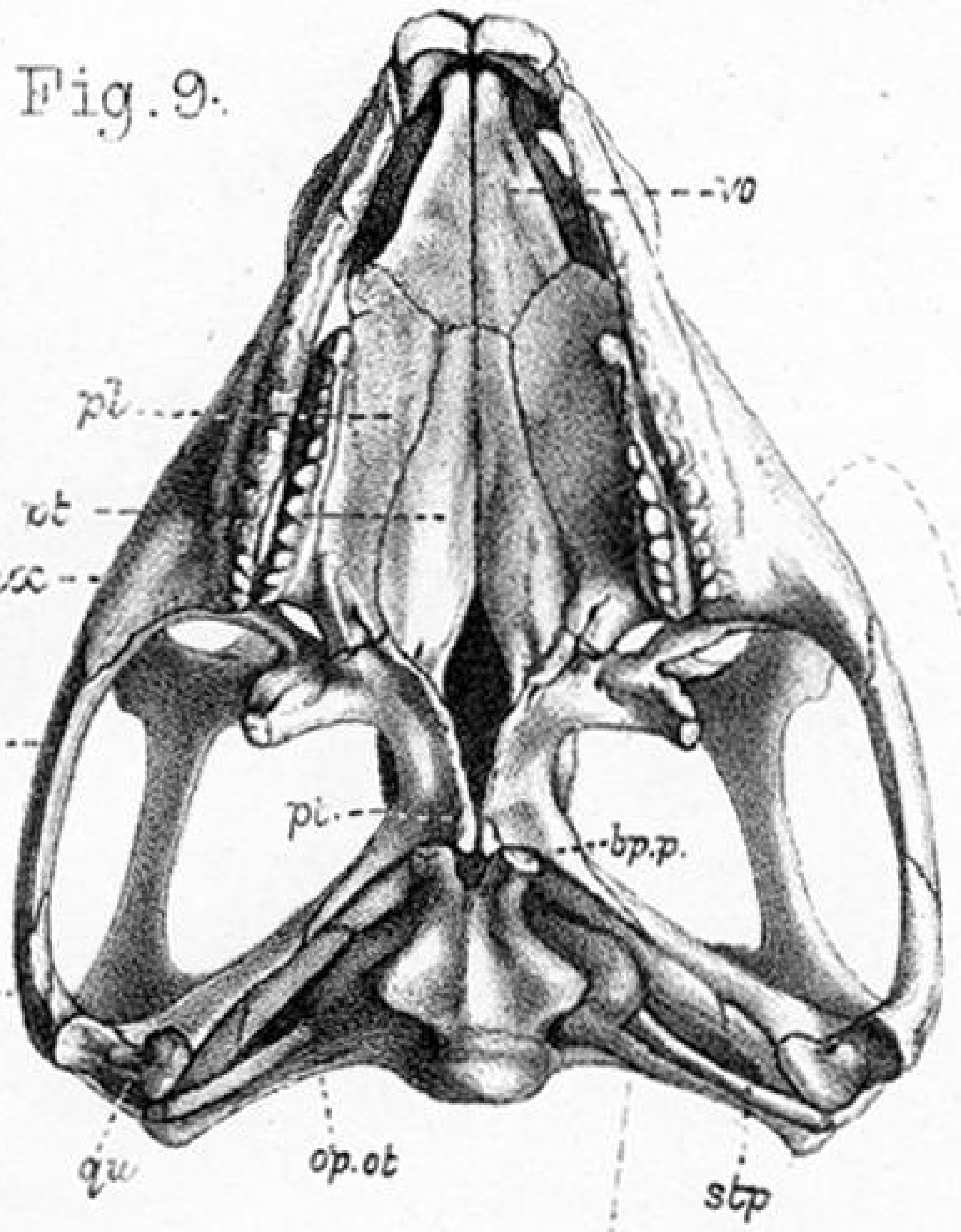


Fig. 3a.

W.H. Wesley lith.

West, Newman & Co. imp.

Fig. 9.



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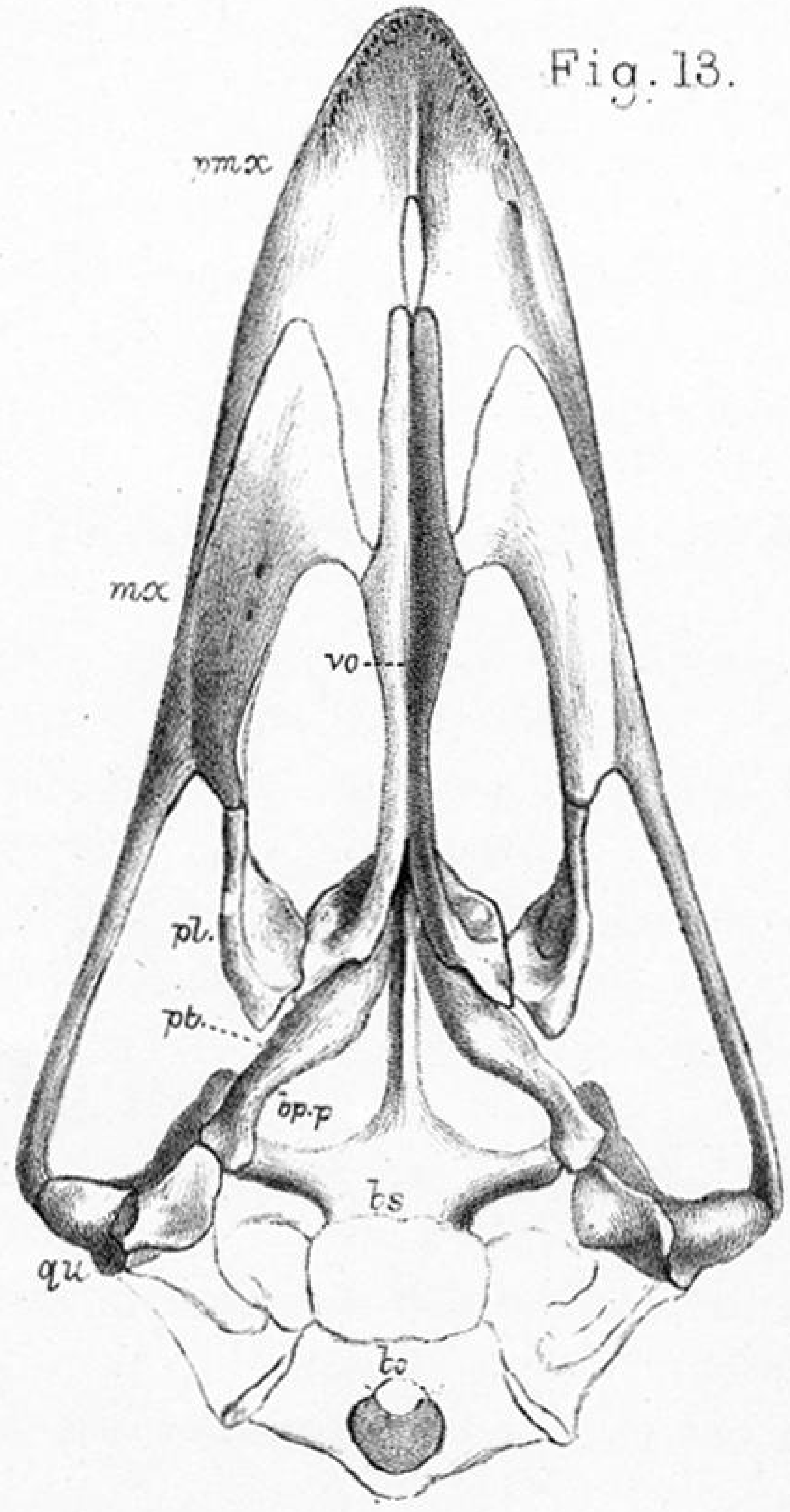

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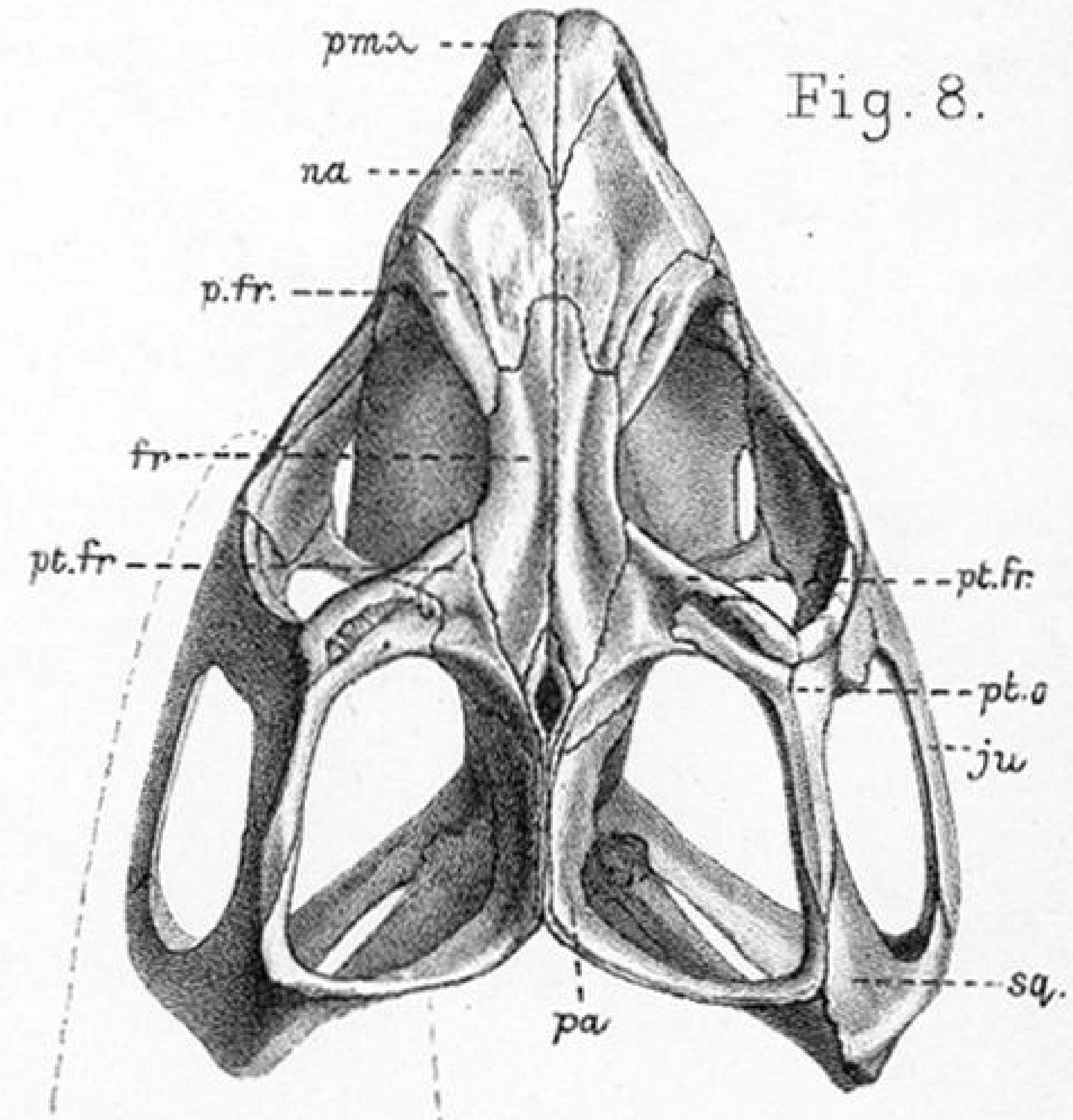

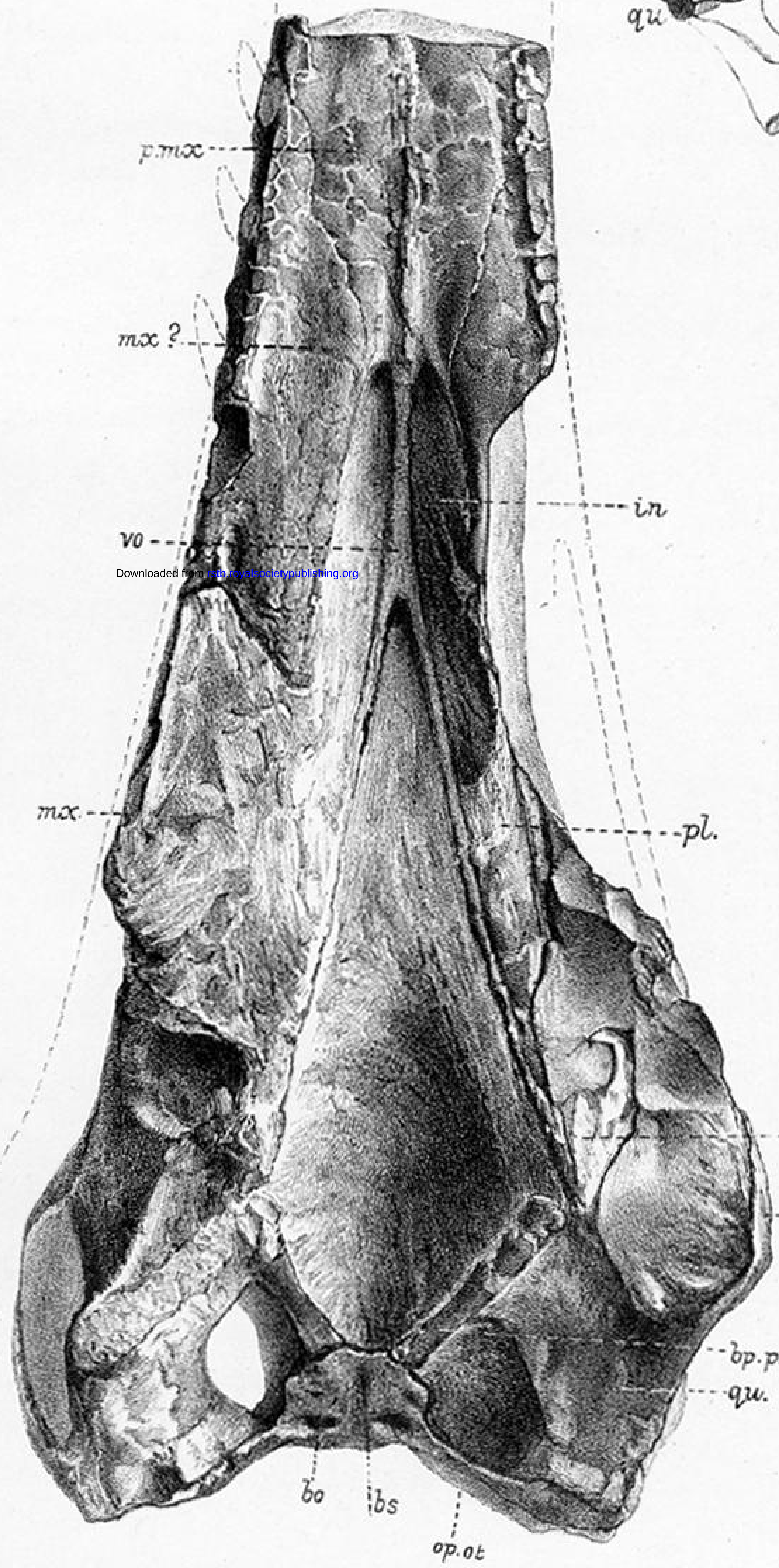

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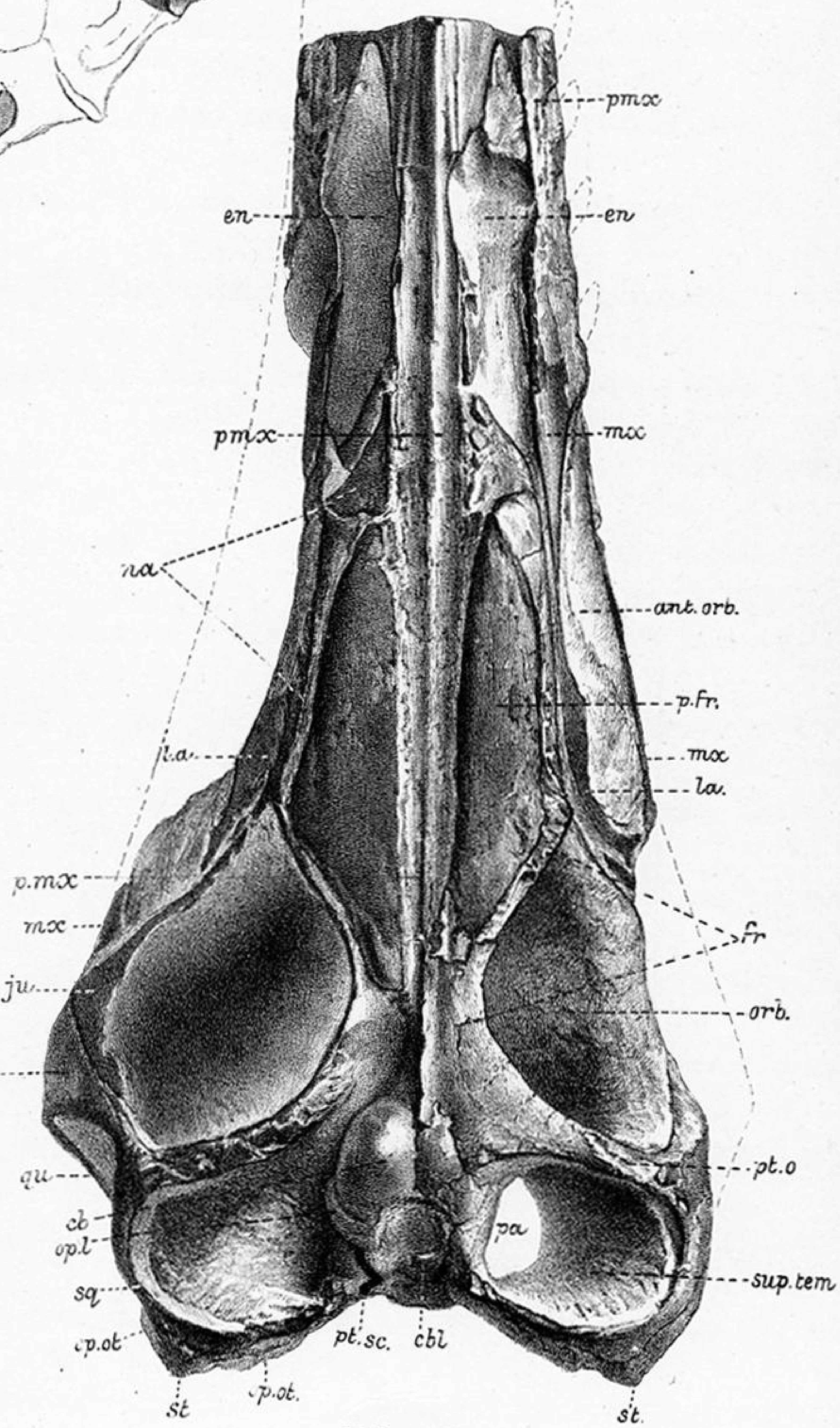

Fig. 1.

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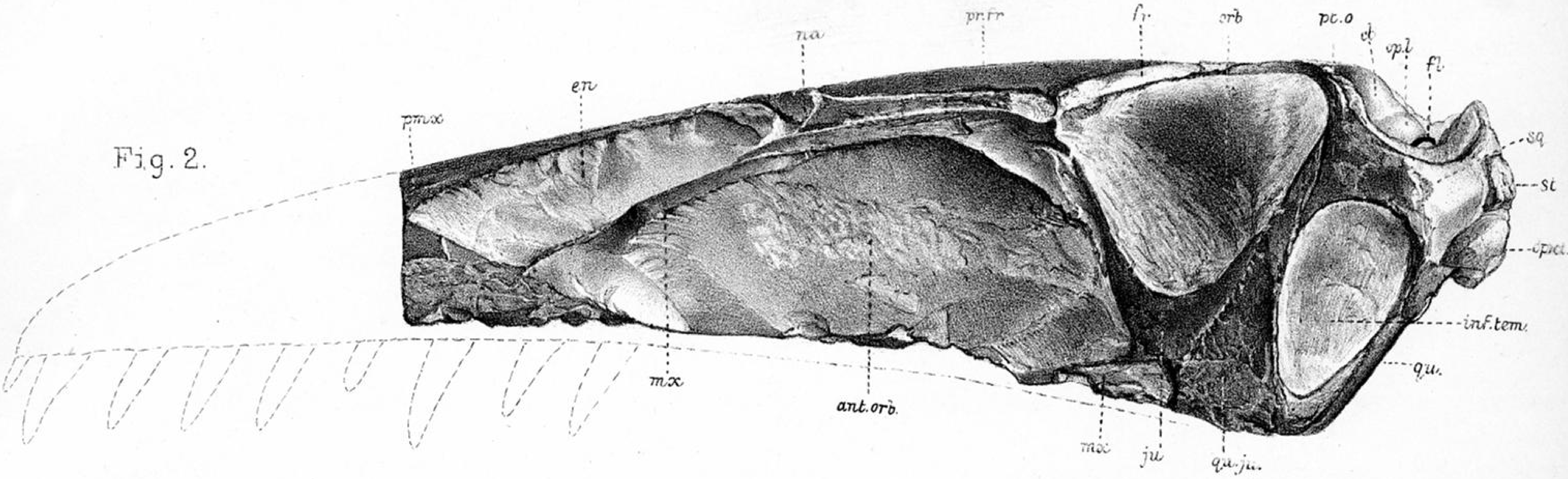

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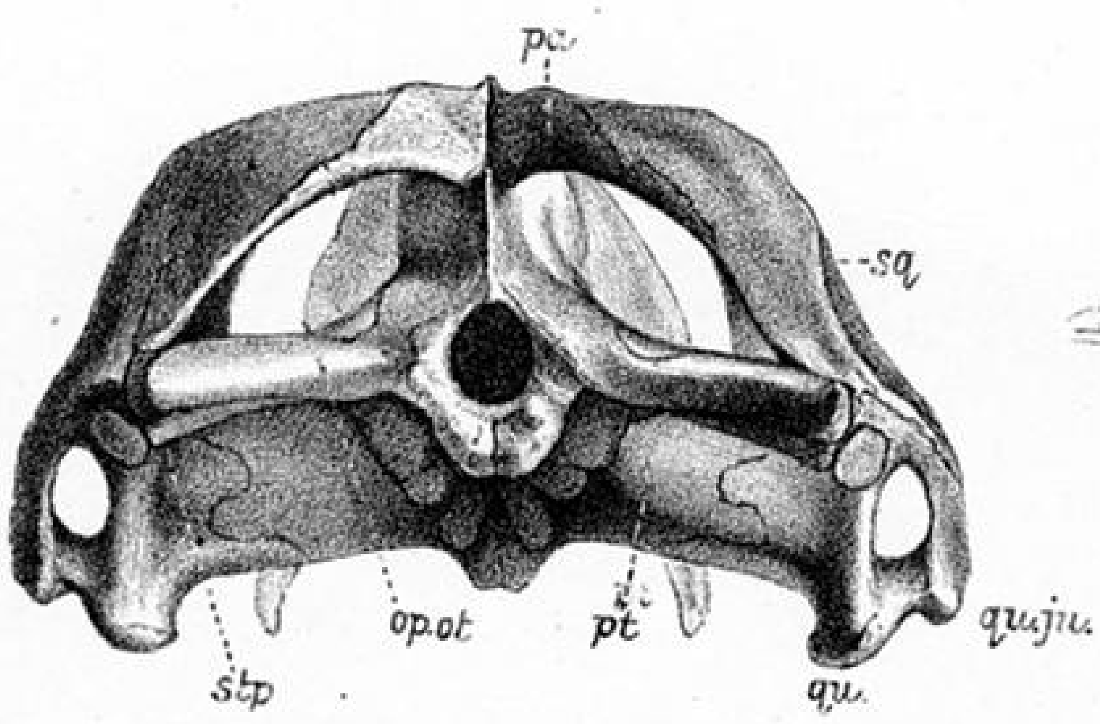


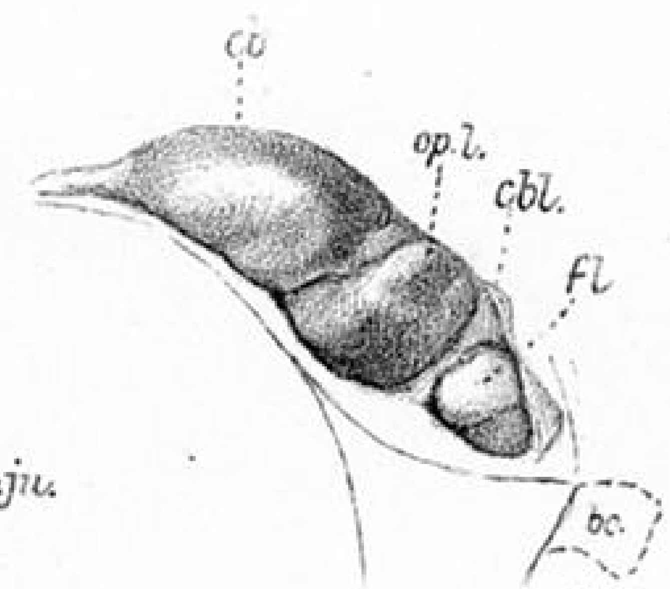
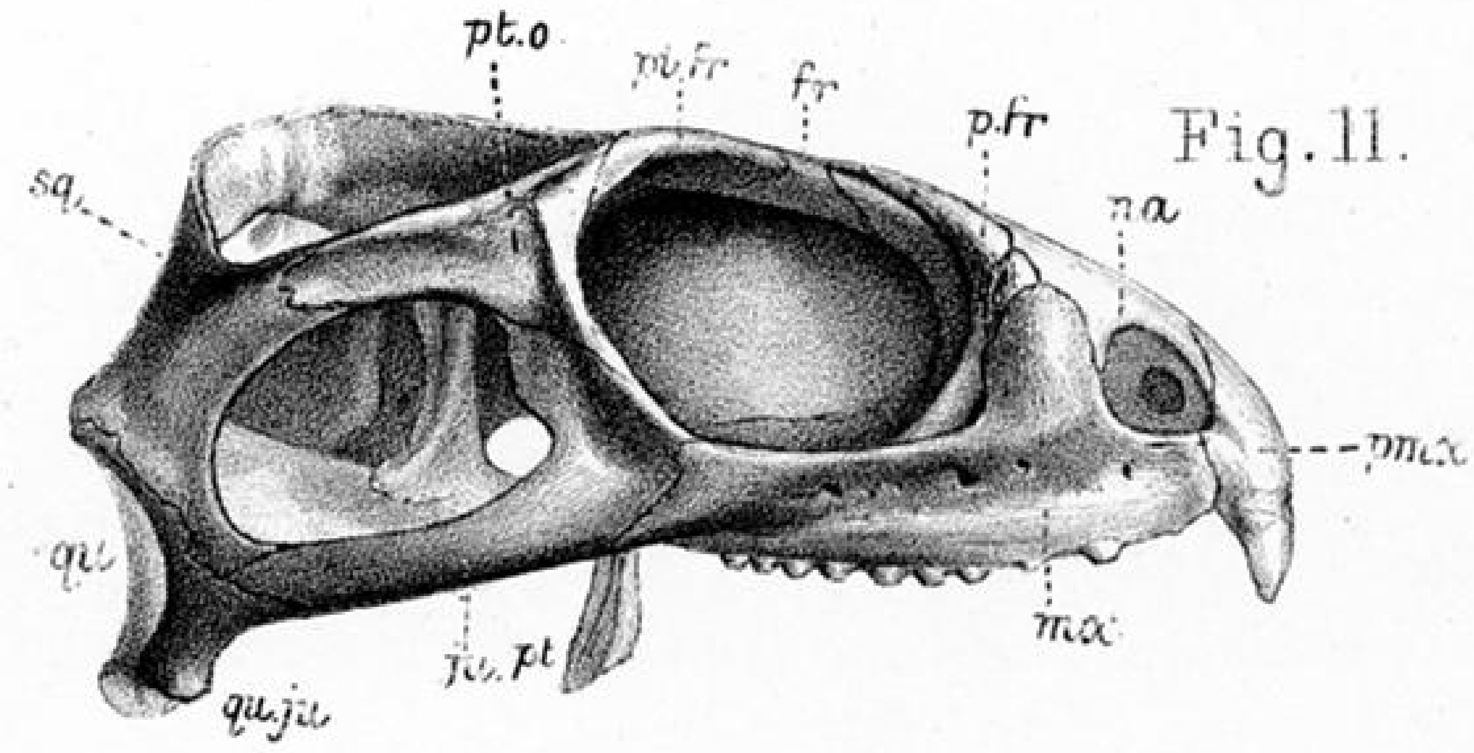


Fig. 6.

Fig. 11.



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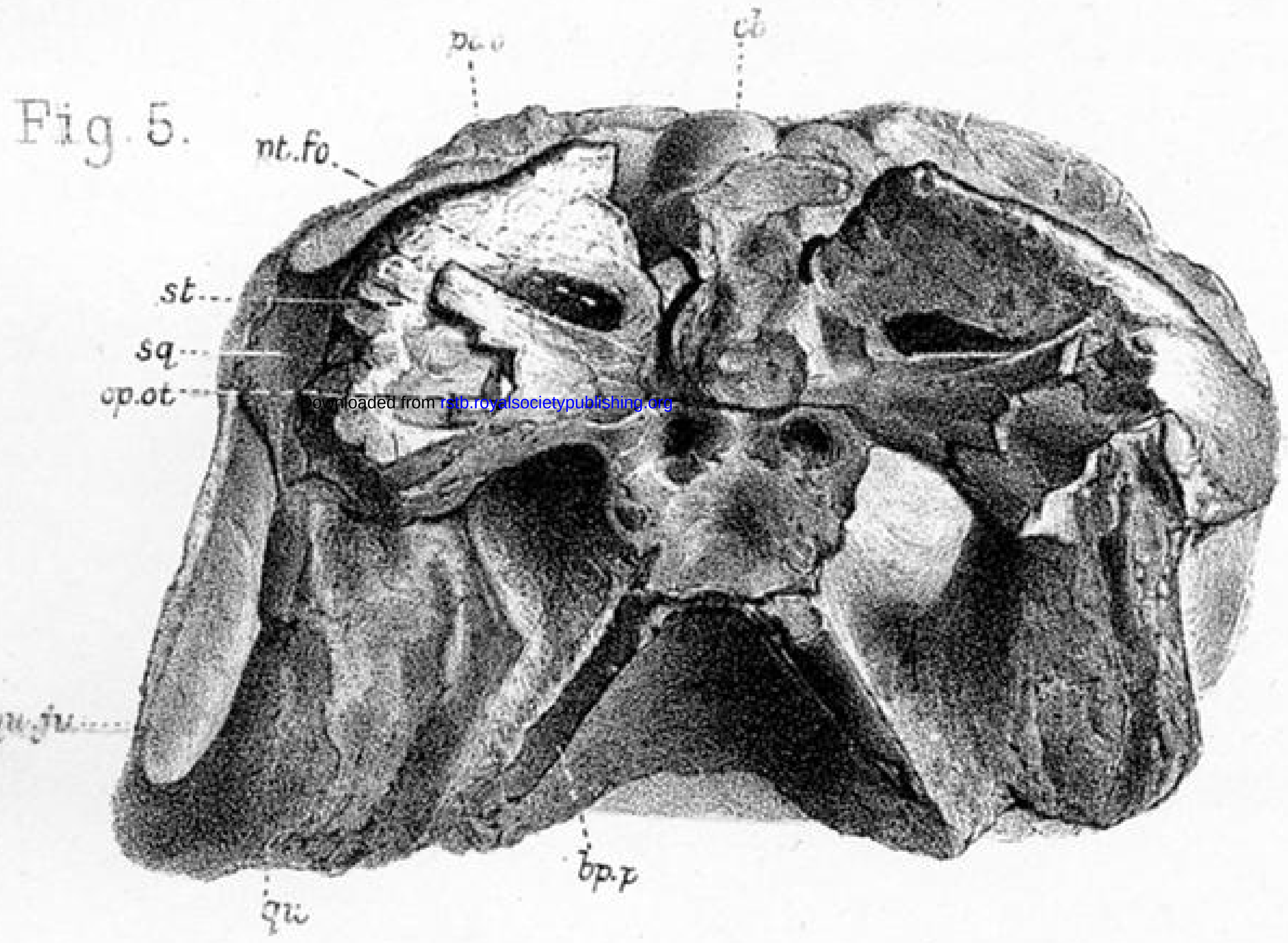

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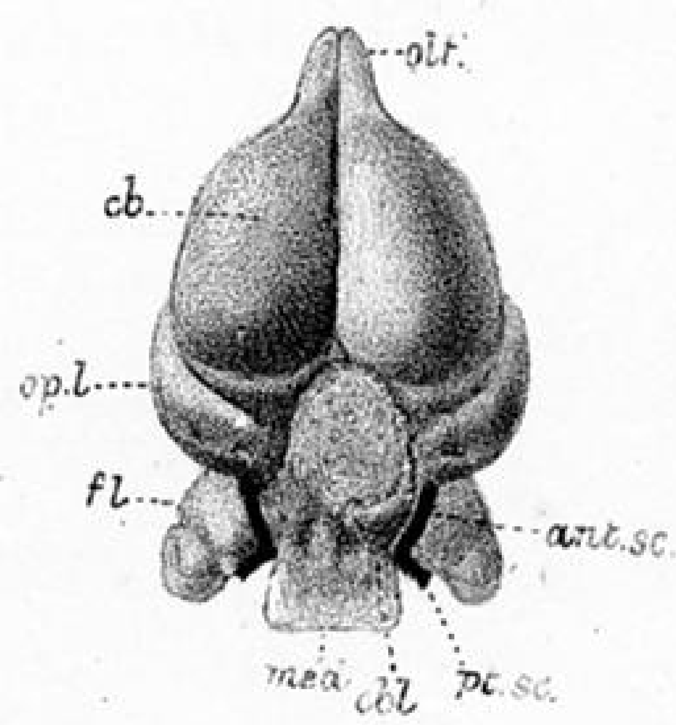

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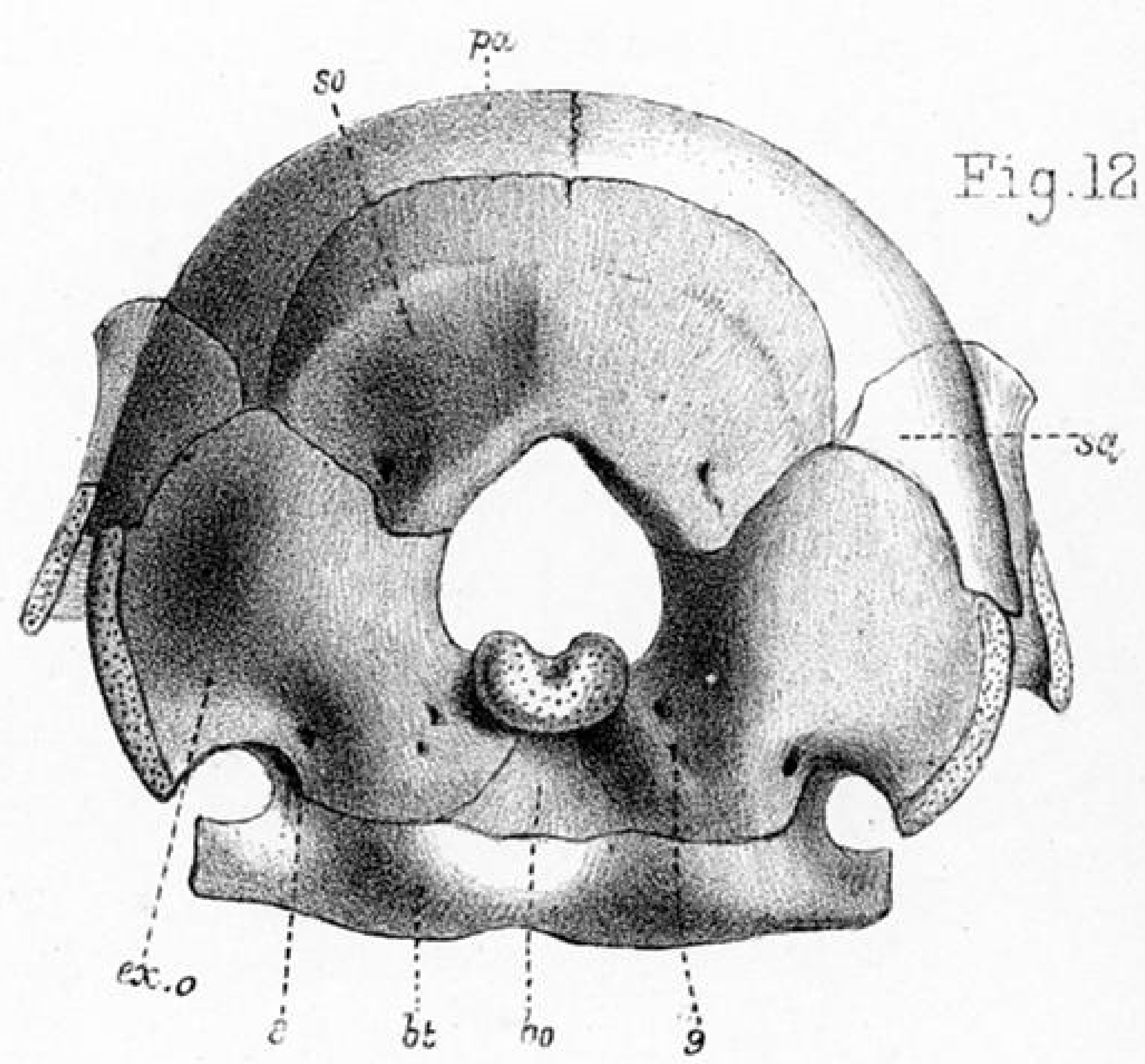

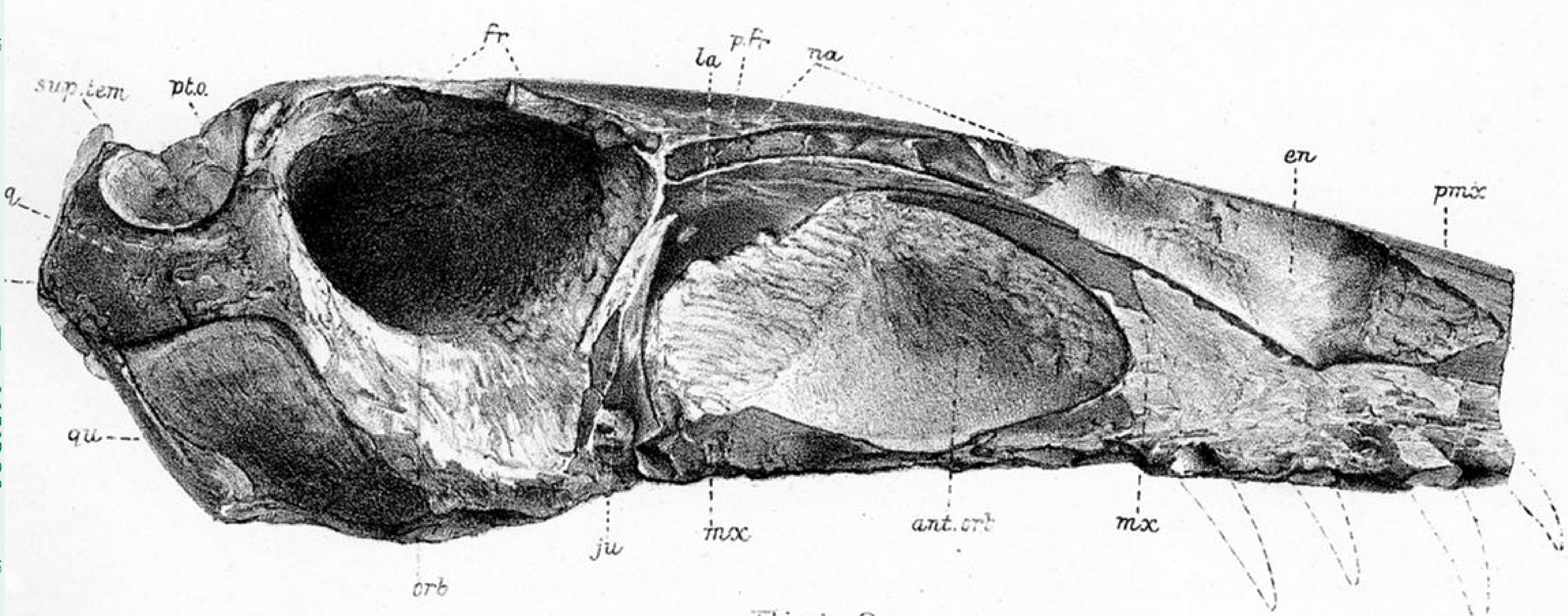

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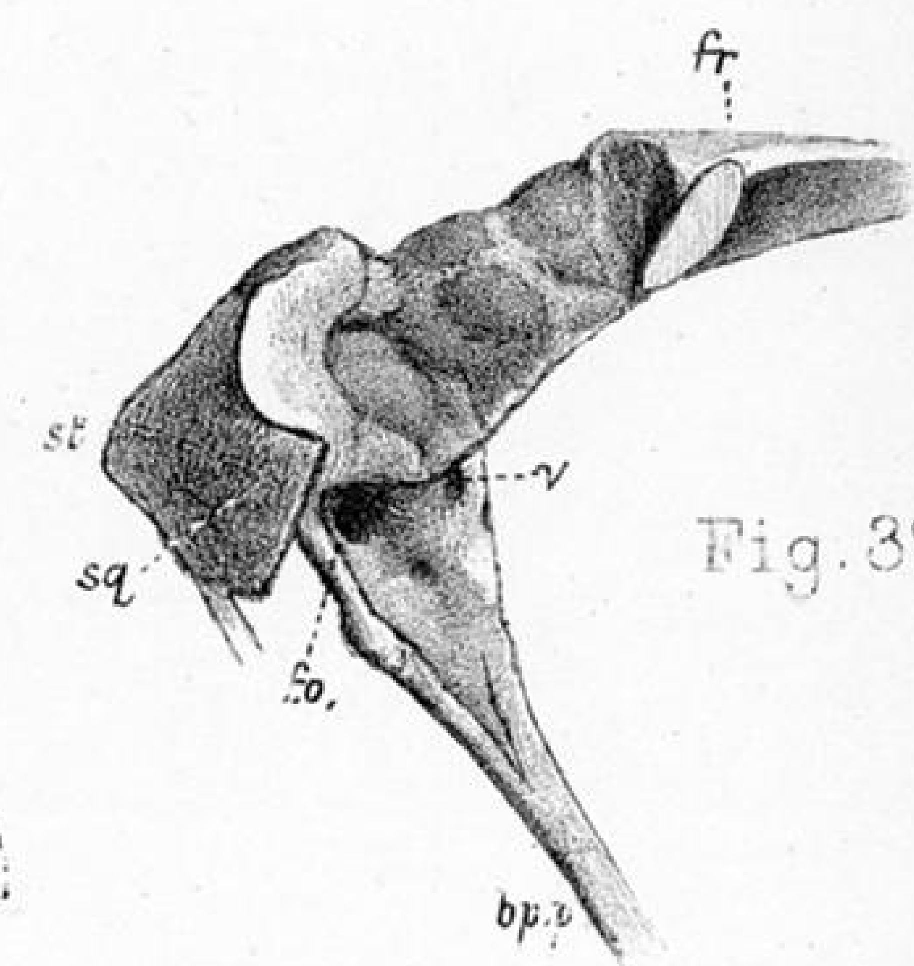

Fig. 3a.