

THE SKULL OF PALEORHINUS  
A WYOMING PHYTOSAUR

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The University of Chicago paleontological expedition to Wyoming during the summer of 1904, under the direction of Dr. S. W. Williston, secured several phytosaurian skulls in excellent preservation. These skulls together with other fossil remains were collected from the Popo Agie beds of the Upper Trias of the Wind River region. One of these, made the type of a new genus by Dr. Williston and given its specific name in honor of its finder, Dr. E. B. Branson, has been studied by the writer during the past winter and the results of the work are here published. A preliminary announcement of the characters of this specimen, together with notes regarding the other specimens found at the same time, was issued some time ago by Dr. Williston (this JOURNAL, Vol. XII, 1904, p. 696).

*General characters.*—Skull greatly elongated, triangular; snout long, slender, depressed. External nares elevated, situated at posterior extremity of snout, entirely in front of antorbital vacuities, separated by downward extensions of nasals. Antorbital vacuities large; supratemporal vacuities small, completely enclosed; otic foramina present and completely enclosed. Quadrate foramina present, small. Squamosal extending but slightly beyond posterior margin of quadrate. Median notch of skull nearly in shape of isosceles triangle; notch above quadrate moderately deep. Plane of orbits directed obliquely upward.

Internal nares situated posterior to external, separated by vomers. Palatines separated by pterygoids. Vomers long and slender, separating pterygoids throughout, extending back to presphenoidal opening. Pterygoids long, entering into posterior margin of nares between palatines and vomers, extending postero-laterally in broad vertical plates for union with quadrates. Basipterygoid processes moderate in size, enlarged distally.

Posterior palatine foramina small, wholly enclosed by palatines and transverses. Presphenoidal opening small, cordiform. Teeth thirty-six on each side of upper jaw, two foremost larger and much elongated.

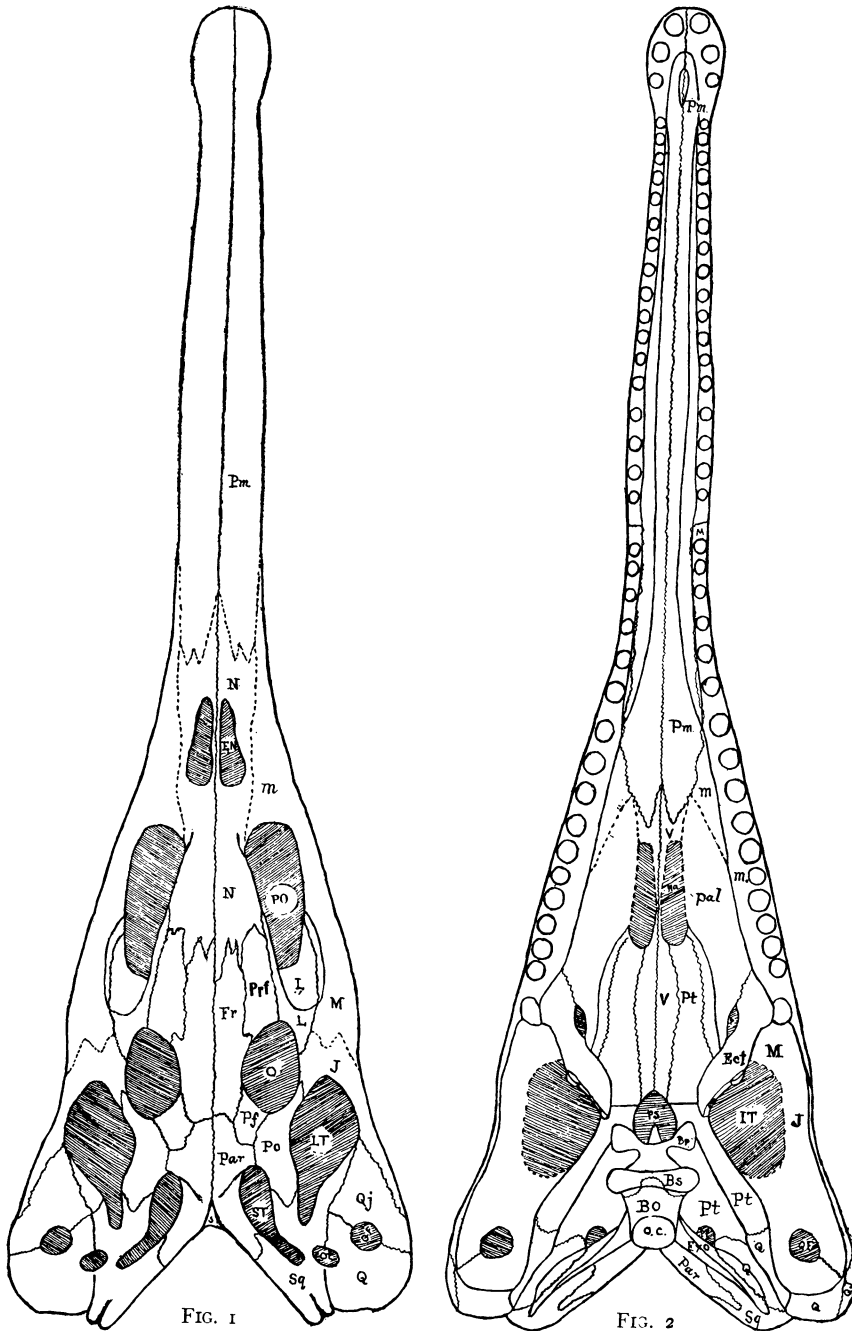
Mandible presenting high surangular crest and short posterior extension. Inner face bearing a strong, subrectangular process which springs from posterior extremity and extends anteriorly parallel to the ramus. Jaw rather slender, pierced by external and internal fenestræ and by small internal mandibular foramen.

Ilium bearing on outer face three strong ridges meeting in a high central knob above acetabulum. Posterior extremity continued in long process. Inner surface quite smooth except for long shallow trench for reception of sacrum, and two ill-defined ridges which bound it.

The skull is quite broad in the occipital region and narrows gradually to the region of the nares. A short distance in front of these the roof slopes downward and merges into the snout, which comprises about one-half the length of the entire skull. The snout is depressed and in cross-section its width is greater than its height. At the anterior extremity it is enlarged and somewhat deflected downward, and bears two large teeth on each side.

Viewed from the side the skull appears rather depressed, as its elevation is about one-half its greatest width. It presents a fairly even crest-line from its posterior margin to a position somewhat in front of the middle of the antorbital vacuities, where it begins to rise to the elevation upon which the nares open. From the nares the slope downward to the snout is rapid.

In the side view nearly all the external openings of the skull are visible—the anterior, excavated portion of the nares, the antorbital vacuity, the orbit itself, the lateral temporal vacuity, the quadrate foramen, and the opening of the otic capsule together with the small notch immediately beneath it. Only the supra-temporal vacuity and the deep median notch remain concealed. The skull is thus given quite a light, open appearance and has a much less massive aspect than some of the related belodonts, especially *B. kapffi*—or *Phytosaurus kapffi*, to follow McGregor—although this contrast is rendered more forcible by the slender snout of the specimen in



Skull of *Paleorhinus bransoni* Williston.

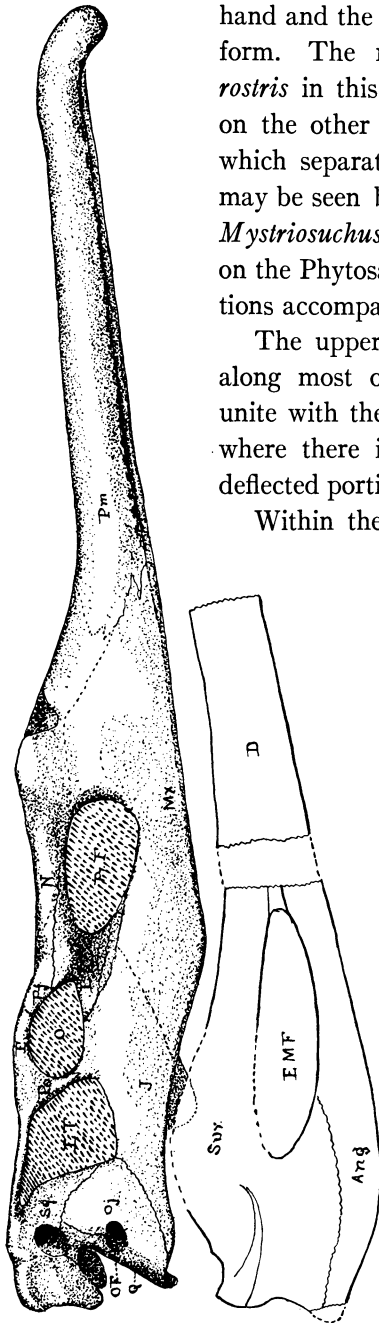


FIG. 3.—Skull of *Paleorhinus bransoni*, from the side.

hand and the enlargement of that in the European form. The resemblance to *Mystriosuchus planirostris* in this respect is much closer, but there are on the other hand some very marked divergences which separate the two individuals rather widely, as may be seen by a comparison of the illustrations of *Mystriosuchus* as given by McGregor in his paper on the Phytosauria. See bibliography and illustrations accompanying this paper.

The upper line of the snout is almost straight along most of its length, except where it rises to unite with the skull and also in the anterior region where there is a slight convexity just behind the deflected portion.

Within the line of the dental alveoli is a strong rounded ridge which probably meets a corresponding ridge on the mandible, as is stated by McGregor to be the case in *Mystriosuchus*, and thus prevented too forcible meeting of the teeth. These latter must have pointed obliquely outward.

The lateral bones of the skull are slightly roughened by irregular pittings and rugosities. This feature becomes more marked on the bones of the roof, especially on the frontals, where, between the anterior portions of the orbits, is a small area of very notable rugosity. Just anterior to this area the frontals are sculptured by narrow longitudinal ridges and furrows about one-eighth inch in width and one-half as deep, and with lengths up to one inch or more. The region between the antorbital vacuities is again roughened by small irregular tubercles and the

narial region is marked by small irregular pits and elevations, while the snout is rather smooth, with ornamentation about like that of the lateral portions of the skull.

*Premaxilla.*—The premaxilla is greatly elongated and makes up the entire rostrum except that portion immediately surrounding the nares. This part of the skull is, however, so shattered that the sutural relations of premaxilla, maxilla, and nasal cannot be determined with accuracy. Judging from von Meyer's figures of *Belodon* the premaxilla should extend to within about two inches of the nares, while the maxilla extends forward about two inches under the premaxilla. The indications point to this being the case. If this is true it gives the premaxilla a length of about fourteen and one-half inches.

The two premaxillæ were never fused; the suture remained distinct throughout life, and the union of the bones was so slight that the post-mortem crushing of the skull has caused them to slip over one another for almost one-half inch in one place.

*Maxilla.*—There seems to be a suture extending from a little in front of the middle of the upper border of the preorbital vacuity forward and slightly upward till it reaches a point opposite the middle of the naris, whence it descends rapidly, about parallel with the upper line of the snout, until it reaches the margin of the jaw about six inches in front of the point of its origin. This would be the union between the maxilla and the nasal for about four inches and between the maxilla and premaxilla for the anterior two inches. How far the maxilla extends backward and where it unites with the jugal cannot be positively stated, though by analogy with the European forms the union should be on that part of the cheek between the antorbital and lateral temporal vacuities. The maxilla lies below the lachrymal behind the antorbital opening and is united with that element for about two inches. Here it probably meets the jugal—about under the middle of the orbit. This would give to the bone a length of between eleven and twelve inches.

*Nasals.*—The nasals are also quite large bones. They extend from the premaxillæ backward about four inches posterior to the nares, which they entirely surround and which they separate by means of thin vertical septa, which pass downward for some distance in the median plane, how far is not determined, but since one

is exposed by the breaking away of the outer bony cover for at least one and one-fourth inches they must extend somewhat further beyond.

As is the case with the premaxillæ, and indeed with all the bones of the roof of the skull adjoining the median line, the median suture remains distinct. The nasal septa are plainly separate and the suture may be readily distinguished along the whole length of the skull as far as the supraoccipital where it becomes indistinguishable.

The nasal has not a very wide lateral extent, but if the boundaries as indicated in describing the maxilla are correct, it is limited to the upper part of the skull and has nowhere a width of more than one and one-half inches, although its extreme length is probably about nine inches. It is somewhat elevated around the naris, and so raises this opening slightly, and it is excavated for nearly its entire depth opposite the anterior half of the naris, leaving this open to the side for a depth of fully one inch. In life this lateral space was doubtless covered by the integument, confining the nostril to the upper surface of the skull. Whether or not the nasal reaches the antorbital vacuity is not certainly known, but it very probably does so for a short distance, perhaps from one-half to one inch, between the lachrymal and the maxilla.

*Frontal.*—Behind the nasal on the roof of the skull is the frontal, a long, narrow, subrectangular bone nearly four inches in length which unites with the nasal by a strong, splintery suture. The bone extends as far as the posterior limit of the orbit, a part of whose superior margin it forms. It is ornamented with irregular, longitudinal grooves and ridges on its anterior portion and by shorter pits and rugosities in the central and posterior regions.

*Prefrontal.*—This is also long and narrow, but is less regular in outline than the frontal. It is limited behind by the orbit and extends forward slightly beyond the frontal, where it terminates bluntly and is inserted into a notch in the nasal.

*Lachrymal.*—Between the prefrontal and the maxilla lies the lachrymal, a broad, irregularly shaped bone which forms the upper part of the arch between the orbit and the antorbital vacuity. Both of these openings penetrate this bone somewhat from front and rear, so that on the line between them it is constricted to a relatively narrow isthmus. The main body of the lachrymal gives off a slender anterior

process which forms the posterior half of the upper margin of the antorbital vacuity and excludes the prefrontal from this opening.

The lachrymal enters into and forms the greater part of a depressed area which lies behind the antorbital vacuity and extends almost to the orbit, leaving only a narrow bar elevated to form the lower anterior margin of the orbit.

*Parietals.*—Behind the frontals the parietals form the posterior portion of the cranial roof. They unite with the frontals by transverse sutures and are here narrow, but after widening gradually for about five-eighths of an inch they suddenly broaden to twice their anterior width and so continue, until they reach the anterior extremities of the supratemporal fossæ. They form the anterior one-half of the inner boundaries of these fossæ and here meet the squamosals in sutures which slant backward for some distance and then pass transversely to the edges of the median notch, along which they slope posteriorly so that on the under surface the parietals extend backward as thin narrow plates under the squamosals to within one-half inch of the posterior margins of these bones. That part of the parietal which borders the supratemporal fossa on its inner margin is deflected steeply downward and outward, leaving a long, oblique depression of triangular cross-section, in the outer wall of which the fossa is excavated. At a point a little more than one-half the distance from their anterior to their posterior margins the parietals separate and diverge widely, leaving a broad, rather deep, triangular recess which is bounded behind the parietals by the squamosals. This notch opens very gradually during the first one-half inch of its length, and then widens much more rapidly to the posterior margin of the skull. It is floored in its anterior part by the supraoccipital, and here the parietals nearly completely arch it over from side to side.

*Jugal.*—Behind the lachrymal and the maxilla lies the very irregularly shaped jugal. Its suture with the quadratojugal is exposed as a long curved line sloping diagonally backward and downward from the lower posterior angle of the lateral temporal vacuity almost to the point of the jaw. The posterior part of this element thus appears as a long, slender, wing-shaped extension forming the margin of the jaw. Anteriorly the bone widens, forms the cheek between the lateral temporal fossa and the margin of the skull and curves upward

in front of the fossa to form part of its anterior margin. This wing of the jugal tapers upward until at its union with the postorbital, which passes down to complete the margin of the fossa, it forms with the postorbital a narrow bar of about one-fourth inch width separating the fossa and the orbit. The jugal also forms part of the lower boundary of the orbit and here unites with the lachrymal. Its anterior limit and its union with the maxilla cannot be determined; the probable relations have already been discussed in connection with the maxilla.

*Postfrontal*.—The postfrontal is a short, irregular, subquadrangular bone lying in the angle formed by the frontal and parietal, with which it unites by oblique sutures. It forms the posterior part of the upper margin of the orbit and laterally unites with the *postorbital*, a long, rather slender, quite irregular bone whose anterior extremity enters into the slender arch between the orbit and the lateral temporal fossa, and the posterior extremity into the robust bar between the supra- and lateral temporal fossæ. This latter bar is completed posteriorly by the squamosal, with which the postorbital unites by a broad, overlapping suture. It has a width of about three-fourths of one inch.

*Squamosal*.—The squamosal has an exceedingly irregular outline owing to its relations both with other bones and with the openings located in this part of the skull. Its anterior margin is incised by both the lateral and supra-temporal fossæ, which divide this part of the bone into three parts. The inner portion forms the proximal margin of the supra-temporal fossa along nearly one-half its length, and unites with the parietal as described in discussing that bone. The central part enters into the arch between the two fossæ, as stated above, while the outer portion extends as a long, gradually tapering wing forming the posterior margin of the lateral temporal fossa along nearly the entire length of that opening. This portion unites along its inferior edge with the quadratojugal and the quadrate in a long, oblique, crescentic, squamous suture. The posterior part of the squamosal borders the posterior half of the large median notch, and forms the rear part of the skull for about one and one-half inches of its width and is then deflected vertically downward to outline the inner border of a small, narrow, obliquely directed notch which pene-



trates the skull margin for an inch. The quadrate also assists in bounding this notch, not only on its outer side, whose entire margin it forms, but also on its forward end and on about one-third of its inner border. Immediately above and in front of this notch the squamosal is hollowed out somewhat to form the opening of the otic capsule, which is also set into the quadrate to about an equal extent.

*Quadrate.*—This element, from being rather narrow above, widens considerably below and on its lower margin is thickened to form the articulation with the lower jaw. Besides being sculptured on the posterior margin for the reception of the otic capsule and the notch as described above, the quadrate also partially encloses on its anterior margin the quadrate foramen, which pierces the side of the skull slightly above the middle of the length of the quadrate, and is bounded anteriorly by the quadrato-jugal. The quadrate extends on to the lower side of the skull for a short distance and unites with the broad posterior wing of the pterygoid and with the lateral process of the exoccipital along its anterior surface.

*Quadratojugal.*—The quadratojugal unites below the quadrate foramen with the quadrate in a large squamous suture which lies in the plane of the quadrato-jugal and at right angles to that of the quadrate. A buttress from the quadrate increases the sutural surface and strengthens the union. The quadratojugal is a thin flattened bone. It is almost entirely excluded from the margin of the jaw by the slender extension of the jugal. It reaches the edge just at the point of the jaw and forms about an inch of the margin in this region, although most of this distance is shared with the quadrate. Its upper anterior portion forms the lower posterior margin of the lateral temporal vacuity for about one inch, but is excluded from the margin above by the squamosal.

The posterior margin of the bone is excavated to some depth at about its middle to assist in forming the quadrate foramen, above which the bone again unites with the quadrate.

#### OPENINGS OF THE SKULL

*Nares.*—As has been said the nares are situated far backward. In fact they are more than half-way from the anterior to the posterior extremities of the skull, as the distance from the end of the snout to the

anterior point of the nares is fifteen and one-half inches, that from the posterior extremity of the nares to the rear line of the skull is twelve and five-eighths inches. The nares are about one and three-fourths inches in length with an extreme width of five-eighths inch. Behind the point of greatest width they narrow somewhat, and in front of this point they taper quite rapidly forward. In this region the outer wall is cut away, leaving the naris open laterally, as previously described in connection with the nasal. The aspect of the nares is upward in the posterior part, forward and lateral in the anterior portion where the side wall is cut away.

About midway between the frontal and the nares the nasals begin to be elevated and rise gradually to the rear point of the openings. From this point forward they begin to descend, very gently for about half the length of the nares, thence more abruptly to their presumable union with the premaxillæ, which continue the slope an inch or so farther, when it merges into the long, horizontal, upper line of the snout.

*Antorbital vacuity.*—A short distance behind the nares lie the antorbital vacuities, large ovoid openings with their smaller ends posterior and their long axes directed obliquely backward, upward, and inward in direct line with the axes of the orbits. The length of the vacuity is three and one-half inches and the width two and one-fourth inches. Of the elements which form the margins of this fossa the maxilla is by far the most important, as it makes up the anterior part of the upper margin (just how much is not certainly known), all the anterior border, and the lower border to within one and one-fourth inches of the rear extremity. Here it meets the lachrymal, which bone continues the rear margin and the posterior half of the upper. This leaves not more than one inch of the upper border into which the nasal enters.

The anterior wall of the vacuity is steep, as is also the posterior part of the upper margin, but between these is a narrow depression in the skull, which seems to be natural and which extends obliquely forward and inward about half-way to the nares. Behind the vacuity is a broad, rather deep depression which extends backward an inch from the rear margin and then slopes upward rather steeply toward the anterior margin of the orbit. It drops the lower anterior part

of the lachrymal, and the upper margin of the maxilla in its vicinity is also depressed to form its wall.

*Orbits.*—One inch behind the antorbitals are the orbits. These are considerably smaller than the antorbital vacuities, as their greatest length is two and three-eighths inches, while their width is one and five-eighths inches. The aspect is upward and outward. The outline is ovoid, with the smaller curve anterior, and the axis points slightly outward and downward. The frontal forms the upper median border, the prefrontal extends thence forward almost to the anterior limit, and the lachrymal contains the narrow curve of the extremity and extends along about one-third of the outer margin. Behind this the upper limb of the jugal enters into the border for another third of its length and meets on the narrow bar between orbit and lateral temporal fossa with the postorbital, which completes the margin to the posterior extremity. From here the postfrontal completes the circuit. The bones forming the inner border of the orbit are turned upward along their margins and form a thickened wall elevating the orbit and giving it a more outward aspect.

*Lateral temporal fossa.*—The upper line of the lateral temporal fossa lies about behind the middle of the orbit and the cavity extends forward and downward at an angle of about  $45^{\circ}$  with the axis of the skull to a point almost opposite the shorter axis of the orbit. It is subquadrangular in outline, but the upper posterior angle is extended into a tongue-like embayment which is excavated into the squamosal for a short distance. The length of the fossa is three inches and its width one and three-fourths inches.

The anterior and posterior walls are practically straight and nearly parallel, with a slight divergence, especially at the lower end. The lower margin is slightly concave and its general trend is about at right angles to the lateral margins.

The upper margin is formed in part by the squamosal, which extends above the vacuity as a bar about three-fourths inch wide. Anteriorly this unites with the postorbital and each makes up about one-half of the arch. The postorbital also extends around in front of the fossa and unites with the jugal to form the narrow bar separating the vacuity from the orbit. The jugal also forms the entire lower border to the point where it begins to rise to the posterior margin.

This curve is formed by the quadratojugal, and immediately above this the squamosal enters the margin and continues its outline to the upper border.

*Supratemporal fossa.*—Lying above the lateral temporal is the supratemporal fossa, much smaller than the lower opening and, unlike the other openings of the skull, facing inwardly, and that in a plane which has a very high inclination. In order to adapt itself to this condition the parietal is in this region deflected downward and forms the floor of the fossa with an outward slope of about  $30^{\circ}$ . The result is the irregular, suboval depression of triangular section described above.

The anterior margin of the fossa is formed by the parietal, with the exception of the outer angle. The parietal also forms a little more than one-half of the inner border, and the squamosal forms the remainder. On the outer border the squamosal forms the margin for at least two-thirds of the length of the fossa. The boundary is completed by the postorbital, which extends to the anterior margin to meet the parietal.

The fossa measures two and one-half inches in length by three-fourths inch in extreme width, in its anterior portion, though in the posterior region it narrows to a width of one-fourth inch. In shape it is a narrow, irregular ovoid, almost gourdlike in outline, as the narrow posterior part curves slightly upward in characteristic fashion. The plane in which the opening lies is not parallel with the median line, but diverges posteriorly at an angle of about  $20^{\circ}$  along the anterior two-thirds of its length; thence the divergence suddenly increases, approaching  $55^{\circ}$ .

*Quadrate foramen.*—One of the smallest apertures of the skull is the quadrate foramen, situated, as previously described, between the quadrate and the quadrato-jugal, about midway in the height of the former bone. It is subcircular in outline and has a diameter of about three-fourths inch. In the natural condition of the skull the opening must have faced almost directly upward.

Another opening of the skull, but one which is imperfectly closed, is the small notch in the posterior margin already mentioned. It is hollowed out of the quadrate in large part, although the squamosal forms part of its posterior margin. It lies in the upper portion of

the quadrate above and behind the quadrate foramen. It has a height of three-fourths inch, with a maximum width of five-eighths inch, at its lower, open end.

*Otic capsule*.—The ear opening is about the same size as the quadrate foramen and lies almost directly above it and separated from it by seven-eighths inch of bone. It is irregularly oval in outline with a height of seven-eighths inch and a width of five-eighths inch. The axes of this opening, and of the small notch which lies below and slightly behind it, lie in the same line, and the two openings are so close together that their margins are confluent.

Within the skull the ear cavity enlarges slightly and extends inward to a depth of seven-eighths of an inch. At the bottom of this subspherical cavity a smaller opening three-eighths by one-fourth inch leads into the cranium through the large cavity between the roof and the floor of the skull. The angle at which the ear opening enters the skull is about  $55^\circ$  from the median line of the skull, similar to that formed by the posterior end of the supratemporal vacuity.

So far as can be ascertained this is the first time this opening has been figured and described. Fraas does not show it in his illustrations of *Belodon kapffi* and *Mystriosuchus planirostris*, nor does Cope figure it in his illustrations of *Belodon buccros*. Von Meyer in his illustrations of *Belodon kapffi* shows an opening in the skull which at first sight appears to correspond with this one, but on further examination it proves to be the posttemporal fossa. Neither is the opening shown on McGregor's excellent illustrations of *Mystriosuchus planirostris* and other forms, given in his recent paper on the *Phytosauria*.

#### THE UNDER SURFACE OF THE SKULL

This surface presents, in general view, a long triangular depression which extends from the anterior portion of the snout backward as far as the basipterygoid processes of the basisphenoid. This depression is very narrow where contained by the premaxillæ, but widens gradually in the posterior part of these bones and behind them, until it attains its greatest width opposite the anterior portion of the transverse bones. It is bounded laterally by the premaxillæ and maxillæ, postero-laterally by the transverse bones and posteriorly by the short, transverse, wedge-like processes of the pterygoids and

by the basisphenoid. It is roofed by the premaxillæ, a little of the maxillæ, the palatines, pterygoids, and vomers. Three openings pierce it—the paired internal nares and the presphenoidal opening. Behind it medially lies the strong framework of the brain-case, and on either side the large depressions inclosed by the quadrates, quadrato-jugals, and jugals, and pierced by the lateral temporal fossæ and the quadrate foramina.

Where contained by the premaxillæ the trough is bounded on either side by a rounded ridge outside of which are the teeth sockets.

This ridge has already been mentioned in connection with the general description of the skull.

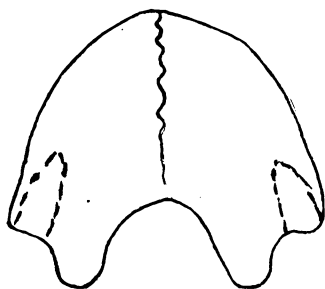


FIG. 4.—Cross-section of premaxilla eight inches from extremity of snout.

The end of the snout bears two large teeth on each bone, then a smaller one, separated from them by about one-fourth of an inch. Between this tooth and its nearest neighbor to the rear is a space of three-fourths inch. The other teeth are closely set—not over one-eighth inch apart in most cases—and increase in size gradually

from front to rear. The total number on each side is thirty-six, of which twenty are on the premaxilla, the remainder on the maxilla. With one exception all the teeth have been lost and the sockets filled with the sandstone matrix. The single tooth which remains is the second from the rear. It has been somewhat flattened by crushing, but its average cross-section is seven-sixteenths inch. It contains within its cavity a younger small tooth. The teeth of this specimen were apparently all of circular cross-section, resembling those of Fraas's *Mystriosuchus* rather than those of von Meyer's *Belodon*. They must have pointed obliquely outward.

The premaxilla extends somewhat farther back on the under surface than above, as in the former region it has a length of eighteen and one-half inches. Along the last six inches of this distance it is excluded from the margin of the jaw by the maxilla.

*Maxilla.*—On its lower side the maxilla presents a flat surface from which spring the rather large teeth of this portion of the jaw.

At its anterior extremity this surface is not over three-eighths inch wide, but at its widest extension, at the thirty-fourth tooth, it is one inch across. Back of the last tooth the bone narrows abruptly. About opposite the posterior end of the premaxilla the dentiferous surface of the maxilla begins to be depressed below the palate and this depression increases until opposite the rear teeth it is about one inch. Just behind this region a rounded buttress-like process passes down the inner surface of the maxilla nearly to the edge of the jaw. It may be that the jugal forms the upper part of this buttress, but this is not known. The process is pierced by a small foramen which extends nearly parallel to and about one-half inch above the edge of the jaw. The purpose served by this foramen is uncertain.

Between the twenty-eighth and thirty-third teeth the maxilla bears an obtusely triangular extension which lies perhaps three-fourths inch above the dentiferous margin and enters into the lateral portion of the bony palate.

*Palatine.*—The anterior limit of this element is not positively known, but its relations with the premaxillæ are believed to be about as indicated in the figure. Posteriorly it widens as the maxilla narrows and reaches its extreme width—one and one-half inch—opposite the posterior limit of the internal nares. Behind this point it tapers gradually, chiefly by being cut away on the outer edge, and leaves the maxilla more and more as it passes backward. Its extreme length is probably six and one-half inches. It is united with the maxilla along the outer edge back to the line of its greatest width, but from here to the posterior end the two are separated by the transverse (ectopterygoid) with which the palatine unites by a roundly serrate suture. The two bones separate slightly about midway along the suture, and leave the narrow palatine vacuity between them. Along the inner margin the palatine unites with the pterygoid as far forward as the internal naris, whose entire outer margin it is believed to form. It probably overlaps the maxilla somewhat in its anterior portion as is apparently true of the European belodonts.

The palatines lie at a somewhat lower level than the pterygoids and so leave between them a cavity in the palate in which lie the pterygoids and vomers. The inner edges of the palatines are turned vertically upward to unite with the pterygoids. It is probably the

ridge thus formed of which Cope speaks in his description of *Belodon buceros* when he says that the palate has a strong ridge on each side so as to be grooved (*Proc. Am. Phil. Soc.*, Vol. XXIV, 1887, p. 217).

*Transverse*.—This is an irregular bone the posterior part of which originally was directed vertically downward, while the anterior part is turned over at right angles and lies horizontally between the maxilla and palatine. The bone has been somewhat displaced from its original position by pressure. Across its widest portion it measures one and three-eighths inches, and its thickness in this same region is five-eighths inch. Farther forward, where the bone is turned over, its breadth is seven-eighths inch and diminishes anteriorly, while its thickness is seven thirty-seconds to nine thirty-seconds of an inch. The anterior part has been broken away, but the full length must have been three and three-eighths inches. Its anterior part united along the outer edge with the maxilla, along the inner with the palatine. The posterior vertical portion united along its whole outer face for the rear one and one-fourth inches with an extension of the pterygoid. The transverse probably touched the above-mentioned buttress of the maxilla.

Apparently the separate existence of this bone was not recognized by von Meyer in describing his specimens of *Belodon*. In discussing *B. kapffi* (*Paleontographica*, Vol. X, p. 234) he says that the anterior end of the pterygoid becomes pointed and extends as far forward as the third alveola of the maxilla with which bone it unites outwardly, while inwardly the union is with a bone which may be the palatine, and with which it bounds a sharp oval opening 26<sup>mm</sup> long and 6½<sup>mm</sup> broad (the palatine vacuity). He also states that this bone, together with the jugal, which it touches, forms the anterior angle of the temporal fossa. These statements apply exactly to the transverse, hence it is certain that von Meyer did not observe the suture between the transverse and the pterygoid. Of what he considered the large area of the palate to consist is not clear, but probably he thought that the palatines extended to the median line. This has been shown not to be the case, however, since they are widely separated by the pterygoids and vomers. Cope does not mention the transverse in his description of *Belodon buceros* (*Proc. Am. Phil. Soc.*, Vol. XXIV, 1887, p. 217), although he recognizes the presence



of the pterygoids in the roof of the palate, which von Meyer did not do. Cope (*Syl. Lect. Vert.*, p. 72) figures the transverse, but his figures do not show any sutures.

E. Koken discusses *Belodon* briefly in his paper on *Thoracosaurus macrorhynchus* in *Zeitschr. d. Deutsch. geol. Gesellschaft*, Jahrg. 1885, pp. 763–65. He recognizes the separate existence of the transverse in the following statement, which he makes under heading 4:

Zusammen mit den Palatinen und Transversen umschliessen sie [Pterygoids] schmale Gaumenlöcher, von deren Umgrenzung der Oberkiefer ausgeschlossen ist und die denen der Crocodiliden gar nicht gleichen, sondern ganz auf Lacertilier herauskommen. Auch das starke Vorspringen der Ossa transversa ist Eidechsen-character.

The transverse is recognized as a separate bone by McGregor in his paper already quoted, where he describes and figures the bone. His illustrations give an excellent idea of the form of the transverse and of its sutural relations. McGregor, however, omitted mention of Koken's article cited above, and does not include it in his bibliography. But since the latter's paper appeared many years previous to that of McGregor his description of course has priority as being, so far as is known to the writer, the first recognition of the element under discussion.

*Pterygoid*.—The pterygoid may be said to consist of three parts: first, the broad, thin, flat bone which forms a considerable part of the palate from the internal naris back almost to the rear end of the transverse; second, the short, almost vertical lateral extension already mentioned as united to the transverse; and third, a long posterior wing which unites with the quadrate. The entire length of the bone is seven and one-half inches and the greatest width, that across the lateral wing, must be about three and one-fourth inches. The anterior extremity forms the outer half of the posterior border of the internal naris and extends for perhaps one-half inch along the outer margin. The bone widens gradually backward for three inches and then gives off the lateral extension. The anterior portion is terminated behind very abruptly by a sharp-edged, vertical, transverse process which marks the beginning of the posterior wing. At first the lateral wing is only five-eighths inch wide, but it broadens

distally so that that part which unites with the transverse has a width of one inch. It bears on its outer free surface a rounded vertical ridge which adds considerable strength to the bone. It is on the inner face of this extension that the transverse is attached.

The posterior wing begins with the vertical process referred to, which has a height of seven-eighths inch and an extent across the palate of one and one-eighth inches, and merges with the lateral wing. The posterior wing forms a broad, nearly vertical plate. Its upper edge comes in contact with the lower part of the cranium. The lower edge is thickened and presents a broad surface very much as this element does in *Amblyrhynchus*. The quadrate unites with the pterygoid along the entire posterior border of the latter bone. This portion of the pterygoid, as indeed the entire bone, presents strong lacertilian affinities, and resembles the bone as found in lizards and mosasaurs much more than that in crocodiles, where the quadrate occupies the space here taken by the pterygoid.

The vertical transverse processes may be taken as marking the posterior boundary of the palate, although between and partly behind them is an opening into the interior of the skull, which may belong to the palatal region.

Koken, in his paper to which reference has already been made, states that the pterygoids *scarcely* come in contact. Whether by this he means that they *do* meet is not clear, but they certainly do not do so in the specimen studied. Here they are separated by the *vomers*, which extend from the posterior wings of the pterygoids forward to the nares and between these as much-narrowed bones. It is probable that they again widen in front of the nostrils and here meet the palatines laterally and the premaxillæ anteriorly, a short distance, perhaps one-half inch, in front of the end of the nares. The maximum width of the vomers is five-eighths inch.

*Cranium*.—The brain-case is very small, measuring not over two and one-half inches from the opening of the foramen magnum to the beginning of the olfactory canal, and about one and one-fourth inches in transverse diameter, external dimensions. The roof is formed by the extreme posterior portion of the frontals, the parietals, and the supraoccipital. The lateral walls are composed of the alisphenoids, the proötics, the inferior processes of the parietals, and the

exoccipitals. The opisthotics may exist coössified with the exoccipitals as in other reptiles, but this is not determinable. The bones forming the floor are the alisphenoids, which are united in their anterior parts only, the basisphenoid and the basioccipital. A small spatulate bone which is attached to the lower margin of the posterior por-

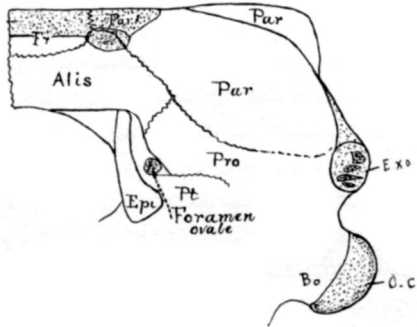


FIG. 5.—Cranine bones from side.

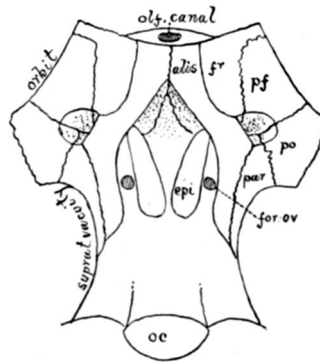


FIG. 6.—Bones of brain case.

tion of the alisphenoid and thence extends downward and slightly posteriorly to unite with the pterygoid, is here considered as the *epipterygoid*. In shape and mode of attachment it occupies a position intermediate between the long slender epipterygoid of the lizards and the short, solidly attached (so-called) epipterygoid of the modern crocodiles. Instead of there being only a small foramen between the epipterygoid and the cranium, as in the crocodile, a large space exists beneath the epipterygoid, more like the condition in *Amblyrhynchus*, for example. It is probable that in life this space was still larger than at present, and that it has been reduced by crushing. Just in front of the epipterygoid is the opening for the III, oculo-motor, and VI, abducens, nerves, and behind it is the fenestra ovale. The foramen magnum is oval in outline and quite large. Its floor is formed by the basioccipital, its walls by the exoccipitals, and the roof by the supraoccipital. The brain-case is continued

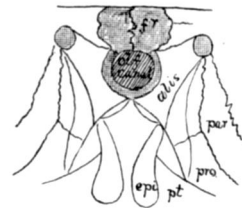


FIG. 7.—Cross-section through rhinencephalic canal.

anteriorly by the olfactory duct, formed by the frontals above and the alisphenoids below. This duct has a diameter of three-eighths inch. Its length is unknown, as the anterior part is concealed in the matrix. It presents a marked contrast to the condition in modern crocodiles, in which its place is taken by a shallow trench and the alisphenoids are not continued forward and do not meet in the middle line. No other openings from the brain-case can be made out because of the presence of matrix where they might be expected to occur.

Of the lower elements of the cranium the most anterior is the *alisphenoid*. This bone is of irregular outline, thin and curved in its front portion to encircle the olfactory lobes. Behind it sends outward and upward a strong process which rests in a depression in the under surface of the postfrontal and postorbital. To the rear the alisphenoid unites with the downward extension of the parietal above and with the proötic below, by oblique sutures. The lower margins of the alisphenoids gape in the posterior region and it is here that the neural foramina occur and that the epipterygoid is attached. As already indicated the anterior portion is concealed.

Only the anterior part of the proötic is exposed and this is seen to be united with the parietal above and the alisphenoid in front. The lower anterior margin is free and borders the foramen ovale. Below this it unites with the pterygoid for a short distance and its lower posterior border meets the exoccipital.

It seems probable that the *basisphenoid* occupies a relation similar to that in the crocodile, that its upper portion is covered by the pterygoid and that the alisphenoid passes downward on the inner side of the pterygoid and epipterygoid to unite with the basisphenoid.

In shape the basisphenoid is very irregular. Where it meets the basioccipital the two bones form a strong transverse ridge, of which however the basioccipital forms only a small part. Anteriorly it sends off the strong downward and forward-reaching basipterygoid processes. Between and above these a vertical rostral plate forms an incomplete septum called by Dr. W. J. Holland the presphenoid in *Diplodocus*. Posteriorly and superiorly the basisphenoid probably unites with the posterior process of the pterygoid and with the exoccipital.

The *basioccipital* forms the chief part of the short stout occipital

condyle. The relations with the basisphenoid have already been mentioned. It is evident from the oblique position of the condyle that the animal held its head at an obtuse angle with the body, very much, probably, as Dr. Holland has figured the dinosaur *Diplodocus carnegiei* in Fig. 1 of his paper on the osteology of *Diplodocus*.

The *exoccipitals* form a little of the condyle, most of the floor and all of the side walls of the foramen magnum, but unlike the condition in the crocodiles and dinosaurs they are widely separated above as in *Amblyrhynchus* and the mosasaurs. Outwardly they have a sub-circular cross-section and distally give rise to the long, flattened paroccipital processes which buttress the under surface of the skull and along which the inferior part of the quadrate is attached for some distance. The inferior processes of the parietals probably touch the exoccipitals along their upper edges for some distance.

The *supraoccipital* is roughly triangular as seen from above, with the apex anterior, and all three sides slightly concave. Its upper surface is also quite concave and slopes backward rather steeply. It forms a floor for the anterior part of the deep median sinus previously mentioned. The bone has a width across its base of two and one-fourth inches and its length along the median line is about one and one-half inches. It unites with the exoccipitals by horizontal sutures and thickens along its margins to unite with the parietals in strong vertical sutures.

#### OPENINGS ON THE UNDER SURFACE OF THE SKULL

*Internal nares.*—These are the most anterior openings on the palatal surface. Unfortunately they have been almost obliterated in the crushing which the skull has undergone and only the posterior portion of one naris is now visible. This has a width of about five-eighths inch. Its probable anterior dimensions are indicated in the figure. The length cannot be greater than two and one-fourth inches and may be somewhat less than this. The nares are separated by the vomers, which also form part of their posterior borders. These are continued by the pterygoids, and the palatines enclose the openings on the sides. The vomers are thought to form the anterior borders. The internal nares are not, like those of *Belodon*, placed beneath the external, but lie entirely behind them. The anterior

limits of the inferior openings must lie at least one and one-half inches posterior to the rear border of the superior nares.

*Palatine foramina.*—The small palatine vacuities follow in order. They are not over one inch in length by one-fourth inch in width, and as has been stated are enclosed by the palatines and transverse bones.

In the median line there exists a cordiform opening with a length of one and three-eighths inches and a maximum width of one and one-eighth inches. The apex of this opening is directed anteriorly and separates the vomers for a short distance. Behind the vomers the pterygoids bound the opening. The basipterygoid processes of the basisphenoid lie below and behind the opening; whether they form part of its margin is not known. The vertical anterior plate of the basisphenoid perhaps partly divided this opening in life, but if so it has since been forced to one side.

*Posttemporal fossa.*—Above the proximal portion of the exoccipital lies the posttemporal opening. As seen from behind this is a small opening nearly an inch long and one-fourth inch high. Immediately above the exoccipital the fossa is roofed by the squamosal; in front of the exoccipital it pierces the roof of the mouth and communicates with the great cavity of the skull. On the outer side the border is formed by the quadrate behind and the pterygoid in front. The anterior border is probably formed by the pterygoid and the posterior wing of the parietal, which also forms the inner border.

*Infratemporal fossa.*—This forms a large irregular opening on the under surface, bounded proximally by the pterygoid and palatine, distally by the quadrate, quadratojugal, jugal, and maxilla.

#### THE LOWER JAW

Only the posterior part of one mandible is present, but this shows strong belodont affinities and differs markedly from that of the crocodiles. In general outline it resembles the mandible of *Belodon plieningeri* figured by von Meyer (*Paleontographica*, Vol. XIV, Pl. 23). The crest of the surangular is much higher than in the Crocodilia and the portion behind the articular surface is much shorter than in that order. It probably does not extend more than an inch behind the

articulation. The external fenestra is quite elongate though its exact limits are unknown. The probable outlines are indicated in the figure. Only a portion of the posterior margin of the internal fenestra remains, together with the lower margin of the small internal mandibular foramen. None of the symphysis is present.

Owing to the condition of the mandible but few sutures can be made out. However, that between the *articular* and the surangular on the broad, vertical posterior face of the jaw is clearly distinguishable. The outlines of the posterior portion of the angular are also quite distinct. The articular forms the inner two-thirds of the articulation with the quadrate, while the outer third is formed by the surangular. The articular also forms nearly all of the transverse vertical area on the posterior extremity previously mentioned. At the inner border of this area is given off a strong, subrectangular process which is widely separated from the inner face of the jaw and extends nearly parallel with it. The main part of the articular extends forward for some distance, forming the lower margin of the internal fenestra. It may extend as far forward as the internal mandibular foramen, as stated by McGregor to be true in *Phytosaurus*, but this cannot be determined.

*Angular*.—This element is exposed for a width of about an inch on both sides of the ramus, whose lower margin it forms. It probably forms the posterior angle of the jaw and constitutes its margin for a considerable distance under the fenestræ.

*Surangular*.—The surangular forms nearly all the outer face of the mandible in its posterior part and makes up the high crest of the jaw, besides entering into the articular surface which meets the quadrate. It is ornamented a little above the middle of its height by a strong, nearly horizontal ridge, slightly concave upward, which starts below the articulation, where it has a width of nearly one-half inch. It narrows anteriorly and becomes quite sharp before it disappears.

The limits of the *splenial* on the inner surface and those of the *dentary* on the outer cannot be determined. Probably they correspond with those of *Belodon* and *Mystriosuchus*.

The outer surface of the mandible is quite rugose in its hinder part and somewhat so farther forward. The rugosities consist

chiefly of small, rounded eminences, with some ridges. The inner surface is rather smooth.

With regard to the nomenclature of the mandible it may be stated that the one generally accepted is here used. As is well known Baur (*Anat. Anz.*, Vol. XI, 1896) attempted to modify the classification of the bones by applying the name of angular to a long splint-like element in front of the articular instead of to the bone previously designated by this name. This necessitated a shifting of names and Baur called the angular "splenial" and the splenial "presplenial." Baur's primary mistake lay in his accepting the turtle as the basis of nomenclature while the original nomenclature was based on the crocodile.

Kingsley has since (*Am. Nat.*, 1905, pp. 59 ff.) corroborated Baur's observations as to the origin of these bones and, taking the crocodile as the standard, has retained the names of the bones as originally given by Cuvier and Owen. Thus he designates the so-called splenial of the turtle of authors, the splenial of Baur, the "dermarticular."

Williston had, however, previously discussed this bone from the plesiosaurs ("North Am. Ples.," *Field Col. Mus., Geol. Ser.*, Vol. II, No. 1, 1903, pp. 29-32) and had given it the name of prearticular. This name should then have priority over that of Kingsley. The prearticular is apparently absent from the crocodiles, while it is a distinct bone in plesiosaurs, dinosaurs, turtles, and some other early reptiles.

#### THE ILIUM

This bone presents features which distinguish it quite markedly from that of *Rhytidodon* as figured by McGregor. The acetabulum is quite broad and must have been quite largely contained by the ilium. Above the acetabulum is a strong process which rises fully two inches above the depth of the cavity. It is of triangular cross-section and is formed by the junction of three ridges, two of which bound the acetabulum and form its upper walls, while the third extends obliquely forward toward the upper anterior corner of the bone. This ridge is very strong where it rises up to aid in forming the process, but it thins distally and does not quite reach the anterior extremity. The upper anterior process has a rounded outline and, unlike *Rhytidodon*, its



upper border is quite elevated and is limited by a broad shallow sinus from the remainder of the upper margin of the bone. The lower anterior process is much shorter and blunter than is that of *Rhytidodon*. Instead of being drawn out to a point it ends in an enlarged, oblique, vertical face of triangular shape. The lower posterior border is rounded and presents a large, roughened surface for the attachment of muscles. The postacetabular process has been broken off but was doubtless similar to that in *Rhytidodon*. The upper border was doubtless somewhat convex, although not so much so as in *Rhytidodon*,

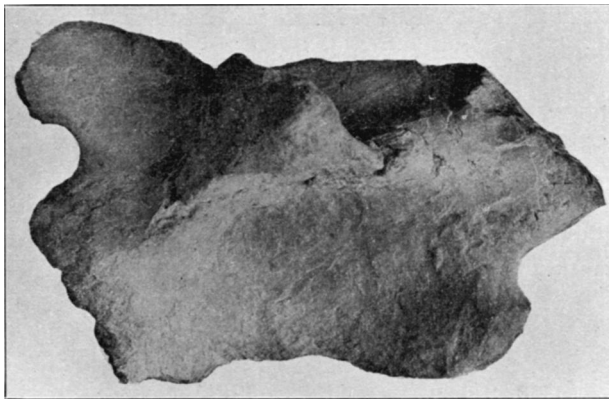


FIG. 8.—Ilium of *Paleorhinus bransoni* Williston.

but as already stated its convexity is interrupted by a broad sinus, giving the anterior part a decidedly concave outline.

On the inner surface the bone is relatively smooth except for the long, shallow trench along its upper part for the reception of the sacrum. This trench is outlined along much of its length by slightly elevated and angular ridges. Below this trench there is also at the anterior extremity of the bone a shallow, ill-defined depression.

The new features which the present study has disclosed may be here summarized. The presence of the otic capsule and its relations and dimensions have been determined. The sutural relations of the palatine, pterygoid, and vomer have been more clearly delineated, and the unsuspected posterior extension of the latter element as far as the presphenoidal vacuity demonstrated. It is believed also that the

elements of the brain-case have been more completely identified than has been possible previously and their relations more clearly made out. The enclosure of the olfactory canal by the alisphenoids, the presence and character of the epipterygoid, here so considered, and the relations of the roof bones and the cranial elements are points which so far as known have not heretofore been noted. It is hoped that these determinations have been made with sufficient accuracy to serve for purposes of future comparison.

Another feature distinctive of this genus, although one mentioned by Dr. Williston in his paper previously noted, is the anterior position of the external nares. The position of the internal nares behind the external also seems to be a new character.

#### RELATIONSHIPS OF PALEORHINUS

In comparing the specimen under discussion with the belodonts we may adopt here McGregor's division of the group into *Phytosaurus* and *Mystriosuchus*. If we include under the former genus the European forms with high rostrum—*Ph. kapffi* and *plieningeri*—and Cope's species, *Ph. buceros*, these may be dismissed at once, since the differences between this group and *Paleorhinus* are great enough to be considered generic. Fraas in 1896 separated *Belodon planirostris* from the genus and founded a new one, *Mystriosuchus*, for it, because of the great differences in the shape of the snout. The skull of *Paleorhinus* presents similar differences, hence its distinctiveness may be taken for granted. Of Cope's species, *Belodon scolopax*, little can be said since that was based on the anterior portion of a rostrum which, Cope states, is "shorter but much more slender than that in *B. plieningeri*." This gives but slight basis for comparison.

Between *Mystriosuchus* and *Paleorhinus*, however, there appears at first glance to be an intimate relationship. But, upon closer examination, certain features are seen to be widely divergent in the two specimens. In the first place, that part of the skull of *Paleorhinus* which lies in front of the anterior point of the nares is one inch longer than the portion behind this point. In the case of *Mystriosuchus*, on the other hand, the distance from the tip of the snout to the anterior point of the nares is five-sevenths of the entire length of the skull.

Furthermore, the proportions of the skull are quite different. The following table of dimensions will serve to make this clear:

	<i>Mystriosuchus plantirostris</i>	<i>Paleorhinus bransonii</i>
Length of skull.....	33.375 inches	30.500 inches
Width of skull across quadrates.....	7.875 "	9.750 "
Width of skull opposite middle of orbits.....	6.625 "	7.250 "
Width opposite anterior extremity of external nares.....	3.000 "	3.000 "
Length from rear of skull to quadrate.....	1.500 "	0.300 "
Length from rear of skull to lateral temporal fossa	2.875 "	2.375 "
Length from rear of skull to supra-temporal fossa, anterior extremity.....	2.875 "	3.700 "
Length from rear of skull to supra-occipital....	1.375 "	2.300 "
Length from rear of skull to rear point of orbit..	4.400 "	5.000 "
Length from rear of skull to rear point of pre-orbital vacuity.....	6.750 "	8.500 "
Length from rear of skull to rear point of nares..	8.000 "	12.500 "
Length from rear of skull to anterior point of nares.....	9.500 "	14.625 "
Length from rear of skull to rear point of internal nares.....	8.000 "	9.000 "
Length of premaxilla.....	23.250 "	14.750 "
Length of maxilla.....	7.500 "	12.500 " (?)
Length of nasals.....	4.875 "	9.000 " (?)
Width of nasals.....	1.375 "	1.000 "
Length of frontals.....	2.000 "	4.000 "
Width of frontals.....	.875 "	1.000 "
Number of teeth on upper jaw.....	94	72

There are several other differences, among which may be noted the following: In *Mystriosuchus* the parietals extend backward between the supratemporal openings at the level of the top of the skull for a little less than one inch, while in *Paleorhinus* they extend in this direction two and one-fourth inches, are widely separated, as already described, and meet the squamosals posteriorly to enclose the supra-temporals at the upper level of the skull. In *Mystriosuchus* this "parietosquamosal arcade," to use McGregor's term, is considerably depressed and forms a thin plate lying on the paroccipitals. This gives the supratemporal openings and the large median notch quite a different appearance in the two specimens. Several of the openings in the skull are of different shapes in the two individuals, and the

nares particularly occupy very different positions. In the European form their anterior limits lie behind those of the preorbitals, while in *Paleorhinus* the whole of the nares lies considerably in advance of the preorbitals.

The paroccipital processes are much wider in *Mystriosuchus* and cover the parietals. The posterior wings of the pterygoids are, however, much smaller and shorter and leave a large opening which in *Paleorhinus* is filled by the quadrate and pterygoid.

Some of the distinctions mentioned above as well as those indicated in the table of dimensions might be considered as being merely specific, but some are undoubtedly of generic rank. Such are the differences in dentition and relative major dimensions of the skull, in location of the nares, in the position of the parieto-squamosal arcade, and its relations to the supratemporal fossa. These divergences would seem to be amply sufficient to warrant the separation of the individuals into different genera, as has been done.

It is impossible to make a close comparison of this specimen with Lucas' genus *Heterodontosuchus*. This latter was founded on the imperfect anterior portion of a lower mandible, while as before stated the only portion of the mandible of *Paleorhinus* which is available is the posterior part, well behind the symphysis. If one may judge from the upper jaw of *Paleorhinus* there must be some difference in the teeth of the two specimens, since Lucas stated that in *Heterodontosuchus* these are separated only by an extremely thin film of bone, while in *Paleorhinus* they are from one-eighth to one-fourth inch apart. There is evidence also that this is true in the lower jaw.

There is no indication of the "deep narrow groove" which Lucas speaks of as extending "along the side of the jaw." Neither do the teeth seem to have been compressed antero-posteriorly as in Lucas' genus. On the contrary the sockets are quite circular.

On the other hand there are some features in which the two specimens show a close similarity. In both specimens the teeth are set very obliquely in a broad, shallow groove, and the two anterior ones, together with the extremity of the jaw, are enlarged. (In all other forms where known the end of the mandible is enlarged and presumably is so in *Paleorhinus*. The enlargement of the upper jaw is very noticeable.)

It scarcely seems wise under the circumstances to make any positive statement regarding the generic identity or separateness of these two specimens without comparison of all the material available, and this has not been possible. There are other nearly perfect skulls in the collection from the Popo Agie beds quite different from the present one which have not yet been studied. Dr. Williston is doubtful as to the distinction, but inclines toward the belief that they belong to the same genus. See his paper on this specimen previously quoted.

It is chiefly because of the marked differences between the ilia of *Rhytidodon carolinensis* as figured by McGregor and of the specimen in hand, differences which are believed to be generic in value, that the specimen is considered as of another genus. These differences may be briefly summarized here. They are: the absence of the transverse ridge from the outer face of the ilium of *Rhytidodon* and its presence in that of *Paleorhinus*; the angularity of the processes in *Rhytidodon* contrasted with their roundness and broadness in *Paleorhinus*; the convex upper edge of the bone in *Rhytidodon* and its general concavity in *Paleorhinus* and the greater size and strength of the central process in *Paleorhinus*.

A comparison of the skulls of the two genera is somewhat difficult owing to the incomplete condition of the skulls of *Rhytidodon*. The distinction which impresses itself most strongly upon the attention is that between the proportions of the skulls. McGregor states (p. 59) that the pre-narial portion of the skull of *Rhytidodon* must be two-thirds the entire length. In *Paleorhinus*, on the other hand, the pre- and post-narial portions are nearly equal—the pre-narial portion is one inch the longer.

Another distinction between the two genera is the long backward projection of the squamosal region over the quadrates in *Rhytidodon*, while in *Paleorhinus* the quadrates and bones associated with them extend almost as far backward as does the upper surface of the skull.

Further, in *Rhytidodon* the external nares are situated over the internal and lie opposite and above the middle of the antorbital vacuities. In *Paleorhinus*, however, the external nares lie far in front of the internal openings, which are situated opposite the middle of the antorbital vacuities. The external nares thus occupy a position well in advance of the antorbital vacuities. This difference is due to the

difference in the relative position of the external nares in the two genera, since the other openings occupy similar positions in both.

There are also some minor differences in the shapes of the various openings of the skull.

The thanks of the writer are due to Dr. S. W. Williston, whose kind personal supervision and interest have made this work possible. Dr. Williston has not only given the study his attention during its prosecution and the benefit of his intimate knowledge of reptilian types, but he has also criticized the completed paper. The writer's thanks are also due him for permission to make use of the material upon which the paper is based.

#### BIBLIOGRAPHY

- BAUR, G. "Ueber die Morphologie des Unterkiefers der Reptilien," *Anatom. Anzeiger*, Vol. XI, 1895, pp. 410-15. Discusses classification of bones of mandible.
- COPE, E. D. "A Contribution to the History of the Vertebrata of the Trias of North America," *Proceedings of the American Philosophical Society*, Vol. XXIV, 1887, pp. 217 ff. Describes *Belodon buceros* and *B. scolopax*.
- . *Syllabus of Lectures on the Vertebrata*, 1898, p. 72, Fig. 24. Gives illustration of *Belodon buceros*.
- EMMONS, E. *Manual of Geology*, 2d ed., 1860, p. 175. Gives illustration of *Rhytidodon carolinensis*.
- FRAAS, E. *Die Schwabischen Trias-Saurier*, pp. 15-17, Plate V. Gives illustration and brief descriptions of *Mystriosuchus planirostris*, etc.
- HOLLAND, W. J. "The Osteology of Diplodocus Marsh," *Memoirs of the Carnegie Museum*, Vol. II, No. 6, 1906. Describes *Diplodocus carnegiei*.
- KINGSLEY, J. S. *American Naturalist*, 1905, pp. 59 ff. Discusses bones of mandible.
- KOKEN, E. "*Thoracosaurus macrorhynchus* Bl., aus der Tuffkreide von Maastricht," *Zeitschr. d. deutsch. geol. Gesellsch.*, Vol. XI, 1888, pp. 763-65. Discusses *Belodon* in connection with other genera.
- LUCAS, F. A. "*Heterodontosuchus ganei*," *American Journal of Science*, 4th Series, Vol. VI, 1898, p. 399. Describes this species.
- MARSH, O. C. "*Rhytidodon rostratus*," *American Journal of Science*, 4th Series, Vol. II, 1896, p. 61. Illustration only.
- MCGREGOR, J. H. "The Phytosauria, with Especial Reference to *Mystriosuchus* and *Rhytidodon*," *Memoirs of the American Museum of Natural History*, Vol. IX, Pt. II, 1906, Plates VI-XI, pp. 30-100.
- VON MEYER, H. "Reptilien aus dem Stubensandstein des obern Keupers," *Paleontographica*, Vol. VII, 1861, Plates 38-47; Vol. X, 1863, p. 234, Plates

38-40; Vol. XIV, 1865, Plates 23-29. Give description and figures of *Belodon kapffi*, *plieningeri*, etc.

WILLISTON, S. W. "North American Plesiosaurs," *Field Columbian Museum Publications*, Geological Series, Vol. II, No. 1, 1903, pp. 29-32. Discusses classification of elements of mandible.

———. "Notice of Some New Reptiles from the Upper Trias of Wyoming," *Journal of Geology*, Vol. XII, 1904, p. 696. Describes briefly *Paleorhinus bransoni* and mentions other genera. Compares with *Heterodontosuchus Belodon*, etc.

## ABBREVIATIONS USED IN FIGURES

Alis.,	alisphenoid.	Ot.,	otic capsule.
Ang.,	angular.	P.,	palatine vacuity.
Ao.,	antorbital vacuity.	Pal.,	palatine.
Bo.,	basioccipital.	Par.,	parietal.
Bp.,	basipterygoid, processes of	Pf.,	postfrontal.
Bs.,	basisphenoid.	Pm.,	premaxilla.
D.,	dentary.	PO.,	antorbital vacuity.
Ect.,	ectopterygoid.	Po.,	postorbital.
E. M. F.,	external mandibular fenestra	Prf., pf.,	prefrontal.
E. N.,	external nares.	Pro.,	Proötic.
Epi.,	epipterygoid.	PS.,	presphenoidal vacuity.
Exo.,	exoccipital.	PT.,	posttemporal vacuity.
Fr.,	frontal.	Pt.,	pterygoid.
I. T.,	infratemporal vacuity.	Q.,	quadrate.
J.,	jugal.	Q F.,	quadrate foramen.
L.,	lachrymal.	Qj.,	quadratojugal.
L T.,	lateral temporal vacuity.	S.,	supraoccipital.
M.,	maxilla.	Sur.,	surangular.
N.,	nasal.	Sq.,	squamosal.
Na.,	internal nares.	ST.,	supratemporal vacuity.
O.,	orbit.	V.,	vomer.
O C.,	occipital condyle.	III, V, VI,	openings of III, V, and VI nerves.