6. A Hitherto Unrecognized Calvert Cetothere

Notwithstanding the presence of the odontocetes *Squalodon*, *Eurhinodelphis*, and *Schizodelphis* (*Cyrtodelphis*) in the Miocene marine faunas of both the Calvert of Maryland and Virginia and the Anversian sands of the Belgian Antwerp basin, the possibility of the occurrence of identical or related mysticetes in these deposits has not been given serious consideration.

To arrive at a more precise evaluation of the generic and specific differentiation of the Calvert cetotheres, skulls, tympanic bullae, periotics, mandibles, vertebrae, and limb bones were assembled for direct visual comparison. The Calvert skeletal materials representing several distinct types were compared with Van Beneden's large scale illustrations, supplemented by my own descriptive notes and measurements of the Belgian types.

Since the bones of Recent species serve as a guide for the establishment of genera and species when available for comparison, Van Beneden (1880, pp. 11–13) concluded, as a result of his review of the skeletons of fossil and living mysticetes in the collections of the Brussels museum, to base his descriptive characterizations of the genera of the Antwerp basin mysticetes on the articular condyle of the mandible and the modifications of the entrance to the mandibular canal. The reliability of the mandibular condyle as an invariable generic character will be reviewed later under the mandible of *Parietobalaena palmeri*. Differentiations of species were based on the periotic and its processes. He also observed that the importance of the tympanic bulla (Van Beneden, 1836) had been exaggerated by naturalists. In this introductory comment also, Van Beneden decided to suppress the generic name *Cetotherium* inasmuch as the condyle of the mandible was unknown and no distinctive generic characters were designated by Brandt (1843a-c, pp. 20, 241, 270).

Relatively little if any consideration was given by Van Beneden to skeletal modifications that are attributed now either to growth or variability. Skulls, mandibles, and other skeletal elements of physically immature individuals were more numerous than those of adults and in many instances comprised the sole representation of a particular form in the Belgian collections. This condition also is thought to have prevailed in the Calvert geologic area. Physically immature and juvenile cetothere skeletal remains are encountered far more frequently than the fully adult in the Calvert deposits along the western shore of Chesapeake Bay. These occurrences tend to support the belief that these waters were sought during the calving and nursing season by Miocene mysticetes.

Abel (1938, pp. 4–5) following his review of the Antwerp basin collections concluded that the osteological basis for described fossil mysticetes was very unsatisfactory, but recognized as valid five upper Miocene (Anversian) species allocated to the genera *Isocetus*, *Mesocetus*, and *Herpetocetus*. Mysticetes related to *Isocetus* and *Mesocetus* are now recognized in the Calvert fauna.

This Calvert study also lead to a review of the applicability of several generic names to Miocene mysticetes. The reference by Van Beneden of mysticete skeletal remains excavated in the Antwerp basin to the genera *Idiocetus* and *Heterocetus* is here regarded as questionable. Some uncertainty will probably always persist regarding the association of skeletal elements recovered from the Antwerp marine deposits. Van Beneden (1886, p. 34) in commenting on the Italian fossil cetaceans, remarks that the bones there are associated in such a manner that they clearly represent the same individual, while at Antwerp the skeletons are dispersed and the bones intermingled.

The genus *Idiocetus* (genotype, *I. guicciardinii*) was proposed by Capellini (1876, pp. 12–13; 1905, pp. 71–80, pls. 1, 2) for a tympanic bulla and attached periotic, portions of the skull, right mandible (length, 1650 mm.), atlas, and scapula from the lower Pliocene (Plaisancian) "argilla turchina" at Montopoli del Valdarno inferiore, Tuscany, Italy.

The Italian lower Pliocene *Idiocetus* is a balaenopterine whale whose tympanic bulla and periotic are readily distinguishable from the upper Miocene species referred to this genus by Van Beneden.

Capellini (1877, p. 613, pl. 1, figs. 15) based the genus *Heterocetus* (genotype, *H. guiscardii*) on a left mandible (length, 1305+ mm.), a left tympanic bulla, a posterior process of a periotic, and four cervical vertebrae from the upper Miocene (Messiniano) conglomerate at Briatico, Golfo di Eufemia, Calabria, Italy. The tympanic bulla (length, 90 mm.) of the upper Miocene Italian *Heterocetus* is larger than that of the lower Pliocene (Diestian) Belgian *Heterocetus affinis* (length,70 mm.), according toVan Beneden (1886, p. 26).

Abel (1938) neither lists nor discusses the species referred to the genera, *Idiocetus* and *Heterocetus*, by Van Beneden.

Considering the uniformity of the functions of the inner ear, it may be anticipated that its structural components will be less susceptible to modification attributed to accidental alterations in cranial architecture than those observable in the protective outer structures that serve for attachment of the periotic and the tympanic bulla. Perhaps the greatest importance, however, should be attached to differences observable in those anatomical structures that appear to subserve identical functions. One of the most obvious modifications of the cetothere periotic is observable in the openings of the aqueducts and the internal acoustic meatus on the cerebral face of the balaenopterine periotic. It is still doubtful that the modifications of the anterior and posterior processes of the periotic bear an obvious and direct relation to some functional requirement, which itself is dependent on some particular circumstance of the environment.

DIOROCETUS, new genus[1]

Type Species: *Diorocetus hiatus*, new species.

Diagnosis: Rostrum strongly tapered anteriorly; an incisure of variable length, commencing near the posterior end of each maxillary internal to the base of its posteroexternal process, extends obliquely forward toward the maxillary-premaxillary contact along the mesorostral trough and separates the triangular area behind it into a dorsal and ventral plate; backward thrust of rostrum limited, median rostral elements (ascending processes of maxillaries, premaxillaries, and the nasals) not carried backward beyond the level of the posteroexternal processes of the maxillaries that project laterally beyond the preorbital angles of the supraorbital processes on the immature type skull, but to level of center of orbit on more mature referred skull; no transverse temporal crest developed on supraorbital process; elongated nasals located for most part anterior to level of preorbital angle of supraorbital processes; apex of supraoccipital shield thrust forward to or slightly beyond level of anterior ends of zygomatic processes; palatines elongated; lateral descending processes of basioccipital knob-like, smaller than pterygoid fossa; anterior process of periotic compressed transversely; a deep lengthwise groove for facial nerve on ventral surface of posterior process; groove behind stapedial fossa on posterior face of *pars labyrinthica* extends from posterointernal angle of posterior process to cerebral face of *pars cochlearis;* horizontal ramus of mandible robust, its depth anteriorly about one fifteenth of its length; coronoid process small and low; condyle expanded from side to side, with deep groove above angle on internal surface for attachment of internal pterygoid muscle; cervical vertebrae separate; scapula fan shaped, with well-developed acromion and coracoid process, prescapular fossa narrow and its height about two thirds of its anteroposterior diameter.

[1] In allusion to the elongated incisure that divides the posterior end of each maxillary into a dorsal and ventral plate.

DIOROCETUS HIATUS, new species

Type Specimen: USNM 16783. Skull essentially complete except for left half of cranium; both lachrymals and jugals also missing; right periotic attached but no right tympanic bulla; right and left mandibles lack condyles and adjacent portion of ramus behind coronoid process; axis, sixth and seventh cervical and first dorsal vertebrae; whole or portions of seven epiphyses; one chevron; and four ribs. Collectors, William F. Foshag and Remington Kellogg; July 6–15, 1941.

Horizon and Locality: In zone 14 (12 inches above base), 18 feet above beach level in third cliff, 2500 feet south of mouth of Parker Creek, Calvert County, Maryland. Calvert formation, middle Miocene.

Referred Specimens: Three as follows: (1) USNM 16871: incomplete rostrum; coll. Alton C. Murray, Oct. 23, 1942; face of cliff 1570 yards north of road end at Governor Run, Calvert Co., Md., Calvert formation, middle Miocene. (2) USNM 23494: skull partially disarticulated when excavated, but since restored; supraorbital processes of frontals detached but restored; rostrum essentially complete except for damaged portions of maxillaries; nasals, lachrymals, and jugals missing. Right and left tympanic bullae; right and left periotics; right and left mandibles; 1 cervical, 5 dorsal, 11 lumbar, and 5 caudal vertebrae; 3 chevrons; right and left scapula; head of right humerus; right and left ulna; 7 carpals; 5 metacarpals; 2 phalanges; and 7 ribs; coll. Albert C. Myrick, Jr., August 1962; about 300 yards north of road end at Governor Run, in sandy clay near base of zone 14, 2 feet

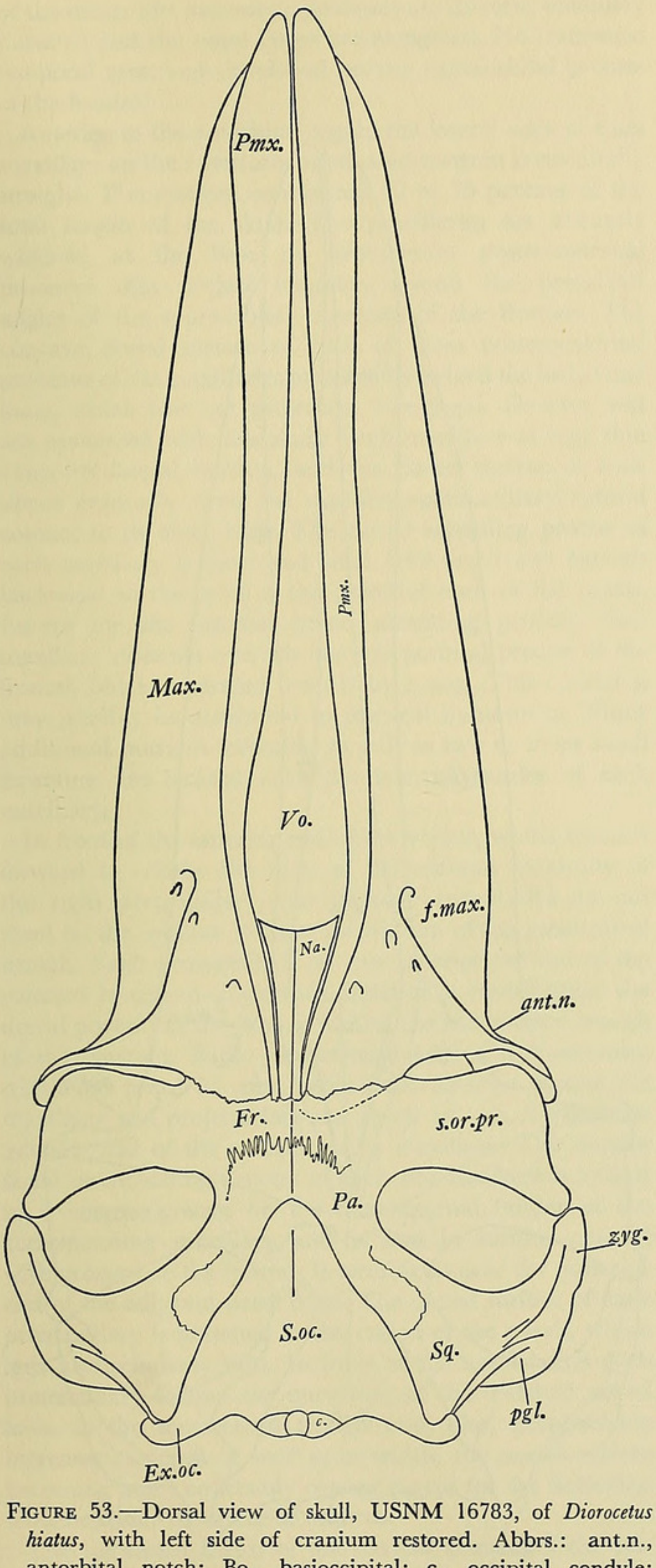


FIGURE 53.—Dorsal view of skull, USNM 16783, of *Diorocetus hiatus*, with left side of cranium restored. Abbrs.: ant.n., antorbital notch; Bo., basioccipital; c., occipital condyle; Ex.oc., exoccipital; f.m., foramen magnum; f.max., maxillary foramen or incisure; f.ov., foramen ovale; Fr., frontal; h.pt., hamular process of pterygoid; j.n., jugular notch or incisure; l.pr., lateral or descending protuberance of basioccipital; Max., maxilla; m.e.a., channel for external auditory meatus; Na., nasal; o.c., optic canal: Pa., parietal; Pal., palatine; pgl. postglenoid process; Pmx., premaxilla; pr.a., anterior process of periotic; pr.p., posterior process of periotic; Pt., pterygoid; pt.f., pterygoid fossa; S.oc., supraoccipital; Sq., squamosal; s.or.pr., supraorbital process of frontal; Ty., tympanic bulla; Vo., vomer; zyg., zygomatic process.

above clay ledge between two shell layers, Calvert Co., Md., Calvert formation, middle Miocene. (3) USNM 16567: 11 caudal vertebrae; 3 detached epiphyses; 1 chevron; collectors, William F. Foshag and Remington Kellogg, Aug. 5, 1940; 965 yards south of mouth of Parker Creek, partially in sandy marl and yellowish sand of zone 14, about 14 feet above beach level, Calvert Co., Md., Calvert formation, middle Miocene.

Skull

Except for the left side of the braincase (USNM 16783; pl. 49), which had been broken off and lost when a section of the exposed cliff face fell on the tide-washed narrow strip of the shore below, this skull was exceptionally well preserved.

The type skull (fig. 53) is readily characterized by the wide incisure (length, 145 mm.), which, commencing 30 mm. distant from the external edge of the maxillary in front of the antorbital notch, extends obliquely forward toward the maxillary-premaxillary contact along the mesorostral trough. This incisure separates the triangular portion of the maxillary behind it into a dorsal and a ventral plate and forms the walls of a broad cavity that extends backward ventrally to the anteroventral edge of the supraorbital process of the frontal. A similar modification of the posterior rostral portions of the maxillaries exists on two additional specimens (USNM 16871, 23494).

On the largest skull (USNM 23494) this incisure (fig. 54) is not continuous but is divided in the right maxillary by intervening bone into three dorsal openings, the internal one large (length, 44 mm.) and two smaller openings (lengths, 22 and 32 mm.) in an overall interval of 147 mm. Three large foramina are also present in this maxillary, one anterior to the incisure, and two behind it. In the left maxillary, this incisure is divided into one large opening (length, 63 mm.) and one small (length, 28 mm.) in an interval of 137 mm.; it terminates 41 mm. inside the outer edge of this bone. Three small foramina are located behind the incisure.

In the left maxillary of the detached rostrum (USNM 16871), one very large incisure (length, 142 mm.; depth 65 mm.) terminates externally about 47 mm. from the outer edge of this bone. Behind this incisure there are three small foramina, and one in front of it. Most of the right incisure was destroyed when the posterior end of this maxillary broke off; this incisure terminates 52 mm. inside of the outer edge of this bone. Four smaller foramina are located anterior to the incisure.

No other fossil mysticete having a similarly modified maxillary seems to have been recorded in the literature. A lithographic plate (True, 1907, pl. 6) prepared in 1850 under the supervision of Louis Agassiz for the type skull of *Agorophius pygmaeus*, however, shows a relatively large circular foramen in each maxillary in a position comparable to this maxillary incisure.

Dissection of a fetal female finback (*Balaenoptera physalus*) by Walmsley (1938, p. 142–143, fig. 14) has shown that the main maxillary artery after passing forward along the pterygoid divides into a leash of small branches that pass ventrally into the maxillary bone to supply the baleen plates. Branches of a superficial temporal branch of this maxillary artery pass forward to the top of the snout where they divide further into a "leash of exceedingly fine twigs." This portion of the rostrum is drained by the maxillary vein. Skulls of Recent as well as fossil mysticetes, whose rostra are sufficiently complete to permit detailed comparisons, have the maxillaries pierced dorsally by one or more relatively small foramina for the passage of vascular vessels and nerves, but at more anterior and inward positions.

In the absence of even a sketchy geological record of the sequence of prior adaptive alterations, the infraorbital foramen of the carnivore skull may also furnish a clew as to the functional purpose of this elongate maxillary incisure. Some of the carnivores, at least, have infraorbital nerves, which are terminal branches of the maxillary nerve (Trigeminus II) that accompany the infraorbital branches of the internal maxillary artery through the infraorbital foramen and then both divide into several smaller branches to supply the snout. On this fossil cetothere skull ramification of these nerves and arterial branches may have been associated also with more numerous and more closely spaced tactile facial vibrissae on the snout.

The skull is also characterized in part by the pronounced tapering of the rostrum, limited interdigitation by the backward overriding of median rostral elements on the frontals, a moderate forward thrust of supraoccipital, and the parietals; exposure of frontals in median interorbital region not markedly reduced; intertemporal region broad, not pinched in; temporal fossa wide; slender zygomatic processes; and normal postglenoid processes.

Dorsal view.—From a dorsal view (fig. 53) the apex of the subtriangular supraoccipital shield projects forward to or slightly beyond the level of the anterior ends of the zygomatic processes. The forward overthrust has carried the anterior ends of the parietals to the level of the center

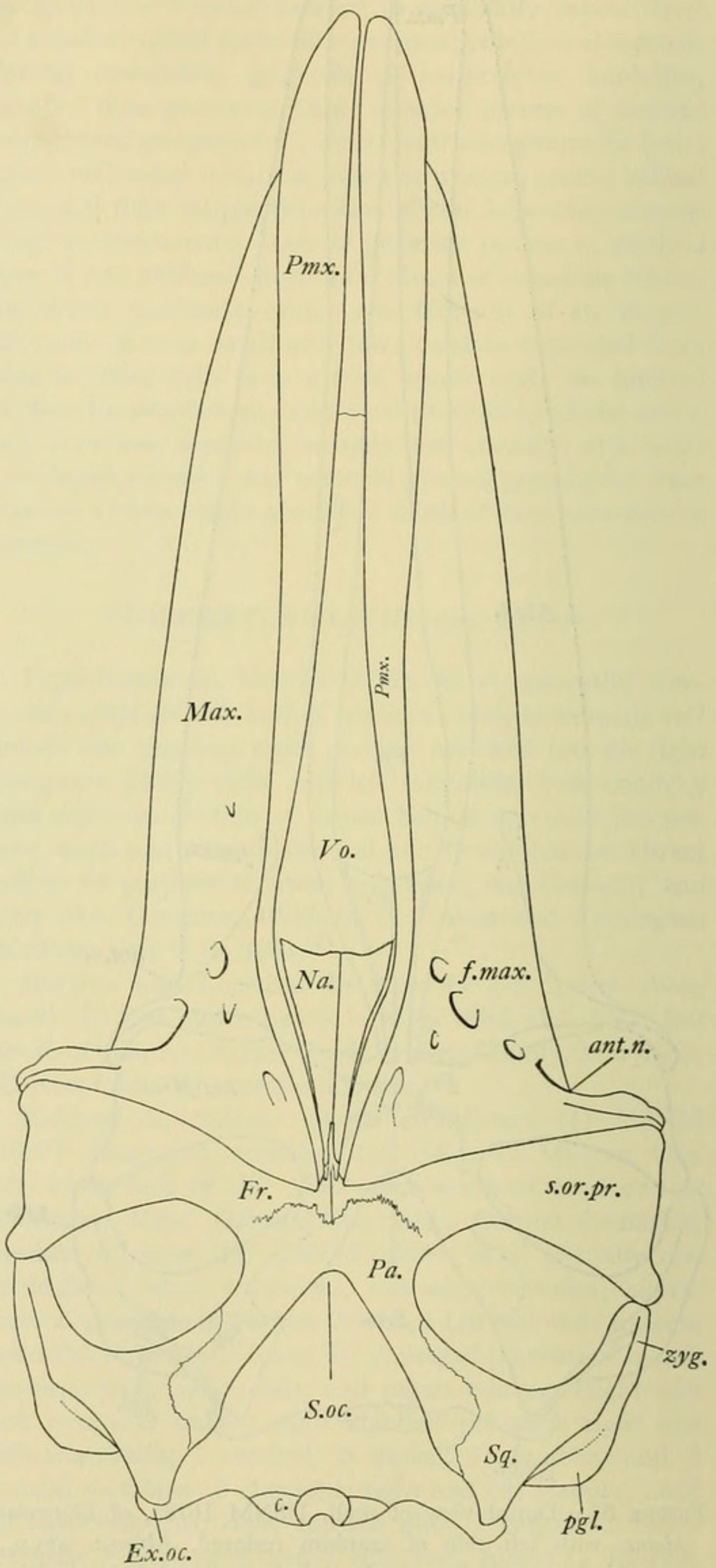


Figure 54.—Dorsal view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

of the orbit. The zygomatic processes are directed obliquely outward and the nasal bones are elongated. No transverse temporal crest was developed on the supraorbital process of the frontal.

Anterior to the antorbital notch, the lateral edge of each maxillary on the anteriorly attenuated rostrum is essentially straight. The rostrum constituted 60 to 75 percent of the total length of the skull. The maxillaries are abruptly widened at the base by protuberant posteroexternal processes that project laterally beyond the preorbital angles of the supraorbital processes of the frontals. The concave dorsal surface of each of these posteroexternal processes of the maxillaries presumably lodged the lachrymal bone, which was not preserved. The jugal, likewise, was not associated with this skull. Each maxillary is very thin along its lateral borders, and the dorsal surface of each slopes gradually from the maxillary-premaxillary sutural contact to its outer edge. The dorsal ascending process of each maxillary is short and wide (100 mm.) and extends backward to the level of the posterior ends of the nasals. Except for the internal broad ascending process, each maxillary does not override the supraorbital process of the frontal, but is separated from it by a gap. This condition may possibly be attributed to physical immaturity. Three additional nutrient foramina as well as two or more small foramina are located near the internal border of each maxillary.

In front of the anterior end of the vomer, which extends forward to within 535 mm. of the anterior extremity of the right premaxillary, the opposite maxillaries do not meet on the midline to form the bottom of the mesorostral trough. Each premaxillary on this anterior portion of the rostrum is curved downward internally, contributing the dorsal portion of the lateral wall of the mesorostral trough of the rostrum. Each premaxillary attains its maximum width (65 mm.) 55 mm. behind the anterior end of the maxillary and projects forward about 50 mm. beyond the anterior end of the corresponding maxillary. The slender facial or ascending process of each premaxillary is lodged in a narrow groove on the dorsointernal border of the corresponding maxillary and is also in sutural contact with grooves on the frontal; it terminates near the posterior end of the adjacent nasal bone. The dorsal surface of each premaxillary is flattened in the region of the nasals, where it is also relatively thin. In front of the nasal bones each premaxillary follows the curvature of the widened narial fossa in the mesorostral trough and, also, progressively increases in depth as well as in width, the dorsal surface becoming more noticeably convex except for the flattening tendency near the anterior end.

The backward thrust of the median portion of the rostrum on the larger skull (USNM 23494; pl. 50) has carried the ends of the ascending processes of the maxillaries and premaxillaries to the level of the center of the orbit. Consequently, the interlocking of the rostral and cranial elements has been accomplished mainly by the thin plate-like ventral border of the maxillary, the vomer, the palatines, and the pterygoids.

The dorsal narial fossa in the mesorostral trough occupies an interval of at least 350 mm. anterior to the extremities of the nasal bones; it attains a maximum width of 100 mm., about 180 mm. in front of the nasals. Although the mesorostral trough is not completely roofed over for a distance of 800 mm., the opposite premaxillaries anterior to the narial fossa gradually close over this gap.

The long slender nasal bones are wedged in between the ascending processes of the opposite premaxillaries; their posterior ends are mortised into the frontals and anteriorly they overhang the hinder portion of the narial fossa; the anterior ends of these nasal bones are widened; they extend backward to the level of the posteroexternal processes of the maxillaries that project laterally beyond the preorbital angles of the supraorbital processes on the immature type skull and to level of center of orbit on more mature referred skull.

The frontal bones are exposed for an interval of not more than 40 mm. on the midline of the interorbital region between the posterior ends of the overriding rostral bones and the intertemporal region contributed by the parietals. Each frontal slopes gradually downward from the dorsal surface of the interorbital region to the orbital rim of its supraorbital process. No transverse crest is developed on either supraorbital process. The preorbital angle of the supraorbital process of the frontal is rounded and presumably is separated from the lateral extension of the posteroexternal end of the maxillary by the interposition of the lachrymal bone. The slender postorbital projection is extended backward to meet the anterior end of the zygomatic process. The orbital rim of the supraorbital process is quite thin except at the thickened anterior and posterior angles.

The opposite parietals, which meet medially to constitute the intertemporal ridge, are overlapped above and behind by the outer borders of the upper portion of the triangular supraoccipital shield. The thin anterior border (30± mm.) of the parietal is groved ventrally and overlaps the anteroposteriorly directed ridges on the median portion of the interorbital region of the frontal. The vertical diameter of each parietal is equivalent to about two-thirds of its anteroposterior diameter and comprises a major portion of the lateral wall of the braincase. Below the level of the supraorbital process of the frontal, the lower edge of the parietal, on another skull (USNM 23494), is in contact with the dorsal edge of the alisphenoid, behind which the sutural contact between the parietal and the squamosal extends backward ventrally and then upward to meet the lateral crest contributed in part by the supraoccipital shield.

The squamosal contributes the posterolateral portion of the braincase. Commencing anteriorly at its contact with the pterygoid, the squamosal curves backward, outward, and forward to the extremity of its zygomatic process to constitute the hinder limit of the temporal fossa. A shallow trough on the dorsal surface of the squamosal extends backward from about the level of the anterior face of the postglenoid process to the lambdoid crest. The zygomatic process is slender and is directed obliquely outward and forward. The lambdoidal crest is continued forward on the dorsal surface of the zygomatic process.

Except at their extremities the exoccipitals are almost hidden from a dorsal view by the lambdoid crest. The transverse diameter (330 mm.) of the triangular occipital shield of the larger skull (USNM 23494) at the level of the foramen magnum exceeds the greatest distance (230 mm.) from the dorsal rim of the foramen magnum to the apex.

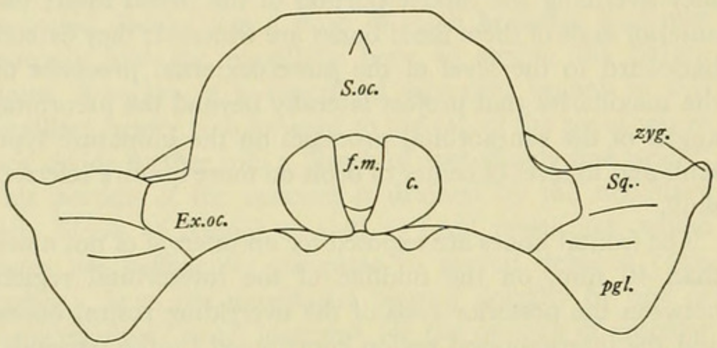


FIGURE 55.—Posterior view of skull, USNM 16783, of *Diorocetus hiatus*. For abbreviations, see figure 53.

The forward thrust of the hinder elements of the skull has pushed the apex of the supraoccipital shield to the level of the anterior end of the zygomatic process. The lower portion of the triangular supraoccipital shield is depressed noticeably below the level of its lateral crestlike margins. From a dorsal view the occipital condyles appear relatively small and not protuberant.

POSTERIOR VIEW.—The subtriangular occipital shield is constituted by the dorsally attenuated supraoccipital and the relatively small lateral exoccipitals. Ventrally each lambdoid crest (fig. 56) does not quite follow the posterior limit of the corresponding squamosal and turning abruptly upward at about the level of the center of the foramen magnum continues along the external margin of the supraoccipital to its pointed apex.

The relatively small exoccipital bones, which are not noticeably thickened anteroposteriorly, constitute the lateral wings of the occipital shield and are directed more obliquely downward than outward (USNM 23494; fig. 56); but their external ends project backward slightly beyond the level of the occipital condyles.

The occipital condyles are relatively large and the foramen magnum proportionately small. The articular surfaces of the condyles are more strongly convex from end to end than from side to side, and are separated ventrally by a narrow notch. On each side anterior to the corresponding condyle is the lateral knob-like descending process of the basioccipital, which constitutes the inner wall of the jugular incisure; the outer wall is contributed by the exoccipital.

Each postglenoid process extends ventrally about 40 mm. below the level of the ventral edge of the exoccipital; its flattened posterior face descends almost vertically.

As regards the posterior aspect of the skull, the contour of the supraoccipital shield shifts in accordance with the angle of sight. For example the vertical distance from the vaginal plate of the vomer to the apex of the supraoccipital shield on each of the two skulls measures about 200 mm. By tilting the braincase upward and backward the subtriangular outline (drawn by pantograph) of the shield is accentuated (fig. 56; USNM 23494) as contrasted with the dorsal flattening when viewed at eye level or almost horizontally (fig. 55; USNM 16783). It will be noted also that the convex curvature of the horizontal portion of the lambdoid crest appears less noticeable in the latter illustration. Since the ventral border of the right exoccipital is eroded, the original profile of this edge may be regarded as slightly conjectural on the skull of the younger individual (USNM 16783). Nevertheless, the exoccipital on this skull obviously was directed less noticeably obliquely downward than on the skull of the other individual (fig. 55).

LATERAL VIEW.—The apex of the supraoccipital shield is the highest point in the dorsal profile and in front of the latter the dorsal profile of the median intertemporal and interorbital regions descends obliquely to the base of the rostrum; the slope of the dorsal profile of the rostrum from base to extremity is very gradual.

The greatest depth of the rostrum is immediately in front of the choanae and the depth gradually decreases toward the distal one fourth where the ventral surface becomes relatively flat. The outer one half or more of each maxillary is rather thin throughout its length. The lateral projection or process of the posteroexternal end of the maxillary is compressed anteroposteriorly, with the posterior border very thin and the anterior edge thickened; this process slopes obliquely downward and backward and terminates at least 25 mm. below the preorbital angle of the supraorbital process. From this lateral view the orifices of two or possibly one additional large foramina can be seen on the internal wall of the maxillary incisure.

The orbital border of the supraorbital process is dorsoventrally compressed and arched in a fore-and-aft direction. In front of the rounded preorbital angle, the missing lachrymal presumably was lodged between it and the posteroexternal process of the maxillary, and below it the jugal was attached by a ligament. The postorbital projection of the supraorbital process is elongated bringing its extremity in contact with the anterior end of the zygomatic process. The supraorbital process of the frontal slopes downward from the interorbital region to its orbital rim, and except for the broad ascending process is not overlapped by the posterior border of the maxillary.

The rather slender zygomatic process of the squamosal tapers to its anterior end. The ventral profile of this process is a uniform curve; the dorsal profile rises gradually behind the anterior end and merges posteriorly with the abruptly elevated lambdoid crest on the squamosal.

From a lateral view the postglenoid process extends downward and backward; its posterior face is flattened and its extremity is compressed anteroposteriorly. Posteriorly the squamosal is firmly ankylosed to the exoccipital. As seen from the side the contact of the parietal with the squamosal is almost horizontal ventrally and nearly vertical posteriorly.

The opposite parietals meet on the midline of the intertemporal region to constitute a short isthmus connecting the occipital portion of the skull with the interorbital region by overlapping the frontals in a rather broad sutural contact. Behind the intertemporal region the dorsal edge of the parietal is overlain by the lateral edge of the supraoccipital shield, the apex of which extends forward to the level of the anterior end of the zygomatic process.

The occipital condyle is not visible when the skull is viewed from the side, since the exoccipital is directed outward and obliquely backward.

In the temporal wall of the braincase, the alisphenoid is relatively small and is situated posterior to the base of the supraorbital process and above the pterygoid. The transverse is greater than the vertical diameter of the exposed outer end of the alisphenoid. The alisphenoid is in contact with the parietal dorsally and the pterygoid ventrally, but is separated from the squamosal.

Ventral view.—Neither the type (pl. 49) nor the referred skull (USNM 23494; pl. 50) has the basicranial region undamaged. The left half of the basicranium of the type skull is missing and both pterygoids lack their hamular processes.

In conformity with the normal construction of a mysticete skull, the maxillaries constitute most of the palatal surface of the rostrum (pl. 49, fig. 2). Along the anterior border the supraorbital process of the frontal is narrowly underlapped by the thin plate-like posterior end of the maxillary. Flattening of the ventral surface of the maxillary is most pronounced on the outer half and medially is curved downward to conform to the curvature of the trough of the vomer against which it abuts. A series of shallow, narrow, and slightly curved grooves, the majority being obliquely directed more forward than outward from their origin near the midline, serve as channels for the nutrient vessels that supply the palate and the attached baleen. Somewhat shorter grooves directed more transversely engrave the ventral face of each maxillary anterior to the level of the anterior ends of the palatines. No recognizable pattern or arrangement of the grooves for the nutrient vessels that supply the baleen on the palatal surface of the rostrum has been observed on skulls that represent one or more closely related species.

The inner edges of the opposite maxillaries diverge on the ventral surface of the rostrum 510 mm. behind the distal end of the right maxillary, which terminates 1200 mm. anterior to the posterior end of the vomer. The distance

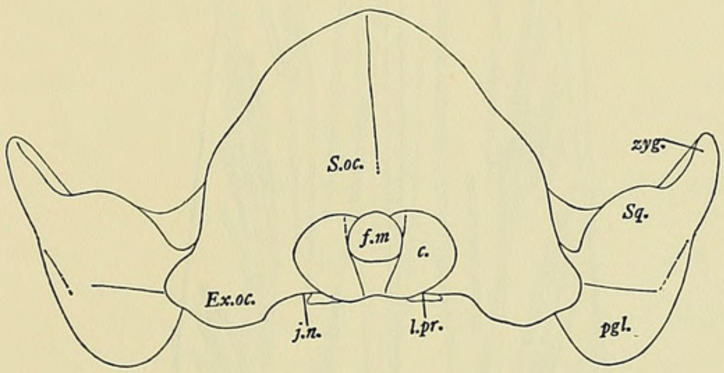


Figure 56.—Posterior view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

on the type skull from the anterior end of the right maxillary to the anterior edge of the optic canal at its point of origin is 1050 mm.

At the anterior end of the vomer on the type skull (fig. 57) the opposite maxillaries diverge more noticeably and this separation continues to their distal ends. To what extent this divergence is natural and not the result of pressure from overlying sediments is not readily determinable. On these two skulls, the premaxillaries do not meet ventrally along the median longitudinal axis of the rostrum to constitute a complete floor for the distal portion of the mesorostral trough.

Divergence of the opposite maxillaries about 130 mm. in advance of the palatines has exposed the ventral keel of the vomer as far as its anterior extremity. On the referred skull (USNM 23494; fig. 58) at a point 200 mm. in front of the posterior edge of the horizontal vaginal plate, the vomer develops a flattened ventral exposure, which continues backward at almost the same horizontal level for a distance of 85 mm., and then as a continuing thin vertical partition between the choanae diminishes in height rather rapidly. The trough of the vomer is widest near the level of the anterior ends of the palatines. The median vertical

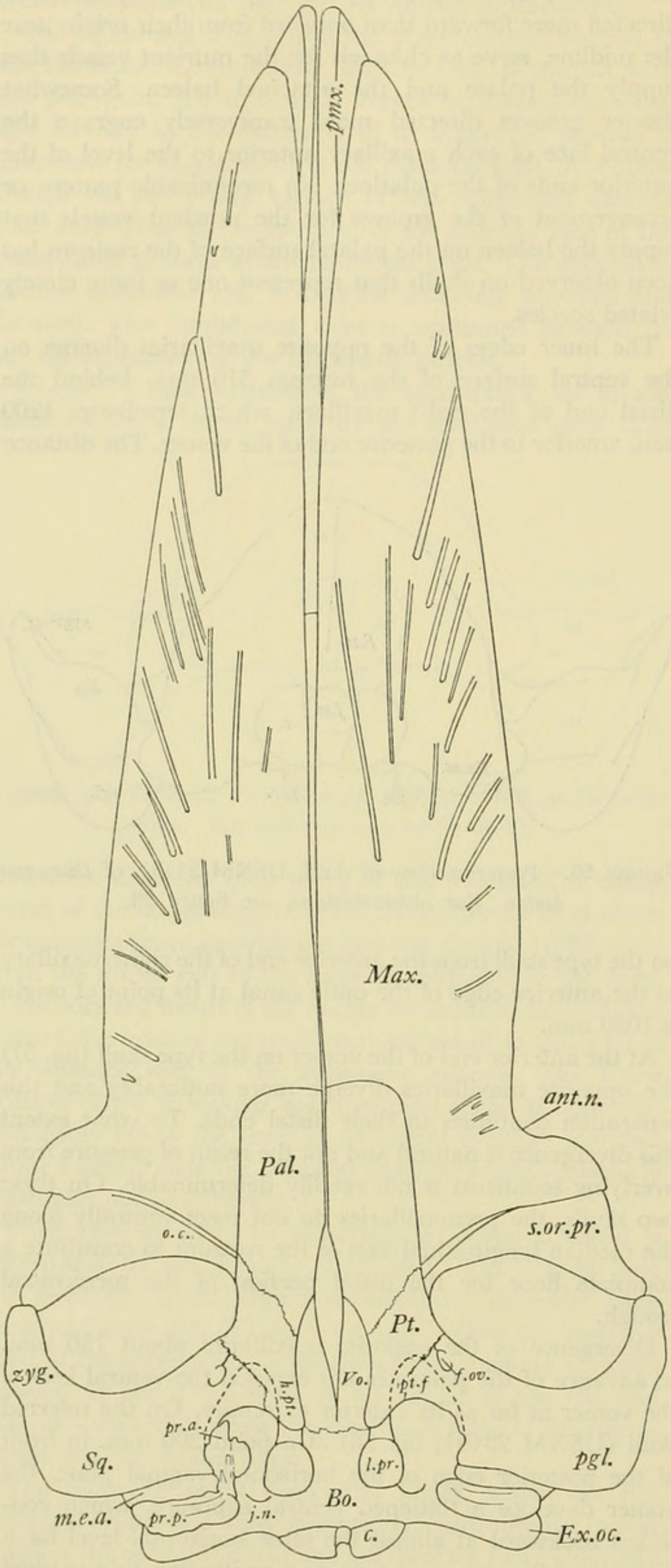


FIGURE 57.—Ventral view of skull, USNM 16783, of *Diorocetus hiatus*, with left side of cranium and hamular processes of pterygoid restored. For abbreviations, see figure 53.

partition between the paired choanae is formed by the vomer and its horizontal posterior plate-like end and is applied to the ventral surface of the basisphenoid; this posterior plate also conceals the transverse contact between the basisphenoid and the basioccipital. Laterally, this widened plate of the vomer is suturally united with the corresponding edge of the vaginal process of the pterygoid.

Each palatine (figs. 57, 58) is obliquely truncated posteriorly and extends backward behind the level of the optic foramen and is suturally united with the pterygoid, which contributes the missing internally projecting hamular process. The anterior end of each palatine is rather squarely truncated and meets the corresponding edge of the adjacent maxillary; it is also applied to the ventral surface of the trough-like vomer. The anteroposterior diameter of the right palatine (USNM 23494) is equivalent to about one seventh of the total length of the skull.

The immediate region of the optic and sphenorbital foramina is damaged on both skulls (USNM 16783 and 23494); the alisphenoid on the right side of the type skull is contiguous to the proximal portion of the optic channel and may possibly participate in the formation of the posterior border of the foramen.

On both skulls, the distally widened supraorbital process of the frontal does not extend outward as far as the postero-external process of the maxillary. The channel for the optic nerve commences at the optic foramen and curves outward on the ventral surface of the supraorbital process of the frontal and increasing in width becomes very wide near the orbital rim of this lateral process. Near its origin this channel follows the hinder face of the supraorbital process for a distance of about 85 mm. and then twists downward until it is located on the ventral face of this process. The anterior wall of this optic channel (USNM 23494) is deeper, but not better defined than the crest along its posterior limit.

The basioccipital is somewhat rectangular in outline, the greatest diameter being transverse to its longitudinal axis; it is ankylosed anteriorly with the basisphenoid, the line of fusion being overspread by the horizontally expanded posterior end of the vomer. On each side in front of and extending laterally beyond the level of the external face of the occipital condyle (USNM 16783) is a large descending knob-like protuberance, which is convex on its internal surface; its external surface is inclined obliquely outward below the tympanoperiotic recess. The transverse distance between the inner faces of these protuberances does not exceed 44 mm. (USNM 23494). The anterior end of each lateral protuberance is suturally united with the vaginal process of the corresponding pterygoid and the line of contact is slightly posterior to the hinder end of the vomer.

The basisphenoid is also a flat rectangular bone, its greatest diameter being along its anteroposterior axis.

It is entirely hidden from view by the overspreading horizontal hinder end of the vomer and is suturally united laterally with the vaginal process of the pterygoid.

This vaginal process of the pterygoid is preserved on both sides of the type skull; it meets along its dorsointernal margin the horizontal exposed hinder end of the vomer. The posterior end of this vaginal process, as stated previously, was united with the anterior surface of the lateral protuberance of the basioccipital. The outer wall of each internal choana is contributed by the vaginal process of the pterygoid. This vaginal process and adjoining lateral protuberance of the basioccipital bound the median region of the basicranium.

The hamular processes of the pterygoids were not prepreserved on either skull; their dimensions, however, are suggested by the broken edge at the point of origin. Between the posterior end of the palatine and the bifurcated anterior end of the squamosal, which encloses the foramen ovale, the pterygoid is intercalated. The pterygoid is also in contact with the ventral surface of the alisphenoid on the inner wall of the temporal fossa. Dorsally in this fossa the pterygoid has a narrow contact with the parietal. Along its entire anterior edge the pterygoid is suturally united with the palatine, but the posterointernal edge of the palatine is free. On its outward course the mandibular branch of the trigeminal nerve follows the groove on the pterygoid on the roof of the pterygoid fossa.

The rather small pterygoid fossa or sinus is bounded internally by the vaginal process of the pterygoid, anteroexternally by the downward curving thickened anterior and external borders of the pterygoid, and to a limited extend posteroexternally by the short and rather narrow falciform process of the squamosal. This air-containing pterygoid fossa is roofed over by the pterygoid, but the partial ventral cover is reduced. No osseous plate limits this fossa posteriorly; it is continuous with the tympanoperiotic recess, which opens into the interior of the cranium. This recess is bounded by the squamosal and its falciform process externally, by the pterygoid anteriorly, by the lateral protuberance of the basioccipital internally and by the exoccipital posteriorly.

The broad notch or incisure (fig. 58) located at the posterointernal angle of the tympanoperiotic recess is bounded by the lateral protuberance of the basioccipital internally and by the exoccipital externally. This notch corresponds to the posterior lacerated foramen for the jugular leash.

Ventrally the contact between the squamosal and the exoccipital is concealed by the posterior process of the periotic, which is lodged in a deep groove on the posterior border of the squamosal. Between this posterior process and the base of the hinder face of the postglenoid process is the curved transverse channel for the external auditory

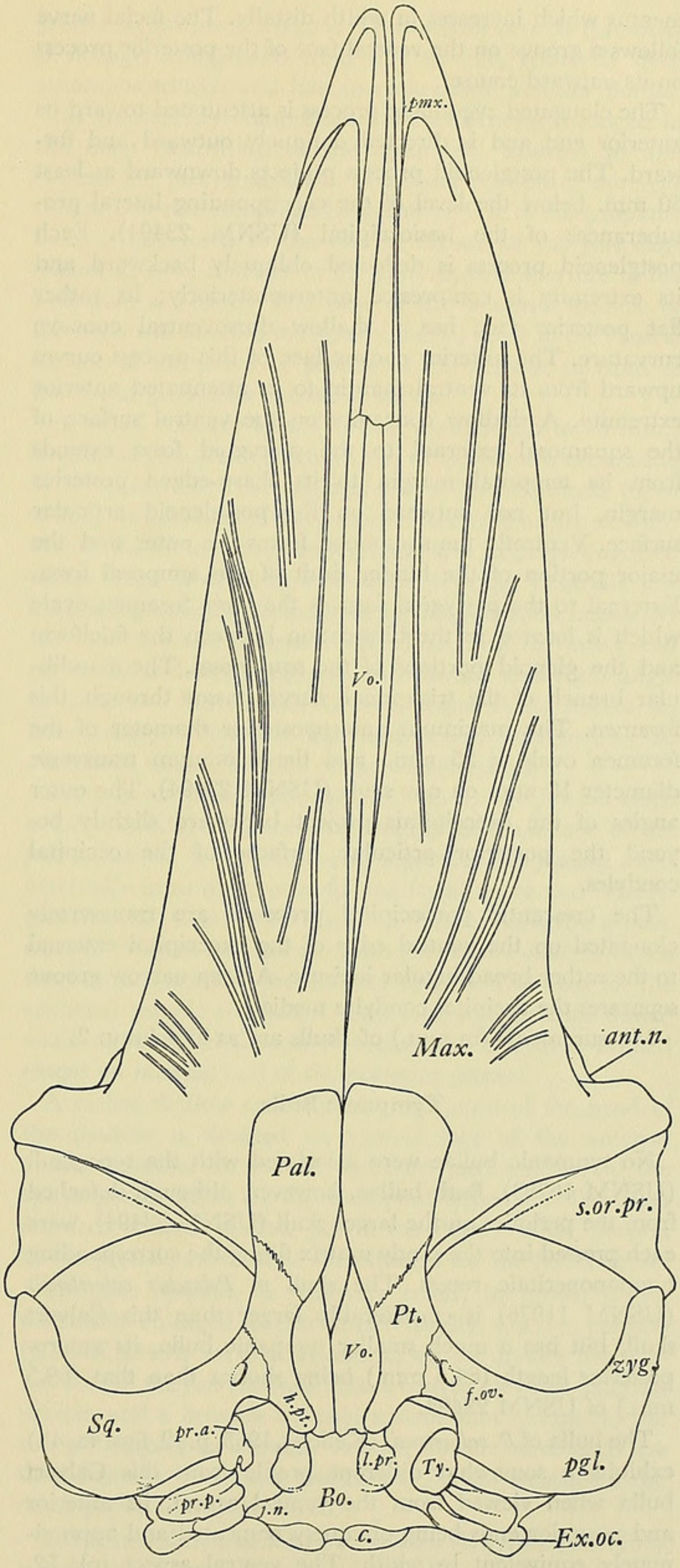


FIGURE 58.—Ventral view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

meatus which increases in width distally. The facial nerve follows a groove on the ventral face of the posterior process on its outward course.

The elongated zygomatic process is attenuated toward its anterior end and is directed obliquely outward and forward. The postglenoid process projects downward at least 50 mm. below the level of the corresponding lateral protuberances of the basioccipital (USNM 23494). Each postglenoid process is deflected obliquely backward and its extremity is compressed anteroposteriorly; its rather flat posterior face has a shallow dorsoventral concave curvature. The anterior convex face of this process curves upward from its ventral margin to its attenuated anterior extremity. A shallow concavity on the ventral surface of the squamosal external to the pterygoid fossa extends from its temporal margin to its sharp-edged posterior margin, but not outward on the postglenoid articular surface. Ventrally the squamosal forms the outer and the major portion of the hinder limit of the temporal fossa. External to the pterygoid fossa is the large foramen ovale which is located in the bifurcation between the falciform and the glenoid portions of the squamosal. The mandibular branch of the trigeminal nerve passes through this foramen. The maximum anteroposterior diameter of the foramen ovale is 25 mm., and the maximum transverse diameter 18 mm. on one skull (USNM 23494). The outer angles of the exoccipitals project backward slightly beyond the posterior articular surfaces of the occipital condyles.

The crescentic paroccipital processes are transversely elongated on the ventral edge of the exoccipital external to the rather broad jugular incisure. A deep narrow groove separates the occipital condyles medially.

Measurements (in mm.) of skulls are as in column 2.

	USNM 16783	*USNM 23949*
Greatest length of skull, anterior end of right premaxillary to level of posteroexternal angle of right exoccipital	1375±	1525
Distance from anterior end of right premaxillary to posterior articular face of right occipital condyle	1365	1540
Distance from anterior end of right premaxillary to apex of supraoccipital shield	1145	1275
Length of rostrum, level of posteroexternal angles of maxillaries to end of right premaxillary	1045	1092
Greatest length of right premaxillary	1035	1090
Distance from apex of supraoccipital shield to posterior end of right nasal bone	115	110
Transverse diameter of skull across posteroexternal angles of supraorbital processes of frontals	520±	655
Greatest anteroposterior diameter of extremity of right supraorbital process of frontal	160	180
Transverse diameter of skull across outer surfaces of zygomatic processes	550±	635
Transverse diameter of skull between outer edges of exoccipitals	305±	370
Transverse distance between outer edges of occipital condyles	138±	144
Greatest or obliquovertical diameter of right occipital condyle	87	84
Greatest transverse diameter of right occipital condyle	50	50
Greatest transverse diameter of foramen magnum	—	52
Distance from dorsal rim of foramen magnum to apex of supraoccipital shield	215	230
Distance between anterior end of right premaxillary and extremity of right postglenoid process	1325	1470
Distance between anterior end of left premaxillary and edge of optic channel (groove) at origin	1050	1130
Greatest breadth of basioccipital across lateral protuberances, outside measurement	118±	123
Greatest length of right zygomatic process, extremity of postglenoid process to anterior end	190	245
Distance between opposite foramina ovale	—	203
Greatest length of vomer	720	1005
Greatest anteroposterior diameter of right palatine	—	210
Greatest transverse diameter of right palatine	—	118
Distance from posterior surface of right occipital condyle to posterior end of vomer	120	123
Distance from posterior surface of right occipital condyle to anterior edge of right palatine	450±	470
Posterior edge of vomer to anterior edge of left palatine	305	350

Tympanic Bulla

No tympanic bullae were associated with the type skull (USNM 16783). Both bullae, however, although detached from the periotics on the larger skull (USNM 23494), were each pressed into the sandy matrix filling the corresponding tympanoperiotic recess. The skull of *Pelocetus calvertensis* (USNM 11976) is considerably larger than this Calvert skull, but has a much smaller tympanic bulla, its anteroposterior length (64.5 mm.) being shorter than that (69.5 mm.) of USNM 23494.

The bulla of *P. calvertensis* (Kellogg, 1965, p. 12, figs. 4a, 4b) exhibits a somewhat different profile from this Calvert bulla when viewed from the ventral aspect, its anterior and posterior ends being obliquely truncated and approximately equivalent in width. The ventral aspect (pl. 52, fig. 3) of this bulla (USNM 23494), however, shows a strong attenuation of the anterior end and a broad (42 mm.)

transversely truncated posterior end; the ventral surface of the hinder end is also concavely depressed between the posterointernal and posteroexternal angles and this entire surface is roughened by numerous pits.

By the usual thin, fragile anterior and posterior pedicles, this bulla was attached to the periotic. The posterior pedicle arises internally from the posterior end of the involucrum and externally from the posterior end of the thin outer lip; on the right bulla this pedicle was separated from the low, blunt posterior conical apophysis by a short crease.

The narrow epitympanic recess or tympanic cavity of the bulla (pl. 52, fig. 2) is bounded externally by the brittle, thin overarching outer lip and internally by the transversely sparsely creased involucrum. The width of this tympanic cavity decreases toward the anterior or eustachian outlet. This thin outer lip is supported in front of the sigmoid process by the slender anterior process, which is ankylosed to the periotic near the epitympanic orifice of the Fallopian canal.

The rounded and thickened extremity of the sigmoid process is twisted at right angles to the longitudinal axis of the bulla, its anterior face convex and its posterior face deeply concave. A deep cleft separates the sigmoid process from the adjacent posterior conical apophysis of Beauregard. The malleus, which was attached to the outer lip of the bulla by its slender stalk-like anterior process along the anterior border of the sigmoid process, is broken off and lost.

Viewed from the external side (pl. 52, fig. 4) the ventral profile is arched, the anterior obliquely truncated and the posterior convex. Viewed from the dorsal aspect, the involucrum attains its maximum width behind the middle of its length.

Measurements (in mm.) of the left tympanic bulla (USNM 23494) are as follows:

Greatest length of tympanic bulla	69.5
Greatest width of tympanic bulla	48.5
Greatest vertical diameter on external side, ventral face to tip of sigmoid process	60.5
Greatest length of tympanic cavity	54

Periotic

On the referred skull (USNM 23494) the posterior processes of both periotics (pl. 50, fig. 2) are firmly lodged in the broad groove between the exoccipital and the postglenoid portion of the squamosal. The right periotic was detached from this skull for illustration and description. A broad deep groove (pl. 51, fig. 4) extends along the ventral face of the posterior process from the outer margin of the fossa for the stapedial muscle to the external end of this process. In recent mysticetes the facial nerve occupies this groove on its outward course. The anterior process (pro-otic) is strongly compressed from side to side, relatively deep anteroposteriorly, and has an emarginate anterior border. This transversely compressed anterior process is lodged in the deep excavation in the squamosal external to and behind the pterygoid fossa. The basal portion of the very thin side-to-side compressed anterior pedicle of the tympanic bulla is ankylosed to the ventral surface of the *pars labyrinthica* 12 mm. anterior to the epitympanic aperture of the Fallopian aqueduct. The base of the posterior pedicle of the bulla was fused to the anterointernal angle of the ventral surface of the posterior process of the periotic in front of the broad groove for the facial nerve.

A broad concave fossa (vertical diameter, 6 to 15 mm.; length, 33 mm.) extends from the deep concave excavation at the posterointernal angle of the posterior process (opisthotic) inward across the posterior face of the *pars cochlearis* above (dorsal to) the *foramen rotunda* and its projecting shelf to the inner or cerebral face of the periotic. Ventrally this fossa is separated from the fossa for the stapedial muscle by the thin crestlike posterior ridge bounding the latter and internally is directed upward and inward at a right angle to this fossa. Dr. Francis C. Fraser and P. E. Purves (in letter) suggest that this depressed smooth surface may be attributed to an extension of the air sac system.

From a tympanic view (pl. 51, fig. 4) the *fenestra ovalis* is largely hidden by the overhanging external face of the *pars cochlearis.* A very thin rim separates the *fenestra ovalis* externally from the groove for the facial nerve and posteriorly from the fossa for the stapedial muscle. A narrow groove extends forward and inward from the *fenestra ovalis* between the *pars cochlearis* and the anterior process. The fossa for the stapedial muscle is broader than long and extends downward on external face of *pars cochlearis* and to a limited extent on internal end of the posterior process.

A rather shallow concavity for reception of the head of the malleus is situated on ventral face of the anterior process external to and for the most part anterior to the epitympanic orifice of the Fallopian aqueduct. The *fossa incudis* is a small shallow pit on the denser outer portion of the periotic external to the channel for the facial nerve.

The *pars cochlearis* is relatively small; its crown is not noticeably enlarged or extended ventrally. On one periotic (USNM 23494) an anteroposterior crease divides the ventral face of the *pars cochlearis* into a convex elevated external portion and a broader internal surface that extends to the rim of the internal acoustic meatus; this crease extends less than halfway backward toward the *fenestra rotunda* on the other periotic (USNM 16783).

The cerebral face of the *pars cochlearis* (labyrinthic region) is relatively small, irregular in outline, and the region dorsal to the internal acoustic meatus is ornamented either with contiguous shallow concavities of variable size, and

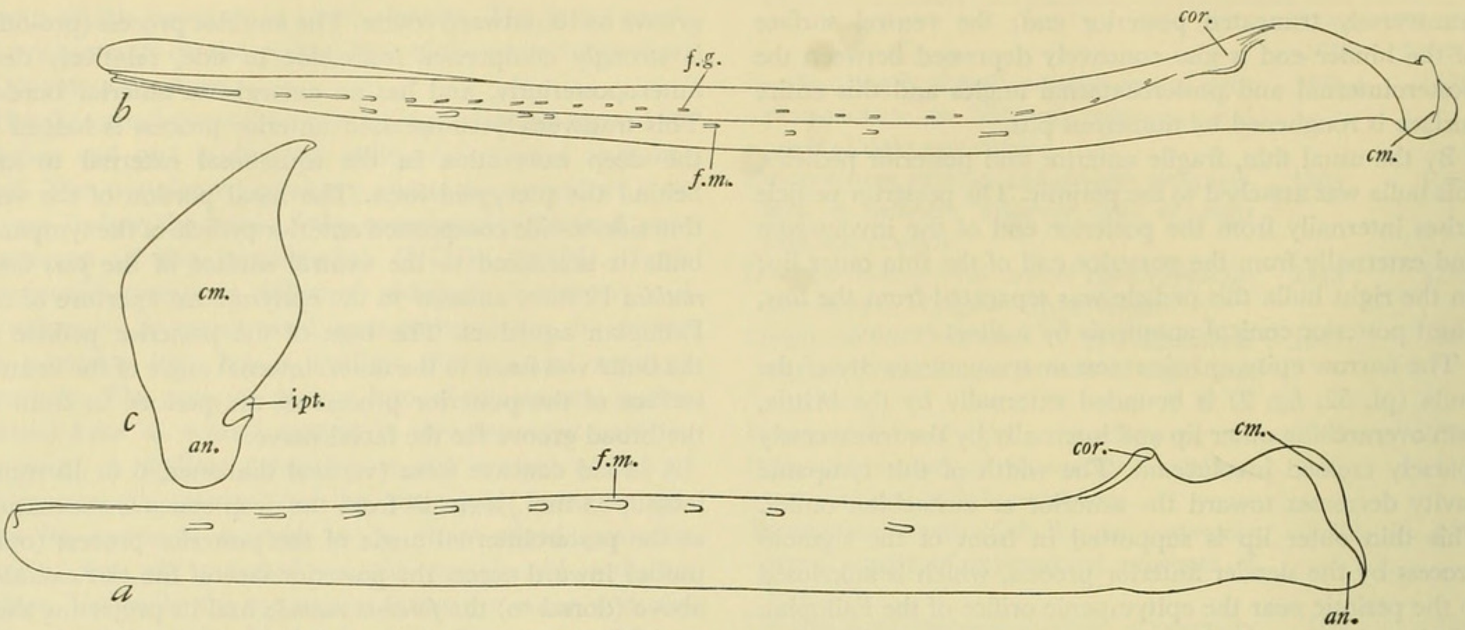


FIGURE 59.—Views of left mandible, USNM 23494, of *Diorocetus hiatus: a*, external view; *b*, dorsal view; *c*, condyle. Abbrs.: an., angle; cm., condyle of mandible; cor., coronoid process; f.g., gingival or alveolar foramen; f.m., mental foramen; ipt., groove for attachment of internal pterygoid muscle.

irregularly spaced (USNM 23494; pl. 51, fig. 3) or porous and rugose (USNM 16783). The internal acoustic meatus at the level of the cerebral rim is either circular or ovoidal; the rim is less than 8 mm. distant from the longitudinal crease on the *pars cochlearis*. The cerebral aperture of the Fallopian aqueduct (pl. 51, fig. 3) is either adjacent to the rim of the internal acoustic meatus, but having a supplemental anterior opening at the anteroexternal angle of the *pars cochlearis* (USNM 23494), or limited to the single anterior opening (USNM 16783) present on the preceding periotic. The vestibular aqueduct opens into a deep ovoidal depression on the cerebral face behind and above the internal acoustic meatus. The small orifice of the cochlear aqueduct is situated ventral to the vestibular aqueduct.

Measurements (in mm.) of the periotics, USNM 16783 and 23494, area as follows:

	USNM 23494 Right	*USNM 16783 Right*
Length of posterior process, distance from external wall of stapedial fossa to extremity	89	96
Greatest dorsoventral diameter of periotic from most inflated portion of tympanic face of *pars cochlearis* to most projecting point on cerebral face	42	44
Distance between epitympanic orifice of *aquaeductus Fallopii* and extremity of anterior process	44	40
Distance from external end of posterior process to anterior end of anterior process (in a straight line)	130	115

Mandibles

The epiphyses of most of the vertebrae accompanying the two skulls and their associated mandibles were not ankylosed to the centra and hence these two cetotheres were not physically mature. Although fractured prior to excavation both of the mandibles associated with the larger skull (USNM 23494) have been restored essentially to their original appearance. Both of the mandibles associated with the smaller skull (USNM 16783) are complete except for the condyle and a portion of the ramus behind the coronoid process. The description will be based mainly on the larger mandibles.

The right mandible of Miocene (Anversian) Belgian *Mesocetus pinguis* (MHNB 13) is larger than the Calvert right mandible (USNM 23494), its measurements being: length, 1642 mm.; vertical diameter at distal end, 123 mm.; and transverse diameter at same point, 39.5 mm. The corresponding measurements of the right mandible of the larger Calvert cetothere are respectively, 1485, 99 and 36 mm.

Except for a noticeable flattening of the anterior one fourth of the internal surface, the internal and external faces of the larger pair of mandibles (USNM 23494) have a dorsoventral convex curvature, more especially on the posterior half of their length, in contrast to the much less obvious convexity of the internal faces of the mandibles of the smaller individual (USNM 16783). The internal and external surfaces of the horizontal ramus meet ventrally to form a low ridge which anteriorly tends to approach the internal face. All four mandibles are slightly bowed outward (fig. 59b); the lengths (1485 and 1487 mm.) of the larger pair (USNM 23494) exceed slightly the distance from the glenoid articular face of the postglenoid process to the extremity of the corresponding premaxillary (1470 mm.).

For a distance of 540 mm. in front of the apex of the coronoid process, the dorsal border of the horizontal ramus is abruptly transversely compressed to constitute a thin longitudinal ridge. This ridge limits the direction of the small internal nutrient foramina, each of which at the posterior end of this series opens into a short antero-obliquely directed groove; these grooves increase in length and progressively shift to a more forward direction. This longitudinal series of small nutrient foramina make their appearance on the internal surface of the ramus below but near the level of the ridgelike dorsal edge. These small foramina begin proximally on the internal surface of the ramus a short distance (80 mm.) in front of the apex of the coronoid process and gradually rise to the dorsal edge anteriorly, those of the anterior extremity opening into a long anteriorly directed narrow groove on the dorsal edge. This anteriormost long (160 to 180 mm.), narrow groove (fig. 59b) on the dorsal edge (USNM 23494) originates in an anteriorly directed foramen, which represents the terminal one of the series of small foramina that move up to the dorsal edge of the ramus.

The most posterior mental foramen (fig. 59a) on the external surface of the ramus is located 490 mm. anterior to the posterior articular face of the condyle on both mandibles (USNM 23494). Ten large external mental foramina are visible on the right mandible of the large individual and eight on the other right mandible (USNM 16783); all of these foramina open into an anteriorly directed groove of variable length, a few as long as 50 mm., and are located below the ridgelike dorsal edge. Most of these grooves increase in width from the orifice to the point where they merge with the external surface or disappear. These mental foramina do not drop down to a lower level at the anterior end of the mandible. A large terminal mental foramen is present below the dorsal edge at the anterior end of the mandibles of the smaller individual (USNM 16783), but is closed on the mandibles of the larger individual.

Viewed from the side the ventral profile of the mandible is slightly bowed upward between the level of the apex of the coronoid process and the commencement of the anterior third of the horizontal ramus. The dorsal edge of the anterior ends of both large mandibles is broader than the ventral edge. On all four mandibles the symphysis was unquestionably short since no noticeably roughened area is present. Above the ventral edge of this anterior portion and below the short longitudinal crease, the lower border (measuring 37 mm. dorsoventrally) of the internal face of the ramus is depressed.

The small coronoid process is low, subtriangular, terminating in a blunt everted apex, concave internally and convex externally, the posterior edge being slightly thinner than the anterior edge. The coronoid process is bent outward and backward above and anterior to the entrance to the large mandibular canal.

The condyle (fig. 59c) on the mandibles of the larger individual (USNM 23494) is large, expanded from side to side at the middle of its vertical diameter, moderately convex, bounded ventrally on the internal face of the ramus above the angle by the deep groove for attachment of the internal pterygoid muscle. On both mandibles this groove terminates at the posterior end of the ramus and does not extend across the posterior face of the condyle. Dorsally the condyle is abruptly compressed and bent inward to conform with the curvature of the thin rim of the horizontal ramus behind the coronoid process. The greatest transverse diameter of the condyle on the left mandible is 89 mm. and the vertical diameter of the condylar end of the ramus is 175 mm. The forward curving external border of the condyle projects noticeably beyond the lateral surfaces of the adjacent portion of the ramus. The transverse diameter of the well-developed angle is 43 mm. The posterior surface of the condyle is 225 mm. distant from the center of the apex of the coronoid process on both of the larger mandibles. Recent mysticetes have the thick fibrous pad, which covers the condyle, connected with the glenoid fossa of the zygomatic process (Turner, 1892, p. 69; Schulte, 1916, p. 483). A similar fibrous pad would be needed for attachment of these heavy Calvert mandibles.

Of the several Miocene (Anversian) mandibles illustrated by Van Beneden, the profile of the posterior aspect of the condyle of the right mandible of *Mesocetus pinguis* (MHNB 13; Van Beneden, 1886, pl. 44, fig. 10) resembles most closely that of this left mandible (USNM 23494). The external border of the condyle of *M. pinguis* is eroded on its ventral half, but this condition does not mask the original indentation of that profile at the level of the opposite internal groove. The Calvert mandibular condyle lacks this indentation. The condyle of the Calvert mandible (fig. 59c) is slightly smaller, the greatest transverse diameter (89 mm.) being less than that (96.5 mm.) of the Belgian cetothere while its vertical diameter (175 mm.) exceeds that (164 mm.) of the latter. On both of these mandibles the greatest width is above the middle of the vertical height of the condyle.

As will be noted on consulting the table of measurements, distortion resulting from crushing and fracturing has affected to a varying extent the vertical and transverse dimensions of the horizontal ramus of opposite mandibles belonging to the same individual. Furthermore, twisting of the left mandible of USNM 23494 has resulted in the inward deflection of the ventral border of the anterior one third of the horizontal ramus (fig. 59b).

Relatively few mandibles with attached condyles have been recovered from the Calvert formation. Three recognizable types of condyles are represented, the most obvious distinguishing characteristics of each of these being associated with the groove for the attachment of the internal pterygoid muscle. Three variants of one type have been noted. That these variants may possibly be attributed to differential growth has not as yet been excluded with certainty.

Measurements (in mm.) of mandibles are as in column 2.

Vertebrae

Associated with the skull (USNM 23494) of the larger individual were one cervical, five dorsal, eleven lumbar, and five caudal vertebrae. Ankylosis of the epiphyses to the centra proceeded rather irregularly in this vertebral series. The anterior epiphysis is attached to one middle and one posterior dorsal, to two middle and one posterior lumbar, and to one middle caudal. Ankylosis of the epiphyses to the centra in Recent mysticetes normally proceeds forward from terminal caudals and backward from the axis until this process is completed near the middle of the vertebral series at physical maturity. Alongside the smaller skull (USNM 16783) were found an axis, two posterior cervical and the first dorsal vertebrae. The posterior epiphysis is attached to the centrum of the last cervical, both epiphyses of the sixth cervical and the first dorsal were detached and lost. The total length of the skeleton (USNM 23494), from the extremity of the rostrum to and including the terminal caudal, apparently did not exceed eighteen feet. This estimate is based on vertebrae of comparable size selected from incomplete skeletons of several individuals to assemble a consecutive series of cervical, dorsal, lumbar, and caudal vertebrae. All of these vertebrae were excavated in zones 11 to 14 of the Calvert formation of Maryland.

Cervical vetebrae.—None of the cervical vertebrae were ankylosed to preceding or succeeding vertebrae. The axis lacks a neural spine; the odontoid process is low and blunt; the moderately elongated transverse processes are directed outward, but not strongly backward. Contour of anterior face of centrum of sixth cervical is broadly elliptical; pedicles of neural arch are low; no vestige of a ventral transverse process is present. Contour of anterior face of centrum of seventh cervical is subelliptical (USNM 16783) or subquadrate (USNM 23494); attenuated diapophysis directed outward and slightly forward; no vestige of a ventral transverse process is present. The

	USNM 16783		*USNM 23494*	
	Right	*Left*	*Right*	*Left*
Greatest length of mandible in straight line when complete, estimated	1330±	1330±	1485	1487
Greatest length of mandible as preserved in a straight line	1242	1151	1485	1487
Greatest length of mandible as preserved along outside curvature	1270	1190	1498	1500
Distance from anterior end to level of center of coronoid process along outside curvature	1140	1135	1280	1275
Greatest vertical diameter 100 mm. behind anterior end of ramus	91	87	99	98
Greatest transverse diameter 100 mm. behind anterior end of ramus	33	31	36	38
Greatest vertical diameter 300 mm. behind anterior end of ramus	80	81	95	95
Greatest transverse diameter 300 mm. behind anterior end of ramus	40	32	52	51
Greatest vertical diameter 500 mm. behind anterior end of ramus	88	86	99	102
Greatest transverse diameter 500 mm. behind anterior end of ramus	48	37	59	59
Greatest vertical diameter 700 mm. behind anterior end of ramus	85	82	104	107
Greatest transverse diameter 700 mm. behind anterior end of ramus	48	42	68	72
Greatest vertical diameter 900 mm. behind anterior end of ramus	88	80	99	104
Greatest transverse diameter 900 mm. behind anterior end of ramus	52	53	72	74
Greatest vertical diameter through coronoid process	128	131±	157	165
Greatest vertical diameter through hinder end including condyle	—	—	176	175
Horizontal distance between center of coronoid process and hinder face of condyle	—	—	235	240
Greatest transverse diameter of condyle	—	—	86	89

estimated length (270 mm.; 10⅝ inches) of the seven consecutive cervical vertebrae is based on vertebrae of comparable size of several individuals from the Calvert formation of Maryland.

Axis: Characterized in part by the short blunt odontoid process. Transverse processes (pl. 53, fig. 1) moderately elongated, dorsoventrally widened distally, directed outward, but not appreciably backward. Foramen transversarium in transverse process for cervical extension of the thoracic retia mirabilia large, but not inclosed by bone dorsally; a large deep concavity on the posterior face of this process encircles this transverse foramen. The greatest width (63 mm.) of the neural canal exceeds its height (53 mm.). The rather large anterior facets for articulation with the atlas are more flattened than depressed, the vertical diameter (84 mm.) of each equivalent to more than half of the transverse width (156 mm.) of the combined anterior articular surfaces. The odontoid process is broad, low, and concave below its most projecting piont. The anterior median portion of the neural arch is broad, truncated transversely, and is extended forward beyond the level of the anterior articular facets to articulate with or rest on the opposing surface of the neural arch of the atlas. The neural spine is not developed; the neural arch is broad and has a deep central notch on the posterior portion of the thickened roof. The floor of the neural canal is shallowly concave; the flat ventral surface of the centrum is almost horizontal. The broad (113 mm.) posterior face of the centrum is deeply concave. The greatest width of the axis is 255 mm. and its greatest vertical diameter 136 mm.

Sixth Cervical: The contour of the anterior face of the centrum of this sixth cervical (USNM 16783) is broadly elliptical, its transverse diameter (96 mm.) being greater than its vertical (68 mm.). The pedicles (left, minimum anteroposterior diameter, 9 mm.) of the neural arch are low, and provide the major support to each diapophysis by their location on the dorsoexternal surface of the centrum. The minimum dorsoventral diameter of the left pedicle is 34 mm. and the greatest width of the neural canal is 76 mm. Both diapophyses are broken off at the base and the roof of the neural arch, the zygapophysial facets and the neural spine are missing. No vestige of the lower transverse process or parapophysis persists.

Seventh Cervical: Two incomplete vertebrae represent the seventh in the cervical series. The anterior face of the centrum of the smaller one (USNM 16783) is subelliptical and the other one (USNM 23494) is subquadrate. No median longitudinal keel is developed on the ventral face of either centrum, but this may be attributed to immaturity. The pedicles of the neural arch are continuous with the broad anteroposteriorly compressed basal portions of the diapophyses which project outward from the dorsal anterolateral angles of the centrum. Each diapophysis is abruptly increased in depth near the base, attenuated toward its extremity, directed outward and slightly forward; the terminal articular facet is barely developed. The prezygapophysial facets are narrow and elongated. Measurements of the larger cervical (USNM 23494; pl. 53, fig. 2) are as follows: Transverse diameter of anterior face of centrum, 92 mm.; vertical diameter of anterior face of centrum, 66 mm.; greatest transverse diameter of neural canal, 80 mm.; greatest distance between outer ends of diapophyses, 244 mm.

Dorsal Vertebrae.—The second to sixth dorsal vertebrae inclusive are not represented among the vertebrae associated with the two skulls (USNM 16783, 23494). At the anterior end of the dorsal series the centrum is subelliptical in outline anteriorly, that of the seventh subcordate and then the contour is progressively altered to elliptical. Posteroexternal demifacets for the capitulum of the following rib were present on the lateral surfaces of the centrum of the first and seventh dorsals but not on succeeding vertebrae. The neural canal decreases in width from the first to the eighth dorsal; behind the eighth dorsal the vertical diameter of the neural canal increases. The pedicles of the neural arch of the seventh dorsal are massive and widened transversely. The thickened diapophyses arise from the pedicle of the neural arch, which is located on the first to eighth dorsals on the dorsoexternal portion of the centrum anteriorly. The parapophyses of the ninth to twelfth dorsals, inclusive, project outward horizontally from the lateral surface of the centrum. The width of the gap between the prezygapophysial facets decreases from the anterior to the posterior end of the dorsal series. Behind the eighth dorsal vertebra, the anteroposterior crest delimiting the outer edge of the prezygapophysial facet increases in prominence as the metapophysis is shifted from horizontal to vertical. These side-to-side compressed metapophyses progressively increase in size and rise higher above the level of the floor of the neural canal.

Dorsal vertebrae belonging to several individuals of comparable size, all derived from the Calvert formation of Maryland, were substituted for the missing anterior dorsals (first to sixth) in one series (USNM 23494) in order to estimate fairly accurately the length of a consecutive series of twelve dorsal vertebrae as 870 mm. (34¼ inches).

First Dorsal: In dimensions the centrum of the first dorsal (USNM 16783; pl. 53, fig. 3) differs from the seventh cervical only in the slight reduction of the vertical diameter of the subelliptical anterior face (62 mm. from 70 mm.). The roof of the neural arch, the neural spine and the zygapophysial facets are missing. The attenuated diapophyses are anteroposteriorly compressed, dorsoventrally widened, as well as concavely depressed anteriorly on the basal half. Each diapophysis, which projects outward and strongly forward, is combined at the base with the pedicle of the neural arch. The distal end of each diapophysis is obliquely truncated in a dorsoventral direction, the flat surface serving as the articular facet for the head of the first rib. The greatest distance between outer ends of diapophyses is 215 mm. The dorsoventrally elongated demifacet for reception of the capitulum of the second rib is located dorsally on the posteroexternal angle of the centrum.

Seventh Dorsal: On this dorsal (USNM 23494; pl. 55, fig. 3) each metapophysis consists of a ridgelike crest which forms the external limit of the prezygapophysial facet; this concave facet extends backward beyond the base of the neural spine anteriorly. Each broad, but dorsoventrally thickened transverse process (diapophysis) projects outward from the transversely widened (32 mm.) pedicle of the neural arch located on the dorsoexternal portion of the centrum; it is bent very slightly upward, but is extended forward barely beyond the level of the anterior face of the centrum. The greatest distance between outer ends of diapophyses is 153 mm. The facet for the tuberculum of the seventh rib on the extremity of each diapophysis is elongated (length 40 mm.), subcrescentic in outline, and deeply concave medially. The postzygapophysial facets are eroded. The neural spine (minimum width, 50 mm.) is incomplete, but is slanted backward. The neural canal is wide (48 mm.) and rather low (21 mm.) and is quite unlike that of the ninth dorsal. The contour of the anterior face of the centrum is subcordate. A reduced posteroexternal demifacet for articulation with the capitulum of an eighth rib is present on the right posterodorsal angle of the centrum.

Ninth Dorsal: The accentuation of the low anteroposterior crest has now culminated in the shift of the metapophysis from horizontal to vertical. This development permits the pair of metapophyses (USNM 23494; pl. 54, fig. 6) to clasp more firmly the backward projecting postzygapophyses for the preceding dorsal. Each metapophysis is compressed from side to side, obtusely pointed anterodorsally, extended forward beyond the level of the anterior face of the centrum and constitutes the outer wall of the narrow concave prezygapophysial facet. The transverse diameter of the neural canal (50 mm.) exceeds the vertical (42 mm.) anteriorly. On the first eight dorsals, inclusive, of Calvert cetotheres the transverse process (diapophysis) projects outward mainly from the more or less massive pedicles of the neural arch and maintains its elevation above the dorsal face of the centrum. On the ninth dorsal (pl. 55, fig. 1) the broad transverse process (parapophysis) projects outward from the dorsoexternal surface of the centrum. The ventral face of the extremity of this process is strongly concave; it ends in an elongated facet (length, 60 mm; vertical diameter, 12 mm. posteriorly and 6 mm. anteriorly) for the head of the ninth rib. The distance between the ends of the parapophyses is 199 mm., and this distance progressively increases to the end of the dorsal series. The postzygapophyses are destroyed. The neural spine, which rises 102 mm. above the roof of the neural canal, tapers from its base to its truncated extremity. The pedicles of the neural arch are quite thin (minimum transverse diameter, 6 mm.); the minimum length of each is 45 mm.

Tenth Dorsal: Longer, horizontally widened, and dorsoventrally compressed transverse processes (parapophyses) and a slightly narrower neural canal distinguish this dorsal (USNM 23494; pl. 55, fig. 2) from the ninth dorsal. Each broad parapophysis projects horizontally outward from the upper portion of the lateral surface of the centrum. The posterior end of the distal facet on this process for the head of the tenth rib is thicker (16 mm.) than the anterior end (5 mm.); the anteroposterior diameter of this facet is 59 mm. The thin pedicles of the neural arch have a slightly greater anteroposterior length (49 mm.) than on the ninth dorsal. The vertical diameter (43 mm.) of the neural canal equals the transverse (43 mm.) diameter. The large metapophyses (pl. 54, fig. 3) project forward nearly horizontally beyond the level of the anterior face of the centrum; they rise 53 mm. above the level of the floor of the neural canal. The prezygapophysial facets are poorly defined and the postzygapophysial facets appear to be nonexistent. The contour of the anterior face of the centrum is subcordate.

Eleventh Dorsal: Long, rather wide, dorsoventrally compressed parapophyses projecting horizontally outward from the lateral surface of the centrum characterize this dorsal (USNM 23494; pl. 54, fig. 7). The anterior edge of each parapophysis is thin and the posterior border thickened; the main area of attachment of the eleventh rib seems to have been on the posterior two-thirds of the distal end. The distance between the ends of the parapophyses is 280 mm. The thin pedicles (pl. 54, fig. 4) of the neural arch are slightly longer (53 mm.) than those on the tenth dorsal. The metapophyses as well as the pre- and post-zygapophysial facets and minor portions of the neural arch are missing. No reduction in the dimensions of the neural canal is as yet evident, the vertical diameter (45 mm.) being slightly greater than the transverse diameter (42 mm.). The contour of the anterior face of the centrum is more elliptical than subcordate.

Twelfth Dorsal: The roughened truncated end of the broad elongated parapophysis indicates the area of attachment of the twelfth rib. Both parapophyses lack portions of the anterior border which was quite thin in contrast to the thickened and rounded posterior border. The distance between the ends of the parapophyses (USNM 23494; pl. 54, fig. 8) is 335 mm. Each parapophysis (pl. 55, fig. 4) projects outward from the lateral surface of the centrum; the posterior edge tends to bend backward toward the extremity. The thin pedicles of the neural arch

USNM 23494–Dorsal Vertebrae	*D.1*	*D.7*	*D.9*	*D.10*	*D.11*	*D.12*
Anteroposterior diameter of centrum	33^b	63^p	72^a	78^a	90	92
Transverse diameter of centrum anteriorly	93	83	86	90	88	91
Vertical diameter of centrum anteriorly	62	62	67	67	71	73
Minimum anteroposterior length of pedicle of neural arch	15	43	45	49	53	53
Transverse diameter of neural canal anteriorly	70	48	50	43	42	39
Vertical diameter of neural canal anteriorly	—	21	42	43	45	43
Distance between ends of transverse processes	215	153	199	222±	280	335
Dorsal edge of metapophysis to ventral face of centrum anteriorly	—	85	113	121	128+	128
Tip of neural spine to ventral face of centrum posteriorly	—	197	200	205±	206±	215

^{a}=Anterior epiphysis missing. ^{b}=Both epiphyses missing. ^{p}=Posterior epiphysis missing.

are damaged. The neural spine is eroded at its extremity and is slanted backward. The transverse diameter (39 mm.) of the neural canal has decreased. The anteroposterior diameter of the centrum apparently did not exceed the transverse diameter of the anterior face (91 mm.); the contour of the anterior face is elliptical.

Measurements (in mm.) of dorsal vertebrae, USNM 23494, are as indicated above.

Lumbar vertebrae.—The processes of all eleven lumbar vertebrae (USNM 23494) are damaged and more or less incomplete. For this reason the lumbar vertebrae will not be described individually. Descriptive comments will be restricted to the successive alterations observable from the anterior to the posterior end of this series. The epiphyses of all the lumbars were detached from the centra when excavated. The ventral median longitudinal keel is not developed on the first and second, but is quite distinct on the fourth lumbar and persists to the eleventh. Arranged in serial sequence the increase in the length of the centrum from the first (86+ mm.) to the eleventh (113+ mm.) is more noticeable than the increase in the minimum anteroposterior diameter of the thin pedicle of the neural arch (from 53 mm. to 57 mm.). There is an increase in the minimum anteroposterior diameter of the transverse process from the second (48 mm.; pl. 55, fig. 7) to the eleventh lumbar (68 mm.) and a decrease in its length (the distance between the outer ends of the parapophyses reduced from 330 to 265 mm.). The width of the neural canal diminishes from the first (40 mm.) to the eleventh lumbar (22 mm.; pl. 55, fig. 6), and there is an imperceptible decrease in the vertical diameter of the neural canal from the first (44 mm.) to the eleventh (41 mm.). The elongated thin lamina-like metapophyses are large processes that project upward and forward from the neural arch beyond the level of the anterior face of the centrum and are inclined obliquely outward from the ventral to the dorsal edges. They do not embrace closely the narrow backwardly projecting dorsal portion of the neural arch of the preceding lumbar. The gap between the metapophyses is gradually reduced from the first lumbar to the eleventh. Viewed from the side, the neural spines are inclined slightly backward. This estimate of the length (1300 mm.; 51 inches) of twelve lumbar vertebrae is based on eleven of one individual (USNM 23494).

Measurements (in mm.) of lumbar vertebrae, USNM 23494, are as indicated below.

USNM 23494–Lumbar Vertebrae	*L.1*	*L.2*	*L.3*	*L.4*	*L.5*	*L.6*	*L.7*	*L.8*	*L.9*	*L.10*	*L.11*
Anteroposterior diameter of centrum	86^p	89^p	91^a	99^a	103	105	106	110	98^b	118	113^p
Transverse diameter of centrum anteriorly	89	92	97	103	96	96	101	100	104	105	110
Vertical diameter of centrum anteriorly	74	79	81	86	84	85	87	92	91	96	100
Minimum anteroposterior length of pedicle of neural arch	54	53	—	55	—	53	48	50	51	51	57
Transverse diameter of neural canal anteriorly	40	44	40	39	39	40	37	35	33	29	22
Vertical diameter of neural canal anteriorly	48	45	—	42	—	45	40	42	42	—	41
Distance between ends of transverse processes	325	—	—	310+	—	—	292+	—	295+	270+	252+
Dorsal edge of metapophysis to ventral face of centrum anteriorly	142	—	—	144	—	148	145	149	148	—	161
Tip of neural spine to ventral face of centrum posteriorly	182+	204+	—	190+	—	—	206+	—	203+	—	—

^{a}=Anterior epiphysis missing. ^{b}=Both epiphyses missing. ^{p}=Posterior epiphysis missing.

Caudal vertebrae.—Eleven caudal vertebrae and detached epiphyses of another (USNM 16567), which were associated with one chevron when excavated, are referred to the same species as the five caudal vertebrae (USNM 23494) found intermingled with other skeletal elements alongside the larger skull. Except for one middle caudal which has the anterior epiphysis attached to the centrum, the epiphyses are detached on the remaining four caudals in one series (USNM 23494). Two anterior caudals (third and fourth) and one middle caudal (seventh) have the anterior epiphysis and three (second, fourth, and sixth) have the posterior epiphysis fused with the centrum in the other series (USNM 16567); the remaining epiphyses were detached.

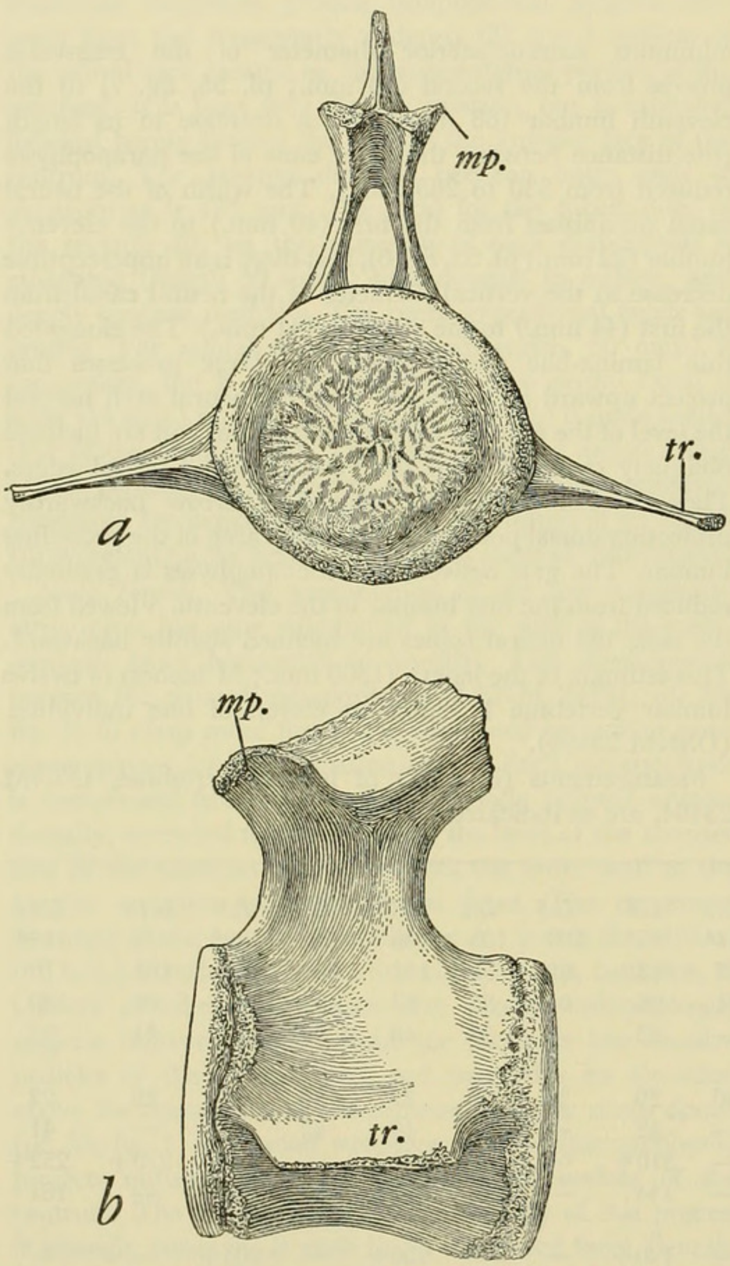


Figure 60.—Views of second caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

At the anterior end of the caudal series, the centra are relatively massive as contrasted with the posterior lumbars, but are progressively shortened from the second to eighth; the neural spine and the neural canal diminish in height from the second to the eighth; the interval between the dorsal edges of the opposite metapophyses progressively increases from the second to the sixth or seventh; and the horizontally outward directed transverse processes become reduced gradually to a flange-like process on the seventh caudal.

On the centrum of the posteriormost lumbar (USNM 23494) there is a single sharply defined median longitudinal ventral ridge; this ridge is replaced by a pair of parallel ridges on the first caudal. The width of the median ventral longitudinal haemal groove between the haemal tubercles (hypapophyses) increases gradually to the fourth or fifth caudal (USNM 16567). The anterior pair of haemal tubercles are not developed on the three anterior caudals. The posterior pair of haemal tubercles increases in size from the third to the sixth; concomitantly the distance between the anterior and the posterior tubercles on each side is decreased. These posterior haemal tubercles certainly are attached to the chevron bone on the third caudal. On the third, fourth, and fifth caudals, the oblique upward course of the segmental blood vessels from the haemal groove to the anterior basal edge of the transverse process and thence to the posterior end of the neural canal is indicated by a faint shallow groove. This groove becomes more distinct on the left side of the sixth caudal; the blood vessels perforate the reduced transverse process on the right side of the sixth, both sides on the seventh and eighth caudal and the lateral face of the centrum on the ninth caudal, The caudals behind the last (ninth) to which the chevrons are attached lack a roof over the neural canal; these centra are pierced by vertical canals from the ventral face to the dorsal neural depression on one series. In the centra of these terminal caudals (USNM 16567) these vertical canals have three openings on the ventral face of the centrum and two on the dorsal face. These vertical canals in the centra of the ninth and following posterior caudal vertebrae provide a passage for blood in the branches of the caudal artery and vein between the haemal groove and the neural canal.

Although no complete consecutive series of caudal vertebrae is now at hand, one may infer with reasonable certainty that fourteen caudals comprise this portion of the vertebral column. This inference is based on series of caudals belonging to five individuals that duplicate one another in part as well as containing one or more caudals missing from otherwise consecutive vertebrae. The eleven caudals comprising the most complete series (USNM 16567) indicate a total length of 1530 mm. (60 inches) for a series of 14 and for the series associated with the skull (USNM 23494) as 1425 mm. (56 inches).

First Caudal: This vertebra is not represented among the caudals in the collection.

Second Caudal: Low, closely approximated parallel longitudinal ventral ridges (pl. 56, fig. 1) bound the shallow haemal groove (minimum width, 10 mm.), which separates the pair of posterior flattened protuberances for articulation with a chevron (USNM 16567); these protuberances are partially eroded and their true function is inferred.

The transverse processes are broad (minimum anteroposterior diameter, 68 mm.), short and squarely truncated (fig. 60b) at extremity; they project outward and slightly downward.

The neural canal (fig. 60a) is high and narrow, its height (44 mm.) being equivalent to twice its width (22 mm.). The metapophyses slope obliquely upward from the ventral to the dorsal margin and apparently projected forward barely beyond the level of the anterior face of the centrum. Although damaged the neural spine is shorter than that of the last lumbar, with a marked backward slope. The width (117 mm.) exceeds the vertical diameter (106 mm.) of the anterior face of the robust centrum.

The second caudal in the other series (USNM 23494) agrees with the above described caudal in having a wide backward slanting neural spine, high (41 mm.) and narrow (21 mm.) neural canal, broad truncated transverse processes, and a narrow ventral longitudinal haemal groove.

Third Caudal: This caudal (USNM 16567) is characterized chiefly by an increase in the width of the ventral longitudinal haemal groove, more prominent posterior haemal tubercles (pl. 56, fig. 2), but as yet undeveloped anterior haemal tubercles and less elevated metapophyses.

On each side of the longitudinal haemal groove, the ventral surface of the centrum is noticeably concavely depressed below the transverse process. This ventral haemal groove is less sharply delimited in front than behind where it is increased in width between the rather narrow but elongated posterior haemal tubercles.

The distally truncated transverse processes (pl. 56, fig. 2) are broad (minimum width, 68 mm.) and short; they project outward and slightly downward (fig. 61a).

The neural canal is high (41 mm.) and narrow (16 mm.). The metapophyses and most of the neural spine are destroyed on one caudal (USNM 16567) and incomplete on the other (USNM 23494).

Fourth Caudal: A decrease in the height (35 mm.) from that of the preceding caudal but not width (20 mm.) of the neural canal of a fourth caudal (USNM 16567) and a less contrasting reduction in the width (15 mm.) and height (33 mm.) of the same caudal associated with the

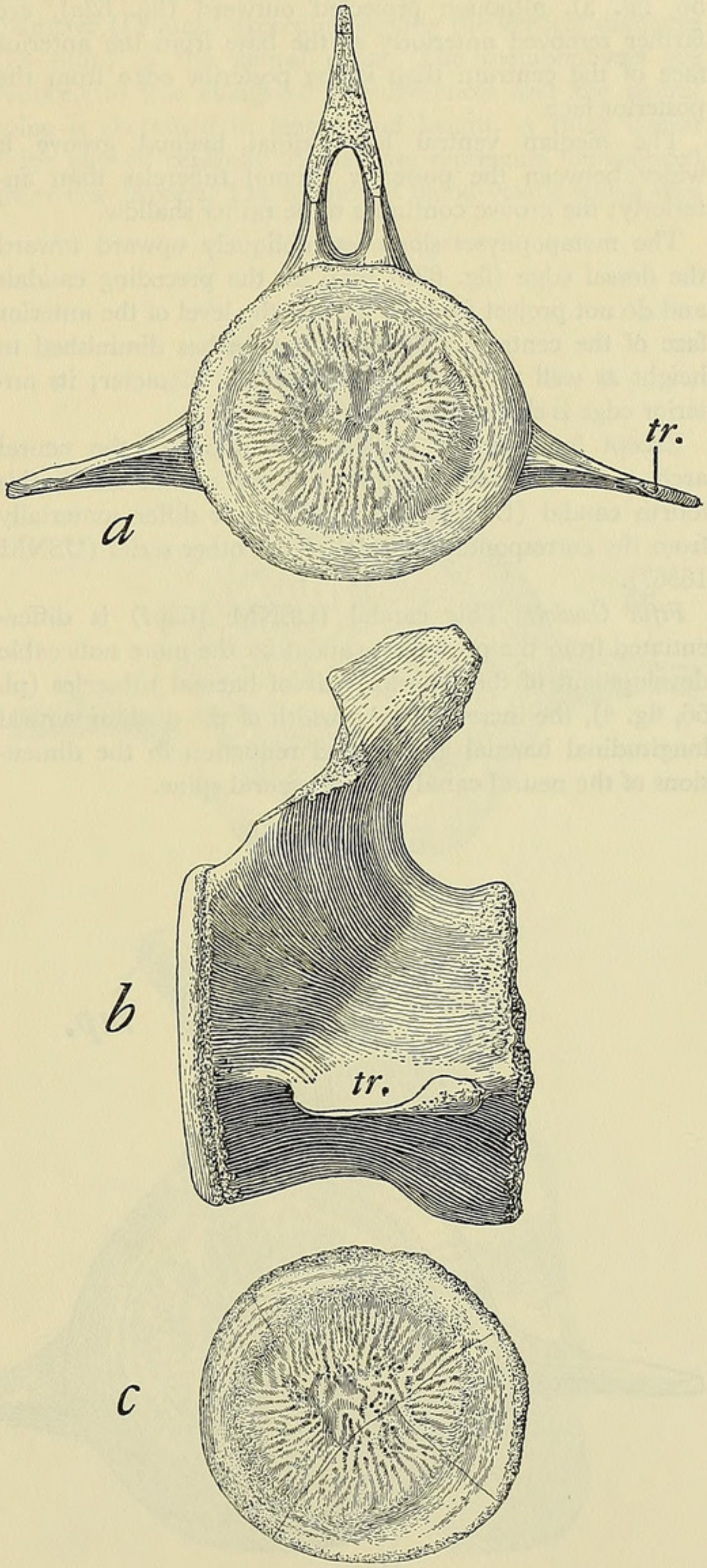


FIGURE 61.—Views of third caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view; *c*, posterior epiphysis. Abbrs.: tr., transverse process.

skull (USNM 23494) suggests that variation in dimensions may not be correlated with either growth or age.

The short distally truncated transverse processes (pl. 56, fig. 3), although projected outward (fig. 62a), are farther removed anteriorly at the base from the anterior face of the centrum than is the posterior edge from the posterior face.

The median ventral longitudinal haemal groove is wider between the posterior haemal tubercles than anteriorly; the groove continues to be rather shallow.

The metapophyses slope less obliquely upward toward the dorsal edge (fig. 62b) than on the preceding caudals and do not project forward beyond the level of the anterior face of the centrum. The neural spine has diminished in height as well as in the anteroposterior diameter; its anterior edge is slanted backward.

Except for widened pedicles (61 mm.) of the neural arch and the lesser dimensions of the neural canal, this fourth caudal (USNM 23494) does not differ materially from the corresponding caudal of the other series (USNM 16567).

Fifth Caudal: This caudal (USNM 16567) is differentiated from the preceding caudal by the more noticeable development of the anterior pair of haemal tubercles (pl. 56, fig. 4), the increase in the width of the median ventral longitudinal haemal groove and reduction in the dimensions of the neural canal and the neural spine.

The short distally rounded transverse processes are projected horizontally outward (fig. 63a). The contour of the posterior face of the centrum of the fourth caudal is hexagonal. Expansion of the posterior end of the centrum is attributable to the enlargement of the posterior pair of haemal tubercles. On each side between the anterior and the posterior haemal tubercle is a notch or gap through which the segmental blood vessels pass on their upward course on the lateral surface of the centrum in a shallow groove which can be traced to the anterobasal angle of the transverse process and thence to the posterior end of the neural canal. Above each transverse process on the lateral surface of the centrum (fig. 63b) is a longitudinal ridge interrupted medially by the above described shallow groove for the blood vessels. The neural canal (fig. 63a) has diminished to an ovoid passage whose width (22 mm.) is less than its height (27 mm.). The metapophyses are lower and the neural spine is smaller and shorter than on the preceding caudal.

Sixth Caudal: The contour (fig. 64a) of both ends of the centrum is definitely hexagonal, but the shape of the posterior epiphysis is almost circular. The ends of the short transverse processes (pl. 56, fig. 5) are obliquely truncated from the anteroexternal angle to the posterobasal angle. The right transverse process (USNM 16567) is pierced at the base near the anterior edge for the passage of the segmental blood vessels; on the left side the groove for these

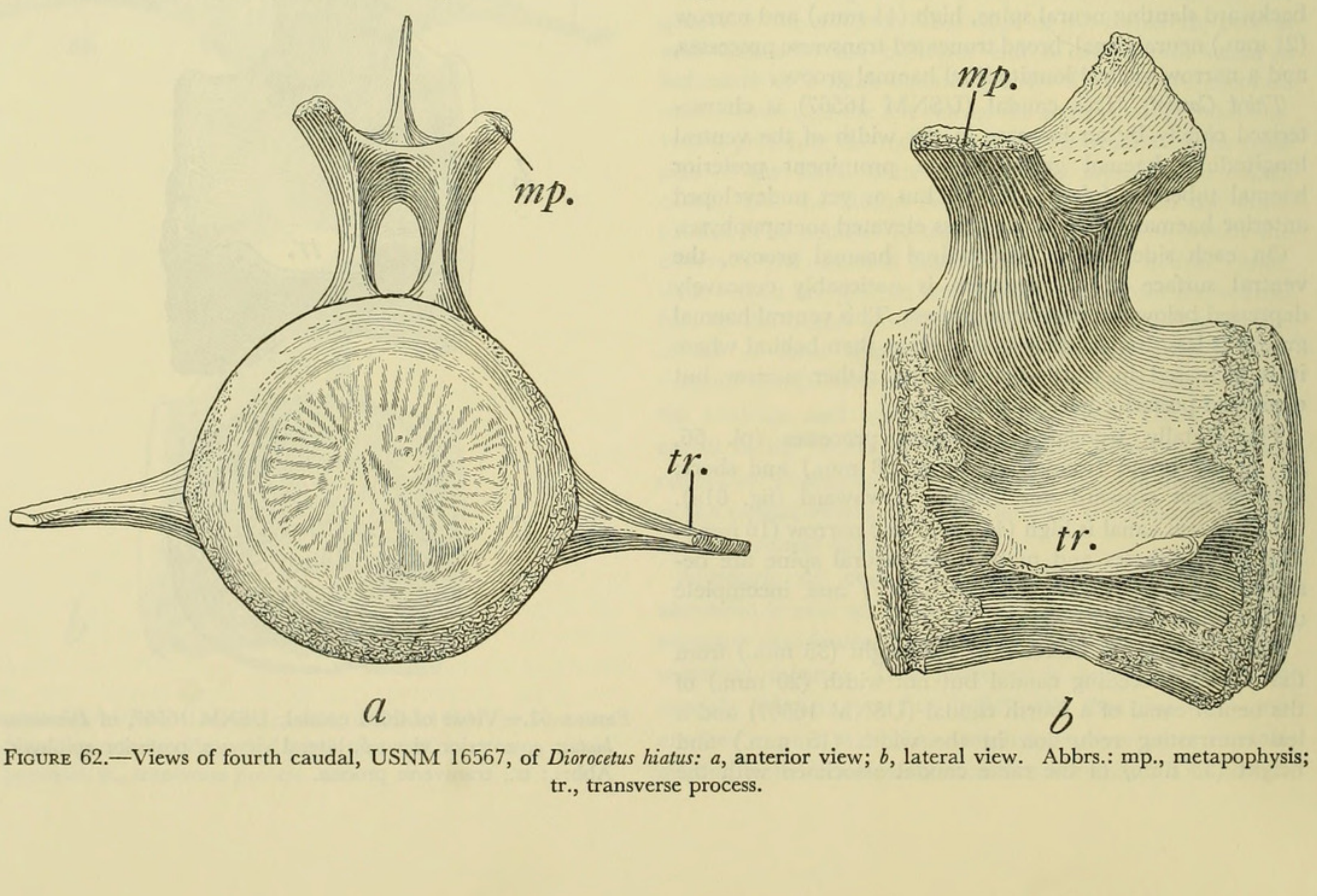


FIGURE 62.—Views of fourth caudal, USNM 16567, of *Diorocetus hiatus*: *a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

blood vessels follows the same course as on the fifth caudal. On the ventral surface of the centrum, the opposite haemal tubercles are separated by the broad concave longitudinal groove; the anterior pair of tubercles are smaller and narrower than the posterior pair and on each side the anterior and posterior tubercle is separated by the gap (fig. 64b) for passage of the segmental blood vessels. A very slight modification of the shape of the neural canal resulted from the further reduction in the vertical diameter (22 mm.) and the width (22 mm.); the greatest width (fig. 64a) is more dorsal than ventral. The low metapophyses do not project forward beyond the level of the anterior face of the centrum. The neural spine is small and short.

In the other series (USNM 23494) the transverse processes of the sixth caudal are broader and both are pierced at the base for the passage of the segmental blood vessels; the height (29 mm.) of the neural canal is greater than the width (17 mm.) on this vertebra. The anteroposterior diameter (58 mm.) of the pedicle of the neural arch of this caudal is also greater than the same measurement (46 mm.) of the other vertebra (USNM 16567) as described above. The pedicles of all the caudals in this series (USNM 23494) have a greater anteroposterior diameter than those in the other series (USNM 16567).

Seventh Caudal: The transverse processes of the seventh caudal (USNM 16567) are reduced to short broad flanges, pierced centrally at the base for passage of segmental blood vessels. Both ends of the centrum are hexagonal, but the epiphyses are nearly circular. On the ventral surface of the centrum the anterior pair of haemal tubercles are more proturberant than the posterior pair; these tubercles bound laterally the broad longitudinal haemal groove which is strongly concave or depressed. The anterior and posterior tubercle on each side are separated by a gap (fig. 65b) for passage of the segmental blood vessels.

Rather broad anterior and posterior remnants of the medially interrupted longitudinal ridge present on the lateral face of the centrum above the transverse process persist on this caudal. The median interruption of this ridge is considerably wider than on the sixth caudal.

The vertical diameter (21 mm.) of the ovoidal neural canal (fig. 65a) is not appreciably greater than its width (19 mm.). The metapophyses are low and less spread apart than on the preceding caudal. The neural spine is reduced both in anteroposterior diameter and in height.

This caudal in the other series (USNM 23494) has wider and longer transverse processes, both pierced centrally at the base by a large foramen, a narrower (16 mm.) neural canal but similar height (20 mm.), a narrower ventral median longitudinal haemal groove, and a longer minimum anteroposterior diameter (52 mm.) of pedicle of neural arch.

Eighth Caudal: Both ends of the centrum of this caudal (USNM 16567) are hexagonal (fig. 66a) but the posterior epiphysis (fig. 66c) is ovoidal in contour, its vertical diameter (110 mm.) exceeding the transverse diameter (105 mm.). The neural arch (fig. 66a) is low, the transverse diameter (15 mm.) exceeding slightly the vertical diameter (13 mm.) of the neural canal. The metapophyses are reduced to low elongated protuberances and the neural spine is shortened in length and height. A thick lateral ridge pierced centrally at the base represents the reduced transverse process. The segmental blood vessels which pass

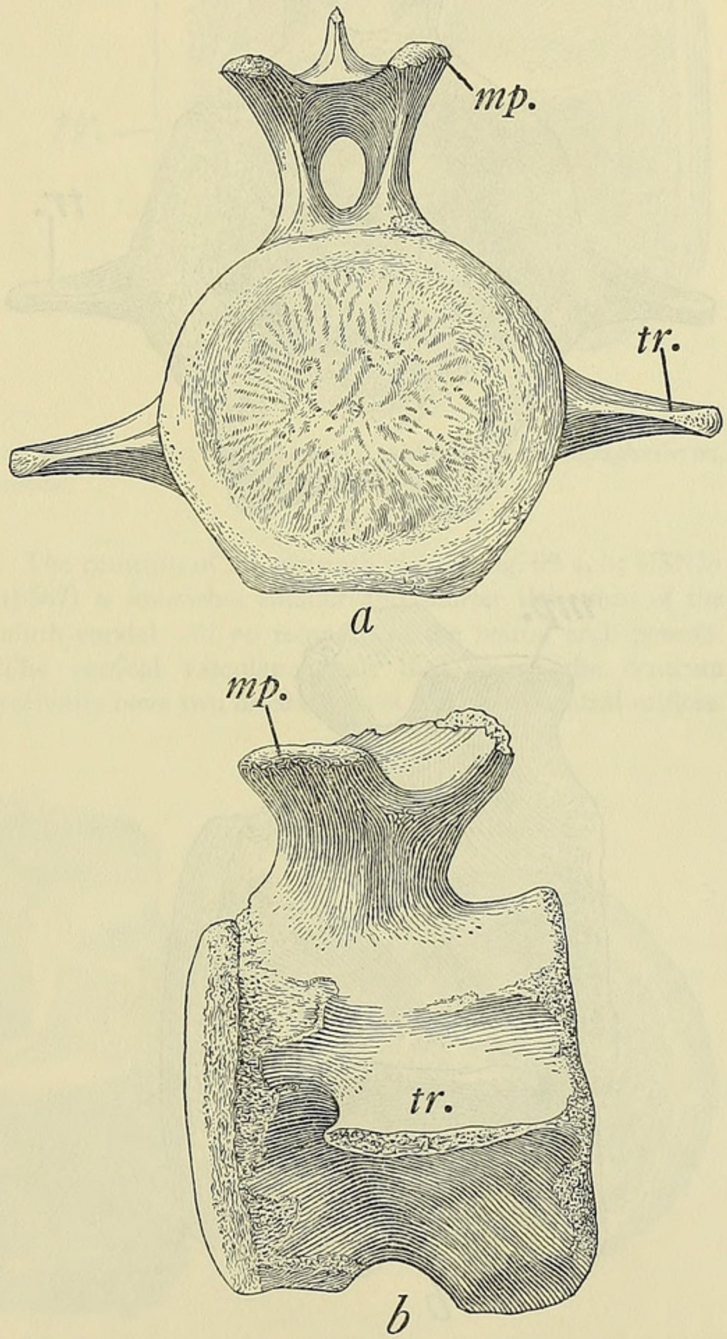


FIGURE 63.—Views of fifth caudal, USNM 16567, of *Diorocetus hiatus: a,* anterior view; *b,* lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

through this foramen follow the groove leading therefrom on their upward course between the anterior and posterior vestiges of the lateral ridge (fig. 66b) to and thence through the centrally located foramen in the pedicle of the neural arch.

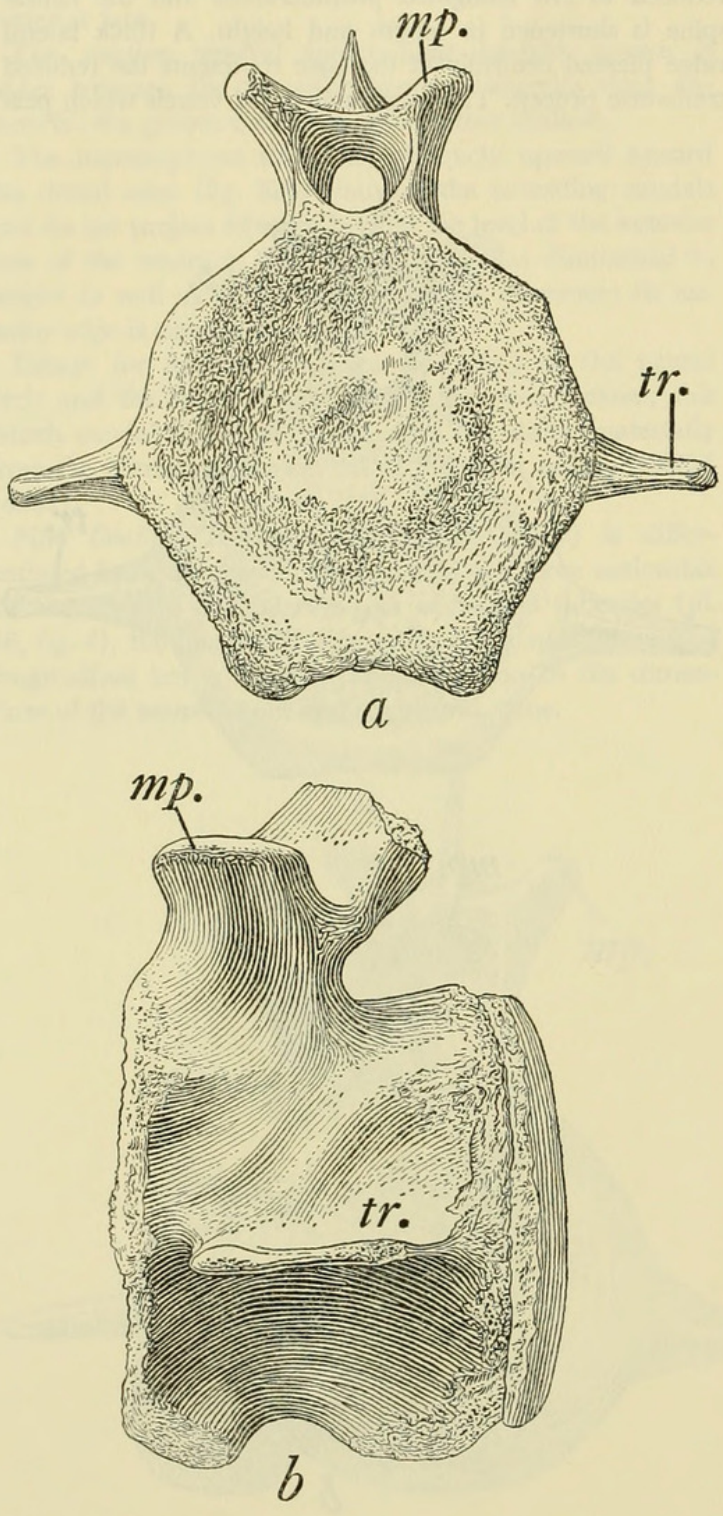


FIGURE 64.—Views of sixth caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.; mp., metapophysis; tr., transverse process.

On the ventral face of the centrum (pl. 56, fig. 7) on each side the anterior and the posterior haemal tubercles are connected by an isthmus of equivalent width which forms a bridge over the centrally located foramen for passage of the segmental blood vessels. The longitudinal haemal groove is broad, deeply concave, and of equal width throughout its length.

This vertebra is not represented in the other series of caudal vertebrae (USNM 23494).

Ninth Caudal: Both ends of the centrum (USNM 16567) are hexagonal; the anterior epiphysis is ovoidal in outline and the posterior epiphysis circular. The tendency for the posterior end (fig. 67b) of the centrum to become smaller than the anterior end apparently commences with the ninth caudal. On each side of the ventral surface of the centrum (pl. 56, fig. 8) the anterior haemal tubercle is united by a broad isthmus with the posterior tubercle. This osseous isthmus is pierced laterally at the middle of its length by a foramen (fig. 67b) for the passage of the segmental blood vessels that continue their upward course through a vertical canal that pierces the lateral face of the centrum for a distance of 50 to 55 mm.; these vessels apparently reach the anterior end of the neural canal via an obliquely directed broad groove leading from the upper orifice of this canal. The median ventral haemal groove is transversely widened at the middle of its length and is deeply concave and more ovoidal than elongate. The neural arch is low and short; the neural spine is reduced to a low ridge. The width (16 mm.) exceeds slightly the height (14 mm.) of the neural canal. The ninth seems to be the most posterior caudal, which has the neural canal roofed over by a neural arch.

This vertebra is not represented in the other series of caudal vertebrae (USNM 23494).

Tenth Caudal: This caudal is not represented by a centrum in one series (USNM 16567). Only the anterior (fig. 68) and posterior epiphyses were excavated.

Near the end of the vertebral column of Recent mysticetes the caudals are embedded in the horizontally expanded tail "flukes." These subterminal and terminal vertebrae do not possess neural arches, transverse processes, or haemal tubercles. This alteration occurs rather abruptly. The tenth caudal (USNM 23494) of this Calvert cetothere is thus modified and the ninth is the transitional caudal since it has a reduced but complete roof for the neural arch and longitudinal thickened ridges external to the depressed haemal groove.

Eleventh Caudal: A smaller physically immature Calvert cetothere (USNM 16667) has five subterminal caudals located posterior to the hindermost caudal that has the neural canal roofed over by the neural arch, although the length of the roof of the neural arch of the sixth, counting

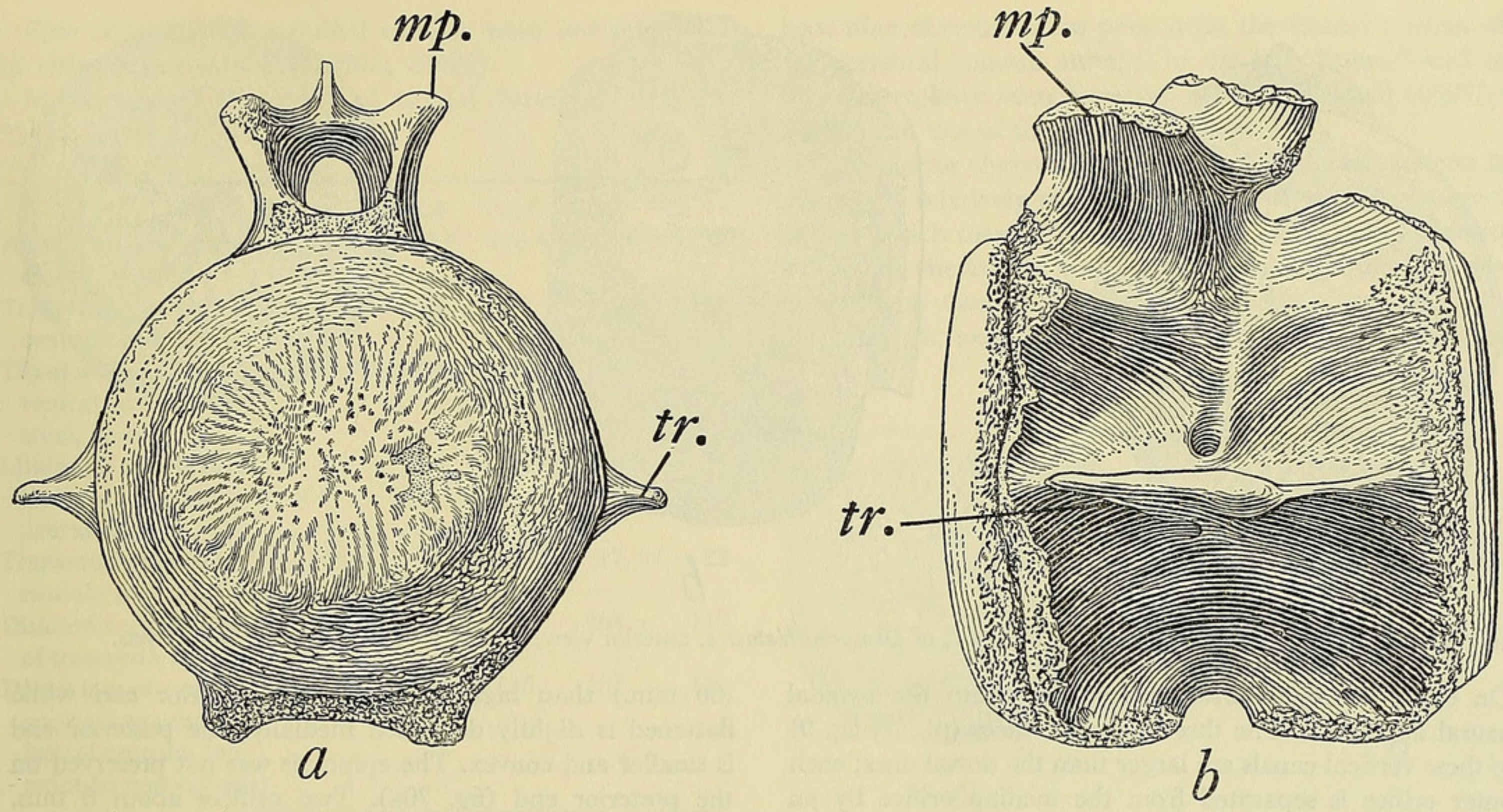


FIGURE 65.—Views of seventh caudal, USNM 16567, of *Diorocetus hiatus: a,* anterior view; *b,* lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

forward from the terminal caudal, is not more than 7 mm. There are eleven consecutive caudals in this series; the three anterior caudals were not found. This series served as a basis for allocating the three subterminal caudals (USNM 16567) hereinafter described.

The centrum of the eleventh caudal (fig. 69 a, b; USNM 16567) is somewhat smaller and shorter than that of the ninth caudal and no remnant of the neural arch persists. The vertical vascular canals that pierce the centrum medially have two dorsal orifices and three ventral orifices.

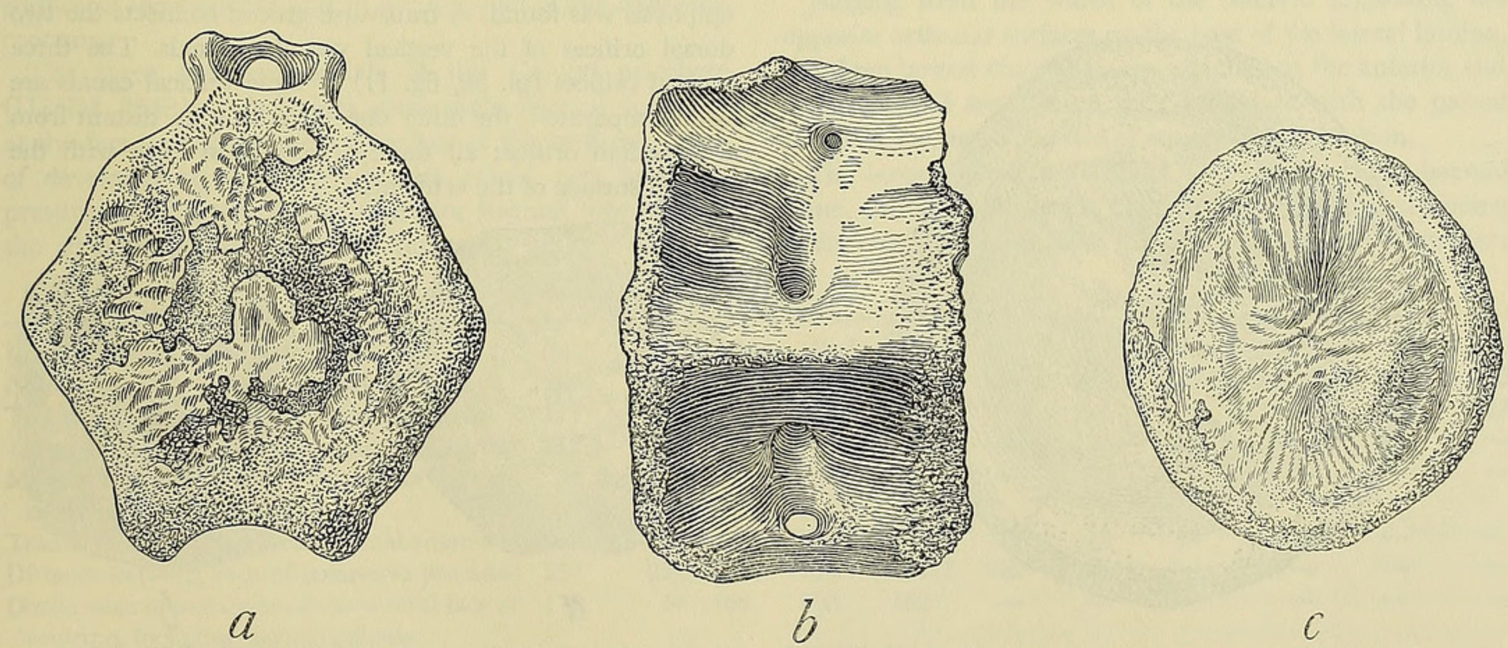


FIGURE 66.—Views of eighth caudal, USNM 16567, of *Diorocetus hiatus: a,* anterior view; *b,* lateral view, reversed; *c,* posterior epiphysis.

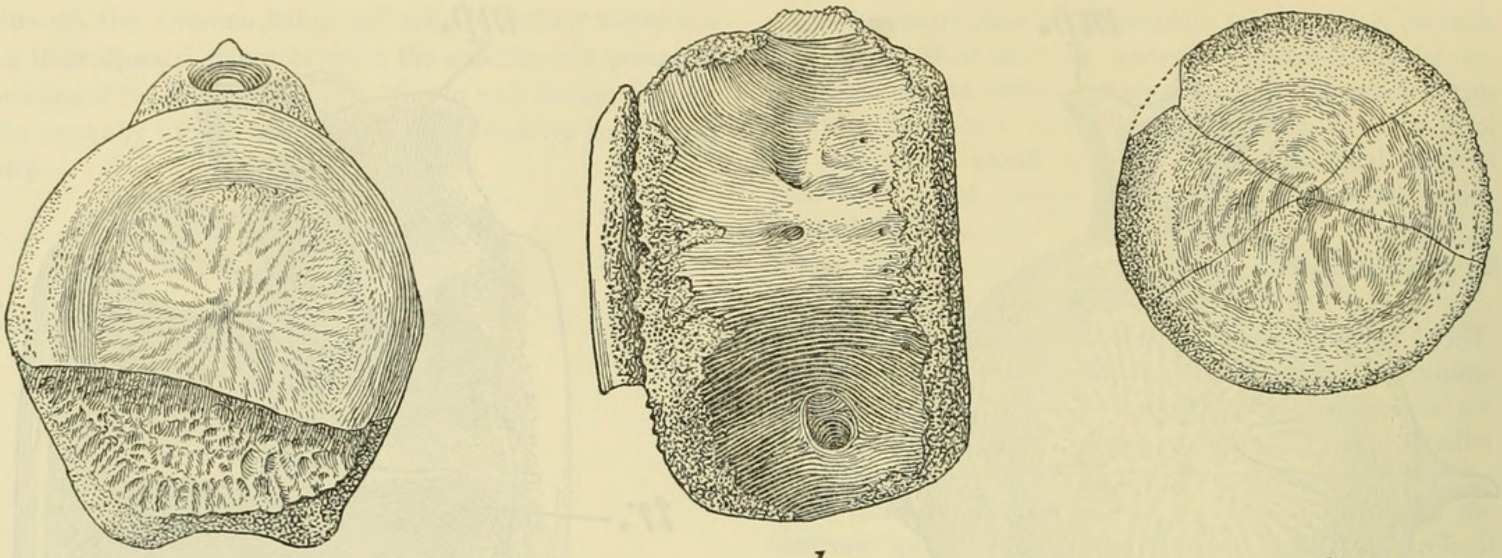


FIGURE 67.—Views of ninth caudal, USNM 16567, of *Diorocetus hiatus:* *a*, anterior view; *b*, lateral view; *c*, posterior epiphysis.

On each side one dorsal orifice opens into the ovoidal neural depression. The three ventral orifices (pl. 56, fig. 9) of these vertical canals are larger than the dorsal ones; each outer orifice is separated from the median orifice by an interval of 27 mm. These vertical vascular canals provide passage for the branches of the caudal artery and caudal vein between the ventral face of the centrum and the dorsal open neural canal or groove. The subhexagonal anterior end of the centrum is distinctly larger than the more circular posterior end.

Twelfth Caudal: A more noticeable foreshortening (pl. 56, fig. 10) and reduction in size of the centrum characterizes this caudal (USNM 16567). The centrum is wider (86 mm.) than high (82 mm.); its anterior end while flattened is slightly depressed medially; the posterior end is smaller and convex. The epiphysis was not preserved on the posterior end (fig. 70a). Two orifices about 8 mm. apart, for the vertical vascular canals open into a short dorsal neural depression; the three ventral orifices open flush with this surface.

Thirteenth Caudal: This quadrangular anteroposteriorly compressed caudal (fig. 71b) was damaged on the left side by the collector's pick axe. A shallow longitudinal groove is present on the right side about the middle of the height of this face. The anterior end of the centrum is flattened and the posterior end convex; the detached posterior epiphysis was found. A transverse groove connects the two dorsal orifices of the vertical vascular canals. The three ventral orifices (pl. 56, fig. 11) of these vertical canals are widely separated, the outer one 17 to 18 mm. distant from the median orifice; all three orifices open flush with the ventral surface of the centrum.

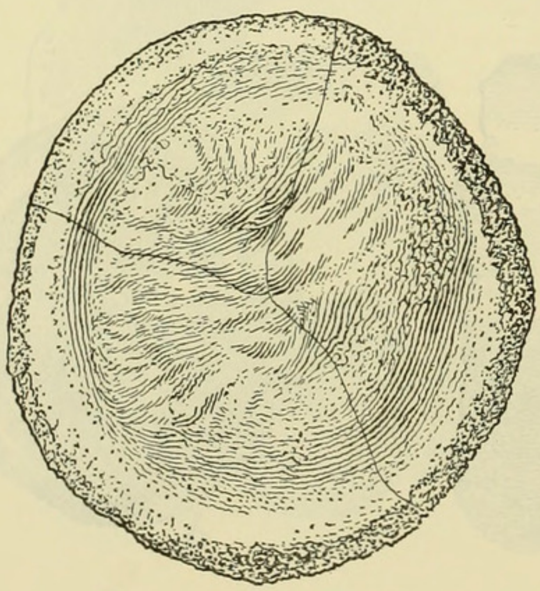


FIGURE 68.—View of anterior epiphysis of tenth caudal, USNM 16567, of *Diorocetus hiatus.*

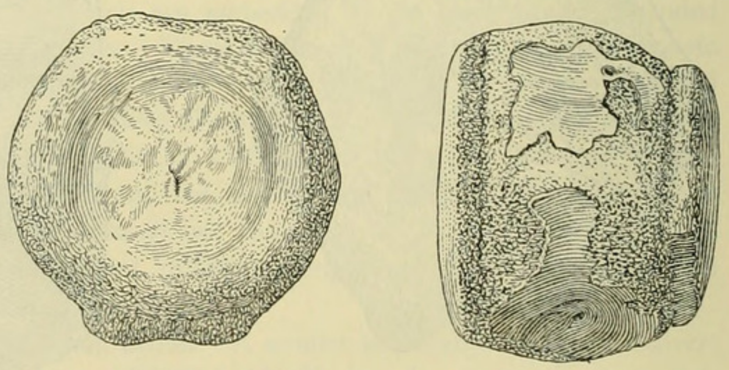


FIGURE 69.—Views of eleventh caudal, USNM 16567, of *Diorocetus hiatus:* *a*, anterior view; *b*, lateral view.

One or two small terminal caudals were not preserved in either series (USNM 16567; 23494).

Measurements (in mm.) of caudal vertebrae, USNM 23494, are as follows:

	Ca.2	*Ca.3*	*Ca.4*	*Ca.5*	*Ca.6*
Anteroposterior diameter of centrum	116 [p]	117 [a]	118 [a]	103 [b]	121
Transverse diameter of centrum anteriorly	113	113	108	117	111
Tip of neural spine to ventral face of centrum, posteriorly	198+	209±	183+	186+	154
Minimum anteroposterior length of pedicle of neural arch	61	—	61	58	51
Transverse diameter of neural canal anteriorly	21	16	20	17.5	23
Distance between ends of transverse processes	260+	247±	232	204	170
Dorsal face of metapophysis to ventral face of centrum (anterior haemapophysis)	162	158	156	157	170

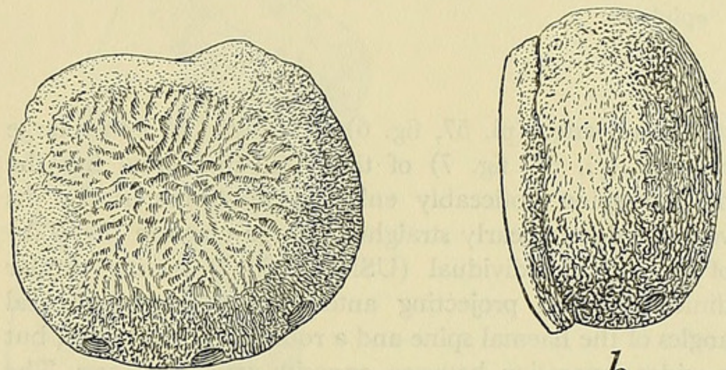
[a]=Anterior epiphysis missing. [p]=Posterior epiphysis missing. [b]=Both epiphyses missing.

Measurements (in mm.) of caudal vertebrae, USNM 16567, are as below:

CHEVRONS.—Chevron bones are always suspended below the intervertebral space of several anterior caudals in skeletons of Recent mysticetes, each chevron being attached to the pair of tubercles at the hinder end of the ventral surface of the centrum and to the fore-end of the following centrum.

The three anterior caudals of this Calvert cetothere (USNM 23494; 16567) lack discernible haemal tubercles at the fore-end of the ventral surface of the centrum. Lack of development of these tubercles would not, however, prevent attachment. Visible posterior haemal tubercles on the second to ninth caudals, inclusive, indicate that at least nine chevrons were present on the caudal portion of the vertebral column anterior to the tail "flukes," and of these, three have been preserved of one individual (USNM 23494) and one of the other (USNM 16567).

The anterior chevron on skeletons of Recent mysticetes is small and relatively simple, consisting of a pair of lateral lamina which may or may not be united ventrally to form a V. This chevron is attached at the intervertebral space below the first and second caudals. The second and succeeding chevrons, except one or more located at the posterior end of the series possess a ventral haemal spine of varying shape, but diminishing in vertical diameter behind the second or third. These chevrons (pl. 57, figs. 9–11) have a Y profile when viewed from in front, and have definitely developed articular facets on the horizontally widened dorsal ends of the lateral lamina.



a b

FIGURE 70.—Views of twelfth caudal, USNM 16567, of *Diorocetus hiatus*: *a*, posterior view; *b*, lateral view.

Judging from the width of the interval separating the opposite articular surfaces on the base of the lateral lamina, the three largest chevrons were attached at the anterior end of the caudal series since they articulate with the paired posterior haemal tubercles of equivalent separation.

The largest chevron (USNM 23494) has a wide haemal spine, the anteroposterior diameter at the extremity being equivalent to about two thirds of its vertical diameter;

USNM 16567–Caudal Vertebrae	*Ca.2*	*Ca.3*	*Ca.4*	*Ca.5*	*Ca.6*	*Ca.7*	*Ca.8*	*Ca.9*	*Ca.11*	*Ca.12*	*Ca.13*
Anteroposterior diameter of centrum	136	139	137.5	120+[p]	114+[a]	128	92+[b]	112.5	88	56	40
Transverse diameter of centrum, anteriorly	117	120	118	119	120	120	121	101	94	82	77
Tip of neural spine to ventral face of centrum	212+	241	200+	169+	169+	153+	127+	118	—	—	—
Minimum anteroposterior length of pedicle neural arch	50.5	54	53	49	46	47	40	26	—	—	—
Transverse diameter of neural canal anteriorly	22	19	20	21.5	23	19	18	16	—	—	—
Distance between ends of transverse processes	257	239	225	212	181.5	146	121	—	—	—	—
Dorsal edge of metapophysis to ventral face of centrum, including haemapophysis	176	—	169	163	162	—	—	—	—	—	—

[a]=Anterior epiphysis missing. [b]=Both epiphyses missing. [p]=Posterior epiphysis missing.

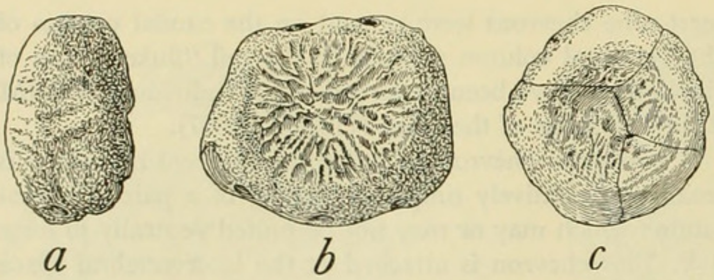


FIGURE 71.—Views of thirteenth caudal, USNM 16567, of *Diorocetus hiatus: a*, lateral view; *b*, posterior view; *c*, posterior epiphysis.

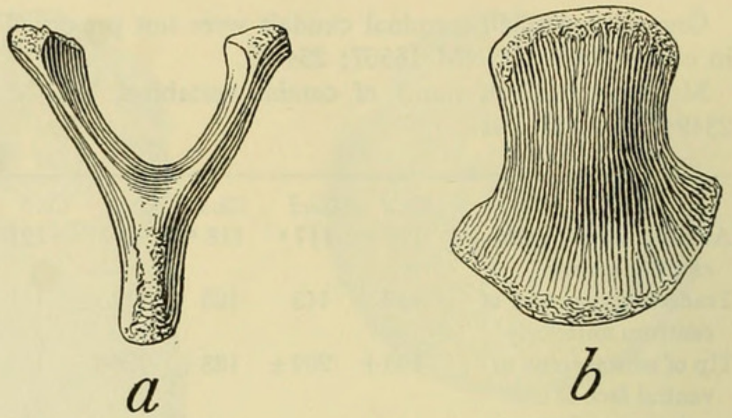


FIGURE 72.—Views of anterior chevron, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view.

its ventral edge (pl. 57, fig. 6) is rounded. Another large chevron (pl. 57, fig. 7) of the same individual has the haemal spine noticeably enlarged anteroposteriorly; its ventral edge is nearly straight. A large chevron (fig. 72b) of the other individual (USNM 16567) having similar dimensions has projecting anterior and posterior basal angles of the haemal spine and a rounded ventral edge, but a wider separation between opposite articular facets. The smallest chevron (USNM 23494) lacking a haemal spine (pl. 57, fig. 8) was presumably attached to the first caudal since the two narrow lateral lamina are united ventrally; the interval (30 mm.) separating the opposite articular facets is wide.

Measurements (in mm.) of the chevrons are as follows:

	Posterior USNM 23494	*Anterior USNM 23494*	*Anterior USNM 23494*	*Anterior USNM 16567*
Vertical diameter of chevron	54	81	71.5	71
Greatest anteroposterior diameter of haemal spine at extremity	—	52.5	62	58
Anteroposterior diameter of articular facet on base of right lateral lamina	23	47	47	41.5
Least distance between internal margins of opposite articular facets	30	22.5	22	32

Forelimb

Right and left scapulae, the proximal detached end of the right humerus, right and left ulnae, seven carpals, five metacarpals, and two phalanges were associated with one of the skulls (USNM 23494).

Assuming that the length of the complete humerus was not less than 180 mm. and not greater than 220 mm. the upper portion of the forelimb of this physically immature cetothere comprising the scapula, humerus, radius, and adjacent ulna measured at least 27 inches (685 mm.) and not more than 28½ inches (725 mm.) in length. Too few of the terminal bones, carpals, metacarpals, and phalanges were found to provide a basis for estimating the length of the entire forelimb. A normal flattened mysticete flipper or paddle is indicated, however, by the shape of the individual bones.

SCAPULA.—As compared with the scapula of Recent mysticetes available for comparison, that of this Calvert cetothere is distinguished by greater height in proportion to its length, the vertical diameter being equivalent to about seven tenths of the latter, and by the more regular curvature of the vertebral margin.

The left scapula lacks the anterovertebral angle, the coracoid, the posterior half of the articular head and a 60 mm. section of the adjoining posterior border of the blade. The anterovertebral and posterovertebral angles of the blade of the right scapula (pl. 52, fig. 1) are missing and the extremity of the coracoid is eroded. The acromion on both scapulae is damaged.

Above the articular head, the external and internal surfaces of the blade are abruptly depressed. A concave curvature characterizes the anterior and posterior margins of the blade. The blade, particularly the posterior border, is thickened toward the articular head, the upper two thirds being rather thin. The prescapular border of the blade is very narrow internal to the acromion, but widens toward the anterovertebral angle, and is deflected obliquely inward. The spine of the scapula is represented by a ridge that extends upward from the acromion almost to the vertebral margin, and the acromion is a relatively broad flattened process that gradually curves inward toward its extremity. The glenoid cavity is concave, the ratio of its exterointernal diameter to its anteroposterior diameter being 7 to 10. The attenuated and laterally flattened coracoid projects forward and inward slightly above the glenoid border.

Measurements (in mm.) of the scapula of USNM 23494 are as follows:

	Right	Left
Greatest anteroposterior diameter of scapula, estimated	345+	345+
Greatest anteroposterior diameter of scapula, as preserved	290	335
Greatest vertical diameter, articular head to vertebral margin	234	230
Length of coracoid, superior margin at base to distal end	33+	—
Posterior face of articular head to distal end of coracoid	115+	—
Length of acromion, superior margin at base to distal end	65+	75+
Greatest anteroposterior diameter of articular head	85	—
Greatest transverse diameter of articular head	58	58

Humerus.—The detached proximal end of the right humerus (USNM 23494) does not with any degree of certainty provide a basis for estimating the length of this bone either at the time of death or when physically mature. One Calvert humerus measuring 180 mm. in length and a larger one 220 mm. in length have a head of approximately the same dimensions; the proximal ends of both of these humeri are firmly ankylosed to the shaft.

The anteroposterior diameter of the convex head is greater than the transverse. The head is set off from the radial tuberosity by a groove which expands on the internal side into a broad smooth surface. The projecting radial tuberosity is eroded.

Radius.—Neither the right nor the left radius was found when this skeleton (USNM 23494) was excavated. A right radius (USNM 23019; fig. 73) from zone 11 of the Calvert formation, 1½ miles south of the former Plum Point wharf, Md., corresponds in length to the ulna (USNM 23494), but represents a physically mature individual. This ulna measures 275 mm. in length; the greatest anteroposterior diameter of the proximal end is 62 mm. and the greatest transverse diameter is 41 mm. The anterior profile of the shaft curves forward proximally, but is nearly straight on the distal two thirds; the external face is convex and the internal flattened. The proximal facet, which articulated with the radial facet of the humerus, is shallowly concave and the facet on the posterior face of the proximal end for articulation with the ulna is relatively small, its transverse diameter being 31 mm. and the proximodistal diameter 15 mm. The anterior edge of the shaft is more rounded than the posterior edge.

Ulna.—The left ulna (USNM 23494) is complete and the right one lacks the dorsal portion of the olecranon process; both have the relatively slender and transversely compressed shaft curved from end to end. The greatest length of the left ulna (pl. 53, fig. 4) is 289 mm. and the distance from the upper margin of the radial facet (radial margin of greater sigmoid cavity) to the distal end of the shaft is 240 mm. The distal or carpal end of the shaft of this left ulna measures 64 mm. anteroposteriorly and 24 mm. transversely; this end is roughened for the attachment of the incompletely

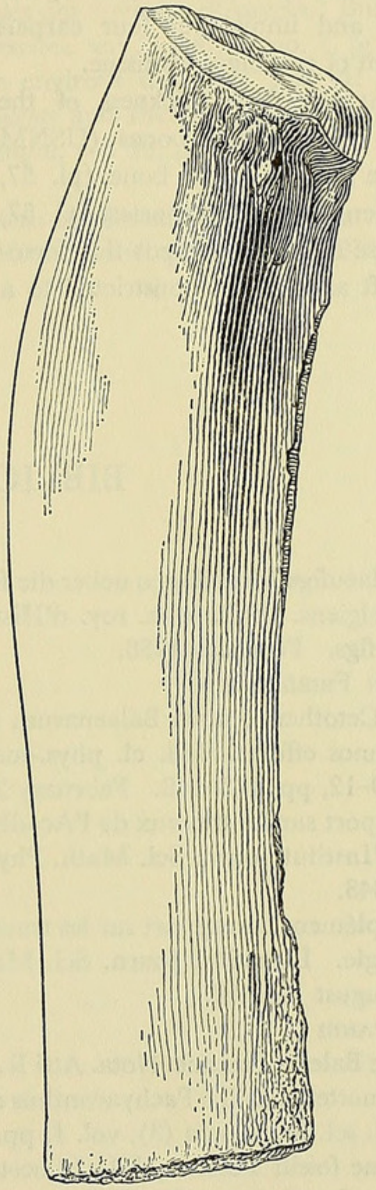


Figure 73.—Internal view of right radius, USNM 23019, of (?)*Diorocetus hiatus*.

ossified epiphysis. The greater sigmoid cavity is pitted, indicating a cartilaginous covering layer and the same condition exists on the posterior curved face of the olecranon. The width of the greater sigmoid cavity decreases toward the dorsal attenuated end of the olecranon; the transverse width of the greater sigmoid cavity below and near its radial margin (36 mm.) is nearly twice the greatest width (22 mm.) of the olecranon posteriorly. The proximal facet for articulation with the radius is weakly developed.

The minimum anteroposterior diameter of the shaft is 44 mm. and the minimum transverse diameter 16 mm. near the distal end. The anterior and posterior edges of the shaft are rounded, except for the slightly developed ridge-like crest anteriorly on the dorsal half of the shaft.

CARPALS.—The seven carpal bones are not sufficiently ossified to indicate their later growth shapes and thus permit allocation to their normal position in the carpus. Two of them possess one smoothly flattened surface, but elsewhere they are porous and immature; four carpals are roughened for attachment of cartilaginous tissue.

METACARPALS AND PHALANGES.—The thickness of the shaft suggests that five of the forelimb bones (USNM 23494) are metacarpals. The longest finger bone (pl. 57, fig. 2) measures 46 mm. in length and the shortest (pl. 57, fig. 3) 40 mm.; the transverse diameter exceeds the dorso-plantar diameter of the shaft and all are constricted to a varying degree near the middle of their length. One end of each finger bone is enlarged more than the other, and both ends are pitted for attachment of cartilaginous tissue.

The two smallest bones (pl. 57, figs. 4, 5) presumably are phalanges, since the shafts are distinctly flattened in a flexor-extensor direction. These bones measure 37 mm. and 36 mm., respectively, in length; they are constricted medially, the minimum transverse diameter of the longest being 15 mm. Both ends of each of these bones are roughened for attachment of cartilaginous tissue. Dissection has shown that the number of phalanges comprising each of the four finger bones inclosed in the right and left fore-flipper of two individuals of the little piked whale (*Balaenoptera acutorostrata*), counting across from the radial (front) edge, was 3–8–6–3 on one and 4–7–6–3 on the other, a total of twenty. A similar arrangement of the bones in the manus of this Calvert cetothere would have added at least 11¼-inches (288 mm.) to the foreflipper length.

BIBLIOGRAPHY

ABEL, OTHENIO

1938. Vorlaeufige Mitteilugen ueber die Revision der fossilen Mystacoceten aus dem Tertiaer. Belgiens. Bull. Mus. roy. d'Hist. nat. Belgique, Bruxelles, vol. 14, no. 1, pp. 1–34, 6 figs. February 1938.

BRANDT, JOHANN FRIEDRICH

1843a. De Cetotherio, novo Balaenarum familiae genere in Rossia meridionali ante aliquot annos effosso. Bull. cl. phys.-math. Acad. Imp. Sci. St. Pétersbourg, vol. 1, nos. 10–12, pp. 145–148. February 2, 1843.

1843b. Rapport sur les travaux de l'Académie pendant l'année 1842: Zoologie et Physiologie. L'Institut Journ. Sci. Math. Phys. et Nat., Paris, vol. 11, no. 499, p. 241. July 20, 1843.

1843c. Supplément au rapport sur les travaux de l'Académie pendant l'année 1842. Paléontologie. L'Institut Journ. Sci. Math. Phys. et Nat., Paris, vol. 11, no. 502, p. 270. August 10, 1843.

CAPELLINI, GIOVANNI

1876. Sulle Balene Toscane. Nota. Atti R. Accad. Lincei, Roma, ser. 2, vol. 3, pt. 2, pp. 9–14.

1877. Balenottere fossili e Pachyacanthus dell'Italia meridionale. Atti R. Accad. Lincei, Mem. Cl. sci. fis., Roma (3), vol. 1, pp. 611–530, 3 pls.

1905. Balene fossili Toscane, III: Idiocetus guicciardinii. Mem. Roy. Accad. Sci. Bologna ser. 6, vol. 2, pp. 71–80, 2 pls.

KELLOGG, REMINGTON

1965. Fossil marine mammals from the Miocene Calvert formation of Maryland and Virginia, 1: A new whalebone whale from the Miocene Calvert formation. U.S. Nat. Mus. Bull. 247, pt. 1, pp. 1–45, figs. 1–28, pls. 1–21. October 15, 1965.

SCHULTE, HERMANN VON WECHLINGER

1916. Monographs of the Pacific Cetacea, II: The sei whale (*Balaenoptera borealis* Lesson). 2: Anatomy of a foetus of *Balaenoptera borealis*. Mem. American Mus. Nat. Hist., new series, vol. 1, pt. 6, pp. 391–491, 10 figs., pls. 43–57. March 1916.

TRUE, FREDERICK WILLIAM
1907. Remarks on the type of the fossil cetacean *Agorophius pygmaeus* (Müller). Publ. 1964 Smithson. Inst. Washington, 8 pp., pl. 6.

TURNER, WILLIAM
1892. The lesser rorqual (*Balaënoptera rostrata*) in the Scottish seas, with observations on its anatomy. Proc. Roy. Soc. Edinburgh, 1891–1892, pp. 36–75, 4 figs.

VAN BENEDEN, PIERRE JOSEPH
1836. Observations sur les caractères spécifiques des grandes cétacés, tires de la conformation de l'oreille osseuse. Ann. Sci. Nat., Paris, ser. 2, vol. 6, Zoologie, pp. 158–159.
1880. Les Mysticètes à courts fanons des sables des environs d'Anvers. Bull. Acad. roy. Sci. Lettres et Beaux-Arts, Belgique, Bruxelles, ser. 2, vol. 50, no. 7, pp. 11–27.
1886. Description des ossements fossiles des environs d'Anvers, Part 5: Cétacés. Genres: *Amphicetus*, *Heterocetus*, *Mesocetus*, *Idiocetus* and *Isocetus*. Ann. Mus. roy. d'Hist. nat. Belgique, Bruxelles, ser. Paléontologique, vol. 13, pp. 139, pls. 75.

WALMSLEY, ROBERT
1938. Some observations on the vascular system of a female fetal finback. Contr. Embryol., Carnegie Inst. Washington, Publ. 496, no. 164, pp. 107–178, 27 figs., 5 pls. May 31, 1938.

Biodiversity Heritage Library

Kellogg, Remington. 1969. "A hitherto unrecognized Calvert cetothere." *Bulletin* 247, 133–161.

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