
SMITHSONIAN INSTITUTION
WASHINGTON, D.C.

UNITED STATES NATIONAL MUSEUM BULLETIN 247

Fossil Marine Mammals From the Miocene Calvert Formation of Maryland and Virginia

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SMITHSONIAN INSTITUTION PRESS
CITY OF WASHINGTON
1969

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This work forms number 247 of the *Bulletin* series.

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U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1969

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FOSSIL MARINE MAMMALS

From the Miocene Calvert Formation
Of Maryland and Virginia

Parts 1 and 2

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MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION • WASHINGTON, D.C. • 1965

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1. A New Whalebone Whale From The Miocene Calvert Formation

2. The Miocene Calvert Sperm Whale Orycterocetus

1. A New Whalebone Whale From The Miocene Calvert Formation

For nearly 100 years beach-worn vertebrae and portions of mandibles comprised the basis for descriptions of many of the mysticetes derived from the Miocene Calvert formation of Maryland and Virginia. Precise localities for the fossil cetaceans were not included by Cope in his descriptions of specimens received from James T. Thomas of Charles County, Md., and since then preserved in the Academy of Natural Sciences of Philadelphia (ANSP). The mysticetes described by Cope in 1895 and 1896 were based on incomplete mandibles and crania belonging to collections assembled for the Woman's College, Baltimore, the Johns Hopkins University, Baltimore, and the Maryland Geological Survey, Annapolis; and several of them, in the passage of time, had become disassociated from original locality information. Critical review and comparison of these type specimens with more complete materials since acquired has provided a better understanding of these extinct mysticetes. A rather comprehensive assemblage of the fossil mysticetes present in the Chesapeake embayment during the interval in which the Calvert formation was deposited were available for the present review, the object of which is to describe one of the larger Calvert species.

It is, however, necessary to make some disposition of the possible applicability of the specific names Cope proposed for mysticete fossil remains from the Miocene Calvert formation to the skeletal remains described in the present study.

Ten of the names proposed for rather inadequate cetacean skeletal remains, which were derived from the Miocene formations of Maryland and Virginia, are now thought to have been applied to mysticetes. Cope based his descriptions of four of these (*Eschrichtius leptocentrus*, 1867; *Eschrichtius pusillus*, 1868; *Delphinapterus tyrannus*, 1868; and *Megaptera expansa*, 1868) wholly or in a large part on vertebrae, three chiefly on portions of mandibles (*Eschrichtius cephalus*, 1867; *Mesocetus siphunculus*, 1895; and *Ulias moratus*, 1895), and one on an incomplete cranium (*Metopocetus durinasus*, 1896). The type of Leidy's *Balaena prisca*, 1852, is restricted to the fragment of a mandible, since the caudal vertebra obviously belonged to another cetacean. A cranium was the basis for *Parietobalaena palmeri* Kellogg, 1924. The configuration and relations of the bones comprising the rostral and occipital portions of the type skulls of *M. durinasus* and *P. palmeri* are quite unlike the skull of the cetothere hereinafter described. As regards the mandible, obvious structural features of the type mandibles of *E. cephalus*, *U. moratus*, *B. priscus* and *M. siphunculus* readily eliminate these species from further consideration.

An imperfectly preserved cervical vertebra, which was obtained in eastern Virginia, was designated as the type (ANSP 12693) of *Eschrichtius leptocentrus* Cope. This vertebra is now regarded as having come from the neck of a balaenopterine whale and this allocation seems also to be in accordance with the considerations which led Cope to employ the generic name *Eschrichtius*.

Cope originally in 1868 based *Megaptera expansa* (ANSP 12769), on numerous vertebrae from the Thomas collection, several from the Nomini Cliffs, Westmoreland Co., Va. (presented to the Academy by Oliver N. Bryan of [Marshall Hall], Charles County, Md.), and some in the Academy's Museum from Virginia. He did not describe the cervicals which he remarked were not in his possession at that time, but he gave some particulars and measurements of one dorsal and one lumbar vertebra. The epiphyses of both of these vertebrae are completely ankylosed to the centrum. The dorsal, the lumbar and other vertebrae included in the type series by Cope conform in general characteristics to the vertebrae of one of the smaller Miocene Calvert cetotheres.

Cope in his description of the centra of the type series of *M. expansa* seems to attribute some importance to the dorsal flattening and transverse subcordate outline of their articular faces or ends. The centra of the anterior and middle dorsal vertebrae of at least three of the Miocene Calvert cetotheres exhibit this shape. The seventh dorsals of the Miocene Anversian *Mesocetus longirostris* (Van Beneden, 1886, pl. 40, fig. 1) and *Mesocetus pinguis* (Van Beneden, 1886, pl. 48, fig. 1) of the Antwerp basin, Belgium, for example, both exhibit this configuration and the first mentioned species agrees closely in dimensions with those of *M. expansa.*

In the original description Cope (1868, p. 190) stated that *Delphinapterus tyrannus* was represented in the collection by one dorsal and three lumbars, but their epiphyses were unfortunately lost, and that three of these vertebrae belonged to one individual. The length of the centrum, including an estimate for the missing epiphyses, of one of these lumbars was given by Cope as 3 inches (76.2 mm.). The vertebrae now labeled as the type series (11252) in the Academy of Natural Sciences of Philadelphia comprise four lumbar and one caudal vertebrae, the centra of which measure in length 57, 71, 70, 89, and 84 mm., respectively. The caudal has both epiphyses attached to the centrum. Cope may have included this caudal in the series at a later date inasmuch as the epiphyses are ankylosed to the centrum. One of the four lumbars may have been regarded as a dorsal. Although this individual was immature these lumbar vertebrae, characterized in part by short and rather narrow transverse processes, unquestionably belonged to a somewhat different and smaller mysticete than the large species hereinafter described.

"Many vertebrae, of which one dorsal, six of the lumbars, and one caudal may serve as types" (Cope (1868, pp. 191–192)) were associated in the same description of *Eschrichtius pusillus* with the mandible of a much smaller cetothere. The published measurements were: dorsal vertebra – centrum length 125 mm., width 108 mm.; lumbar vertebra – centrum length 125 mm., width 106 mm.; caudal vertebra – centrum length 101.6 mm., width 101.6 mm. The articular end of the dorsal is described as a depressed oval which normally would correspond with a vertebra at the posterior end of that series. Aside from the usual longitudinal ventral keel, the lumbar is described as having vascular foramina "so small as not to be noticeable." On the caudal vertebra the pair of ventral keels (haemapophyses) bounding the haemal groove are described as "very slight," and the transverse processes not perforated. These processes have been broken off and lost. Nonperforated transverse processes and the complete enclosure of the neural canal by an arch extending three-fourths the length of the centrum place this caudal in the anterior half of this series. An examination of the series of vertebrae (ANSP 12769) labeled as types reveals that all are beach worn specimens generally devoid of all processes of the centrum. The dimensions, proportions and configurations of the best preserved centra in this type series of *Eschrichtius pusillus* agree most closely with a Calvert cetothere (USNM 15885) whose lumbar vertebrae possess rather short and broad transverse processes and a broad neural spine of moderate height. The ventral surface of the centrum, presumably designated as the dorsal by Cope, is eroded to such an extent that the original outer surface is no longer visible and no trace of a ventral keel is observable.

Some allowance should be made in evaluating the importance of differences in the measurements of mysticete vertebrae for purposes of identification. Growth seemingly continues at a decreasing rate as long as inter-cartilaginous discs persist between the centra of the vertebra and its epiphyses. When this process of ossification of the vertebral column (which proceeds forward from the terminal caudal and backward from the axis toward the middle of the vertebral column), is completed, physical maturity is attained and growth is thought to have ceased. Nevertheless, physical maturity is attained by females of the Recent blue whale at lengths varying from 81 to 94 feet, and yet the largest definitely recorded immature blue whale was 93 feet. Blue whales measuring about 100 feet have been encountered as well as undersized individuals. It may be presumed from the examination of the vertebrae of a number of individuals representing at least three species of Miocene Calvert mysticetes that similar conditions of growth and attainment of physical maturity prevailed at least during this period of their geological history.

In the present state of our knowledge the vertebral columns of the Miocene Calvert mysticetes seem to be most readily distinguished from one another by structural features of their lumbar vertebrae. For example the lumbar vertebrae of the large cetothere described in the present study possess high broad neural spines and wide elongated transverse processes. The lumbar vertebrae of another cetothere of medium size possess broad, but slightly shorter neural spines and less elongated spatulate transverse processes. The lumbar vertebrae of the smallest Calvert cetothere possess narrower transverse processes and rather slender neural spines.

Winge (1910) and True (1912) have commented on the characters ascribed by Cope to his genera *Cephalotropis*, *Metopocetus*, *Rhegnopsis*, *Siphonocetus*, *Tretulias* and *Ulias*, the genotype specimens of which were derived from the Miocene Chesapeake series of Maryland and Virginia. Since the time when these comments were published considerably more new and adequately preserved skeletal materials have been accumulated. These materials do not substantiate all of the conclusions set forth by these investigators, especially the validity of allocations of these genera to *Cetotherium* and *Plesiocetus.* Discussion of the validity of these genera will be included in forthcoming revisions of their mysticete skeletal remains and further comment will be deferred until then.

Abel (1938, p. 15) did not accept the distinction between skulls of Cetotheriidae and Balaenopteridae proposed by Miller (1923, p. 21) and Kellogg (1931, pp. 305–306). One quite obvious modification observable in cranial remodeling among genera assigned to these two families, respectively, was described as follows:

As viewed from the dorsal aspect the supraorbital process of the frontal is abruptly depressed at the base to a level below the dorsal surface of the interorbital region of the balaenopterine whale skull. Conversely, the supraorbital process of the frontal slopes gradually downward and outward from the level of the dorsal surface of the interorbital region of the cetothere skull. Abel contends that such a distinction is not valid since this condition represents a gradual modification of the skulls of the more ancient and the more recent Balaenopteridae. Abel mentions also the skull of *Rhachianectes* [=*Eschrichtius*], the sole living representative of another family (Rhachianectidae=Eschrichtiidae), which has a gradually sloping supraorbital process.

As yet no fossil mysticete skull has been described which exhibits transitional stages in this alteration of the basal portion of the supraorbital process of the frontal. It does not necessarily follow, however, that such stages were nonexistent. Irrespective of differences of opinion as regards the functional significance of this balaenopterine cranial remodeling, this modification does provide a readily observable structural feature for the family allocation of similarly constructed genera.

The skeletal length of the largest of the three individuals represented in part by vertebrae and hereinafter described is estimated as at least 22 feet. From other Miocene Calvert mysticetes this cetothere is characterized chiefly by having a scapula that lacks an acromion process, but possesses a rather wide prescapular fossa. Elongated transverse processes and a high, broad neural spine distinguish the lumbar vertebrae from those of coexistent species. The skull measures slightly more than six feet in length, and its mandibles are massive.

Cetothere genera most frequently have been distinguished from one another by the particular combination of structural cranial details and less often by only one differing feature.

PELOCETUS, *new genus*

Type Species: *Pelocetus calvertensis*, new species.

Diagnosis: Apex of supraoccipital shield thrust forward slightly beyond level of anterior ends of zygomatic processes; elongated nasals located in part anterior to level of preorbital angles of supraorbital processes of frontals; strong forward overthrust has carried anterior borders of parietals to median interorbital region, overriding frontals, but not extending forward to level of posterior ends of median rostral elements (ascending processes of maxillaries, premaxillaries and nasals); backward thrust of rostrum limited, median rostral elements (ascending processes of maxillaries, premaxillaries and nasals) not carried backward beyond level of middle of orbit; exposure of frontals in median interorbital region reduced to a narrow strip; a thin temporal crest on each supraorbital process; a short, pinched-in intertemporal constriction formed by opposite parietals meeting on midline; wide temporal fossae; slender, bowed outward zygomatic processes; alisphenoid present in temporal wall of cranium; rostrum broad, sides nearly parallel on basal half and then rather strongly curved to distal end and equivalent to 68 percent of total length of skull; narial fossae elongated; palatines elongated, diverging posteriorly; lateral protuberances of basioccipital massive, larger than pterygoid fossae; posterior process of periotic elongated and expanded distally; horizontal ramus of mandible relatively deep, and thick, the condyle large and convex in all directions; articular facet for capitulum of following rib situated on first to eighth dorsal vertebrae, inclusive, below level of floor of neural canal and adjacent to edge of posterior face of centrum; lumbar vertebrae have relatively broad and high neural spines, elongated transverse processes and thin lamina-like metapophyses; second to ninth ribs, inclusive, have capitulum at end of elongated neck; scapula fan-shaped, exhibiting no vestige of acromion although possessing a coracoid process, and having prescapular fossa relatively broad and flat; humerus has anterior or radial face of shaft markedly rugose; distal epiphyses of radius and ulna detached and not completely ossified.

PELOCETUS CALVERTENSIS, *new species*

Type Specimen: USNM 11976. Skull (essentially complete except for both lachrymals and right jugal); left jugal detached; both tympanic bullae and periotics; both mandibles, somewhat damaged distally; six cervical vertebrae; nine dorsal vertebrae; eight lumbar vertebrae; two caudal vertebrae; left scapula essentially complete; right scapula, basal and anterior borders preserved; right and left humeri; right and left radii; distal portion of left ulna; eleven carpals; nine metacarpals; nine phalanges; fourteen ribs, more or less complete; united basihyal and thyrohyals; right stylohyal, nearly complete; left stylohyal, inner portion only. Collectors, A. Lincoln Dryden, Jr., Willard Berry, William L. Jones, Arthur J. Poole, and Remington Kellogg; August 22–27, 1929, and August 14–20, 1931.

Horizon and Locality: Three feet below top of Zone 13 at base of cliff about 665 yards north of old wharf at end of road at Governor Run, Calvert County, Maryland. Calvert formation, upper Miocene.

Referred Specimens: Four, as follows: (1) USNM 14693: anterior end of right mandible, coll. Charles W. Gilmore, Ed. Mullins and Remington Kellogg, July 29, 1936; in zone 13 on face of high cliff 2⅕ miles south of Chesapeake Beach wharf, Calvert County, Md., Calvert formation, middle Miocene. (2) USNM 21306: anterior end of right mandible, coll. Charles L. Kimbell, July 9, 1949; in zone 17, red brown shell band about 40 feet above beach level, 35 feet south of commencement of first cliff south of Parker Creek, Calvert Co., Md. Choptank formation, middle Miocene. (3) USNM 23058: four dorsal vertebrae, seven lumbar vertebrae, six ribs and two rib heads, three phalanges, coll. Robert E. Weems, September 1962; Stratford Cliffs, about 3.8 miles below mouth of Pope's Creek, about 200 feet west of second swamp below (east of) "Big Meadows" in bluish sandy clay with vertical seams about 3 feet above beach level, Westmoreland County, Va., Calvert formation, middle Miocene. (4) USNM 23059: atlas, 3 dorsal vertebrae, 1 lumbar vertebra and a detached neural spine, 5 caudal vetebrae, right scapula (articular end), right ulna, 6 phalanges, 4 carpals, 16 ribs, right occipital condyle and right squamosal and adjoining bones, 2 tympanic bullae, left periotic, 1 jugal, coll. Robert E. Weems, August 1963; about 3.5 miles below mouth of Pope's Creek in Stratford Cliffs, about 100 feet beyond swamp below (east of) "Big Meadows," in blue marly clay with vertical seams about 4 feet above beach level, Westmoreland Co., Va., Calvert formation, middle Miocene.

Skull

This is the largest and best preserved cetothere skull (USNM 11976; pl. 1) thus far collected in the Miocene Calvert formation. Erosion or weathering removed the original external osseous surface of the squamosals and of their zygomatic processes as well as the surface on the posterior portion of the parietals. The outer border of the right maxillary on the rostrum and the anteroexternal portion of the right supraorbital process of the frontal were damaged prior to excavation. Both supraorbital processes were crushed and cracked, seemingly by the pressure applied by superimposed vertebral centra and limb bones.

This skull is characterized chiefly by absence of a pronounced tapering of the rostrum, limited interdigitation by backward thrust of rostral elements, strong forward thrust of supraoccipital and the parietals, reduced exposure of the frontals in median interorbital region, pinched-in intertemporal constriction, wide temporal fossae, elongated dorsal narial fossa, slender zygomatic processes, and large robust postglenoid processes.

Dorsal view.—When this skull (fig. 1) is examined from a dorsal view, attention is directed to the large subtriangular occipital shield whose pointed apex extends forward slightly beyond the level of the anterior ends of the zygomatic processes, the forward overthrust of the parietals on the frontals in the median interorbital region, outward bowed zygomatic processes, the presence of a thin transverse crest on each supraorbital process, elongated nasal bones, and a broad rostrum.

For more than half of the length of the rostrum, the sides are almost parallel proximally and then become rather strongly curved to the distal end. The rostrum contributed more than 68 percent of the total length of the skull. The maxillaries are broad at the base of the rostrum, and are relatively thin along their lateral borders. The dorsal surface of each maxillary slopes gradually from the maxillary-premaxillary suture to its outer edge. The dorsal ascending process of each maxillary is quite short, although it extends backward to the level of the posterior ends of the premaxillaries and nasals. No abrupt indentation for an antorbital notch is developed and the posteroexternal portion of the maxillary immediately in contact with the preorbital angle of the supraorbital process of the frontal is reduced to a narrow platelike strip. Each maxillary was, however, interlocked with the corresponding frontal even though it does not overspread the supraorbital process. Both maxillaries are pierced by five foramina, which are, however, differently located in each.

On each side of the rostrum of a somewhat smaller cetothere skull (USNM 16783), regarded as belonging to a different species with a strongly attenuated rostrum, a wide incisure extends obliquely forward toward the maxillary-premaxillary sutural contact commencing in front of the antorbital notch, separating the triangular portion of the maxillary behind it into a dorsal and ventral plate and thus forming the walls of a broad cavity that extends backward ventrally to the anteroventral edge of the supraorbital process of the frontal. That this incisure is not a fortuitous aberration is shown by a similar modification on the rostral portions of the maxillaries of a second individual (USNM 16871) of the same species. A deep pitlike depression in conjuction with the possible destruction of the dorsal plate of the corresponding portion of each maxillary of this larger skull may if this interpretation is correct be attributable to a like structural modification. In view of the existing uncertainties these depressions are not indicated on the text illustration (fig. 1).

Anterior to the forward extension of the vomer, each premaxillary curves downward and inward to meet its opposite on the midline of the rostrum. The vomer posteriorly and the premaxillaries anteriorly contribute the floor and the sides of the longitudinal rostral gutter. Each premaxillary attains its maximum width (105 mm.) at the level of the anterior ends of the maxillaries, and projects forward 140 mm. beyond the level of the anterior ends of the latter. The slender facial or ascending process of each

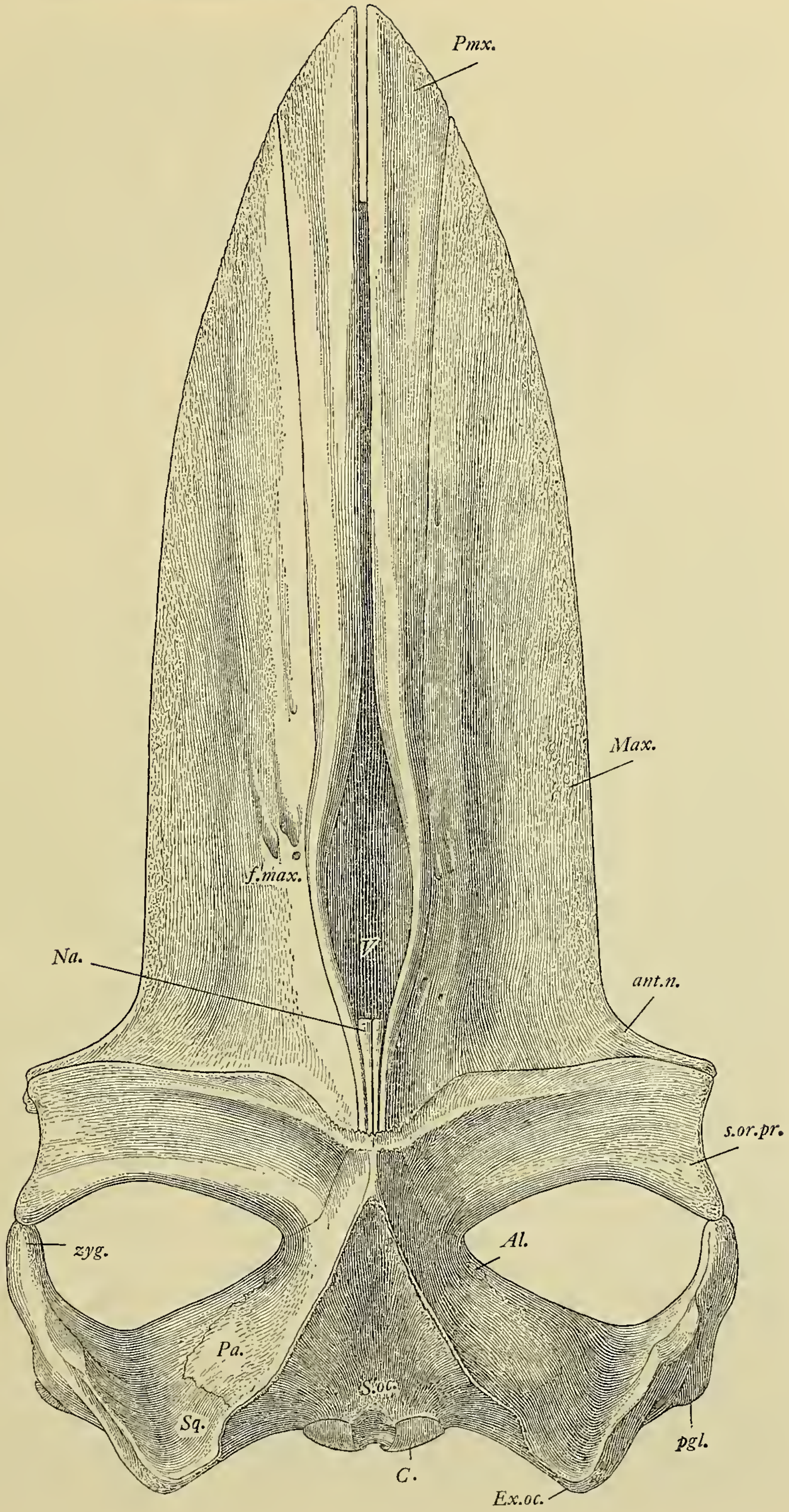


Figure 1.—Dorsal view of skull, USNM 11976, of *Pelocetus calvertensis*, with restored borders of rostrum and right supraorbital process. Abbrs.: Al., alisphenoid; ant.n., antorbital notch; Bo., basioccipital; C., occipital condyle; Ex.oc., exoccipital; f.max., maxillary foramen; f.ov., foramen ovale; h.pt., hamular process of pterygoid; j.n., jugular notch or incisure; l.pr., lateral or descending process of basioccipital; Max., maxilla; Na., nasal; o.c., optic canal; Pal., palatine; Par., parietal; pgl., postglenoid process; Pmx., premaxilla; pr.p., posterior process of periotic; Pt., pterygoid; S.oc., supraoccipital; Ty., tympanic bulla; V., vomer; zyg., zygomatic process.

premaxillary is lodged in a groove which parallels the dorsointernal angle of the hinder end of the maxillary and the external edge of the corresponding nasal and terminates at the level of the posterior ends of these nasal bones. The dorsal surface of each premaxillary in front of the dorsal narial fossa is slightly convex transversely, but becomes noticeably flattened toward the anterior end. The backward thrust of the median portion of the rostrum has carried the ascending processes of the maxillaries and premaxillaries as well as the nasals backward almost to the level of the center of the orbit.

The dorsal narial fossa is deep, elongate and rather narrow, the maximum transverse diameter at a point 235 mm. in front of the anterior ends of the nasal bones being 135 mm. The maximum anteroposterior diameter of this fossa is approximately 350 mm.

The long, slender nasal bones are wedged in between the ascending processes of the opposite premaxillaries; their posterior extremities are mortised into the frontals and anteriorly they overhang the dorsal narial fossa. The anterior ends of both nasals are rounded.

The frontals are exposed for a very short interval (30 mm.) between the hinder ends of the backward overriding rostral bones and the intertemporal constriction occupied by the parietals. The frontals, which are excluded from the vertex by the parietals, slope gradually downward from the dorsal surface of the interorbital region toward the orbital rim of their supraorbital processes. The relatively narrow anterior border of the dorsal surface of each supraorbital process is demarcated from the much broader, downward and backward sloping hinder portion by a low curved transverse crest. The preorbital angle of the supraorbital process of the frontal is in close contact with the dorsoexternal end of the maxillary; the postorbital projection is extended backward and outward to contact the anterior end of the zygomatic process. The orbital rim of the supraorbital process of the frontal is quite thin and arched.

The opposite parietals, which meet medially to constitute the short intertemporal constriction, are overridden on their edges above and behind by the large triangular supraoccipital shield. Anteriorly the thin narrow plate of the parietal, which overrides the base of the supraorbital process, extends forward to within 30 mm. of the hinder ends of the ascending processes of the maxillaries. Each parietal bone is relatively broad dorsoventrally and is situated below the level of the lambdoidal crest to which it contributes the outer edge; it comprises the major portion of the lateral wall of the braincase. Behind the level of the supraorbital process, the lower edge of the parietal anteriorly is suturally in contact with the dorsal edge of the alisphenoid and, behind the latter, the sutural contact between the parietal and the squamosal curves outward, then upward and backward to meet the supraoccipital on the lambdoidal crest.

The squamosal comprises the posterolateral portion of the skull; its anterior face, which constitutes the hinder wall of the temporal fossa, curves backward and outward from the pterygoid and then forward to the extremity of its zygomatic process. The squamosal is markedly depressed dorsoventrally, forming an elongated trough which is bounded behind and externally by the lambdoidal crest. An obvious outward bulge of the cranial cavity is developed above and below the sutural contact between the parietal and the squamosal. The zygomatic process is relatively slender, and is bent outward and forward, flattened on its internal face, convex externally, and narrowed dorsally to form a longitudinal crest which, however, is not continuous posteriorly with the lambdoidal crest. Posteriorly, the dorsal surface of each zygomatic process is excavated to form a fore-and-aft concave depression whose function is not readily apparent.

From a dorsal view the occipital condyles appear relatively small. Except at their outer ends the exoccipitals were concealed from a dorsal view by the overhanging lambdoidal crest.

The transverse diameter of the triangular occipital shield (445 mm.) at the level of the top of the foramen magnum exceeds its greatest length (distance from dorsal rim of foramen magnum to apex, 325 mm.). The forward thrust of the hinder elements of the cranium has pushed the apex of the supraoccipital shield to the level of the most advanced portion of the hinder edge of the supraorbital process of the frontal and slightly beyond the level of the anterior ends of the zygomatic processes. The median portion of the triangular occipital shield is deeply depressed below its lateral crestlike edges.

Posterior view.—The broad occipital shield (fig. 2) which forms the posterior wall of the braincase, is constituted by the medially depressed supraoccipital and the large anteroposteriorly thickened exoccipitals. Both lambdoidal crests are well preserved and each curves upward and forward to the acutely pointed apex of the shield.

The exoccipitals are relatively large massive bones, which constitute the lateral wings of the occipital shield, and their external angles project backward at least 50 mm. beyond the level of the articular faces of the occipital condyles. The occipital condyles are large and the foramen magnum relatively small. The articular surfaces of these condyles are convex from end to end and also from side to side. They are separated ventrally by a deep narrow notch. Anterior to the condyles on each side of the basicranium is the lateral knoblike descending process of the basioccipital which contributes the inner wall of the wide jugular incisure. The outer wall of this incisure for the jugular leash is contributed by the exoccipital.

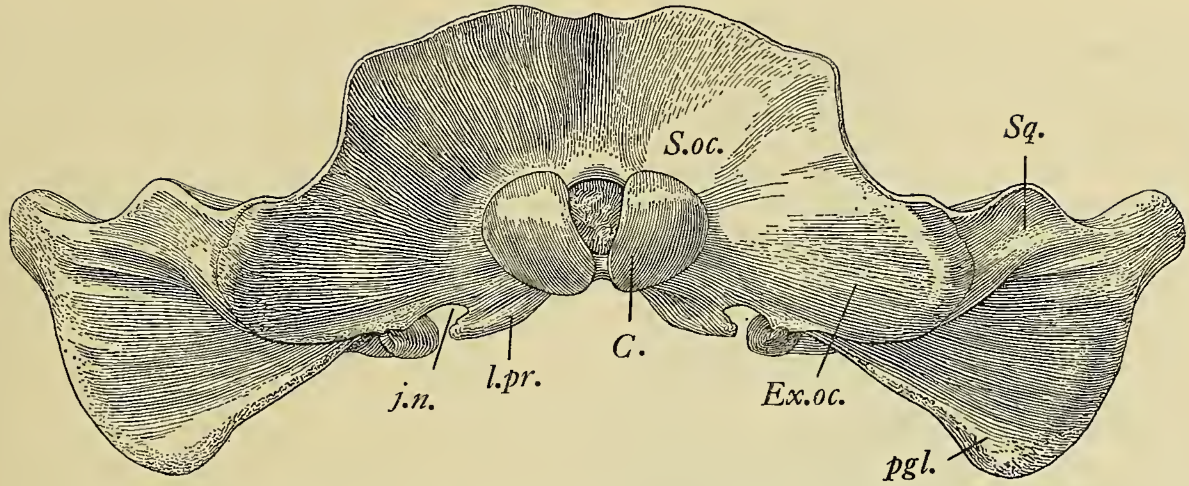


FIGURE 2.—Posterior view of skull, USNM 11976, of *Pelocetus calvertensis*. For abbreviations, see figure 1.

Each large postglenoid process projects ventrally approximately 110 mm. below the level of the ventral edge of the exoccipitals. Although the braincase appears somewhat depressed, there is no visible evidence of a ruptured cranial wall in either temporal fossa, although the dorsal rim of the foramen magnum is pushed downward a few millimeters.

LATERAL VIEW.—The apex of the supraoccipital shield forms the highest point in the dorsal profile, although it is only slightly higher than the point where the opposite transverse temporal crests on the supraorbital processes converge medially (limiting the forward overthrust of the parietals) and in front of the latter, the dorsal profile of the median interorbital region and of the rostrum slopes gradually forward and downward to the extremity of the rostrum.

The rostrum is rather deep proximally at the level of the anterior ends of the palatine bones and gradually decreases in depth anteriorly. The outer edge of the maxillary is quite thin throughout its length.

The orbital border of the supraorbital process is dorsoventrally compressed and arched in a fore-and-aft direction. Its preorbital angle is bluntly rounded and is underridden by the posteroexternal angle of the maxillary. The postorbital projection is slightly deeper dorsoventrally (33 mm.) than the preorbital angle. The supraorbital process as a whole slopes downward from the interorbital region to the orbital rim, and the much broader hinder portion is set off from the narrower anterior border by a low curved temporal crest.

The attenuated zygomatic process of the squamosal is deepened dorsoventrally and its ventral profile exhibits a regular curvature. The dorsal profile of the zygomatic process rises gradually behind its anterior end and merges posteriorly beyond the hinder dorsal depression with the outwardly overrolling lateral crest on the squamosal, which in turn is continuous behind with the short forward extension of the lambdoidal crest.

Viewed from the side, the thick postglenoid process projects downward and backward, its posterior face is flattened and its extremity is bent backward. The squamosal as a whole is rather large and constitutes a considerable portion of the external construction of the braincase. It is strongly depressed in front of the hinder portion of the lambdoidal crest as well as internal to the low lateral crest which is continuous anteriorly with the dorsal edge of the zygomatic process. Posteriorly, the squamosal is broadly sutured to the anterior surface of the corresponding exoccipital.

The more or less vertical parietal is concavely curved from end to end and constitutes the major portion of the lateral wall of the braincase. It meets the parietal from the opposite side of the cranium to form a short and very narrow isthmus or intertemporal constriction which connects the occipital portion of the skull with the facial or interorbital portion. The dorsal and hinder edges of the parietal form a continuous curve, which is overlain by the lateral edge of the supraoccipital shield, the apex of which extends forward slightly beyond the level of the anterior ends of the zygomatic processes.

The occipital condyles are not visible when the skull is viewed from the side. The ventral profile of the maxillaries in the interval where they are overlain by the palatine bones displays a gradual slope in a fore-and-aft direction when viewed from the side.

The alisphenoid appears on the temporal wall of the braincase as an irregularly shaped element and is located behind the base of the posterointernal angle of the supraorbital process, but above the pterygoid. The exposed outer end of the alisphenoid is somewhat elongated, the greater length being in the anteroposterior direction. In the temporal fossa, the alisphenoid is bounded dorsally and anteriorly by the parietal, and ventrally by the pterygoid. The alisphenoid has no contact posteriorly with the squamosal (See Muller, 1954).

Ventral view.—The ventral surface of this skull (pl. 2) is fairly well preserved with the exception of portions of the posterior region of each maxillary. During the past thirty years the ventral surface of each maxillary has deteriorated to a varying extent; as a result of crushing the opposite palatines and maxillaries had spread apart along the median longitudinal axis, exposing portions of the ventral ridge of the trough of the vomer.

The horizontally widened maxillaries comprise the major portion of the palatal surface of the skull (fig. 3). In front of the supraorbital process of the frontal the palatal surface of each maxillary is depressed, concavely curved from side to side. Anterior to the palatine bones, a strong tendency toward flattening on the outer portion is exhibited by the maxillary, but throughout its length this bone exhibits an upward convex curvature where it abuts against the ventral surface of the trough of the vomer. The ventral surface of the maxillary is also engraved with a series of shallow, narrow and slightly curved grooves which extend forward in an oblique direction from their origin near the midline toward the outer margin of this bone. These grooves on the posterior portion of the maxillary in front of the level of the anterior ends of the palatines are quite short and are bent more strongly obliquely outward. The ligamentary tissues as well as the blades of baleen which are attached to the roof of the mouth in Recent mysticetes are supplied in these vascular grooves. The thin posterior platelike border of each maxillary is thrust backward on the ventral face of the supraorbital process of the frontal almost to the edge of the broad channel for the optic nerve.

The inner edges of the maxillaries commence to diverge on the ventral aspect of the rostrum 365 mm. behind the extremity of the right maxillary and 980 mm. in front of the anterior edge of the right palatine. The right maxillary terminates at a point 1340 mm. in front of the anterior end of the left palatine. The distance from the anterior end of the right maxillary to the anterior edge of the optic canal at the base of the right supraorbital process is 1465 mm.

Between the anterior end of the vomer and the point of divergence of the premaxillaries toward the end of the rostrum, the premaxillaries meet ventrally along the median longitudinal axis of the rostrum to constitute a complete floor for the distal portion of the dorsal narial gutter.

Commencing at a point 380 mm. in front of the anterior edge of the right palatine, the inner edges of the maxillaries are spread apart slightly, exposing the ventral keel of the vomer. At a point 480 mm. in front of the posterior edge of the horizontal vaginal plate, the vomer develops a wide, flattened ventral exposure, which extends backward at almost the same horizontal level for a distance of 395 mm. and then diminishes in height rather rapidly toward its posterior edge. The trough of the vomer is widest near the the level of the anterior ends of the palatines. The median partition between the paired internal choanae is constituted by the vomer. The hinder horizontally expanded thin plate of the vomer is applied to the ventral surface of the basisphenoid and overrides the anterior border of the basioccipital and, in front of the former, it also envelops the ventral and lateral surfaces of the alisphenoid. Externally this horizontally expanded plate of the vomer is suturally united with the vaginal process of the corresponding pterygoid along each lateral margin.

The palatines are similar to those of the Modelo cetothere, *Mixocetus elysius* (Kellogg, 1934) in that they constitute the lower boundary of the optic foramen and extend backward beyond the latter. The anterior end of each palatine is obliquely truncated and is suturally united with the posterointernal angle of the corresponding maxillary as well as applied to the ventral face of the troughlike vomer. Laterally for a distance of 150 to 160 mm. each palatine is also mortised into the internal border of the hinder portion of the corresponding maxillary. The hinder end of each palatine is suturally united with the anterior edge of the corresponding pterygoid. The anteroposterior diameter of the palatine equals 16 percent of the total length of the skull.

The distally expanded supraorbital processes of the frontals are extended outward almost to the level of the posteroexternal angles of the maxillaries. The channel for the optic nerve commences at the optic foramen and curves transversely across the ventral surface of the supraorbital process of the frontal, becoming noticeably wider toward the orbital rim of this process. Near its origin this channel for the optic nerve is restricted to the hinder face of the supraorbital process for a distance of about 90 mm. and then twists downward until it is located wholly on the ventral surface of the supraorbital process. In width, this channel increases from a minimum diameter of 15 mm. near its origin to a maximum of 110 mm. at the orbital rim of this process. This optic channel is bounded by a high curved osseous crest which at its origin constitutes the ventral wall of the canal and then follows the hinder margin of the supraorbital process to constitute the posterior boundary for this channel. The anterior boundary is formed by a high crest which is continued outward to the orbital rim of this process.

The basioccipital viewed from the ventral side is a rectangular shaped bone, with its long axis transverse to the longitudinal axis of the skull. The basioccipital is

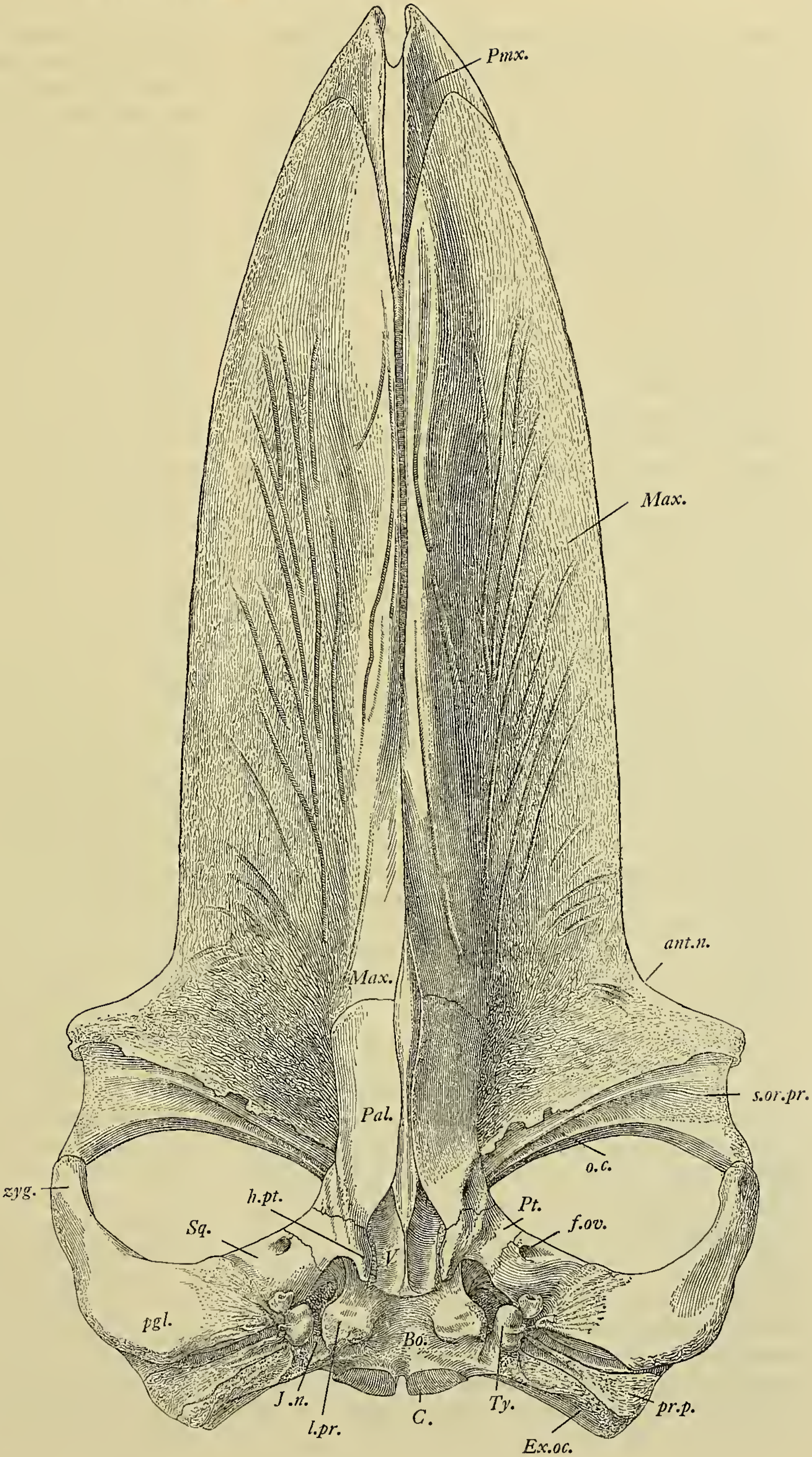


FIGURE 3.—Ventral view of skull, USNM 11976, of *Pelocetus calvertensis*, with restored borders of rostrum and right supraorbital process. For abbreviations, see figure 1.

ankylosed in front with the basisphenoid, the line of contact being overspread by the horizontally expanded posterior end of the vomer. On each side in front of and extending externally beyond the level of the external face of the occipital condyle is the very large, irregularly shaped descending protuberance, which is obliquely flattened internally on its anterior half. These opposite enlarged lateral protuberances of the basioccipital greatly reduce the transverse diameter of the median basicranial depression. The transverse distance between the inner faces of these protuberances does not exceed 75 mm. The somewhat concavely curved external surfaces of these lateral protuberances slope obliquely upward. The anterior end of each lateral protuberance is fused with the vaginal process of the corresponding pterygoid, and the line of contact nearly coincides with the hinder end of the vomer. The ventral surface of the vaginal process of the pterygoid is bent to conform to the curvature of the corresponding surface of the lateral protuberance. The basisphenoid is a flat rectangular bone, the greater length being in the anteroposterior direction. It is entirely concealed by the horizontally expanded hinder plate of the vomer. This bone is suturally united on each side with the vaginal process of the pterygoid.

The vaginal process of the pterygoid is preserved in its entirety on the right side and is slightly damaged on the left side. This process is suturally united along its dorsal edge with the outer edge of the basisphenoid. Along its dorsointernal margin it meets or is ankylosed to the horizontally expanded hinder plate of the vomer. The posterior end of this vaginal process, as mentioned previously, is fused with the anterior end of the lateral protuberance of the basioccipital. These vaginal processes of the opposite pterygoids take part in the formation of the lower boundaries of the internal choanae and, in conjunction with the lateral protuberances of the basioccipital bound the median region of the basicranium.

The hamular processes of the pterygoids curve backward below and internal to the pterygoid fossa. A narrow strip of the pterygoid is exposed between the hinder end of the palatine and the bifurcated anterior end of the squamosal which incloses the foramen ovale. The pterygoid extends upward on the inner wall of the temporal fossa to meet the lower edge of the alisphenoid. Dorsally and posteriorly behind the alisphenoid, the pterygoid meets the parietal edge to edge. The outer portion of the pterygoid extends forward and is suturally united along its entire anterior edge with the palatine, although the posterointernal angle of the palatine is free. Behind the level of the origin of the channel for the optic nerve on the supraorbital process of the frontal, the lateral (external) wall of the narial passage is formed by the pterygoid. The mandibular branch of the trigeminal nerve follows the broad curved groove on the ventral surface of the pterygoid on the roof of the pterygoid fossa.

The rather small pterygoid fossa (Ridewood, 1922, p. 260) or sinus is bounded internally by the vaginal process of the pterygoid anteriorly and anteroexternally by the downward curvature of the thickened anterior and external borders of the pterygoid and posteroexternally by the short and rather narrow falciform process of the squamosal. The roof of this air containing pterygoid fossa is constituted by the pterygoid and ventrally it has no apparent osseous cover. The pterygoid fossa is not limited posteriorly by any bony plate or process, but is continuous with the tympanoperiotic recess. The rather large tympanoperiotic recess 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 posterior lacerated foramen for the jugular leash is represented by a broad notch or incisure which is located at the posterointernal angle of the tympanoperiotic recess. This notch is bounded by the lateral protuberance of the basioccipital internally and by the exoccipital externally and dorsally.

On this Calvert skull there is a groove leading through the notch in the squamosal in front of the level of the sigmoid process of the bulla and behind the anterior process of the periotic, but in the same relative position as the well defined foramen on the Astoria cetothere skull, *Cophocetus oregonensis* (Packard and Kellogg, 1934, fig. 4).

On the ventral surface, the contact between the squamosal and the exoccipital lies above the posterior process of the periotic, and the latter is firmly wedged in between these two bones. Between the posterior process of the periotic and the base of the hinder face of the postglenoid process is a curved transverse channel for the external auditory meatus, which widens toward its external terminus. This channel, which is directed at an oblique angle to the longitudinal axis of the skull, originates at the inner edge of the squamosal and extends outward to a limited extent on the ventral surface of the posterior process of the periotic.

The elongated zygomatic process is attenuated from its base toward the extremity and is bowed outward, its external profile viewed from below, exhibiting a convex curvature from end to end. The postglenoid process projects downward at least 110 mm. below the level of the corresponding lateral protuberance of the basioccipital. This postglenoid process is very robust, with its extremity compressed anteroposteriorly and deflected backward, its posterior face curved concavely and its external face convex. This process is also characterized by a more or less flattened anterior face which slopes obliquely upward from its extremity to the external concave glenoid facet for articulation with the condyle of the mandible.

External to the anterior process of the periotic, the ventral surface of the squamosal is hollowed out, forming a shallow concavity, widest anteriorly, which extends forward obliquely from the posterointernal angle of the postglenoid process to near the glenoid angle of the squamosal, and also downward on the inner face of the postglenoid process.

On the ventral surface of the skull, the squamosal forms the outer and the major portion of the hinder boundary of the temporal fossa, the internal margin being coextensive with the outer edge of the pterygoid. External to the pterygoid fossa and behind the posteroexternal angle of the pterygoid is the large foramen ovale, which transmits the mandibular branch of the trigeminal nerve. This foramen is located in the bifurcation between the falciform and glenoid processes of the squamosal, which are suturally united in front with the pterygoid. The maximum anteroposterior diameter of the foramen ovale is 20 mm., and its maximum verticle diameter is 10 mm. The falciform process of the squamosal is convex in both directions, and its internal border overhangs a portion of the tympanoperiotic recess, as well as the hinder end of the oterygoid fossa.

The thickened exoccipitals constitute the most backwardly projecting elements of the skull. The paroccipital processes are merely roughened areas on the ventral edge of the exoccipital. The occipital condyles are separated medially by a deep very narrow groove.

The left jugal, which when in normal position provides the inverted arch below the orbital rim of the supraorbital process of the frontal, was detached from the skull when found. The posterior end (pl. 3, fig. 2) of this bone (diameter, 50 ± mm.) is attenuated and bent almost at right angles to the adjacent more flattened horizontal portion. The external and internal edges of the horizontal portion are founded and about equal in thickness. The proximal end (pl. 3, fig. 1), which is obliquely truncated, is much thinner and more markedly flattened; it is compressed for a distance of 55 mm. and is turned upward. This flat end may have been inserted between the preorbital angle of the supraorbital process of the frontal and the posterior ventral overriding plate of the maxillary. The greatest width of the jugal is 50 mm. The length of this left jugal in a straight line is 152 mm.

Measurements (in mm.) of the skull of USNM 11976 are as follows:

Greatest length of skull, anterior end of left premaxillary to level of posteroexternal angle of exoccipital	1965
Distance between anterior end of right premaxillary and posterior articular face of right occipital condyle	1895
Distance between anterior end of right premaxillary and apex of supraoccipital shield	1550
Length of rostrum, level of antorbital notches to end of left premaxillary	1350
Greatest length of right premaxillary	1455
Distance between anterior end of right premaxillary and anterior end of right nasal bone	1345
Distance from apex of supraoccipital shield to posterior end of right nasal bone	90
Greatest length of right nasal bone	115
Combined width of nasal bones, anteriorly	30
Combined width of nasal bones at hinder ends	10
Transverse distance between outside margins of premaxillaries at level of anterior ends of nasal bones	73
Maximum transverse distance between outside margins of premaxillaries at level of anterior ends of maxillaries	225
Transverse diameter of skull across posteroexternal angles of supraorbital processes	865
Greatest anteroposterior diameter of extremity of left supraorbital process	186
Transverse diameter of skull across outer surfaces of zygomatic processes	945
Transverse diameter of skull between outer margins of exoccipitals	610
Transverse distance between outer margins of occipital condyles	183
Greatest or obliquovertical diameter of right occipital condyle	95
Greatest transverse diameter of right occipital condyle	79
Greatest transverse diameter of foramen magnum	48
Distance from dorsal rim of foramen magnum to apex of supraoccipital shield	325
Greatest length of left zygomatic process, extremity of postglenoid process to anterior end of zygoma	380
Greatest breadth of basioccipital across lateral protuberances, outside measurement	226
Least intertemporal diameter of cranium on ventral face	215
Greatest anteroposterior diameter of left palatine bone	310
Maximum transverse diameter of left palatine bone	100±
Distance from posterior end of vomer to anterior end of palatine bone	405
Distance between opposite foramina ovale	302

Tympanic Bulla

Although both tympanic bullae (USNM 11976) were associated with the periotics when the skull was excavated, the left bulla is crushed and broken; the right bulla is complete except for the terminal portion of the posterior process and the anterior pedicle. The right tympanic bulla was detached for study and description. This tympanic bulla possessed the normal thin attachments to the periotic, one anterior and the other posterior. In shape, the bulla resembles somewhat that of *Parietobalaena palmeri*, but is larger, the anterior end being proportionately wider and the ventral face less convex. The right tympanic bulla is sufficiently well preserved to show the contour of the epitympanic recess or tympanic cavity (pl. 3, fig. 4), which is bounded externally by the brittle, thin overarching outer lip, internally by the involucrum, as well as the size and shape of the anterior outlet or tympanic aperture of the eustachian canal.

The posterior process (pl. 3, fig. 4) projected in front from the hinder end of the involucrum and behind from the posterior edge of the thin outer lip. In cross section, the posterior pedicle at the base resembles a compressed "V" in contrast to the open "U" of *Parietobalaena palmeri.*

The anterior pedicle of the bulla, which is ankylosed to the periotic, is broken off at the level of the free edge of the outer lip. The bluntly rounded extremity of the sigmoid process (pl. 3, fig. 3) is twisted at right angles to the longitudinal axis of the bulla, its anterior face is convex and its posterior face deeply excavated. There is a deep, broad vertical furrow on the outer lip (fig. 4a) in front of the sigmoid process. A deep narrow groove separates this sigmoid process from the so-called conical apophysis of Beauregard which is blunt, rounded and projects slightly below the level of the involucrum.

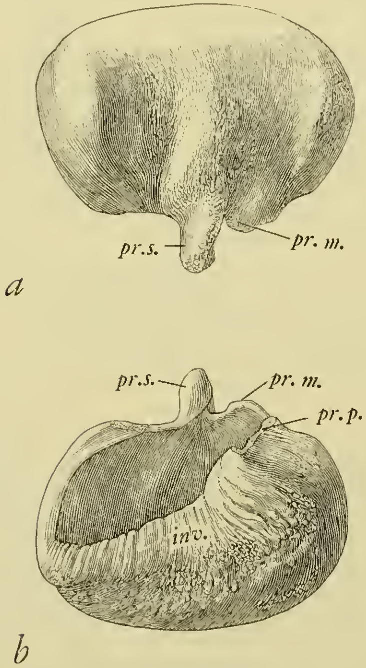


FIGURE 4.—Views of right tympanic bulla, USNM 11976, of *Pelocetus calvertensis: a*, external view; *b*, dorsal view. Abbrs.: inv., involucrum; pr.m., processus medius or conical apophysis; pr.p., base of pedicle of posterior process; pr.s., sigmoid process.

The involucrum (fig. 4b) attains its maximum width posteriorly, particularly on the posterior third of its length, and then becomes strongly narrowed toward the anterior outlet. Internally, the dorsal face of the involucrum is roughened by closely spaced transverse creases.

In ventral aspect the tympanic bulla is characterized by an obliquely truncated anterior end which is wider than the more rounded posterior end, although the profile of both ends slopes obliquely backward from internal to external angles. Viewed from the side, the ventral profile is not depressed medially.

Measurements (in mm.) of right tympanic bulla of USNM 11976 are as follows:

Greatest length of tympanic bulla	64
Greatest width of tympanic bulla	35
Greatest depth of tympanic bulla on internal side	39
Greatest depth of tympanic bulla on external side, ventral face to tip of sigmoid process	52.5
Thickness of lip of bulla at anterior outlet	4

Periotic

On the type skull (USNM 11976) the posterior process (fig. 5) is unusually elongated, expanded distally to more than twice (65 mm.) its proximal width (24 mm.), and relatively narrow for more than two-thirds of its length. This process is firmly wedged in a deep groove between the exoccipital and the postglenoid portion of the squamosal. The *pars cochlearis* projects into a large recess behind the pterygoid fossa and its short stout anterior process is lodged in a cavity or rather deep excavation in the squamosal. The posterior pedicle of the tympanic bulla, before it broke off, was fused with the internal end of the rather broad ridge that parallels the anterior edge of the ventral face of the posterior process. Behind this ridge is a deep broad groove, which in Recent mysticetes is traversed by the facial nerve on its outward course. The external denser portion of the periotic is lodged in the deep cavity occupied in part by the anterior process and is hidden for the most part by the overhanging internal edge of the squamosal; it is, however, compressed from side to side. The anterior process is rather short, very broad, and its extremity is emarginate and pitted.

The *pars cochlearis* is markedly compressed transversely, its anteroposterior diameter (33 mm.) is at least twice its width (16 mm.). Externally, the *pars cochlearis* rises almost vertically to the inner margin of the *fenestra ovalis;* and its ventral or tympanic surface is convex in both directions. Viewed from the ventral side, the cerebral profile of the *pars cochlearis* is sinuous and the posterior face is abruptly truncated above the very large *fenestra rotunda.*

A very narrow rim encircles the *fenestra ovalis*, which is elevated above the level of the channel for the facial nerve.

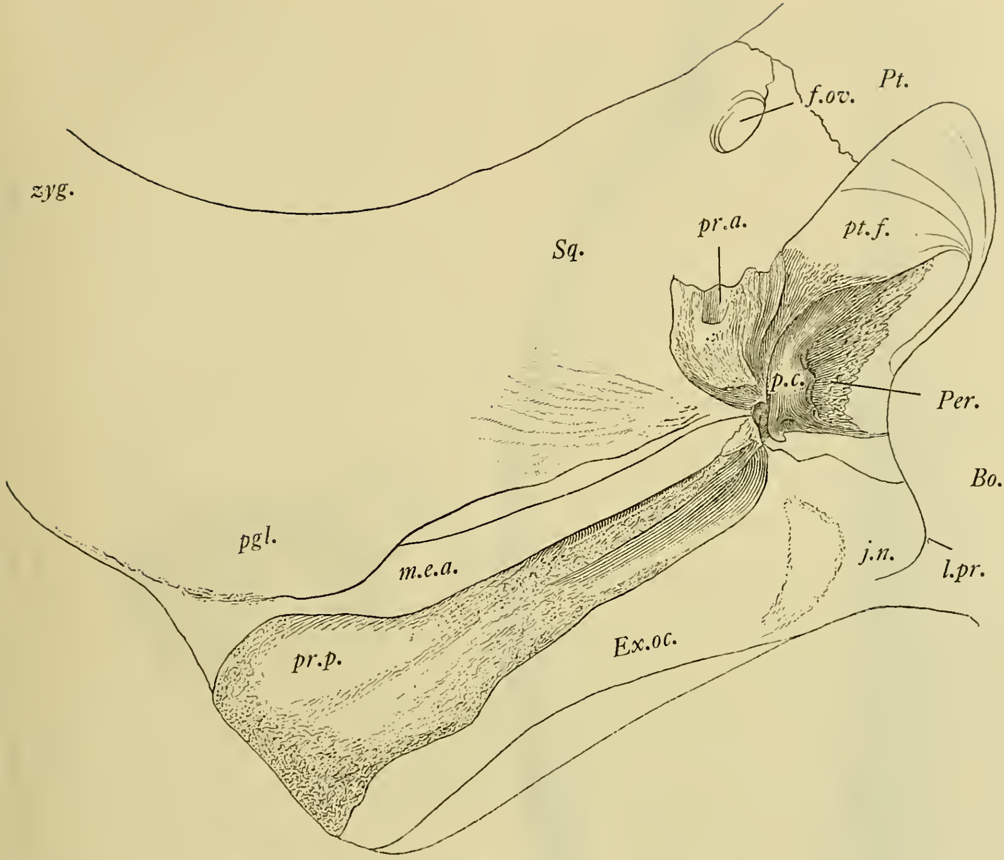


FIGURE 5.—Ventral view of right periotic, USNM 11976, of *Pelocetus calvertensis*. Abbrs.: Bo., basioccipital; Ex.oc., exoccipital; f.ov., foramen ovale; j.n., jugular notch or incisure; l.pr., lateral or descending process of basioccipital; m.e.a., channel for external auditory meatus; p.c., pars cochlearis; Per., periotic; pgl., postglenoid process; pr.a., anterior process of periotic; pr.p., posterior process of periotic; Pt., pterygoid; pt.f., pterygoid fossa; Sq., squamosal; zyg., zygomatic process.

This *fenestra ovalis* is largely concealed from a tympanic view by the overhanging external face of the *pars cochlearis*. A thin carina intervenes between this channel for the facial nerve and the *fenestra ovalis*. Small orifices of the semicircular canals are visible at the bottom and on the outer wall of the vestibule. There is a deep and narrow groove extending forward from the external rim of the *fenestra ovalis* through the notch between the *pars cochlearis* and the anterior process. The fossa for the stapedial muscle is rugose, broader than long and extends downward on the internal face of the posterior process and on the external face of the *pars cochlearis*.

A large shallow concavity (pl. 16, fig. 2) for reception of the head of the malleus is situated adjacent and external to the epitympanic orifice of the *aquaeductus Fallopii*. The precise margins of this articular facet are not clearly indicated, but it appears to be continuous externally with the depressed area on the outer denser portion of the periotic. In front of this facet the base of the slender anterior pedicle of the tympanic bulla is fused with the anterior process.

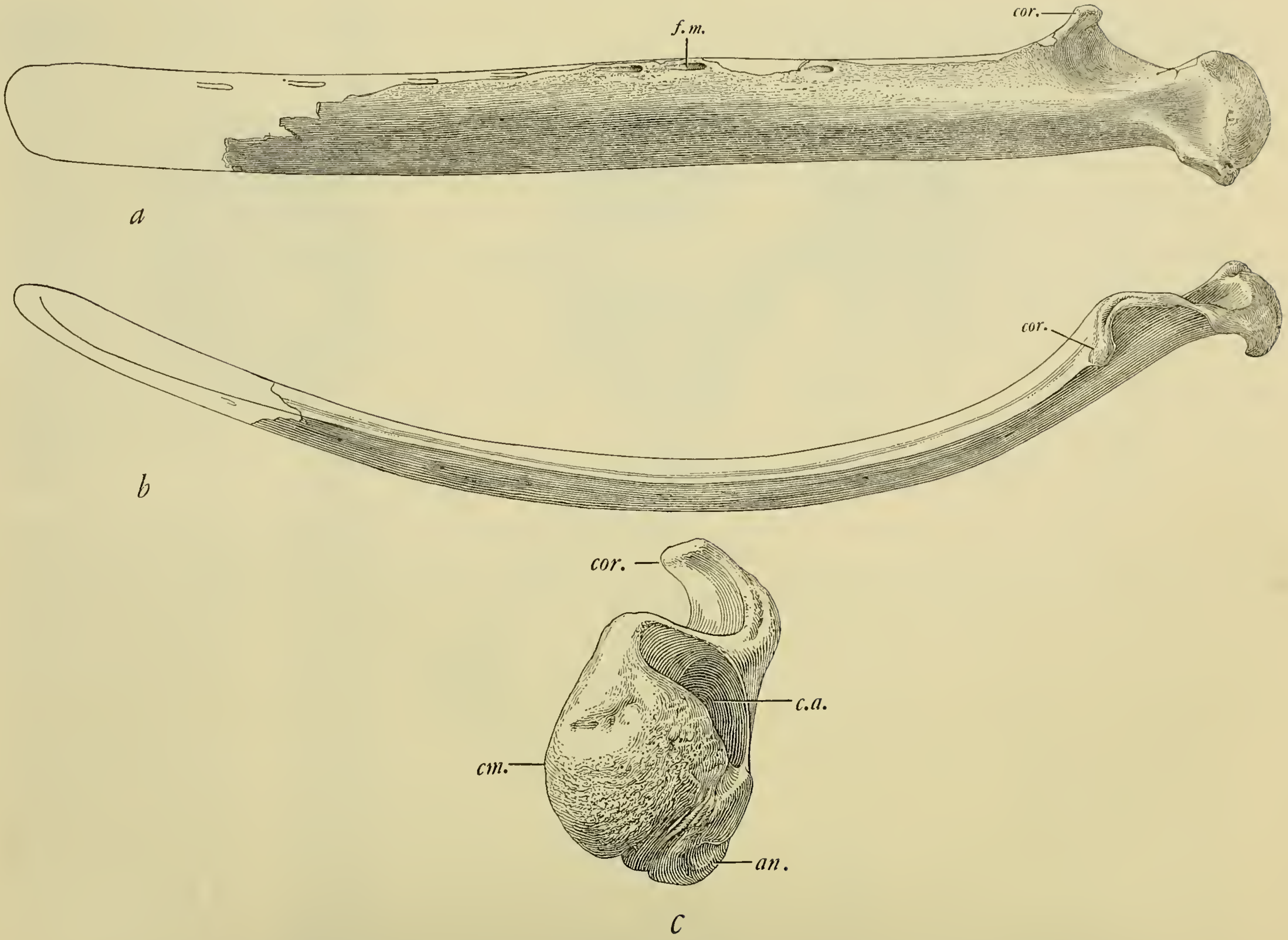


Figure 6.—Left mandible, USNM 11976, of *Pelocetus calvertensis:* *a*, external view; *b*, dorsal view; *c*, posterior view. Abbrs.: an., angle; c.a., alveolar or mandibular canal; cm., condyle of mandible; cor., coronoid process; f.m., mental foramen.

The *fossa incudis* may be described as a small pit located on the outer denser portion of the periotic external to the channel for the facial nerve and posterior to the area of attachment of the anterior pedicle of the tympanic bulla.

The structural peculiarities of the cerebral face of the *pars cochlearis* are often diagnostic. Below the apex of the *pars cochlearis* is the internal acoustic meatus at the bottom of which is the spiral tract and a minute *foramen singulare*, which on this type specimen can only be seen with the aid of a mirror. The description of the cerebral face will be based largely on the left periotic (USNM 23059) of the referred specimen. Because of the oblique inclination of the encircling wall of this meatus, the *tractus spiralis foraminosus* is partially concealed from a cerebral view (pl. 16, fig. 3). A thick osseous partition (7.5 mm.) separates the large entrance to the aqueduct of Fallopius from the more centrally located internal acoustic meatus. This cerebral entrance to the Fallopian aqueduct opens into a deep excavation on the anterointernal face of the *pars cochlearis.* Posterior to this meatus is the small orifice of the aqueduct of the cochlea and above the latter is the large deep fossa into which the aqueduct of the vestibule opens. The area of this somewhat triangular vestibular fossa is almost as large as the area encircled by the cerebral rim of the internal acoustic meatus. Between this vestibular fossa and the vertically elongated rim of the internal acoustic meatus is a rather blunt projection. The smooth convex surface of the tympanic face of the *pars cochlearis* does not extend inward as far as the rim of the internal acoustic meatus, and the irregular margin resulting threfrom accentuates the rugose appearance of the cerebral face. On the cerebral side also, the dorsal borders of the *pars cochlearis* and the anterior process are pitted and spongy, transversely compressed and extended inward and forward.

Measurements (in mm.) of periotics are as follows:

	Right USNM 11976	*Left USNM 23059*
Length of posterior process, distance from external end to outer wall of groove for facial nerve	210	135
Greatest dorsoventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	40	45
Distance between epitympanic orifice of *aquaeductus Fallopii* and extremity of anterior process	56	45
Distance from external end of posterior process to anterior end of anterior process (in a straight line)	246	—

Mandibles

Both of the mandibles (USNM 11976) associated with the skull are incompletely preserved and lack a considerable portion of their dorsal borders above the level of the series of external nutrient foramina. In general proportions these mandibles are considerably more robust and exhibit a relatively much deeper horizontal ramus than any of the other Calvert cetotheres heretofore discovered. The anterior ends of both of these mandibles are missing. The internal surface of each mandible is distinctly flattened, especially on the anterior three-fourths. The dorsoventral convex curvature of the external face of the mandible is quite pronounced and the maximum transverse diameter is below the center of the height of the horizontal ramus. The right mandible measures 73 mm. transversely at a point 1135 mm. (in a straight line) anterior to the posterior articular face of the condyle. The ventral face of the middle portion of the horizontal ramus is almost flat. Anteriorly for a distance of 220 mm. from the apex of the coronoid process a sufficient portion of the dorsal border of the horizontal ramus of the right mandible is preserved to show that it is abruptly compressed to form a narrow longitudinal ridge.

Both of these mandibles are bowed outward (fig. 6b) and their original length (1900±mm.) was undoubtedly greater than the distance from the glenoid face of the postglenoid process to the extremity of the corresponding premaxillary (1820 mm.). Viewed from the side the ventral profile of the mandible exhibits a slight convex curvature. One mental foramen is preserved on the right mandible some 1480 mm. anterior to the articular face of the condyle and it opens into a groove that leads horizontally forward. On the left mandible (fig. 6a) one and vestiges of two others in the external series of nutrient mental foramina are preserved. On this left mandible, the most posterior of these external mental foramina is located 665 mm. anterior to the posterior articular face of the condyle. These foramina are relatively large and apparently drop to a lower level toward the anterior end of the mandible. Each of these mental foramina opens into a groove, which not only is directed forward, but also increases in width from its orifice to the point where it becomes indistinct. On both mandibles the small internal foramina forming the longitudinal alveolar series, which normally runs forward below the upper edge of the mandible, were destroyed.

The large coronoid process is low, subtriangular, terminating in an everted apex, the anterior and posterior edges displaying a convex curvature, the inner face convex and the outer face strongly concave. The apex of the coronoid process bends strongly outward, above and anterior to the internal orifice for the large mandibular canal. Behind the apex the posterior edge of the coronoid process becomes thickened (31 mm.) in contrast to the thin anterior edge.

The condyle (fig. 6c) is quite large, expanded from side to side and convex in all directions. Dorsally the condyle is strongly compressed, especially from the inner side, narrowing the articular face to some 34 mm. on the left mandible. The maximum transverse diameter (130 mm.) of the condyle of the left mandible is slightly below the center. Ventrally the condyle maintains its width; it is bounded by a wide furrow between its internal border and the angle of the condyle. The angle of the mandible is robust and well developed. The outer border of the condyle projects noticeably outward and less so forward. The distance from the articular face of the condyle to center of the apex of the coronoid process is 270 mm. The distance from the articular face of the condyle to the orifice of the mandibular (dental) canal is 235 mm. on the light mandible.

Well preserved anterior ends of two right mandibles obtained elsewhere from the Calvert Cliffs are referred to this species. The largest one (USNM 21306) measures 405 mm. in length; its vertical diameter 100 mm. behind the anterior end is 166 mm., and at a point 200 mm. behind, 172 mm. This fragment compares most favorably with the measurements of the two above described mandibles. The other slightly smaller mandible (USNM 14693, fig. 7) measures 445 mm. in length; its vertical diameter at both 100 and 200 mm. behind the anterior end is 147 mm. The dorsal faces of both of these mandibular ends are noticeably broader than the ventral faces. On both of these mandibles the symphysis is quite short, the roughened area not exceeding 70 to 80 mm. The groove on the dorsal face (USNM 21306) terminates in an anteriorly directed foramen. This groove represents the anterior continuation of the series of small internal foramina which move up to the dorsal face of the ramus to join this groove of fissure at its posterior end. Above the ventral edge of this anterior section and below the longitudinal crease, the lower border of the internal face is depressed along a strip measuring 55 mm. dorsoventrally.

Measurements (in mm.) of mandibles of USNM 11976 are as follows:

	Right	*Left*
Greatest length of mandible along outside curvature, as preserved	1690	1610
Greatest length of mandible in a straight line, as preserved	1650	1540
Greatest vertical diameter of mandible at a point 670 mm. anterior to posterior articular face of condyle	—	150
Greatest vertical diameter at coronoid process	214.5	212
Greatest transverse diameter of ramus at coronoid process	85.5	78
Least vertical diameter of mandible behind coronoid process	125	127.5
Greatest vertical diameter of condyle	185	—
Greatest transverse diameter of condyle	126	130
Greatest vertical diameter of hinder end of mandible, including condyle	196	
Center of apex of coronoid process to posterior articular face of condyle	270	280

Hyoid Bones

Unlike those of balaenopterine whales the great horns (thyrohyals) of this hyoid (fig. 8a) are directed backward as well as upturned, and are progressively attenuated beyond the middle of their length toward their rugose ends which are pitted for the attachment of cartilage. No line of demarcation can be discerned between the relatively small basihyal and the large slightly flattened hornlike thyrohyals. The area on the front edge of the central portion (basihyal), where the pair of anterior conical processes (certaophyals) are normally located on the mysticete basihyal, is eroded to such an extent that the original appearance can only be surmised. Cartilages connecting with an end of the corresponding stylohyal are attached to each of the conical processes. The basihyal is more noticeably compressed dorsoventrally than either thyrohyal and exhibits a shal-

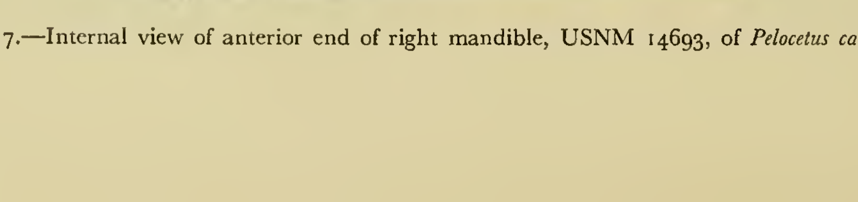


Figure 7.—Internal view of anterior end of right mandible, USNM 14693, of *Pelocetus calvertensis.*

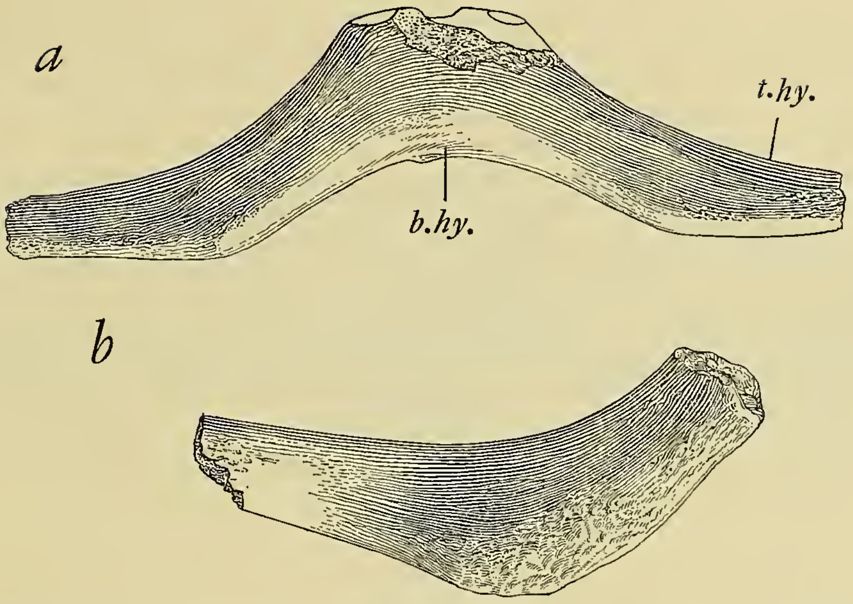


FIGURE 8.—Views of hyoid bones, USNM 11976, of *Pelocetus calvertensis:* *a*, dorsal view of basihyal and ankylosed thyrohyals; *b*, ventral view of right stylohyal. Abbrs.: b.hy., basihyal; t.hy., thyrohyals.

lowly concave posterior margin and a protuberant convex anterior margin. The thyrohyals are robust, dilated anteroposteriorly near the middle of their length which results in an angular deflection of the posterior profile in contrast to the slightly concave anterior profile. The stylohyal resembles in some respects those of *Balaenoptera acuto-rostrata.* The right stylohyal (fig. 8b) is essentially complete except for the eroded proximal extremity. This bone is noticeably flattened except at the enlarged and pitted end which is connected by cartilage with the corresponding anterior conical process of the basihyal. This stylohyal is also markedly widened anteroposteriorly, producing a pronounced bulge on the posterior profile.

Measurements (in mm.) of the hyoid bones of USNM 11976 are as follows:

Maximum transverse diameter of hyoid between extremities of great horns (thyrohyals)	333
Anteroposterior diameter of central portion (basihyal)	62
Maximum thickness of central portion (basihyal)	22
Maximum anteroposterior diameter of great horn (thyrohyal)	51
Maximum thickness of great horn (thyrohyal)	33
Maximum diameter of great horn (thyrohyal) at outer end	25
Length of right stylohyal	224+
Maximum diameter of the end of stylohyal connected to ceratohyal	50
Maximum anteroposterior diameter of stylohyal	65
Maximum thickness of stylohyal at same point	22.5

Vertebrae

Since the epiphyses are firmly ankylosed to the centrum of all the cervical, dorsal, lumbar and caudal vertebrae of both the type specimen (USNM 11976) and the referred specimen (USNM 23059) both whales were physically fully mature.

CERVICAL VERTEBRAE.—All of the cervical vertebrae (USNM 11976), except the fifth, were found behind the skull when it was excavated. These vertebrae were partially visible on the surface of the compact bluish sandy clay whose exposed bayward sloping surface was being scoured by the sand in the tidal wash. Souvenir seekers also had unsuccessfully attempted to extricate some of the vertebrae. As a result the neural arches and the lateral processes of the cervicals in the series behind the third as well as those of several dorsals were either damaged or destroyed.

All of the cervical vertebrae with the exception of the axis and the third cervical were free. The diagnostic features of this series are summarized as follows: Atlas massive, with stout neural spine, robust transverse processes, and short hyapophysial process; axis characterized by absence of a neural spine, a short and blunt odontoid process, and large dorsoventrally widened as well as elongated transverse processes; upper and lower transverse processes of third cervical elongated and united externally to inclose the large vascular mass; fourth to seventh cervicals characterized by a broad flattened centrum, narrow pedicle (neurapophysis), and rather wide neural canal.

Atlas: Except for a portion of the neural spine the atlas (USNM 11976) is well preserved. It is relatively large as compared to those of other Calvert cetotheres. This massive atlas (fig. 9a) measures 176 mm. between the outer margins of the anterior facets for articulation with the occipital condyles of the skull, each facet being deeply concave, broadest ventrally, and inclined obliquely outward; these two facets are separated ventrally by a rather narrow interval (7 mm.). The neural arch (pl. 4, fig. 6) is rather broad anteroposteriorly. On each side the arch (neurapophysis) is pierced ventrally near the middle of its length (fig. 9c) by a large vertebra-arterial canal, which opens into a broad ventrally directed groove. The neural spine, judging from the broken basal edges, was rather robust. The transverse process on each side of the atlas is massive and directed more outward than backward, attenuated distally, and terminating in a blunt extremity. The neural canal (pl. 4, fig. 1) is large, but partially obstructed ventrally by a pair of osseous excrescences.

The two opposite posterior facets (fig. 9b) for articulation with the axis are very broad, but their external margins are not sharply set off from the posterior face of the centrum. The hyapophysial process below the neural canal is low, bluntly pointed and irregularly pitted or roughened. Between the opposite posterior facets and below the neural canal is a broad upwardly sloping surface for articulation with the odontoid process of the axis.

All of the Calvert Miocene cetothere atlases available for study have a reduced and unobtrusive hyapophysial process on the posteroventral border of the centrum and but one

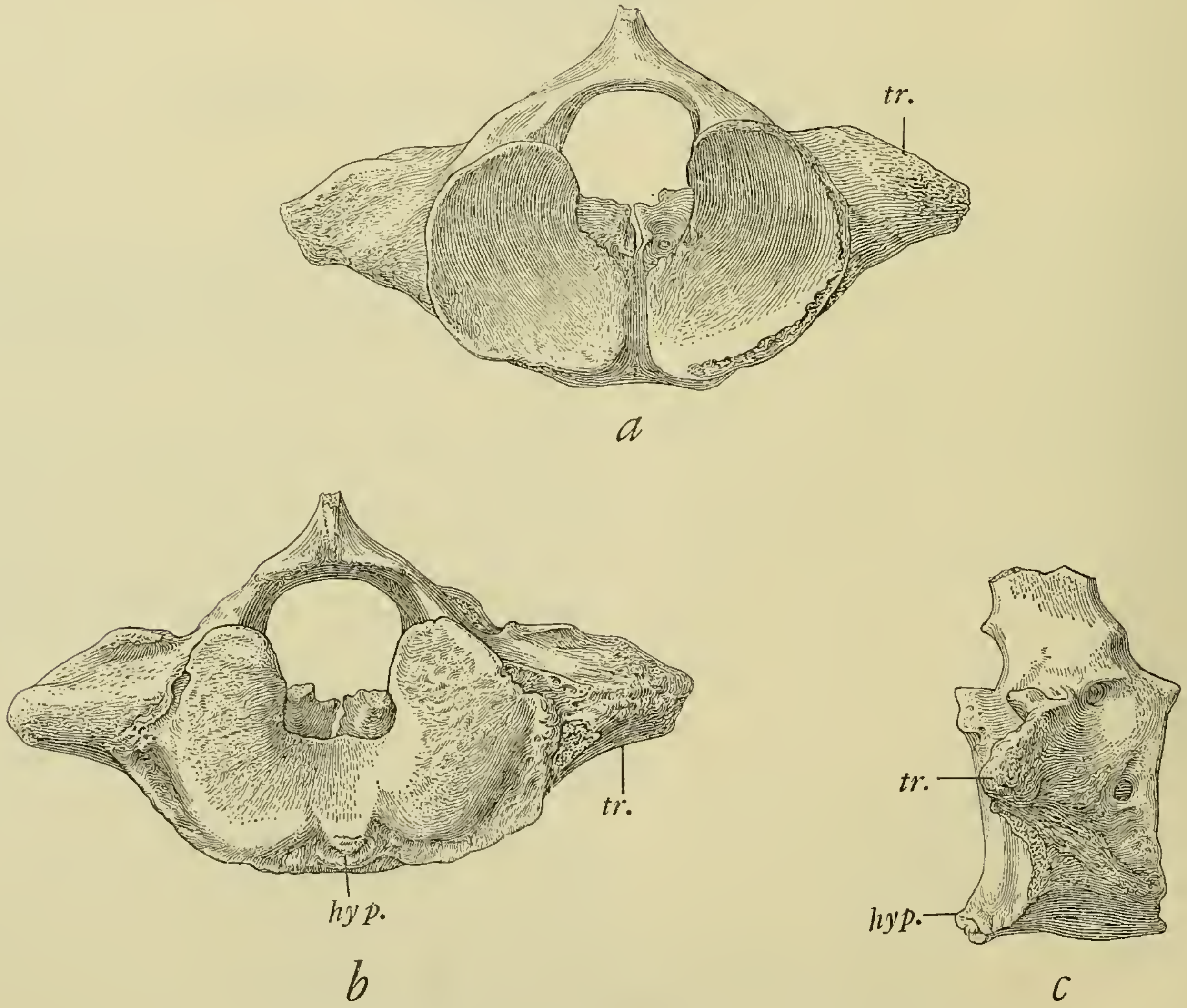


Figure 9.—Views of atlas, USNM 11976, of *Pelocetus calvertensis:* *a*, anterior view; *b*, posterior view; *c*, lateral view. Abbrs.: hyp., hyapophysial process; tr., transverse process.

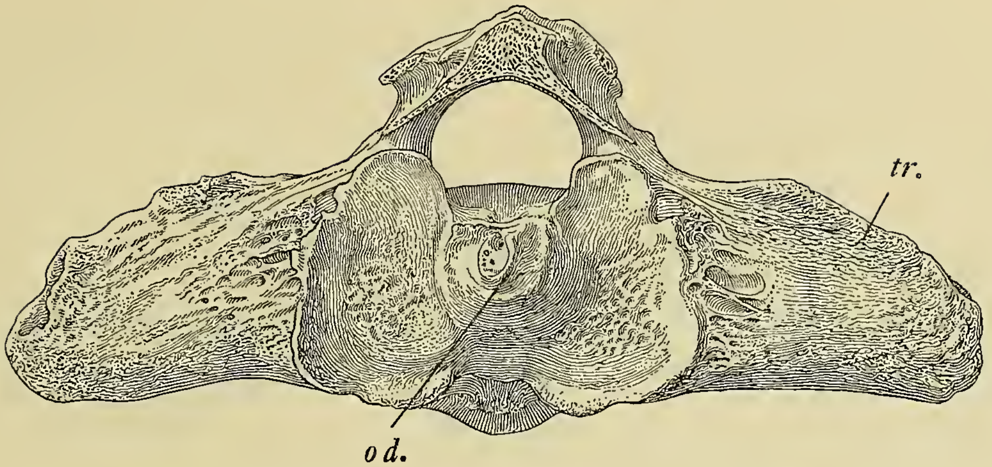


FIGURE 10.—Anterior view of axis, USNM 11976, of *Pelocetus calvertensis*. Abbrs.: od., odontoid process; tr., transverse process.

transverse process on each lateral face. Conversely, the atlases of all the Calvert Miocene odontocetes possess a prominent and often noticeably elongated or enlarged hyapophysial process and usually a fairly well developed lower (parapophysis) and a variably developed upper (diapophysis) transverse process.

On the atlas (USNM 23059, pl. 3, fig. 5) of the referred specimen, the distance (183 mm.) between the outer margins of the anterior facets for articulation with the occipital condyles of the skull exceeds slightly the same measurement of the type atlas, yet the anteroposterior diameter (72 mm.) of the centrum is less. Both transverse processes of this referred atlas are eroded. The two posterior facets for articulation with the axis are slightly larger than those of the type atlas, but no hyapophysial process below the neural canal is developed as a distinct entity. The usual broad upward sloping surface for articulation with the odontoid process of the axis is present between the opposite large articular facets.

Additional measurements of this referred atlas are as follows: Vertical diameter of axis, tip of neural spine to ventral face of centrum, 163+ mm.; maximum vertical diameter of neural canal anteriorly, 80 mm.; maximum transverse diameter of neural canal, 57 mm.; maximum distance between outer ends of diapophyses, 142+ mm.; and least anteroposterior diameter of right pedicle of neural arch, 54 mm.

Axis: The axis (pl. 4, fig. 2) is solidly fused with the third cervical (pl. 4, fig. 7), not only between the centra but also between the post- and pre-metapophysial facets. The transverse diameter (388 mm.) of the axis (fig. 10) is greater than twice its vertical diameter (165 mm.). Each ventral transverse process is massive, elongated, dorsoventrally widened, and diminishes slightly in height to the bluntly truncated outer end. The height (56.5 mm.) of the neural canal anteriorly is less than the transverse diameter (63 mm.) The anterior facets for articulation with the atlas are shallowly concave from side to side, the vertical diameter (103 mm.) of the right facet being considerably greater than the minimum transverse diameter (60 mm.) and they are separated ventrally by an interval of approximately 25 mm. The odontoid process is large, wider than high, rugose dorsally, and not noticeably elongated (fig. 10). The ankylosis of the centra of the axis and the third cervical is so complete (fig. 11) that all evidence of coalescence is obliterated on the lateral and ventral surfaces of these two centra, but not dorsally on the floor of the neural canal where a distinct separation exists, the anteroposterior diameter of the centrum of the third cervical being 34 mm.

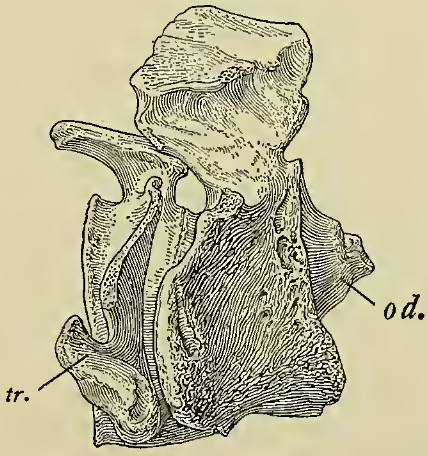


FIGURE 11.—Lateral view of ankylosed axis and third cervical, USNM 11976, of *Pelocetus calvertensis*. Abbrs.: od., odontoid process; tr., transverse process.

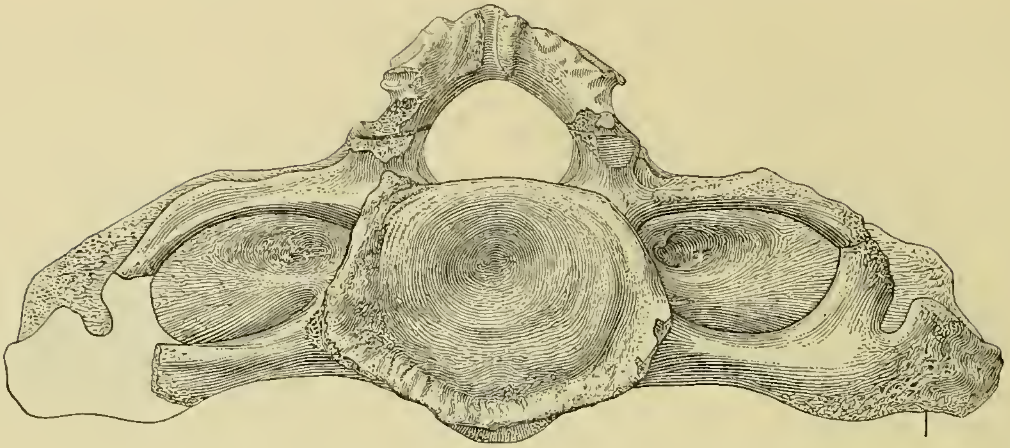


FIGURE 12.—Posterior view of third cervical and axis, USNM 11976, of *Pelocetus calvertensis.* Abbr.: tr., transverse process.

Neither transverse process is perforated by the foramen transversaria, and no trace of this aperture is visible on the anterior face of this process; on the posterior face (fig. 12), however, close to the base on each process is a circular depression approximately 35 x 20 mm. in diameter which indicates the former course of the cervical extension of the thoracic retia mirabile. It seems possible that this foramen may have been closed during growth by the exostosis which has affected several vertebrae in the column.

The neural arch is stout, measuring 70 mm. anteroposteriorly at the apex of the coalesced arch, but actually 43 mm. on each pedicle at the level of the floor of the neural canal. A sharp edged anteroposterior crest on the dorsal surface of the neural arch persists as a vestige of the neural spine. The dorsal surface of the centrum is depressed and the ventral surface is excavated shallowly on each side of the broad median longitudinal ridge.

Third Cervical: In contrast to the axis, the third cervical (fig. 12) is less massively constructed even though the centrum is rather broad (140 mm.), but its anteroposterior diameter (34 mm.) is less. The concave posterior surface of the centrum has raised margins. A median anteroposterior ridge on the dorsal and ventral face of the centrum separate shallow depressions. The relatively slender pedicles (pl. 4, fig. 7) of the neural arch (anteroposterior diameter, 18–20 mm.) support rather short anterior zygapophyses which are fused with corresponding lateral surfaces on the neural arch of the axis. The postzygaphyses are elongated, rodlike and project at least 10 mm. beyond the level of the hinder face of the centrum. The neural canal is slightly wider (68 mm. posteriorly) than that of the axis. The upper (diapophysis) and lower (parapophysis) transverse processes are elongated and slender and unite or are ankylosed externally, inclosing a very large lateral foramen (foramen transversaria). This large completely bounded opening or foramen incloses a large vascular mass, the cervical extension of the thoracic retia mirabile in recent balaenopterine whales (Walmsley, 1938). The vertical diameter of this foramen on the right side is 50 mm. The extremity of the lower transverse process is prolonged about 48 mm. outward beyond the outer wall or limit of this foramen; it is expanded distally in a dorsoventral direction and bent backward dorsally (fig. 12). The lower transverse process is stouter and much broader near the centrum than the upper, and its upper and lower surfaces are rounded. Both the upper and lower transverse processes are incomplete externally on the left side.

Fourth Cervical: The fourth, sixth and seventh cervical vertebrae have a broad anteriorly and posteriorly flattened centrum, narrow pedicle for the neural arch and a rather wide neural canal. On the fourth cervical (pl. 4, fig. 3) a 90 mm. basal portion of the right lower transverse process is attached to the centrum, but the left process is broken off at the base. The lower transverse process is rather slender, directed more outward than downward, and projects outward with a twist, the outer portion being anteroposteriorly compressed. The short inner section of the upper transverse process indicates that it also was slender. The dorsoventral gap (at least 60 mm.) suggests that the large lateral foramen may have been larger than that of the third cervical. The pedicle of the neural arch (pl. 4, fig. 8) preserved on the right side is relatively short and low, its minimum anteroposterior diameter being 22 mm. The prezygapophysial facet is shallowly concave and longer (20 mm.) than wide (18 mm.). The ventral articular facet on the right postzygapophysis projects backward 20 mm. beyond the hinder face of the centrum. On the dorsal and ventral faces of the centrum the anteroposterior ridges are low and broad, separating opposite depressed areas. The rims of the anterior and posterior faces of the centrum project beyond and overhang the lateral faces.

Sixth Cervical: On both sides of the centrum (pl. 4, fig. 4), the upper and lower transverse processes are broken off 10 to 20 mm. beyond their point of origin. The sixth cervical is characterized in part by a change in the direction of its transverse processes, the upper process instead of being directed outward in a line with the transverse axis of the centrum was projected somewhat forward as well as outward at least at the base; the ventral process was rather slender at the base and directed more downward than outward. The pedicle (pl. 4, fig. 9) supporting this ventral transverse process was obviously stronger than the pedicle for the upper transverse process. A thin lamina, compressed anteroposteriorly, which has its origin on the anterolateral border of the centrum but joined dorsally to the base of the pedicle of the neural arch supports the upper transverse processes. Both pedicles (neurapophyses) are wider transversely (34 mm.) than anteroposteriorly (19 mm.) near the base.

The anterior face of the centrum is depressed, shallowly concave, its elevated rims projecting beyond and overhanging the lateral faces. The anteroposterior ridge separating the lateral depressions is broader and more conspicuously developed on the ventral face than on the dorsal face.

Seventh Cervical: The anterior face of the centrum (pl. 4, fig. 5) is shallowly concave and its rim is not elevated but does project beyond the ventral face; the posterior face is nearly flat. The median anteroposterior ridge on the ventral face is decidedly more prominent than the corresponding ridge on the dorsal face. No ventral transverse process is present, a characteristic of the mysticetes. The broad dorsoventrally widened lamina supporting the upper transverse process is noticeably larger than the corresponding structure on the sixth cervical in conformity with the dimensions of this process, its posterior surface passing imperceptibly into that of the neural arch. A broken surface area on the anteroventral portion of this broad lamina suggests that the diapophysis may have had its origin either here or on the similar area located on the upper external border of this lamina. Presumably this process was directed somewhat forward and downward and then outward. The prezygapophysial articular facet is preserved on the left side, its inner margin being less than 15 mm. above the floor of the neural canal. The minimum diameter of the left pedicle of the neural arch is 40 mm. transversely and 20 mm. anteroposteriorly.

Measurements (in mm.) of cervical vertebrae of USNM 11976 are as follows:

	Atlas	*Axis*	*C.3*	*C.4*	*C.5*	*C.6*	*C.7*
Maximum vertical diameter of vertebra, tip of neural spine to ventral face of centrum	158+	165	—	—	—	—	—
Maximum anteroposterior diameter of centrum	96 [a]	79 [b]	35	36	—	37.7	38
Maximum vertical diameter of centrum anteriorly	—	93 [c]	100 [c]	99	—	96.5	95
Maximum transverse diameter of centrum anteriorly	—	—	140 [c]	129	—	138	114
Maximum vertical diameter of neural canal, anteriorly	70	56.5	—	—	—	—	—
Maximum transverse diameter of neural canal, anteriorly	55	63	67.5	—	—	84	—
Maximum distance between outer surfaces of diapophyses	266	—	296	—	—	—	—
Maximum distance between outer surfaces of parapophyses	—	388	396±	284+	—	—	—
Least anteroposterior diameter of right pedicle of neural arch	52.3	63	18.2	20	—	—	—
Maximum distance between outer margins of anterior articular facets	176	162	—	—	—	—	—

[a] Dorsally.

[b] Plus odontoid process.

[c] Posteriorly.

Dorsal vertebrae.—All of the epiphyses on the nine dorsal vertebrae (USNM 11976) excavated at the site are firmly ankylosed to the centra and this condition in Recent mysticetes is regarded as evidence of physical maturity. Inasmuch as each dorsal vertebra has attached to the distal end of its transverse processes a pair of ribs which in succession contribute their share of the framework for the thorax, this series of vertebrae must correspond at a minimum to the number of here associated ribs. When these externally different ribs are arranged in what appears to be their normal sequential positions and placed in contact with corresponding articular surfaces, the conclusion is inescapable that twelve vertebrae comprised the dorsal series. The centra increase in length from the first to the twelfth dorsal and all are broader than high. The breadth also exceeds the length of the centrum of all the dorsal vertebrae. The outline of the anterior end of the centrum of the first to the tenth dorsals is subcordate. On each side of the centrum of the first to eighth dorsals inclusive, below the level of the floor of the neural canal and adjacent to the edge of the posterior face of the centrum, there is an articular facet for the accomodation of the following rib. Furthermore, the facet for the capitulum of the following ribs is gradually but progressively located higher on the lateral surface of the centrum from the first to the eighth dorsal. Although the centra of the dorsal vertebrae of Recent balaenopterine whales lack these facets, capitular articular surfaces are located posteroexternally on the centra of adult *Eubalaena glacialis* (Turner, 1913, p. 905) and *Balaena mysticetus* (Eschricht and Reinhardt, 1866, p. 116).

The neural canal decreases in width and increases in height from the first to twelfth dorsals. The pedicles (neurapophyses) of the neural arch of the eight anterior dorsals are massive and unusually thick; they occupy more than half the length of the centrum on all the dorsals. The diapophyses become progressively more robust. The transverse processes (diapophyses) of the first five dorsals arise partly from the neural arch and partly from the external face of the centrum, while on the ninth, tenth, eleventh and twelfth dorsals (USNM 23058) the transverse processes are derived from the centrum. On the six anterior dorsals the outer or terminal facet for articulation with the tuberculum of the corresponding rib is located for the most part anterior to the level of the anterior face of the centrum. This facet for the tuberculum is located almost vertically on the attenuated extremity of the anteroposteriorly compressed diapophysis of the second dorsal, obliquely on that of the third dorsal and is conspicuously and progressively elongated horizontally on the fourth to twelfth dorsals inclusive. The neural spines increase in heighth from the first to the twelfth dorsals.

The width of the interval separating the prezygapophysial facets seems to decrease markedly from the anterior to the posterior end of the dorsal series and behind the sixth dorsal, the width of the interval separating the prezygapophysial facets become markedly reduced. The prezygapophysial facets of the first to sixth dorsal vertebrae are large, elongated, deeply concave and slope steeply from outer to inner margin. On the sixth, seventh, and eighth dorsals at least the backwardly projecting dorsal portion of the neural arch and the postzygapophysial facets extend backward beyond the level of the posterior face of the centrum and are firmly clasped by the prezygapophysial facets and metapophyses of the next dorsal.

Since some of the vertebrae are missing in the dorsal series of USNM 11976, it is fortunate that four consecutive posterior dorsals of a mature individual were associated with the skeletal remains of USNM 23058. In the text that follows the vertebrae will be described under one or both of these numbers as indicated.

First Dorsal: The centrum (USNM 11976, pl. 6, fig. 6) is more massive and thicker than that of the seventh cervical. The vertical diameter of the centrum anteriorly is 88 mm. Although the transverse process (diapophysis) is broken off on both sides (pl. 5, fig. 1) near its origin, the remnant preserved shows that each process arises partly from the neural arch and partly from the dorsoexternal angle of the centrum. Furthermore, the basal portion of the neural arch (neurapophysis) preserved on the right side indicates that the forward curvature of the upper transverse process was apparently more accentuated than that of the seventh cervical. At the base of the anteroposterior diameter of the pedicle (neurapophysis) of the neural arch does not exceed 25 mm., and the transverse diameter of the neural canal on its floor was 80 mm. A fairly large articular facet with elevated margins is located on the lower posteroexternal angle of the centrum for the accommodation of the capitulum of the following or second rib.

Second Dorsal: The rather slender transverse process (diapophysis) of this dorsal (USNM 11976, pl. 5, fig. 4) is continuous at its thickened base with the pedicle of the neural arch and the dorsoexternal angle of the centrum, and is projected forward and outward. In cross section the left diapophysis (pl. 6, fig. 2) is compressed anteroposteriorly and the articular facet on its extremity for reception of the tuberculum of the second rib is narrow and nearly vertical in position. The distance between the ends of the opposite diapophyses is estimated to be 290 ± mm. The centrum is larger, both in breadth (118 mm.) and thickness (47.5 mm.) than the first dorsal. The left pedicle of the neural arch is low, widened transversely and measures 26 mm. anteroposteriorly. The transverse diameter of the neural canal is 82 mm. On the left side the elongated, concave prezygapophysial facet measures 60 mm. in length and 23 mm. in width. The facet (pl. 6, fig. 7) for the capitulum of the third rib is smaller than that on the preceding dorsal.

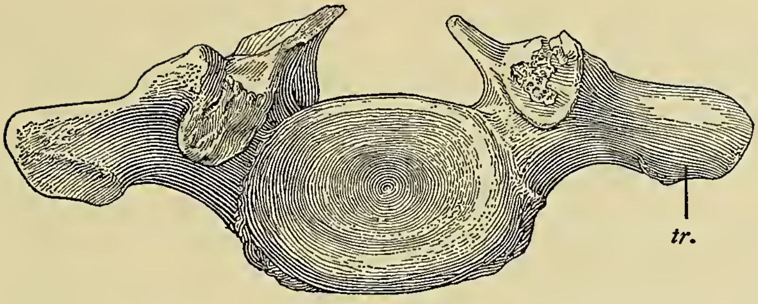


Figure 13.—Anterior view of third dorsal, USNM 11976, of *Pelocetus calvertensis*. Abbr.: tr., transverse process.

Third Dorsal: This dorsal (pl. 5, fig. 2) is notably larger and more massive than the second dorsal. A marked increase occurs in the dimensions of the diapophysis which projects outward and is inclined obliquely forward, its dorsal profile sloping to the extremity. The thickened basal portion of the right diapophysis (fig. 13) likewise arises from the transversely broadened pedicle (right, width 54 mm.) of the neural arch and the dorsoexternal angle of the centrum. The concave articular facet (length, 50 mm.) on the extremity of the diapophysis for reception of the tuberculum of the rib is elongated and is directed obliquely from above and in front downward and backward. The distance between the ends of the opposite diapophyses is 292 mm. The left pedicle of the neural arch measures 35 mm. anteroposteriorly at its base. The elongated prezygapophysial facet (pl. 6, fig. 3) is deeply concave in an anteroposterior direction, shallowly concave from side to side, and slopes obliquely inward and downward from its outer margin, The left metapophysis is a bluntly pointed anterior projection. The neural canal near its floor measures 75 mm. transversely. The anteroposterior increase in the thickness of the centrum (58 mm.) is proportionately greater than the increase in its transvese diameter anteriorly. The flattened facet (pl. 6, fig. 8) for the capitulum of the fourth rib is flush with the posterior face of the lateral surface of the centrum.

Fourth Dorsal: A less noticeable increase in the thickness (67 mm.) of the centrum (pl. 6, fig. 4) of the fourth dorsal (USNM 11976) is observable and but very little if any change in the dorsoventral diameter (82 mm.) of the centrum anteriorly. The most marked change is seen in the shortening of the robust diapophysis (fig. 14) which is projected more outward and less forward and its dorsal profile is more nearly horizontal. On the dorsoventrally thickened extremity of the diapophysis the concave facet for reception of the tuberculum of the fourth rib is almost horizontal and measures 42 mm. in length. At the base this transverse process is similar to that of the preceding vertebra. The thickened pedicle of the neural arch measures 42 mm. anteroposteriorly and the minimum transverse diameter of the combined pedicle of the neural arch and the diapophysis is 50 mm. Near its floor the neural canal (pl. 5, fig. 5) measures 68 mm. transversely and although the roof is incomplete the neural canal seems to have been wider than high. The prezygapophysial facets are shallowly concave and broader anteriorly than posteriorly. The metapophyses are not developed as distinct entities. The margins of the facet (pl. 6, fig. 9) for the capitulum of the fifth rib, which is located on the posterodorsal border of the lateral surface of the centrum, are elevated above the adjoining surface.

Fifth Dorsal: Not represented.

Sixth Dorsal: The narrowing of the distance between the outer margins of opposite prezygapophysial facets on the second, third, and fourth dorsals has been rather uniform. Hence the reduction of the same measurement to 91 mm. on the dorsal (USNM 11976, pl. 6, fig. 5) regarded as the sixth from the measured gap of 126 mm. on the fourth dorsal and the 140 mm. gap on the third dorsal seems to confirm the absence of the fifth dorsal from the series that were excavated.

This sixth dorsal has a rather wide neural spine which measured at least 85 mm. anteroposteriorly at the base. The distance between the ends of opposite diapophyses is 222 mm., a marked decrease from the 258 mm. measurement for the fourth dorsal. The centrum of this sixth dorsal

Figure 14.—Anterior view of fourth dorsal, USNM 11976, of *Pelocetus calvertensis*. Abbr.: tr., transverse process.

has slightly increased its anteroposterior diameter (73.5 mm.) and its depth anteriorly (85 mm.). The pedicles (neurapophyses) of the neural arch continue to be massive and relatively low in height and measure 38 mm. both anteroposteriorly and transversely. The width (57 mm.) of the neural canal is almost twice the vertical diameter (30 mm.) anteriorly. The anteroposteriorly widened diapophysis now projects outward and obliquely forward mainly from the pedicle of the neural arch and bends upward slightly toward its outer end. A shallow concave facet occupies the truncated outer end of this dorsoventrally compressed transverse process for articulation with the tuberculum of the sixth rib. The anterior ends of both metapophyses are broken off; the concave prezygapophysial articular facets are extended backward beyond the anterior margin of the neural arch and anteriorly slope rather steeply from external to internal margins. The postzygapophysial facets (pl. 6, fig. 10) are elongated, slope obliquely downward from outer to inner margins and project backward beyond the level of the posterior face of the centrum. As noted for the fourth dorsal, the margins of the facet for the capitulum of the seventh rib are elevated above the adjoining lateral surface of the centrum.

Seventh Dorsal: This dorsal (USNM 11976) exhibits a general increase in the length (81.5 mm.) of the centrum as well as the anteroposterior diameter of the neural arch at the base of the neural spine. The dorsoventrally compressed diapophysis (pl. 7, fig. 4) is bent more strongly upward than on the sixth dorsal and the distance between the ends of the opposite processes is 211 mm. At the end of each diapophysis is an elongated (50+ mm.) concave facet for tuberculum of the seventh rib. The transverse diameter (52 mm.) continues to exceed the vertical diameter (35 mm.) of the neural canal anteriorly. The low pedicle of the neural arch measures 44 mm. anteroposteriorly and 39 mm. transversely. With the exception of the posterior 30 mm. of the right facet, both prezygapophysial surfaces as well as both metapophyses are destroyed on this vertebra. Viewed from the side the neural spine is rather broad, its anterior margin more nearly vertical than its posterior margin; the spine measures 73 mm. anteroposteriorly below its broken-off extremity. The left postzygapophysial facet (pl. 8, fig. 3) is elongated, slopes obliquely from outer to inner margins and projects at least 35 mm. beyond the level of the posterior face of the centrum. It is obvious that such projecting articular surfaces are clasped by the prezygapophysial facets of the following dorsal so securely that little lateral motion by these vertebrae seems possible. The facet (pl. 9, fig. 1) for the capitulum of the eighth rib is located on a somewhat more prominent protuberance than on the sixth dorsal.

Eighth Dorsal: The disparity between the length (90 mm.) of the centrum of this dorsal (USNM 11976) and the corresponding measurement (81 mm.) of the seventh dorsal is less noticeable than the somewhat abrupt decrease in the gap between the prezygapophysial facets. The broad (minimum breadth, 61 mm.) dorsoventrally compressed diapophysis (fig. 15b) projects outward and slightly upward from the pedicle (neurapophysis) of the neural arch. Each diapophysis differs very slightly in position from those on the seventh dorsal, but is noticeably broader. On the outer end of the diapophysis the horizontally elongated (70 mm.) concave facet for the tuberculum of the eighth rib has an arcuate upper margin. The distance between the ends of the opposite diapophyses is 216 mm. The left metapophysis is sufficiently preserved to show that is was attenuated and projected considerably beyond the level of the anterior face of the centrum. The prezygapophysial facets (pl. 8, fig. 1) are deep concavities which extend backward at least 30 mm. beyond the anterior basal edge of the neural spine. Narrowing of the gap between the prezygapophysial facets has become quite pronounced, the distance between outer margins of opposite articular facets is 62 mm. The transverse diameter (48 mm.) is greater than the vertical diameter (35 mm.) of the neural canal (pl. 7, fig. 2) anteriorly. The pedicles (neurapophyses) of the neural arch (fig. 15a) are still massive and thick, measuring 41 mm. anteroposteriorly and 52 mm. transversely. Although the eroded anterior border imparts a deceptive profile, the broad neural spine (fig. 15b) projected more upward than backward, notwithstanding the concave curvature of its posterior edge. The elongated (52 mm.) postzygapophysial facet on the backwardly projecting neural arch is fairly complete on the left side and extended at least 25 mm. beyond the level of the posterior face of the centrum. The facet (pl. 9, fig. 2) for the reception of the capitulum of the ninth rib has a kidney shaped outline and is located on a prominent protuberance on the posterodorsal angle of the lateral face of the centrum.

Ninth Dorsal: Inasmuch as the eighth dorsal has a large protuberant articular facet on the posterodorsal angle of the centrum, the ninth dorsal (USNM 23058) necessarily possessed a rib with a fairly long neck, a well developed capitulum and a tuberculum which articulated with the extremity of its transverse process, as well as a centrum of equal length or slightly longer than that of the preceding dorsal.

From the first to the eighth dorsal inclusive, the transverse process (diapophysis) projects laterally mainly from the thickened pedicle (neurapophysis) of the neural arch and does not materially shift its relative position. On the ninth dorsal (pl. 12, fig. 2), however, the markedly widened, dorsoventrally flattened and distally upturned transverse process (parapophysis) projects outward from the dorsoexternal surface of the centrum. A rugose and excavated surface for the attachment of the tuberculum of the ninth rib is present. The distance between the ends of the opposite transverse processes (pl. 11, fig. 1) is 290± mm. on this vertebra. Although both metapophyses are incomplete, the remnants remaining show that they projected forward beyond the level of the anterior face of the centrum; the gap between them is quite narrow. The prezygapophysial facets were obviously greatly reduced in size. The transverse diameter (56 mm.) is greater than the vertical diameter (48 mm.) of the neural canal anteriorly.

The pedicles of the neural canal measure 67 mm. anteroposteriorly, but are quite thin. The broad neural spine (pl. 11, fig. 1), truncated abruptly distally, projects more upward than backward, and rises 147 mm. above the roof of the neural arch. The backwardly projecting dorsal portion of the neural arch is eroded and seemingly did not possess postzygapophysial articular surfaces although it extended beyond the level of the posterior face of the centrum.

The length of the centrum (104 mm.) is less than its transverse diameter (118.5 mm.) anteriorly. The outline of the anterior end of the centrum (pl. 12, fig. 2) continues to be subcordate, flattened dorsally. No facet for the capitulum of the following rib exists either anteriorly or posteriorly on the lateral surface of the centrum.

Ten Dorsal: The tenth dorsal (USNM 11976) associated with the skull, aside from small excrescences on the centrum, shows the effects of spondylitis deformans mainly in the deformation of the extremity of the transverse processes. Each transverse process (minimum width, 68 mm.) is inclined slightly upward toward its outer end which bears a deep horizontal depression (pl. 9, fig. 3) for articulation with the head of the corresponding rib. The distance (262 mm.) between the ends of the opposite transverse processes (pl. 8, fig. 2) is much greater than on the eighth dorsal (USNM 11976) and the neural canal (fig. 16a) has diminished in width (42 mm.) and in height (32 mm.) anteriorly. The pedicle of the neural arch has become quite thin (minimum thickness, 15 mm.) and widened anteroposteriorly (60 mm.). Although largely destroyed on this dorsal, the metapophyses (pl. 8, fig. 2) were compressed from side to side and their dorsal edge has its origin some 33 mm. behind the notch or gap between the prezygapophysial facets. Only remnants of the prezygapophysial facets are preserved; on both sides they are usually narrow and are separated by a small U-shaped notch (width, 17 mm.). The postzygapophysial facets (fig. 16b) are destroyed as is the backwardly projecting dorsal portion of the neural arch. The broad neural spine (fig. 16b) is relatively high, rising 197 mm. above the roof of the neural canal and slanting slightly backward. Unfortunately, the anterior and posterior edges of the neural spine are eroded.

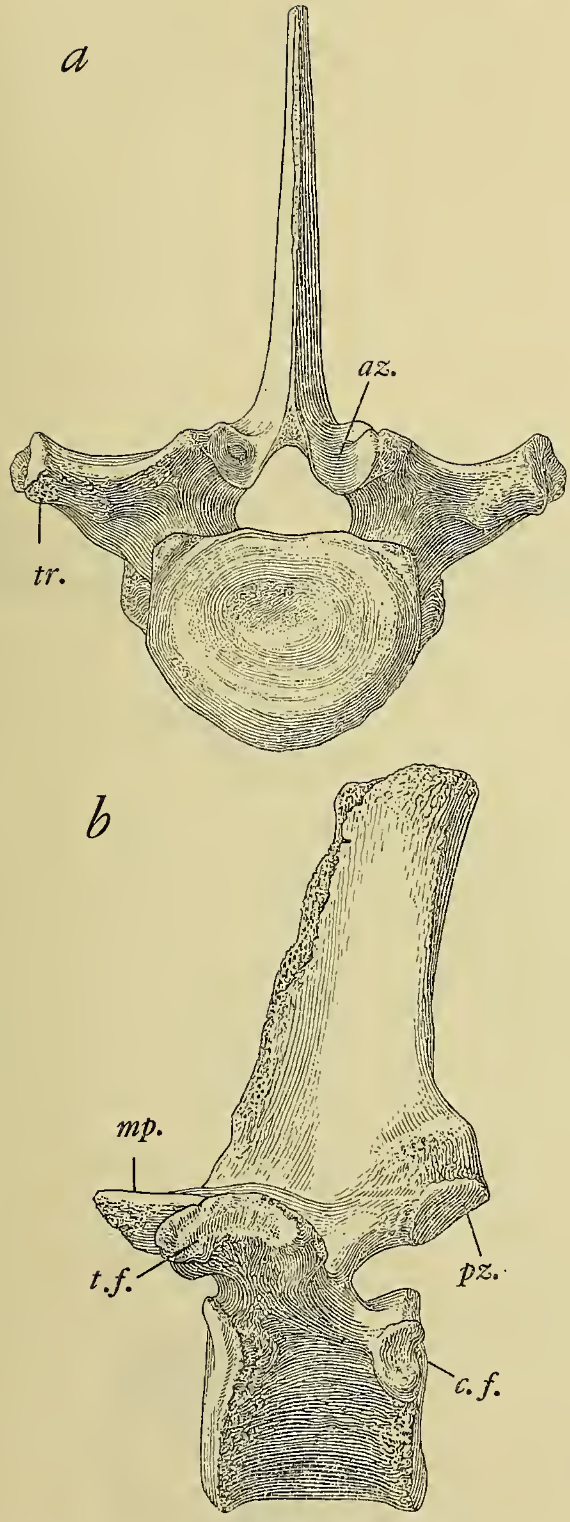


FIGURE 15.—Views of eighth dorsal, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: az., prezygapophysial facet; c.f., facet for capitulum; mp., metapophysis; pz., postzygapophysial facet; t.f., facet for tuberculum; tr., transverse process.

The centrum of the tenth dorsal (USNM 23058) in the referred vertebral series is slightly larger (length, 110 mm.) than the preceding (length, 103.5 mm.). Although fully adult (pl. 12, fig. 1), both epiphyses being ankylosed to the centrum, no malformation is present. The outline of the anterior end of the centrum is subcordate, flattened dorsally, and the lateral surfaces are deeply concave. On the right side, the transverse process (pl. 11, fig. 2) is complete; it is more noticeably widened (minimum width, 63 mm.) and expanded distally (96 mm.) than that of the preceding vertebra. The elongated but narrow extremity of this process is roughened for the attachment of the head of the tenth rib. The width (46 mm.) and height (45 mm.) of the neural canal anteriorly are approximately equal. The pedicle of the neural canal is very thin (7 mm.), but measures 67 mm. anteroposteriorly.

Eleventh Dorsal: This dorsal (USNM 11976) is noticeably malformed in consequence of spondylitis deformans. Longer transverse processes (parapophyses) with increased horizontal enlargement, slightly longer centrum, and a narrower neural canal distinguish this dorsal (pl. 7, fig. 3) from the preceding vertebra. Although a perceptible increase in the length (107 mm.) of the centrum is observable, the width (120 mm.) of its posterior face as compared to the width (112 mm.) of the anterior face has not been materially altered. The distance (312 mm.) between the ends of the opposite transverse processes (pl. 8, fig. 4) is considerably greater than that of the preceding dorsal. Each transverse process (parapophysis) projects outward from the upper portion of the lateral surface of the centrum below the level of the base of the neural arch and at a lower level than on the preceding dorsal. Each parapophysis is compressed dorsoventrally (right, minimum anteroposterior diameter, 56 mm.) and is expanded horizontally distally and also thickened to provide an increased area for the attachment of the singleheaded rib. The minimum anteroposterior diameter (62 mm.) of the laterally compressed pedicle of the neural arch does not differ materially from the corresponding measurement (60 mm.) of the preceding vertebra. The neural canal anteriorly is slightly higher (39 mm.) than wide (38 mm.). The extremities of both metapophyses are broken off as well as the prezygapophysial facets, if present. The backwardly projecting dorsal portion of the neural arch is likewise missing. An abnormal development of a large osseous projection (pl. 9, fig. 4) on the posterior half of the ventral face of the centrum has resulted in an unusual malformation of this vertebra.

This vertebra (USNM 23058) is represented in the referred series. The outline of the anterior end of the centrum (pl. 12, fig. 3) is less noticeably subcordate, and the lateral surfaces remain deeply concave. This vertebra is characterized in part by the wide transverse processes (minimum width, 65 mm.) which are strongly expanded distally

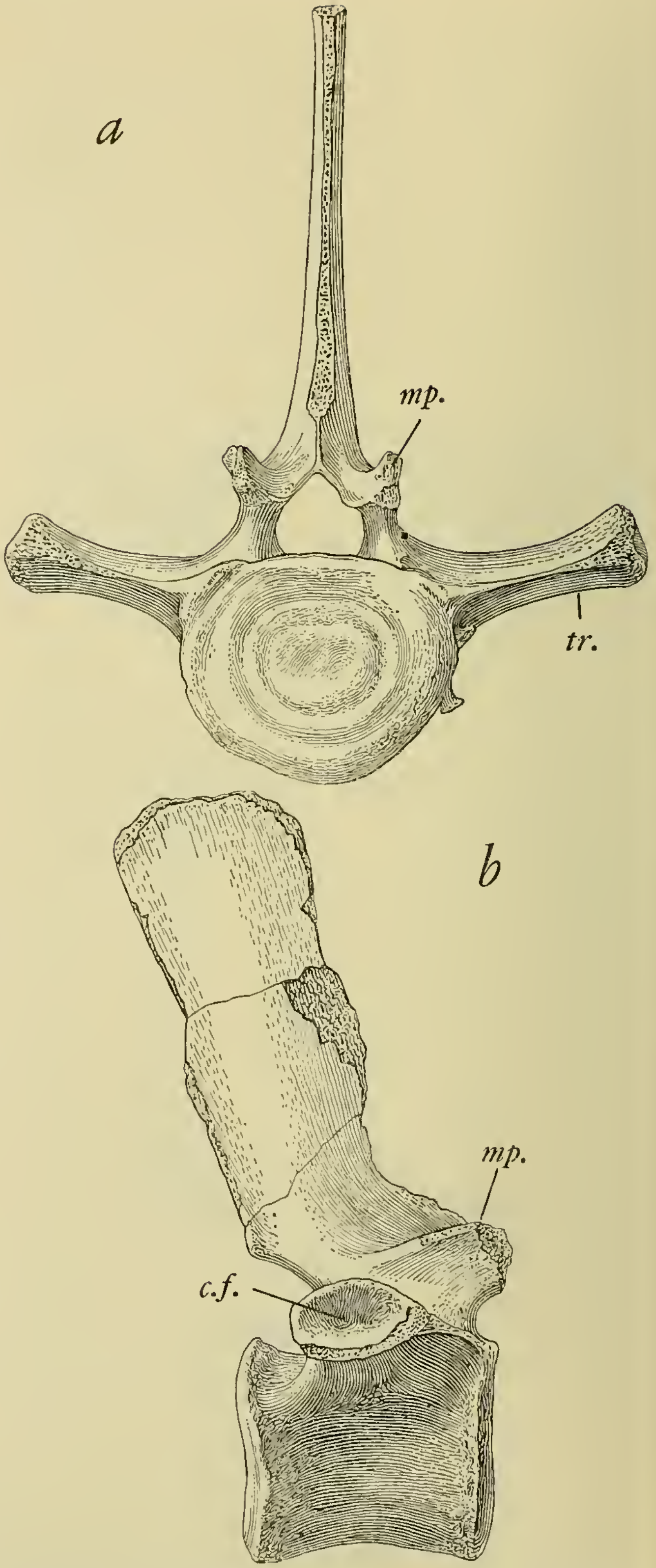


Figure 16.—Views of tenth dorsal, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: c.f., facet for capitulum; mp., metapophysis; tr., transverse process.

USNM 11976–Dorsal Vertebrae:	*D.1*	*D.2*	*D.3*	*D.4*	*D.6*	*D.7*	*D.8*	*D.10*	*D.11*
Anteroposterior diameter of centrum	41.5	47.5	58	67	73.5	81	90	103.5	107
Transverse diameter of centrum anteriorly	112	118	117	115	113.5	111.5	110.5	112	112
Vertical diameter of centrum anteriorly	91	84	80	83	84	85	86	93	90
Tip of neural spine to ventral face of centrum	—	—	—	—	176+	248+	298	313	—
Minimum anteroposterior diameter of pedicle of neural arch	—	26	35	41	40	45	51	62.5	62
Transverse diameter of neural canal	80	82	75	68	57	54	53	42	38
Distance between ends of diapophyses	—	254+	292	258	222	211	216	—	—
Distance between ends of transverse processes	—	—	—	—	—	—	—	262	312
Dorsal face of metapophysis to ventral face of centrum	—	103	110	106	107	—	131	134+	—

(width, 106 mm.). The anterior one-half of the extremity of this process is quite thin, markedly compressed dorsoventrally in contrast to the thickened posterior 50 mm. of the articular end which attains a maximum thickness of 24 mm., to which is attached the head of the corresponding rib. The distance (375 mm.) between the ends of the opposite transverse processes (pl. 11, fig. 3) is considerably greater than that of the preceding dorsal in the referred series. The minimum anteroposterior diameter (70 mm.) of the laterally compressed pedicle of the neural arch represents a slight increase over that of the preceding dorsal. The height and width of the neural canal anteriorly are approximately equal (45 mm.). The neural spine has increased slightly in height, but no postzygapophysial facets are developed on the backwardly projecting dorsal portion of the neural arch. This backward slanting neural spine (pl. 11, fig. 7) is broad, its posterior profile convex, and its anterior profile more nearly straight. Presumably this neural spine was truncated at its extremity in conformity with that of the twelfth dorsal.

Twelfth Dorsal: The occurrence of a twelfth rib among the ribs associated with the skeletal remains (USNM 11976) justifies the inclusion of a twelfth dorsal in this series of vertebrae, although this vertebra was not included among those associated with the skull.

The twelfth dorsal (USNM 23058) of the referred series is the largest of the thoracic vertebrae and possesses the highest neural spine (pl. 11, fig. 8) and the longest transverse processes. The distance (436 mm.) between the ends of the opposite broad transverse processes (pl. 11, fig. 4) has increased over that of the preceding dorsal, although the roughened extremity of the process is narrower (79 mm.) and not quite so thick (20 mm.). Nevertheless, the area for the cartilaginous attachment of the twelfth rib may have been restricted to the posterior half of this extremity. Both transverse processes project outward nearly horizontally.

The width and height of the neural canal anteriorly are equal (42 mm.). The pedicles of the neural arch are thin and measure approximately 74 mm. anteroposteriorly. Both metapophyses are incomplete, but the left process is sufficiently preserved to show that it projected forward beyond the level of the anterior face of the centrum. The gap between the opposite metapophyses is narrow and may have been adequate for clasping the backwardly projecting portion of the neural arch and base of the neural spine. The broad neural spine (pl. 11, fig. 8) is inclined backward, truncated abruptly at its extremity and rises 170 mm. above the roof of the neural canal.

The outline of the anterior end of the centrum (pl. 12, fig. 4) is more ovate than subcordate, and the lateral surfaces are deeply concave. The transverse diameter (124 mm.) of the posterior end of the centrum exceeds very slightly that (121 mm.) of the anterior end.

Measurements (in mm.) of dorsal vertebrae of USNM 11976 are tabulated above.

Measurements (in mm.) of dorsal vertebrae of USNM 23058 are tabulated below.

USNM 23058–Dorsal Vertebrae:	*D.9*	*D.10*	*D.11*	*D.12*
Anteroposterior diameter of centrum	104	110	114	119
Transverse diameter of centrum anteriorly	118.5	118.5	121	122
Vertical diameter of centrum anteriorly	96	98	98.5	102
Tip of neural spine to ventral face of centrum	285	292±	302±	324
Minimum anteroposterior diameter of pedicle of neural arch	67	67	70	74
Transverse diameter of neural canal	56	46	45	42
Distance between ends of transverse processes	290±	345±	375	436
Dorsal face of metapophysis to ventral face of centrum	155	158±	168±	165±

Lumbar vertebrae.—Eight lumbar vertebrae (USNM 11976) were associated with the skeleton of this cetothere, although for one only the neural spine was recovered. The epiphyses are ankylosed to the centra of all the lumbars. Five consecutive lumbars (fig. 19) are firmly bound together by an advanced stage of spondylitis deformans or osteophytosis (Tobin and Stewart, 1952, p. 407), the ankylosed osseous outgrowths protruding ventrally in a continuous band along the under side of these centra. The ossification of the longitudinal ligaments of this portion of the vertebral column and this bony bridging effectively prevented spinal motion during life. When arranged in serial sequence the centra in this series progressively increase in length, which exceeds slightly their width, respectively, although the true measurement is masked by this external exostosis. The usual ventral longitudinal keel or carina is malformed by bony excrescences. The dorsoventrally compressed transverse processes (parapophyses) are widened beyond the middle of their length and possess rounded distal ends. These transverse processes decrease in length from the fourth to the ninth in the series.

The neural canals are higher than wide anteriorly and decrease in width from the second to the ninth. Neither pre- nor post-zygapophysial facets are developed on these lumbars. The elongated thin lamina-like metapophyses are large, well-developed processes that project upward and forward from the neural arch and are also inclined obliquely outward from ventral to dorsal edges. They do not embrace tightly the rather narrow backwardly projecting dorsal portion of the neural arch of the preceding vertebra which on the anterior lumbars extends slightly beyond the level of the posterior face of the centrum. The opposite metapophyses are separated ventrally in front of the base of the neural spine by a gap varying from 20 mm. to 30 mm.

Viewed from the side, the neural spines are relatively broad and high, and are inclined slightly backward. Either the anterodistal or the posterodistal angle of the neural spine may project beyond the general inclination of the corresponding edge.

A smaller lumbar vertebra (length of centrum, 106 mm.; transverse diameter anteriorly, 105.5 mm.), with somewhat shorter and narrower transverse processes, fortuitously associated with the skeletal remains (USNM 11976) is referred to another Calvert cetothere.

Seven consecutive lumbar vertebrae (USNM 23058) of a fully mature individual, all epiphyses being firmly ankylosed to the centra, are included in the vertebral series of this referred specimen, which supplements the skeletal material obtained in 1929. The usual longitudinal keel or carina is not developed on the ventral face of the centra of the anterior four of these vertebrae, although it is faintly indicated on the third (or fourth); it is quite distinct on the fifth, sixth, and seventh lumbars. No vestige of an area for possible cartilaginous attachment of the head of a rib is discernible on the extremities of the transverse processes of these four anterior vertebrae here referred to the lumbar series. Inasmuch as these seven lumbars were excavated in their natural sequence following the four posteriormost dorsals, the descriptions that follow will be based primarily on them. No indication of malformation resulting from occurrence of spondylitis deformans was observed on any of the seven vertebrae. The lumbars of USNM 11976 will be allocated to their assumed position in the normal sequence.

First Lumbar: It is apparent that the first lumbar is not represented among the lumbars of USNM 11976 inasmuch as none of them seem to meet the structural requirements of the first vertebra in this portion of the vertebral column. It seems to be the general rule among mysticetes that the anteroposterior diameter of the pedicle of the neural arch of the first lumbar is gradually and not abruptly increased over that of the posterior dorsal vertebrae.

The most obvious alteration in anterior lumbars is the progressive dorsoventral compression of the transverse process (parapophysis) which contines to project outward from the external face of the centrum at approximately the same level as on the twelfth dorsal. The absence of an attached rib-end eliminates any necessity for a thickening of this process.

The first lumbar (USNM 23058) of the referred series has a slightly longer (122 mm.) centrum than the twelfth dorsal, and the distance (480 ± mm.) between the ends of the opposite transverse processes has increased noticeably. The right transverse process (pl. 13, fig. 1) is incomplete; the distal half of the anterior border as well as the extremity of the left process are eroded, and consequently the present oblique truncation may not be accurately shown. Except for the basal portions of the pedicles, the neural arch, the neural spine and the metapophyses were missing when this vertebra was excavated. The pedicles of the neural arch extend more than three-fourths of the length of the centrum. The transverse diameter of the neural canal anteriorly is 44 mm.

The outline of the anterior face of the centrum is more nearly circular (though flattened dorsally) than subcordate. The lateral and ventral surfaces are deeply concave and no ventral longitudinal carina or keel is visible. A low longitudinal ridge is present on floor of the neural canal.

Second Lumbar: This vertebra (USNM 23058) in the referred series was not completely preserved when found. All of the neural arch except the basal portions of its pedicles and the lower half of the neural spine were not preserved, although the basal portions of both metapophyses were found. The centrum of this lumbar is slightly longer (125 mm.) than the first lumbar and the outline of the anterior end is quite similar. The lateral and ventral surfaces of the centrum are deeply concave; no median longitudinal ventral keel is developed and no visible longitudinal ridge is present on the floor of the neural canal.

Portions of both dorsoventrally compressed transverse processes (pl. 13, fig. 2) are missing. The borders of the right process are sufficiently complete to indicate that the distal end was not widened perceptibly. This process resembles that of the first lumbar in being somewhat narrower than those of the succeeding lumbars.

The base of the thin right pedicle of the neural arch occupies slightly more than two-thirds of the length of the centrum. The neural spine (pl. 13, fig. 6) apparently had not noticeably increased in width; the distal extremity is strongly truncated.

Third Lumbar: The third lumbar in the referred series (USNM 23058) is the first to exhibit the tendency toward a distal widening of the transverse process. For this reason, the anterior lumbar (USNM 11976) whose transverse process (pl. 10, fig. 1) is noticeably compressed dorsoventrally, widened beyond the middle of its length, and rounded at the extremity is regarded as the third. The anterior margin of this process is convexly curved, but its posterior edge is more nearly straight. The distance between the ends of the opposite transverse processes is 440 mm. The pedicles (neurapophyses) of the neural arch are compressed from side to side, extend more than half the length of the centrum, and measure anteroposteriorly 67 mm. (minimum). The neural canal (fig. 17a) anteriorly is higher (40 mm.) than wide (35 mm.). A strong median longitudinal ridge extended the length of the floor of the neural canal. Neither pre- nor postzygapophysial facets are present. Although both metapophyses (fig. 17b) are broken off, their basal remnants show that they were compressed from side to side and project upward and forward from the neural arch beyond the level of the anterior face of the centrum. The broad neural spine projects upward 162 ± mm. above the roof of the neural canal and is inclined backward. The anterior border of the neural spine is, however, incomplete, particularly the anterodistal angle.

The centrum of this lumbar is longer (116 mm.) and slightly wider (114 mm.) than the tenth dorsal (corresponding measurements, 107 and 112 mm.). The usual ventral longitudinal keel on the centrum, if originally present, has been obliterated by exostosis, which has resulted in the formation of a rather large osseous protuberance on the posterior end of the ventral surface.

The third lumbar in the referred series (USNM 23058) has a narrow (39 mm.) and high (47 mm.) neural canal, and the pedicles of the neural arch occupy almost 68 percent of the length of the centrum. Although the extremities of both metapophyses are missing, the preserved remnants project forward beyond the level of the anterior end of the centrum. The backward projecting dorsal portion of the neural arch and the adjoining basal portion of the neural spine are broken off. The thin backward slanting neural spine (pl. 13, fig. 7) projects 188 mm. above the roof of the neural canal.

The outline of the anterior end of the centrum is similar to that of the second lumbar, the lateral surfaces are deeply concave, and a low rounded ventral longitudinal keel is discernible. Each dorsoventrally compressed transverse process (pl. 13, fig. 3) projects outward from the lateral surface of the centrum but is bent forward to such an extent that its anterodistal angle extends forward beyond the level of the anterior face of the centrum.

Fourth Lumbar: The shape, dimensions, and backward inclination of the detached neural spine (USNM 11976, pl. 10, fig. 3) conform to the anticipated general characteristics of the fourth in the lumbar series. This rather broad (anteroposterior diameter at base, 96 mm.) neural spine projects upward 205 mm. above the roof of the neural canal and is obliquely truncated at its extremity. Both anterior and posterior edges are slightly curved; the anterodistal angle is prominent and projects forward. Both metapophyses are broken off at the base, but originate in the same relative position as on the second lumbar, although the internal gap between them (37 mm.) seems to be reduced.

On the fourth lumbar of the referred series (USNM 23058) the dimensions of the neural canal are approximately the same as those of the third lumbar. The thin pedicles of the neural arch occupy 67 percent of the length of the centrum. The left metapophysis although eroded projects forward beyond the level of the anterior end of the centrum and presumably clasped the backwardly projecting basal portion of the neural spine of the preceding lumbar. The dorsal portion of the neural arch is incomplete on both sides. The width of the backward slanting neural spine (pl. 13, fig. 8) is approximately the same as that of the preceding lumbar and the distal end is rounded. The neural spine projects 194 mm. above the roof of the neural canal.

On the right side the transverse process (pl. 13, fig. 4) is broken off near its base; on the left side the anterior and posterior borders of this process are missing. This transverse process is strongly inclined forward and its distal end is rounded.

Fifth Lumbar: Longer transverse processes, higher neural spine, narrower neural canal, and more robust metapophyses distinguish this lumbar from the third in this series (USNM 11976). The broad (minimum diameter, 68 mm.) transverse processes (pl. 10, fig. 2) are directed outward and slightly forward, and noticeably increase in width toward their extremities. The distance between the ends of the opposite transverse processes is 470 mm. The anterior edge of each process is more strongly curved

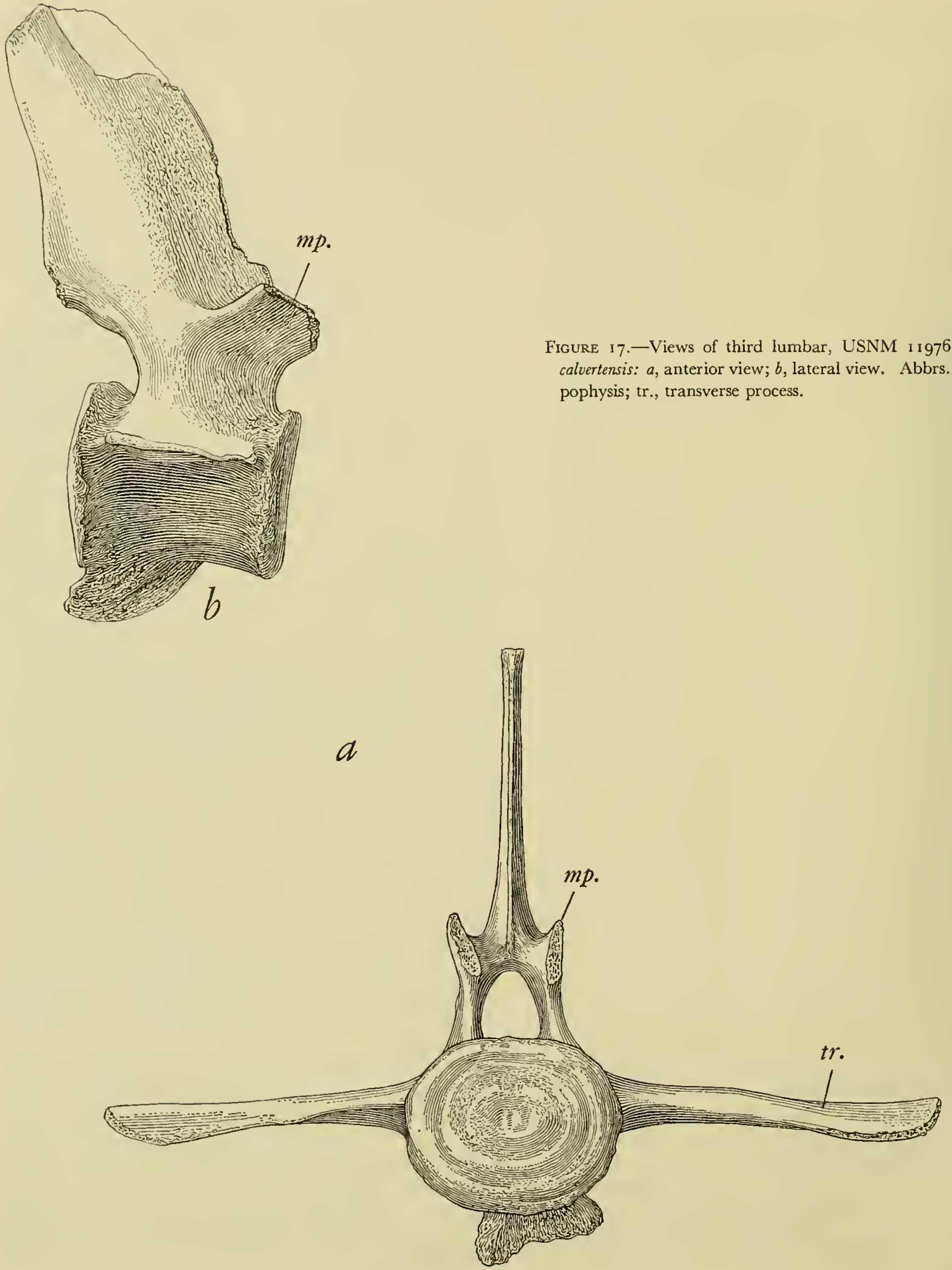
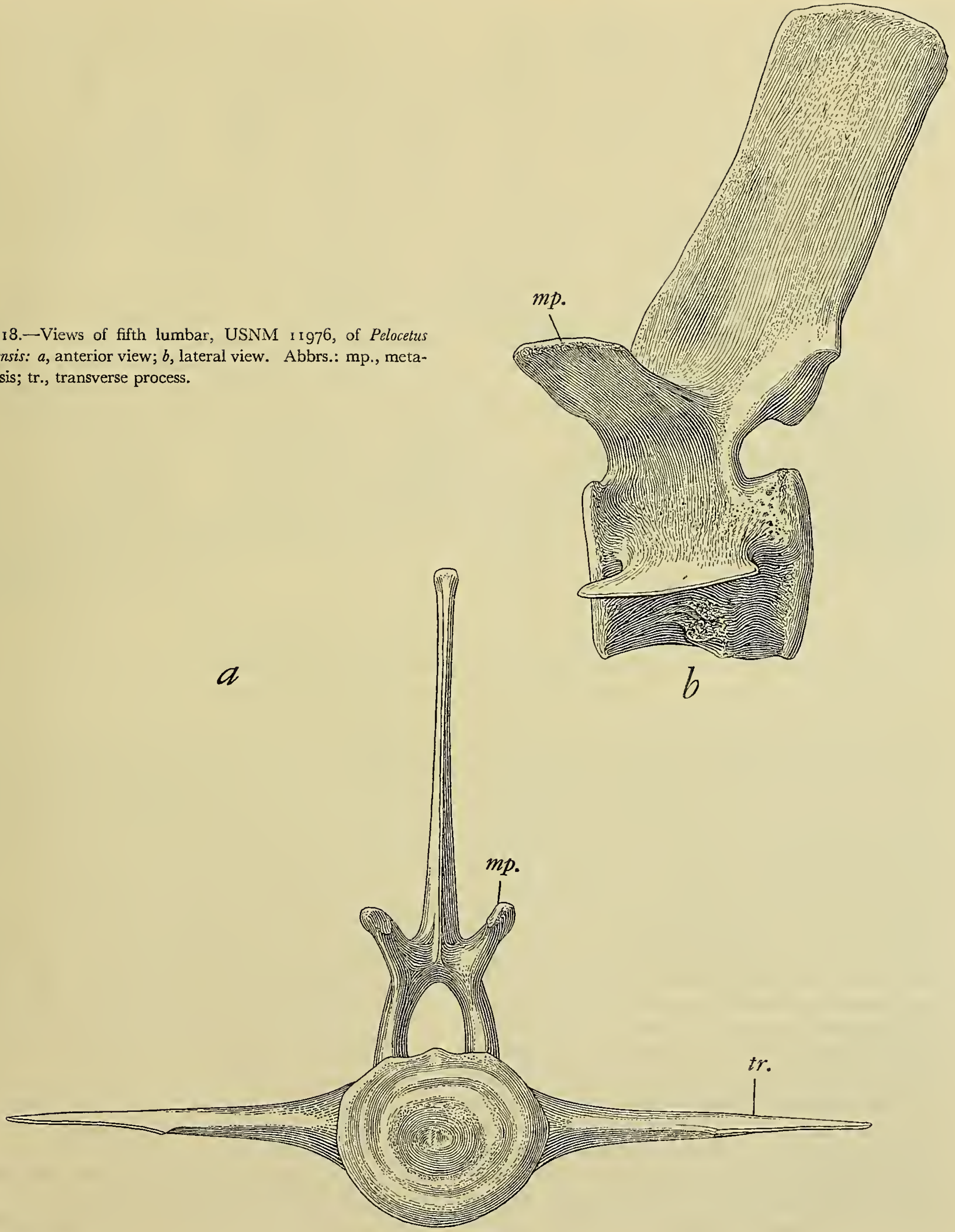


Figure 17.—Views of third lumbar, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

FIGURE 18.—Views of fifth lumbar, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.



than the posterior. The pedicles of the neural arch do not differ materially from those of the third lumbar (minimum anteroposterior diameter, 71 mm.). The neural canal (fig. 18a) anteriorly is higher (36 mm.) than wide (32 mm.) and a strong median longitudinal carina between rather deep paralleling grooves extends the length of the floor of the neural canal.

No vestige exists of either pre- or postzygapophysial facets. The backwardly projecting dorsal portion of the neural arch (fig. 18b) projects very little if at all beyond the level of the posterior face of the centrum, and obviously could not have been firmly clasped by the metapophyses of the next lumbar. The elongated lamina-like metapophyses (pl. 10, fig. 2) are large, rather thick transversely (13 mm.), and project upward and forward at least 30 mm. beyond the level of the anterior face of the centrum. The opposite metapophyses diverge slightly.

The neural spine (fig. 18b) is wider (103 mm.) anteroposteriorly at the base than that of the third lumbar, inclined noticeably backward, and projects upward 232 mm. above the level of the roof of the neural canal; its anterior edge is slightly curved and its posterior edge nearly straight.

Although the diameters of the anterior and posterior ends of the centrum of this vertebra are not materially different from those of the third lumbar, the centrum is longer (121.5 mm.). Bony excrescences are attached on all sides around the posterior end of the centrum.

On the fifth lumbar (pl. 14, fig. 5) of the referred series (USNM 23058) the anteroposterior diameter of the neural spine has increased and its extremity is abruptly truncated. The neural spine rises 190 mm. above the roof of the neural canal. Little if any change in the dimensions of the neural canal are visible, the width (35 mm.) and the highth (40 mm.) do not differ materially from the preceding lumbar. The thin pedicles of the neural arch occupy 71 percent of the length of the centrum. On the left side the metapophysis although slightly eroded projects forward beyond the level of the anterior face of the centrum.

Anteriorly the transverse diameter (124 mm.) of the circular end of the centrum exceeds the vertical diameter (112.5 mm.). The lateral surfaces of the centrum are deeply concave and the low, rounded longitudinal ventral keel is depressed medially. A decrease in the distance (482 mm.) between the ends of the opposite transverse processes (pl. 14, fig. 1) presumably commenced with this lumbar, although the distance (360 mm.) between the tip of the neural spine and the ventral face of the centrum increases on the sixth and seventh lumbars at least. Each transverse process is directed outward, but more strongly inclined forward than on the fourth lumbar. The extremity of this process is rounded.

Sixth Lumbar: The sixth lumbar (pl. 14, fig. 6) in the referred series (USNM 23058) lacks most of the dorsal portion of the neural arch and the metapophyses. The highth (47 mm.) of the neural canal has increased, but only a very minor decrease in the width (34 mm.) is observable. The pedicles of the neural arch occupy 69 percent of the length of the centrum. No visible median longitudinal ridge is present on the floor of the neural canal. The broad, backward slanting and squarely truncated neural spine rises 203 mm. above the roof of the neural canal. Unfortunately, the posterobasal portion of the neural spine is missing.

A slight increase in the length (136.5 mm.) of the centrum is accompanied by a minor decrease (120 mm.) in the width of the circular anterior face. The lateral faces of the centrum are deeply concave and the lower rounded ventral longitudinal keel is a little more prominent. Each transverse process (pl. 14, fig. 2) projects outward and slightly forward from the lateral surface of the centrum and is slightly widened beyond the middle of its length, but beyond that point the anterior and posterior edges curve toward the bluntly rounded extremity. The extremity of each transverse process extends forward beyond the level of the anterior end of the centrum.

Seventh Lumbar: This lumbar (pl. 14, fig. 7) is the largest vertebra in the referred series (USNM 23058). Although the posterior portion of the neural arch was not preserved, the anterior portion was continuous with the neural spine. On the right side the remaining portion of the metapophysis does not project forward beyond the level of the anterior end of the centrum. The broad neural spine exhibits a concavely curved anterior profile, a convexly curved posterior profile, and a rounded extremity. This neural spine rises 210 mm. above the roof of the neural canal. The thin pedicles of the neural arch occupy 68 percent of the length of the centrum. No obvious change is observable in the width (34 mm.) and the highth (50 mm.) of the neural canal anteriorly. No median longitudinal ridge is present on the floor of the neural canal.

The width (121 mm.) and the height (109 mm.) of the circular anterior end of the centrum are essentially the same as for the sixth lumbar. A more obvious rounded ventral longitudinal keel is developed on the centrum, but no material change is observable in the concaveness of the lateral surfaces. The transverse processes (pl. 14, fig. 3) project outward and forward from the lateral surface of the centrum at the same level as on the sixth lumbar, although the rounded distal ends do not extend as far forward beyond the level of the anterior end.

Sixth, Seventh, Eighth, Ninth, and Tenth Lumbars: These five firmly ankylosed consecutive lumbar vertebrae (fig. 19) possess long, anteroposteriorly widened and backwardly inclined neural spines that decrease slightly in

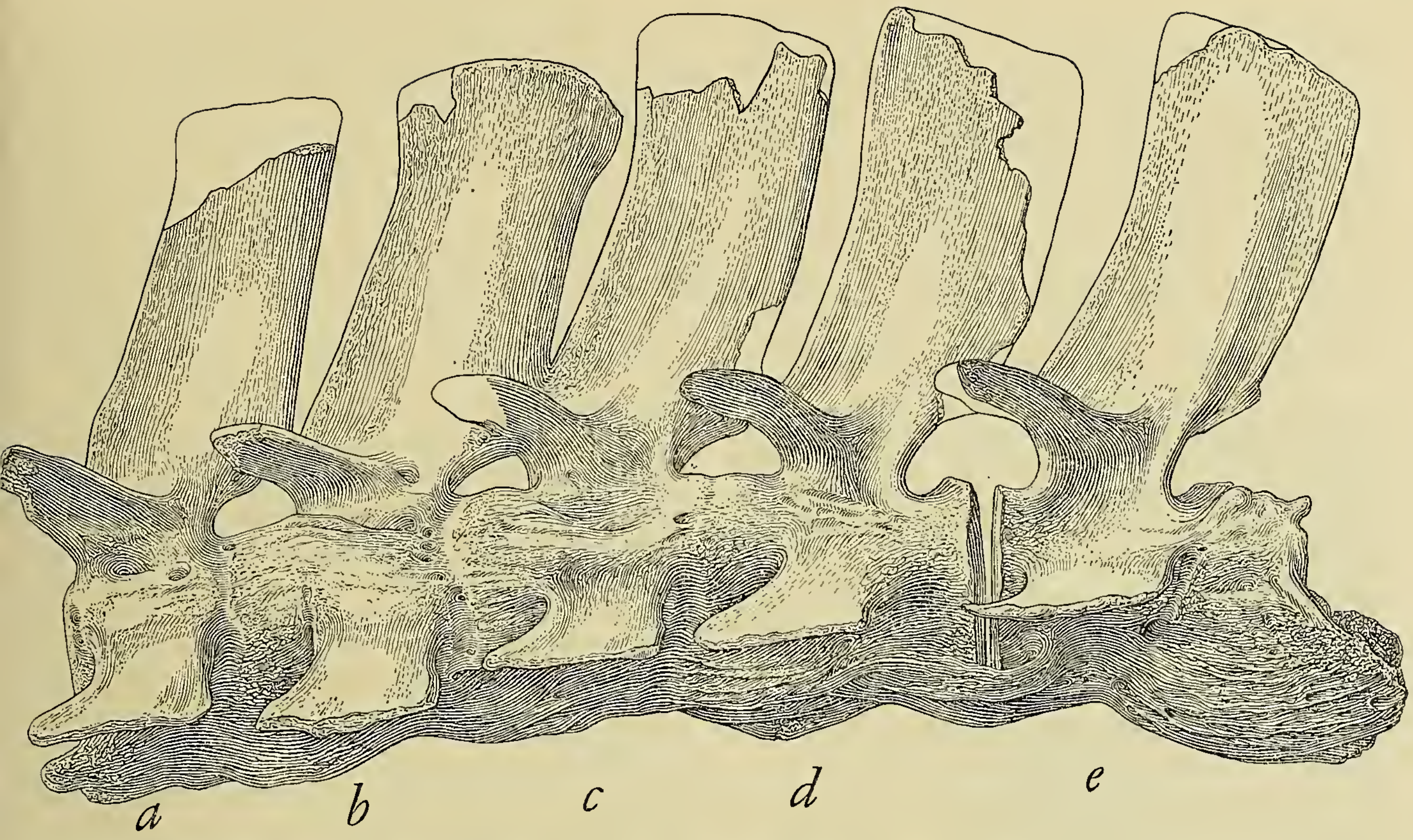


Figure 19.—Lateral views of ankylosed lumbar vertebrae, USNM 11976, of *Pelocetus calvertensis: a,* sixth lumbar; *b,* seventh lumbar; *c,* eighth lumbar; *d,* ninth lumbar; *e,* tenth lumbar.

height toward the hinder end of the series and are not uniform in width. The minimum anteroposterior diameter (110 mm.) of the neural spine of the tenth lumbar exceeds the corresponding measurement (95 mm.) of the sixth lumbar. Variable profiles are displayed when the neural spines are viewed from the side, the terminal end being rounded on the sixth and obliquely truncated on the ninth.

The metapophyses of the sixth lumbar are longer, broader and thicker than on the succeeding vertebrae, those of the tenth being rather slender. The backwardly projecting dorsal portion of the neural arch on these lumbars does not extend far enough beyond the level of the posterior end of the centrum to be tightly embraced by the metapophyses of the next vertebra, except in the case of the seventh which is thrust back against the base of the eighth's neural spine and fused with it for a depth of 60 mm. Toward the hinder end of this series of consecutive lumbars the metapophyses tend to approximate their opposites more closely and their anterior ends become slightly more elevated. On all five lumbars the metapophyses project forward beyond the level of the anterior end of the centrum.

An increase in the anteroposterior diameter of the centrum is observable from the sixth (120 mm.) to the tenth (137 mm.) as well as the width.

The neural canal is progressively reduced in width to 26 mm. on the tenth lumbar. The median longitudinal ridge on the floor of the neural canal is markedly reduced on the tenth lumbar. The pedicles (neurapophyses) of the neural arch are all compressed from side to side, but vary in minimum anteroposterior diameter from 78 mm. (sixth lumbar) to 70 mm. (eighth lumbar).

From the anterior to the posterior end of this series of five lumbars the broad and rather thin transverse processes decrease in length as well as in breadth on the distal half, but very slightly in relative position and direction. The distance between the ends of opposite transverse processes decreases from more than 420 mm. (sixth lumbar) to 365 mm. (tenth lumbar).

As mentioned previously this whale was a mature individual which displayed a far advanced stage of osteophytosis. A continuous thick irregular osseous band extends the entire length of the ventral aspect of these five consecu-

USNM 11976–Lumbar Vertebrae:	*L.3*	*L.5*	*L.6*	*L.7*	*L.8*	*L.9*	*L.10*
Anteroposterior diameter of centrum	116	121.5	120	120	132	131	137
Transverse diameter of centrum anteriorly	105.5	115.5	115.5	120	—	—	—
Vertical diameter of centrum anteriorly	93	96	98	—	—	—	130
Tip of neural spine to ventral face of centrum	317	370	360+	375	380	395	400
Minimum anteroposterior diameter of pedicle of neural arch	68.5	71	78	74	70	71	74
Transverse diameter of neural canal	35	31	29	30	30	37	33
Distance between ends of transverse processes	440	470	420+	405+	360+	325+	365
Dorsal face of metapophysis to ventral face of centrum	154.5	177	180	—	—	—	190

tive lumbars and projects also beyond the anterior end of the sixth and the posterior end of the tenth lumbar. The centra of the sixth, seventh, eighth, and ninth lumbars are completely ankylosed on the left side by an osseous bridging. On the left side a narrow gap separates the centra of the sixth and seventh as well as the seventh and eighth. Except at the ventral border and on the right side, the centra of the ninth and tenth lumbars are not in contact with each other.

Posterior Lumbar: A somewhat larger lumbar vertebra (USNM 23056) with fully ankylosed epiphyses has similarly elongated transverse processes, high neural spine, thin lamina-like metapophyses (directed more strongly upward) and rather high neural canal (60 mm.). The measurements of this lumbar are as follows: length of centrum, 154 mm.; width of centrum anteriorly, 128 mm.; and vertical height of centrum anteriorly, 118 mm. The dimensions of this lumbar indicate that this Miocene cetothere may possibly attain a length of 25 feet, assuming that the remainder of the skeleton shows a similar increase. The estimated length of the skeleton (USNM 11976) herein described is about 22 feet of which the lumbar series (i.e., 12 vertebrae) seemingly measured 1580 mm. (62 inches) as compared to possibly 1900 mm. (75 inches) for this larger individual.

Measurements (in mm.) of lumbar vertebrae of USNM 11976 are tabulated above.

Measurements (in mm.) of lumbar vertebrae of USNM 23058 are tabulated below.

Caudal vertebrae.—At least one (pl. 10, fig. 4) of the caudal vertebrae associated with the skeleton (USNM 11976) belongs to another smaller cetothere and probably is referable to the same skeleton as the small lumbar vertebra heretofore mentioned. The two small terminal caudals are, however, tentatively referred to *Pelocetus*. Five caudal vertebrae (USNM 23059) found associated with an atlas, three dorsals, one lumbar and other skeletal elements of *Pelocetus* furnish a minimum of information regarding the caudal series.

Anterior Caudal: In view of the development of the posterior haemal tubercles (haemapophyses), the posterior widening of the centrum, and the large thickened metapophyses, the largest caudal vertebra (USNM 23059) is regarded as the third or fourth in the caudal series. These posterior haemal tubercles attain their largest size on the third caudal of *Megaptera*.

The largest and most anteriorly situated of these five caudals (pl. 14, fig. 4) lacks portions of the transverse processes, the right metapophysis and the neural spine. The anterior caudals of these Calvert cetotheres usually are characterized by an enlargement of the posterior end of the centrum, resulting from the development of the posterior haemal tubercles. The transverse diameter posteriorly (160 mm.) of this caudal exceeds that (153 mm.) of the anterior end. The metapophyses are noticeably thickened, bent upward and outward, and do not project beyond the level of the anterior end of the centrum and hence did not clasp the base of the neural spine of the preceding caudal.

USNM 23058–Lumbar Vertebrae:	*L.1*	*L.2*	*L.3*	*L.4*	*L.5*	*L.6*	*L.7*
Anteroposterior diameter of centrum	122	125	127	130	132.5	136.5	139
Transverse diameter of centrum anteriorly	118	118	121	125	124	120	121
Vertical diameter of centrum anteriorly	103.5	104	108	108	112.5	110	109
Tip of neural spine to ventral face of centrum	325±	330±	353	348±	360	363	375
Minimum anteroposterior diameter of pedicle of neural arch	81	80±	75	75±	82±	84±	80
Distance between ends of transverse processes	480±	475+	492	—	482	463	445
Dorsal face of metapophysis to ventral face of centrum	175±	175±	182±	178	180	182±	192

The neural spine presumably was rather short, judging from its posterior location on the roof of the neural arch. This condition may be taken as an indication of the rapid diminution of the neural spines of the anterior caudals. The height (32 mm.) exceeds slightly twice the width (15 mm.) of the neural canal anteriorly.

The massive centrum (pl. 14, fig. 8), which measures 162 mm. anteroposteriorly, is noticeably depressed or hollowed out above and below the transverse processes. The anterior boarder and extremity of the right transverse process (pl. 14, fig. 4) is missing and the left process is broken off at the base. Both processes were broad at the base which occupies more than half the length of the centrum. On the four or five anterior caudals of some recent mysticetes the segmented blood vessels do not follow their upward course on the centrum in well defined grooves. On this Calvert caudal, however, these blood vessels obviously traversed a broad shallow groove which is directed obliquely upward and backward, commencing in front of the transverse process, to the posterior end of the neural canal. On the ventral surface of the centrum the anterior haemal tubercles although partially eroded are smaller and less protuberant than the large posterior pair which are also eroded. Medially between these haemal tubercles is the broad shallow groove or haemal canal which transmits the caudal artery and caudal vein.

Posterior Caudals: The four small terminal caudals (USNM 23059) were located posterior to the last caudal which has the neural canal inclosed by the neural arch. The smaller Calvert cetothere (USNM 16667) has six caudals of this type. The anterior end of the largest (pl. 15, fig. 1) of these four caudals is higher (117 mm.) than wide (106 mm.). The posterior end of the centrum is slightly convex and the anterior end is flattened. There is an obvious tendency in these posterior caudals for the posterior end of the centrum to become smaller than the anterior as well as more convex. The centrum is pierced dorsoventrally by two large vascular canals, which are closely approximated dorsally and open into a deep longitudinally elongated pit, bounded on each side by vestiges of the pedicles of the neural arch; the ventral orifices are located on the portion of the centrum that is missing. The vertical vascular canals that pierce the centra in the posterior caudal region of Recent mysticetes permit communication of the branches of the caudal artery and caudal vein between the ventral haemal groove and the dorsal neural canal.

A less noticeable difference exists between the width (108 mm.) and the height (101 mm.) of the anterior face of the next largest caudal (USNM 23059). The anterior end (pl. 15, fig. 2) while flattened is depressed medially and the posterior end is convex. The vertical vascular canals open dorsally into a fairly deep longitudinal ovoidal cavity. As regards the three ventral orifices of these vascular canals, the outer ones are separated from the median orifice by an interval of approximately 30 mm.

The third of these posterior caudals (USNM 23059) is wider (64 mm.) than high (55 mm.), its flattened anterior end (pl. 15, fig. 3) is depressed medially as is its more rounded posterior end. The two vertical vascular canals open dorsally into a rather small transversely oval cavity. On the flattened ventral face of the centrum the three orifices of these canals are larger than the dorsal orifices. Both sides of the centrum are deeply grooved longitudinally about the middle of their highth.

The smallest of these (USNM 23059) posterior caudals (pl. 15, fig. 4) has the flattened anterior end depressed medially; the more rounded posterior end is seemingly slightly eroded. The outline of this caudal is quadrangular, its lateral surfaces being irregularly grooved longitudinally about the middle of their height. The two dorsal orifices of the vascular canals open into a transverse and somewhat elliptical cavity, but there are only two ventral orifices separated by an interval of 21 mm.

FIGURE 20.—Anterior view of posterior caudal, USNM 11976, of *Pelocetus calvertensis.*

The largest of the two posterior caudals associated with the skeletal remains (USNM 11976) is almost quadrangular in outline when viewed from in front (fig. 20). Both sides of the centrum are broadly grooved longitudinally near the middle of their height. The centrum is pierced dorsoventrally by two large vascular canals which are closely approximated dorsally and rather widely separated ventrally (32 mm.). Between the ventral orifices of these two canals are two fairly deep blind pits of similar dimensions (pl. 5, fig. 6). The anterior end of the centrum is concave in contrast to the less depressed posterior surface. The measurements of this caudal are as follows: greatest thickness of centrum, 42 mm.; height of centrum anteriorly, 57 mm.; breadth of centrum anteriorly, 68 mm.; height of centrum posteriorly, 62 mm.; and breadth of centrum posteriorly, 71 mm.

More than half of the very small porous terminal caudal (USNM 11976) is missing. The direction of the two dorsoventral vascular canals indicates that their orifices were more widely separated ventrally (15 mm.) than dorsally. All surfaces of the centrum are strongly rugose, and the greatest thickness is 25 mm.

Figure 21.—Views of left scapula, with restored anterior and vertebral borders, USNM 11976, of *Pelocetus calvertensis: a*, external view of left scapula; *b*, view of glenoid articular cavity of left scapula. Abbr.: c.pr., coracoid process.

Measurements (in mm.) of the caudal vertebrae of USNM 23059 are as follows:

	Ant. Ca.	*Post. Ca.*	*Second Post. Ca.*	*Third Post. Ca.*	*Fourth Post. Ca.*
Anteroposterior diameter of centrum	162	86	65	47	41
Transverse diameter of centrum anteriorly	153	106	108	64	54
Vertical diameter of centrum anteriorly	145	117	101	55	41
Transverse diameter of neural canal	15	15	—	—	—
Distance between ends of transverse processes	235+	—	—	—	—
Dorsal face of metapophysis to ventral face of centrum	213	—	—	—	—

Fore Limb

The shoulder blade is represented by a nearly complete left scapula and the anterior and basal portions of the right. The right and left humeri and the right and left radii are unusually well preserved. The distal 220 mm. of the left ulna also was recovered during the excavation of the skeleton (USNM 11976). The upper portion of the fore limb, comprising the scapula, humerus and radius, measured at least 39 inches (990 mm.) in length. Eleven carpal bones, nine metacarpals and nine phalanges were associated with the limb bones. Judging from the shape of the individual bones representing the manus, the paddle or foreflipper exhibited the normal flattened condition of mysticetes. The eighteen digital elements associated with this skeleton quite probably do not belong to only one flipper since eleven carpal bones were found. An estimate of the entire length of the manus calculated on the basis of what seemed to be a plausible arrangement of the recovered carpals, metacarpals and phalanges suggests that it may not have exceeded 19¼ inches (490 mm.) in length. The flipper itself would have been approximately 45 inches (1145 mm.) long.

Scapula.—This broad fan-shaped scapula (fig. 21a) exhibits no vestige of the existence of an acromion, although

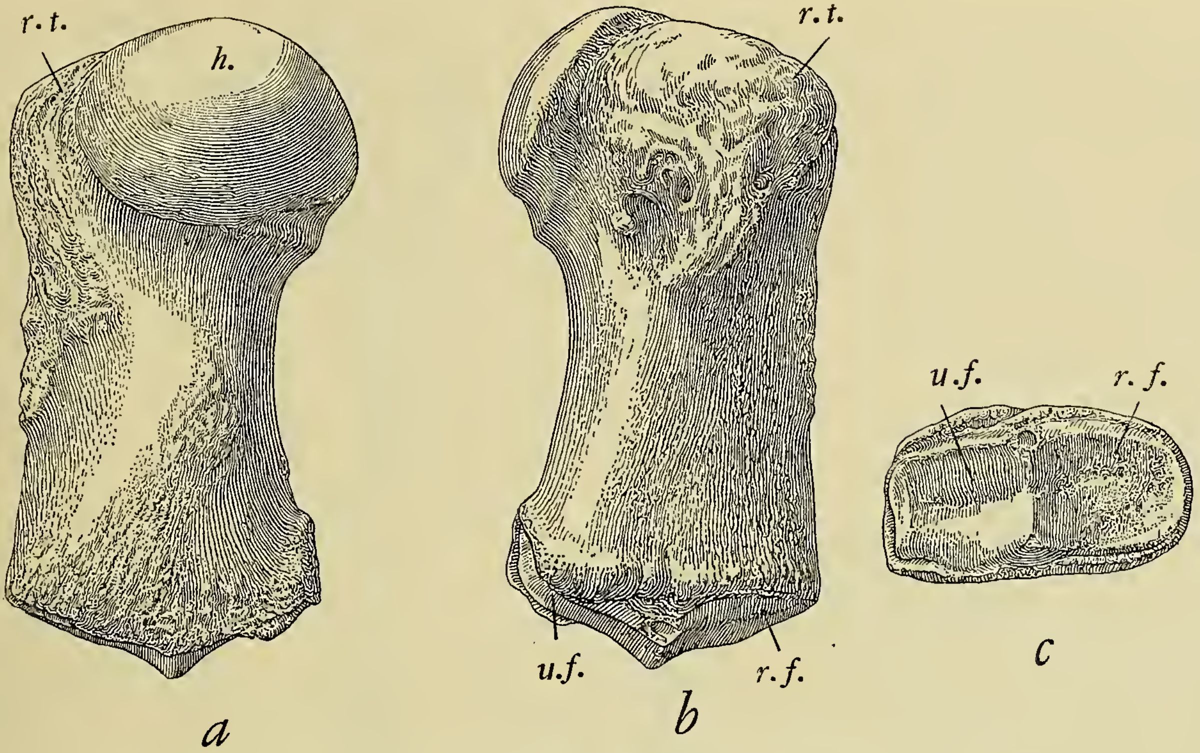


FIGURE 22.—View of left humerus, USNM 11976, of *Pelocetus calvertensis: a*, external view; *b*, internal view; *c*, view of distal end. Abbrs.: h., head; r.f., radial facet; r.t., radial tuberosity; u.f.; ulnar facet.

the coracoid process is well developed. This condition can hardly be regarded as an anomaly since the acromion is lacking on both scapulae. Among Recent mysticetes, the humpback whale (*Megaptera*) lacks both the acromion and the coracoid processes. Unfortunately, the posterovertebral angle is missing on both the right and left scapulae, but nevertheless the maximum anteroposterior diameter when complete must have exceeded 500 mm. The blade, which is noticeably thickened on its basal half, becomes progressively thinner toward the vertebral border.

The glenoid cavity (fig. 21b) is deeply concave and measures 110 mm. anteroposteriorly and 80 mm. exterointernally. The spine of the scapula seems to be represented by the prominent oblique dorsoventral ridge which fades into the outer surface above the coracoid process and disappears near but below the vertebral margin. The outer surface of the scapula is marked by three, possibly four, ridges that radiate upward from the depression above the glenoid border. The fingerlike attenuated coracoid process projects outward and slightly inward from the base of the scapula anteriorly above the glenoid border, and measures about 65 mm. in length, the free end being somewhat knoblike, and the inner surface slightly flattened. The prescapular fossa is relatively broad and flat, the maximum width being greater than 105 mm. The posterior margin of the scapula is concavely curved in contrast to the convex curvature of the anterior margin; the vertebral margin seems to have been somewhat convex and presumably was characterized by a cartilaginous condition similar to that of Recent mysticetes.

Measurements (in mm.) of the scapula of USNM 11976 are as follows:

	Left	*Right*
Maximum anteroposterior diameter of scapula, as preserved	420+	—
Maximum vertical diameter, articular head to vertebral margin	360	—
Length of coracoid, superior margin at base to distal end	40+	—
Posterior face of articular head to distal end of coracoid	174	148+
Maximum anteroposterior diameter of articular head	115	108
Maximum transverse diameter of articular head	86	89

HUMERUS.—As in most mysticetes the humerus is rather short, broad and robust. Both epiphyses are ankylosed to the shaft. The humerus (fig. 22a) has a large, markedly convex, smooth head which articulated freely in the concave glenoid cavity of the scapula; its maximum diameter is 115 mm. The head is placed obliquely on the shaft and faces more or less outward and backward. The posteroventral border of the articular head is also traversed by a shallow groove. Between the head and the large radial tuberosity, the inner face of the proximal end of the humerus is unusually rugose, including the large centrally placed swelling or protuberance. On the humeri of Recent mysticetes, the supraspinatus from the scapula and the mastohumeralis are attached in this area; the rugose surface of the large radial tuberosity serves as a similar proximal area for attachment of the deltoideus. The rugose radial tuberosity (fig. 22b) is rather broad, projecting externally.

The shaft is thickest below the head and is distinctly flattened exterointernally toward the distal end. The anterior or radial face (fig. 22a) of the shaft is markedly rugose, most conspicuously so toward the tuberosity, presumably for the insertion of the deltoid muscle. The hinder or ulnar face of the shaft is broader and more rounded. The rugose area (fig. 22a) on the outer face of the shaft between the head and the ulnar facet may possibly indicate the position of the origin of the short head of the triceps. On the lower or distal end (fig. 22c) of the transversely flattened shaft the ulnar facet is slightly narrower than the radial facet, more concave, saddle-shaped, and extended upward on the posterior face of the shaft distally. The radial facet is broad, flattened and set off from the ulnar facet by an exterointernal ridgelike crest.

Measurements (in mm.) of the humerus of USNM 11976 are as follows:

	Right	*Left*
Maximum length of humerus	266.5	264
Maximum anteroposterior diameter of proximal end	153.5	151.5
Maximum anteroposterior diameter of head	114	112
Maximum exterointernal (transverse) diameter of head	114	114.5
Least anteroposterior diameter of shaft	108.5	108.5
Least exterointernal (transverse) diameter of shaft	73.5	71
Maximum anteroposterior diameter of distal end	127	125.5
Maximum exterointernal (transverse) diameter of distal end	71.5	72
Maximum anteroposterior diameter of radial facet	71	69
Maximum anteroposterior diameter of ulnar facet (in a straight line)	70	73.5

Radius.—The right and left radius both have the proximal epiphysis ankylosed to the shaft, but the lower or distal carpal epiphysis was not attached to either shaft. Among the miscellaneous pieces recovered are two elongated rugose and porous centers of ossification, the largest measuring 63 x 31 mm., which apparently represent incompletely formed distal epiphyses. The radius (fig. 23a) is a rather long, stout, slightly curved and transversely flattened bone, measuring about 15⅝ inches (398 mm.) in length.

The proximal facet which articulated with the radial facet on the distal end of the humerus is shallowly concave, its anteroposterior diameter being greater than the transverse. This articular surface rolls over on the external and internal faces of the proximal end of the shaft. The facet on the posterior face of the proximal end (fig. 23b) for articulation with the olecranon of the ulna is relatively small, its transverse diameter being 42 mm. and the proximodistal diameter 27 mm.

The outer and inner surfaces of the elongated shaft are slightly convex. The shaft possibly has the posterior edge sharper than the anterior. The distal extremity (fig. 23c) of the shaft of both radii is rugose and deeply pitted which indicates the presence of a cartilaginous cap or epiphysis.

Measurements (in mm.) of the radius of USNM 11976 are as follows:

	Right	*Left*
Maximum length	397	398
Maximum anteroposterior diameter of proximal end	84	—
Maximum transverse diameter of proximal end	61	59.5
Least anteroposterior diameter near middle of shaft	78.2	78
Least transverse diameter near middle of shaft	40	43
Maximum anteroposterior diameter of distal end	88	89.5
Maximum transverse diameter of distal end	48.2	49

Ulna.—Only the distal 220 mm. of the right ulna (fig. 24) was recovered during the excavation of the skeleton. The shaft was elongated, presumably of a length corresponding to that of the radius, and noticeably widened at the distal or carpal end. Viewed from the side the hinder profile is more strongly curved than the anterior profile. The middle portion of the shaft is oval in cross section. The shaft is also rather imperceptibly bowed outward, the internal face being rather flat and the external slightly convex. The distal or carpal epiphysis was not ankylosed inasmuch as the distal extremity of the shaft is very rugose and deeply pitted. One small incomplete irregularly shaped porous bone (pl. 19,

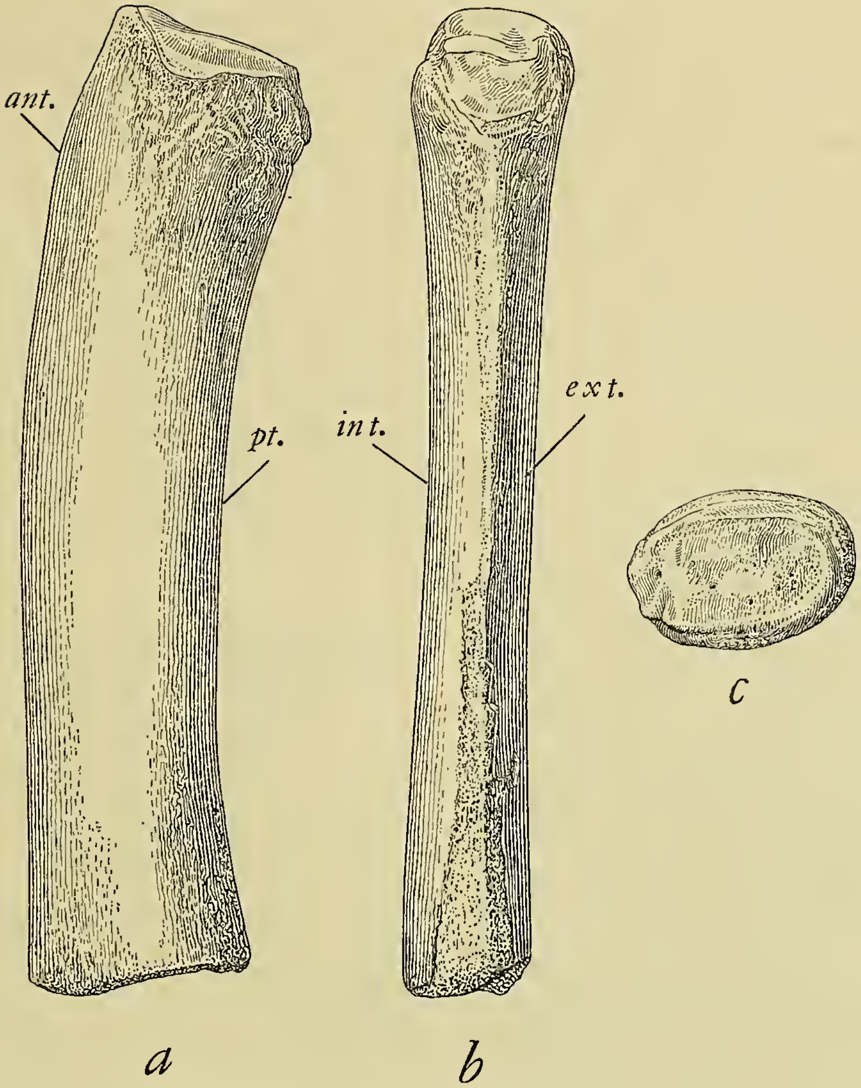


Figure 23.—Views of right radius, USNM 11976, of *Pelocetus calvertensis: a*, internal view; *b*, posterior view; *c*, view of distal end. Abbrs.: ant., anterior face; ext., external face; int., internal face; pt., posterior face.

Figure 24.—External outline of right ulna, USNM 11976, of *Pelocetus calvertensis*.

fig. 10), similar in general appearance to the two heretofore associated with the radii, presumably represents a portion of the incompletely ossified distal epiphysis.

The measurements are as follows: minimum anteroposterior diameter of shaft near middle of its length, 50 mm.; minimum transverse diameter of shaft at same level, 29 mm.; maximum anteroposterior diameter of shaft at distal end, 96.7 mm.; and transverse diameter of shaft at distal end, 41 mm.

The right ulna (USNM 23059, pl. 16, fig. 1) of the referred specimen is elongated, measuring 436 mm. in length, and its relatively slender and transversely compressed shaft is curved from end to end. From the upper margin of the radial facet (radial margin) to the distal end the shaft measures 365 mm. The distal or carpal end measures 76 mm. anteroposteriorly and 33 mm. transversely and is roughened for cartilaginous attachment of the incompletely ossified epiphysis which was found detached. The proximal end is enlarged and thickened to form the backward projecting olecranon process. The curvature of the greater sigmoid cavity forms about one quadrant of a circle, having a diameter of approximately 100 mm. Near its upper end, the articular surface of the greater sigmoid cavity does not exceed 17 mm. in width, but measures at least 53 mm. near the radial articular facet, whose dorsoventral diameter is greatest internally. The posterior border of the olecranon process is eroded.

Carpals.—The ten metapodials found during the excavation of the skeleton undoubtedly represent carpal bones belonging to the manus of both forelimbs. There is no certainty that not more than five centers of ossification were present in each carpus. Four of these bones exhibit to some degree the shape and appearance of carpals which seemingly should be regarded as corresponding bones in the right or left manus, even though allocation to either the right or the left flipper cannot be made with certainty. Although ossified, the orientation of the surfaces of all the carpals remains uncertain. All of these carpals (fig. 25) have fairly smooth dorsal and plantar surfaces, the other faces being markedly irregular with interspersed nodosities and pits. This roughening of the adjoining surfaces of these bones indicates that the carpus was in a large part cartilaginous.

Tentative identifications are made for four carpals allocated to the right manus (terminology of Kunze, 1912) by comparison with the manus of flippers of skeletons of the Recent *Balaenoptera acutorostrata* and *Sibbaldus musculus* in the United States National Museum. The radiale in the manus of both of these Recent mysticetes is the largest carpal and is located in the proximal row anteriorly below the distal end of the radius. The largest carpal of this Calvert cetothere (fig. 25a; pl. 17, fig. 9) measures 70 mm. transversely and 46 mm. in depth, and is thus assumed to be the radiale.

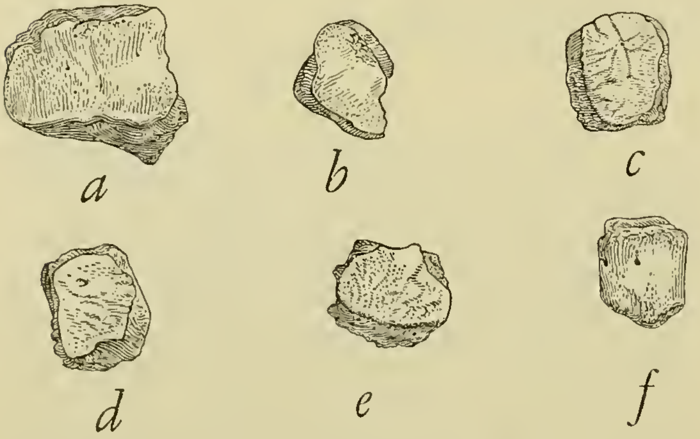


Figure 25.—View of carpal bones, USNM 11976, of *Pelocetus calvertensis: a,* radiale; *b,* pisiforme; *c,* intermedium; *d,* carpalia; *e,* ulnare; *f,* carpalia.

The next largest carpal (fig. 25c; pl. 17, fig. 8) is 45 mm. wide and 43 mm. deep; it is regarded as the intermedium. Another carpal (fig. 25e; pl. 17, fig. 7) of somewhat similar shape has a maximum diameter of 41 mm. and a depth of 40 mm., and is thought to be the ulnare. The dorsoplantar measurements of three carpals (pl. 17, figs. 7, 8, 9) are greater than those of two others presumed to have comprised the distal row and thus seem to conform to the requirements of the three in the proximal row. One somewhat elongated carpal (fig. 25b; pl. 17, fig.1) with relatively small dorsal and plantar smooth surfaces may represent the pisiforme.

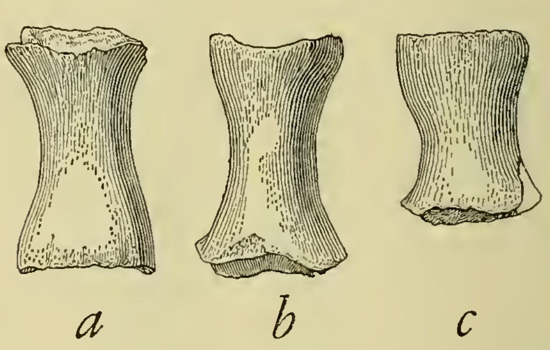


Figure 26.—Views of metacarpals, USNM 11976, of *Pelocetus calvertensis: a,* right metacarpal III; *b,* left metacarpal III; *c,* right metacarpal IV.

The maximum transverse diameter of an irregularly shaped fourth carpal (pl. 17, fig. 2) is 46 mm., and its dorsoplantar diameter is 33 mm.; it is regarded as one of the two carpals in the distal row as is another slightly smaller bone (fig. 25f; pl. 17, fig. 3). The last mentioned carpal is unquestionably a replica of one from the opposite manus. Both differ from all other carpals in having two obliquely directed flat faces which almost meet at an acute angle, thus reducing the roughened faces to three.

Metacarpals.—A number of bones belonging to the manus were found associated with the skeleton of *Cophocetus oregonensis* (Packard and Kellogg, 1934, pp. 54–58, fig. 21) when it was excavated in the Miocene Astoria formation at Newport, Ore. Of the eight bones found in close proximity to the right ulna, three metacarpals (I, II, III) were embedded in the matrix apparently in their natural position and sequence. Neither the right nor the left radius of *C. oregonensis* was found. As regards the left manus, metacarpals IV and V were found lying side by side,

USNM 11976 – Metacarpals:	*Plate 18*							
	Fig. 6	*Fig. 3*	*Fig. 2*	*Fig. 9*	*Fig. 4*	*Fig. 1*	*Fig. 7*	*Fig. 5*
Maximum length	99.5	97.5	78	77	77.5	71	67	71.5
Minimum transverse diameter of shaft	34	35	37	39	34	31	18	36
Minimum thickness of shaft	23	25	20	20.5	24	22	17	15.5
Maximum transverse diameter of proximal end	55.5	57.5	46.5	43+	47	42	30	41
Maximum transverse diameter of distal end	54	53	52.5	56	39	32	29	44

and metacarpal III lay nearby. Metacarpal III is the largest of the metacarpals and is readily recognizable. Since the four remaining metacarpals are quite dissimilar in appearance, there seems to be a reasonable basis for the conclusion that the manus of *C. oregonensis* consisted of five digits. Inasmuch as there exists a general resemblance between the metacarpals of this Calvert cetothere and those of *Cophocetus*, particularly metacarpal III, allocations of individual bones of the digits have been made on the assumption that five digits were present. It should be noted, however, that so far as known the manus of Recent balaenopterine whales is comprised of four digits (Kunze, 1912; Harmer, 1927, p. 61, fig. 30).

The digits are represented by sixteen essentially complete bones and the extremities of two others. Six of these bones (pl. 18, figs. 3 and 6, 1 and 4, as well as 2 and 9) thought to be metacarpals seem to represent the same elements in opposite flippers. The two largest bones (pl. 18, figs. 3 and 6) are less noticeably flattened in a dorsoplantar direction than two other fairly large bones (pl. 18, figs. 2 and 9). Both ends of these four bones are roughened by the presence of nodosities and pits, the proximal end being more irregularly sculptured than the distal and by adherence to cartilage. In the flipper of Recent mysticetes metacarpal III is larger and longer than the others. Tentatively, two of these bones (figs. 26a, 26b; pl. 18, figs. 3 and 6) are allocated to metacarpal III. There may have been limited contact between the proximal ends of metacarpals II and III.

A somewhat shorter bone (pl. 18, fig. 5) not duplicated among the bones recovered, is strongly flattened in a dorsoplantar direction except proximally, and roughened at both ends, the proximal end being truncated obliquely; it is regarded as probably metacarpal I.

Two rather robust bones (pl. 18, figs. 1 and 4) whose shafts are somewhat narrower, more cylindrical and less flattened as well as relatively less widened transversely at the distal end than the two larger metacarpals are identified tentatively as metacarpal II.

The shafts of two bones (fig. 26c; pl. 18, figs. 2 and 9) slightly shorter than metacarpal III are more noticeably flattened and relatively wide transversely at the distal end; they may represent metacarpal IV.

Two relatively slender bones (pl. 18, figs. 7 and 10) possibly represent metacarpal V in opposite flippers. The somewhat cylindrical shafts of these two metacarpals are constricted near the middle of their length and expanded at both roughened extremities.

Measurements (in mm.) of the metacarpals of USNM 11976 are tabulated above.

Phalanges.—All but two (pl. 19, fig. 5; and pl. 18, fig. 8) of these bones regarded as phalanges (fig. 27) are noticeably flattened, more or less constricted near the middle of their length and widened distally. The longest (pl. 19, fig. 7) measures 85.5 mm. in length and the shortest (pl. 19, fig. 2) 47 mm. Four of these bones have at least one end roughened and truncated obliquely. In Recent mysticetes the phalanges in each digit progressively diminish in length from the proximal to the distal one. Presumably not more than six or seven phalanges comprised the third digit. If this assumption is correct at least one to three of the shorter terminal phalanges are not here represented for any digit. Two very slender phalanges (pl. 18, fig. 8; and pl. 19, fig. 5), much wider proximally than distally, and measuring 46 and 51 mm. in length respectively are regarded as belonging to the first digit in opposite flippers.

Measurements (in mm.) of the phalanges of USNM 11976 are tabulated below.

USNM 11976 – Phalanges:	*Plate 19*							*Plate 23*
	Fig. 7	*Fig. 6*	*Fig. 1*	*Fig. 3*	*Fig. 2*	*Fig. 4*	*Fig. 5*	*Fig. 8*
Maximum length	85.5	68.5	68.5	54	47	47	51	46
Minimum transverse diameter of shaft	32.5	29	28	24	21	22.5	9.5	9.5
Minimum thickness of shaft	17	16	16	11	10	11.5	9	9
Maximum transverse diameter of proximal end	48	42	36	33	30	33	19.5	20
Maximum transverse diameter of distal end	46.5	43	44.5	28.5	31.5	32.5	10.5	11

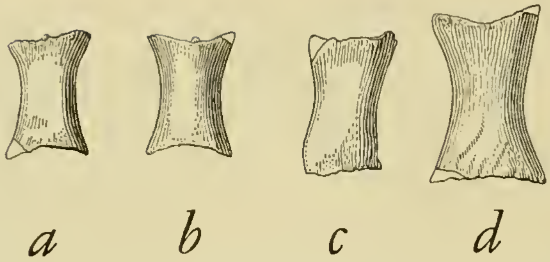


Figure 27.—Views of phalanges, USNM 11976, of *Pelocetus calvertensis:* *a* and *b*, small phalanges; *c*, medium size phalange; *d*, large phalange.

Sternum

One or more of four bones (pl. 20) not otherwise identified with some part of the skeleton may possibly represent the sternum. These bones do not, however, agree with the sternum of living mysticetes, which in some species consists of a broad flattened presternum extended backward into a ziphoid process. In these Recent whalebone whales this bone varies in shape from heart-shaped, longitudinally oval to trilobate. True (1904, pp. 140–141) has figured the extreme variability of the sternum of *Balaenoptera physalus.* No mesosternal elements are retained and hence no ribs other than the first pair are attached to the sternum. Except for the heart-shaped sternum of the Miocene *Cetotherium klinderi* figured by Brandt (1873, pl. 5, figs. 13A, 13B), the cetothere sternum seems to have escaped the notice of cetologists. The largest of these Calvert bones (pl. 20, fig. 2) measures 112 x 76 mm.; it is somewhat heart-shaped and is produced medially into a rather large, blunt tuberosity whose apex is elevated 50 mm. above the opposite concave surface. Although ossified, all the rather thick free edges are irregularly sculptured, presumably for adherence of cartilage. The ventral and dorsal faces of this bone are pitted and slightly roughened. The longest free edge of the thickest of these four bones (pl. 20, fig. 1) is deeply pitted, no doubt for attachment of cartilage. Both of the two smallest bones (pl. 20, figs. 3, 4) possess one deeply sculptured edge and one rounded edge; the other edges are incomplete. No satisfactory interpretation of the relative positions of these bones, if all do pertain to the sternum, is readily apparent.

Ribs

All of the ribs found associated with this skeleton are incomplete and all lack varying lengths of their distal extremities. The proximal portions, however, of eleven of the twelve ribs are sufficiently complete to permit accurate description. The first rib has but one terminal facet which articulates with the end of the transverse process (diapophysis) of the first dorsal vertebra. Only the first pair of ribs articulates or is connected with the sternum in all living mysticetes, and this condition may have prevailed on this fossil whale skeleton. The second to ninth ribs, inclusive, possess two articulating surfaces, one (the tuberculum) having a ligamentous attachment to the end of the transverse process and the other (the capitulum) to the posterodorsal facet on the lateral surface of the centrum. The tenth, eleventh and twelfth ribs have a single, horizontally elongated head. The second rib has a noticeably elongated and anteroposteriorly flattened neck; the shaft is abruptly turned downward below the rather small tubercular facet. The vertebral end of the shaft of the third rib is likewise anteroposteriorly flattened, but the neck is shorter and stouter. On the fourth, fifth, sixth and seventh ribs, the shafts are noticeably thicker. the necks rather short, and the distance from the capitular end to the angle (the point where the shaft is turned downward) is progressively increased. The neck of the eighth rib is slightly longer than the preceding, the shaft is more slender and the angle is much less noticeably developed. No neck is retained on the tenth rib and the elongated head is dorsoventrally compressed; the distal third of the shaft is thin, compressed and attenuated. On the eleventh rib the vertebral end of the shaft is somewhat circular in cross section, but the rest of the shaft becomes progressively more flattened toward the distal end, which is distinctly twisted backward. Although the twelfth rib lacks the distal portion, its dimensions indicate a much shorter and more slender shaft, which is dorsoventrally compressed proximally (for a length of 125± mm.) and flattened anteroposteriorly on the remainder of the shaft.

First Rib: Of the twelve pairs of ribs the first obviously was the shortest. This rib (pl. 21, fig. 1) has a stout heavy shaft which is rather regularly curved from the capitular end to the broken-off extremity; the capitular portion of the shaft is malformed by exostosis. The characteristics of the sternal end are unknown. The thoracic face of the shaft is slightly flattened in contrast to the convexity of the other faces.

Second Rib: The vertebral end of the shaft is markedly flattened in an anteroposterior direction and widened in an externointernal direction; the broken distal end of the shaft is ovoidal in cross section (35 x 30 mm.). Both tubercular and capitular facets are small, that of the latter is slightly larger than the former; the compressed neck (pl. 21, fig. 2) is elongated (distance between outer margin of the capitulum and inner margin of tubercular facet, 100 mm.) and is bent slightly backward.

Third Rib: Only the vertebral end of the shaft of this rib (pl. 21, fig. 3) is preserved. It is similarly compressed, but noticeably widened, the neck is markedly shortened (distance between outer margin of capitulum and inner margin of tubercular facet, 44 mm.) and strongly bent upward. The capitular facet is large, and knoblike; the tubercular facet is elongated and its thoracic border overhangs that face of the shaft.

Fourth Rib: The shaft (pl. 21, fig. 4) is thick, stout, flattened on the thoracic face proximally, but otherwise convex, and is turned abruptly downward below the angle. The concave ovoidal tubercular facet is larger than the upturned knoblike capitulum and overhangs the external face of the shaft. The neck is rather short (distance between outer margin of capitulum and inner margin of tubercular facet, 35 mm.); the dorsoventral diameter of the neck is greater than its anteroposterior diameter.

Fifth Rib: The shaft (pl. 21, fig. 5) is thick, stout, almost subquadrangular in cross section near the angle, below which it is turned abruptly downward. The concave tubercular facet is almost saddleshaped and much larger than the knoblike capitulum; it overhangs both faces of the shaft. The neck is short (distance between outer margin of capitulum and inner margin of tubercular facet, 37 mm.) and its depth is greater than its breadth. The distance between the articular face of the capitulum and the angle of the shaft is 190 mm.

Sixth Rib: The shaft (pl. 21, fig. 6) is almost as stout as that of the fifth rib and the distance between the articular face of the capitulum and the angle of the shaft is 210 mm. On both the thoracic and outer surfaces the shaft is progressively compressed toward the distally widened extremity. The concave tubercular facet is noticeably wider than the upturned knoblike capitulum and overhangs both faces of the shaft; the thick neck is short (distance between outer margin of capitulum and inner margin of tubercular facet, 33 mm.) and its depth is about equal to its breadth.

Seventh Rib: The shaft (pl. 21, fig. 7) is distinctly more slender than that of the sixth rib and the distance between the articular face of the capitulum and the angle of the shaft is 235 mm. Proximally the shaft is subquadrangular in cross section below which this contour is modified by strong compression in a thoracic-external direction as well as a more obvious flattening of the thoracic face distally. The somewhat flattened tubercular facet is smaller than the knoblike capitulum. The stout neck is short (distance between outer margin of capitulum and inner margin of tubercular facet, 35 mm.).

Eighth Rib: The shaft (pl. 21, fig. 8) is slender, but compressed distally; the angle of the shaft is even farther removed (265 mm.) from the articular face of the capitulum than on the seventh rib. On this rib, the tubercular facet is largely destroyed, but was separated from the large knoblike capitulum by at least 50 mm.

Ninth Rib: This rib has not been recognized among the rib fragments associated with this skeleton.

Tenth Rib: The vertebral end of this slender elongated rib (p. 21, fig. 9) is compressed in a thoracic-external direction, but has no visible neck. The narrow articular head is horizontally widened and is rather rugose for its ligamentous attachment to the end of the transverse process. The shaft is thickest near the end of the proximal third of its length, below which a rather sharp crest is developed on the posterior face; its distal end is flattened, attenuated and incurved. This rib measures along the outside curve, 930 mm., but the distal end is not complete.

Eleventh Rib: The shaft (pl. 21, fig. 10) is narrowest, almost circular in cross section, proximally, but is strongly compressed distally as well as bent backward near the extremity. Both edges of the shaft on this lower section are rather sharp or crestlike.

Twelfth Rib: This rib (pl. 21, fig. 11) was obviously shorter than the preceding rib. Its narrowed and horizontally elongated articular head (fig. 28) is located on the obliquely truncated vertebral end of the shaft, which is strongly compressed in a dorsoventral direction for about 125 mm. below this end. The shaft then twists so that the remaining distal portion is compressed in an anteroposterior direction, the posterior edge being rather sharp. The end-to-end curvature is relatively slight.

FIGURE 28.—Lateral view of twelfth rib, USNM 11976, of *Pelocetus calvertensis*.

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2. The Miocene Calvert Sperm Whale Orycterocetus

A SINGULAR SORT OF REMODELING of the skull led to the separation of the physeteroid stock from other odontocetes which, with the exception of the ziphioids, seem to have followed a more conventional line of development in cranial architecture. As early as the lower Miocene, sperm whales were differentiated by these cranial modifications from the main odontocete stocks. On the skulls of two lower Miocene genera (*Diaphorocetus* and *Idiorophus*), the adipose cushion, or reservoir for spermaceti, had spread backward behind the nasal passages and the consequential adjustment of involved cranial bones formed a supracranial basin. The "dishing-in" of the roof of the braincase is attributable in part, at least, to the pressure of this developing spermaceti reservoir. The accompanying alterations of the relative proportions and relations of the dorsal cranial bones included the depression of the frontal bones along the median longitudinal line, the posterior enlargement or widening of the upturned right premaxillary, the crestlike elevation of the maxillaries laterally, the loss or marked reduction of one of the nasal bones and the flattening of the other against the frontal behind the greatly enlarged left nasal passage, and the marked widening of the rostrum proximally. Some genera of extinct physeteroids retain a functional dentition in the upper jaws to the close of their known geological history. Other genera exhibit a tendency for the teeth to become loosely implanted in large alveoli, while the intervening septa diminish in thickness and ultimately disappear, leaving an open alveolar gutter in the maxillary (*Aulophyseter*). Teeth were lodged in distinct alveoli in each maxillary of this Calvert Miocene *Orycterocetus*.

Owen seems to have been the first to recognize the physeteroid affinities of a Tertiary fossil tooth, and consequently *Balaenodon* (Owen, 1846, p. 536, figs. 226–229) became the first generic name to be applied to a fossil sperm whale. The type of *Balaenodon physaloides* Owen comprises a portion of the root of a tooth from the Red Crag of Felixstowe, Suffolk, England. Abel (1905, p. 52) concluded that without doubt this tooth belonged to the physeteroid *Scaldicetus caretti*, but that the basis for validation of the scientific name was insufficient. The type tooth, however, is considerably larger and structurally different from the teeth of *Orycterocetus*.

The next oldest available name for a fossil sperm whale is *Hoplocetus* Gervais (1849, p. 161, pl. 20, figs. 10–11) based on two teeth found in the middle Miocene shell marl (faluns) in the vicinity of Romans, Department Drôme, France. The two type teeth of *Hoplocetus crassidens* (type species) are characterized by an enlarged or swollen root set off from a proportionately small crown by a necklike constriction. Abel (1905, p. 53) rejects the validity of the stated generic characters of *Hoplocetus*, but nevertheless places it in the synonymy of *Scaldicetus*. The pulp cavity is closed on one of these teeth and reduced to a vestige on the other.

The teeth of *Scaldicetus caretti* aside from their larger dimensions are characterized by having the enamel on the crown very coarse and rugose, the ridges anastomosing but generally running toward apex of crown with numerous connecting or intersecting striae; no perceptible constriction of the root at base of crown.

Inasmuch as the above-mentioned extinct physeteroids cannot conceivably have any bearing on the generic allocation of the Calvert Miocene sperm whale, no further consideration is given to their status.

ORYCTEROCETUS Leidy

Orycterocetus Leidy, Proc. Acad. Nat. Sci. Philadelphia, vol. 6 (1852–53), p. 378, August 1853.

Type Species: *Orycterocetus quadratidens* Leidy.

Diagnosis: Twenty teeth in each upper jaw (17 of which were lodged in alveoli in maxillary and 3 present on premaxillary). Dentine core of slender curved teeth often with open funnellike pulp cavity; fine annular lines of growth and longitudinal fluting characterize the dentine core of larger teeth; outer layer of cementum may completely cover the dentine on undamaged teeth; conical tip or crown of teeth occasionally black and polished, but lacks enamel; no perceptible distinction between crown and root or visible constriction to form neck below crown. Vertex of cranium eliminated by development of large supracranial basin for reception of reservoir for spermaceti. Supracranial basin bounded laterally on right side by elevated border of right maxillary; on left side by left premaxillary and elevated crest of underlying left maxillary; and posteriorly by hinder borders of both maxillaries which override medially the posterior ends of the frontals and abut against the dorsal crest of the supraoccipital. Right nasal bone either lost or greatly reduced; the left nasal bone flattened against the frontal behind greatly enlarged left nasal passage and partially concealed by squamous overlap of markedly expanded posterior portion of right premaxillary.

ORYCTEROCETUS QUADRATIDENS Leidy

Orycterocetus quadratidens Leidy, Proc. Acad. Nat. Sci. Philadelphia, vol. 6 (1852–53), p. 378, August 1853.

Type Specimen: Two teeth, together with small fragments of a jaw (ANSP 9065–69), presented by Prof. Francis Simmons Holmes.

Horizon and Locality: Miocene formation, Virginia.

Leidy (1853, p. 378; 1869, pp. 436–437, pl. 30, figs. 16–17) has characterized the two type teeth as being long and conical, one being nearly straight, the other strongly curved. Both teeth in transverse section are rather ovoidal near the tip, but more quadrate near the base. The annular lines of growth are strongly marked and longitudinal fluting is present on the dentine. A thin patch of cementum is present on one side at the base of one tooth, but no enamel. No perceptible distinction between crown and root exists. A funnellike pulp cavity is open at the base of the root. The largest tooth measures about 127 mm. (5 inches) in length and the diameters at the base 21.16 and 23.27 mm.

No characters of generic importance can be defined to distinguish these teeth from *Orycterocetus crocodilinus.* The quadrate transverse shape of the basal portion of the root of this physeteroid may possibly indicate a specific difference unless it can be shown that teeth with identical features are present in the Calvert formation. The only information at present available is that the type teeth came from the "Miocene formation" of Virginia, which as currently recognized would include the Calvert, Choptank, St. Marys and Yorktown formations. It would seem advisable to defer a decision as to the possible identity of this species with *O. crocodilinus* until teeth with identical characteristics are found in the Calvert formation, or more precise information regarding the source of the type teeth of *Orycterocetus quadratidens* is located in contemporary records.

ORYCTEROCETUS CROCODILINUS Cope

Orycterocetus crocodilinus Cope, Proc. Acad. Nat. Sci. Philadelphia, vol. 19 (1867), p. 144, Mar. 10, 1868.

Type Specimen: One tooth. (ANSP 9126), collector, James T. Thomas, October 1867.

Horizon and Locality: Charles County, Md., not far from the Patuxent River in "Yorktown" beds [=Near the Patuxent River, not far from the home of James T. Thomas, about one mile east of site marked Patuxent (U.S.G.S. sheet Brandywine, Md.), two miles east of Hughesville, Charles County, Md.]. Calvert formation, upper Miocene.

Cope describes the single tooth on which this species is based as having the form of an elongate curved cone, with flattened sides, the posterior face being convex and broad, and the anterior face narrower; no enamel is present on the apical portion. The tip of the crown is worn, which Cope regards as attesting maturity. Irregular transverse annular growth lines and more or less parallel longitudinal grooves are present on the dentine core. The large pulp cavity of this tooth is open at the base and extends two-thirds of the length of the tooth. The measurements given by Cope for this tooth are as follows: length, 61.38 mm.; diameter at base, 17.46 mm.; diameter at middle, 12.7 mm. The type tooth is figured by Case (1904, pl. 18, fig. 7).

Referred Specimens: Eighteen, as follows: (1) USNM 1158: one tooth, coll. Frank Burns, 1892; Jones Wharf, St. Marys Co., Md., Choptank formation, middle Miocene. (2) USNM 8575: one tooth, coll., Mark M. Shoemaker, 1916; Chesapeake Beach, Calvert Co., Md., Calvert formation, middle Miocene. (3) USNM 8576: one tooth, coll. Mark M. Shoemaker, 1916; Chesapeake Beach, Calvert Co., Md., Calvert formation, middle Miocene. (4) USNM 11234: right periotic, coll. A. Wetmore, May 24, 1925; Chesapeake Beach, Calvert Co., Md. Calvert formation, middle Miocene. (5) USNM 13778: one tooth, coll. Mrs. J. Homer Smith; Plum Point, Calvert Co., Md. Calvert formation, middle Miocene. (6) USNM 14729: skull lacking distal end of rostrum, supraorbital processes of frontals, occipital condyles, palatines and pterygoids, coll. R. Lee Collins and W. Gardiner Lynn, July 1, 1935; in fallen block of sandy clay, presumably from Zone 11, ½ mile south of Randle Cliff Beach, Calvert Co., Md. Calvert formation, middle Miocene. (7) USNM 14730; skull lacking distal end of rostrum, zygomatic processes, palatines and pterygoids, coll. William F. Foshag, July 25, 1936; base of Zone 12, about 18 inches above high tide level, 8/10 mile south of mouth of Parker Creek, [in third cliff south of mouth of Parker Creek, about 820 yards], Calvert Co., Md., Calvert formation, middle Miocene. (8) USNM 22926: skull essentially complete, except for missing distal end of rostrum and postorbital projection of right supraorbital process, left periotic, 16 teeth, posterior end of left mandible, and rib fragments, coll. Wallace L. Ashby, Jr., Feb. 24, 1959; about 100 yards south of north end of first cliff south of mouth of Parker Creek, in Zone 13 (6 feet below zone 14), Calvert Co., Md., Calvert formation, middle Miocene. (9) USNM 22930: incomplete skull of young sperm whale, comprising right side of top of braincase, left supraorbital process detached, basicranium with both exoccipitals and zygomatic processes, and short section of frontal-supraoccipital crest, coll. W. Gardiner Lynn, Apr. 1935; 7/10 mile south of mouth of Parker Creek, in Zone 12, about 3 feet above beach level. Calvert formation, middle Miocene. (10) USNM 22931: rostrum complete anterior to maxillary incisure; right zygomatic process incomplete; portion of basioccipital and miscellaneous bone fragments, coll. W. Gardiner Lynn and R. Lee Collins, August 1934; about 1.2 miles south of Chesapeake Beach, near top of Zone 9, about 25 or 30 feet above beach level, Calvert Co., Md., Calvert formation, middle Miocene. (11) USNM 22932: one tooth, collector and date not recorded; ¼ mile from mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (12) USNM 22933: four isolated teeth, coll. Remington Kellogg, Sept. 27, 1925; in Zone 10 (shell band) 2 feet above water level at high tide, ½ kilometer south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (13) USNM 22934: one tooth, coll. R. Lee Collins, Sept. 15, 1936; found on beach, ¾ mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (14) USNM 22935: nine isolated teeth, collector and date not recorded; probably from beach, Calvert Co., Md., Calvert formation, middle Miocene. (15) USNM 22952: left periotic, coll. R. Lee Collins and W. Gardiner Lynn, 1934–1935; South Chesapeake Beach, Calvert Co., Md., Calvert formation, middle Miocene. (16) USNM 22953: Right periotic, right tympanic bulla, and laminated spongy osseous mass associated with extremity of posterior process of bulla, coll. R. Lee Collins, May 15, 1937; in fallen block of sandy clay from Zone 14, about 8/10 mile south of Randle Cliff beach, Calvert Co., Md., Calvert formation, middle Miocene. (17) USNM 22967: 390 mm. long posterior rostral fragment of left maxillary, coll. Wallace L. Ashby, Jr., March 1954; Zone 12, 36 yards south of small cove in cliff south of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (18) USNM 10860: right periotic and detached accessory ossicle, coll. F. W. True (original no. 844), date not recorded; Calvert Cliffs, Calvert Co., Md., Calvert formation, middle Miocene.

Skull

Bilateral asymmetry of the skull (fig. 29) is accentuated in all fossil and Recent physeteroids. The distortion resulting from this alteration of the usual relationships of the bones comprising the roof of the cranium is not restricted to the region of the nasal passages, but involves all the bones that contribute to the formation of the supracranial basin.

A 390 mm. long posterior rostral fragment of the left maxillary (USNM 22957) tends to confirm the assumption that the four skulls hereinafter described may represent growth stages of this Calvert physeteroid. On the basis of comparative measurements the skull, of which this maxillary fragment was a relic, is estimated to have measured 950 mm. in length, as contrasted to 830 ± mm. for the largest of the four skulls.

It should also be noted that among living cetaceans, the male sperm whale attains a much greater size than the female. If this disparity between the dimensions of males and females also characterized the sexes of these Miocene physeteroids, the possibility also exists that this large rostral fragment may have been derived from a male. The presence of the skull of a quite young individual (USNM 22930) suggests that these Calvert Miocene waters may have been a calving area.

Dorsal view.—From a dorsal view (pl. 22) the skull of this Miocene sperm whale differs most obviously in some minor details from that of a young Recent *Physeter catodon* (Kellogg, 1925, pl. 6), the right premaxillary bone being markedly widened behind the nasal passages, overriding the flattened nasal bone, and almost coming in contact with the posterior end of the left premaxillary. These premaxillaries comprise the dorsal surface of the middle longitudinal portion of the rostrum and the rather deep supracranial basin. This posterior widening of the right premaxillary seems to have its closest counterpart in the lower Miocene *Diaphorocetus poucheti* (Lydekker, 1894, pl. 3). As in the Patagonian sperm whale a small foramen (the orifice looking upward and connecting ventrally with the infraorbital system) pierces the maxillary on both the inner and the outer faces of the lateral crest of the supracranial basin, the inner one at the level of the center of the orbit and the outer one usually behind the supraorbital process. The larger maxillary foramen opens into the slitlike incisure in the maxillary between the antorbital notch and the supracranial basin. The posterior end of the maxillary overrides the underlying frontal above the temporal fossa and contributes the lateral border of the supracranial basin.

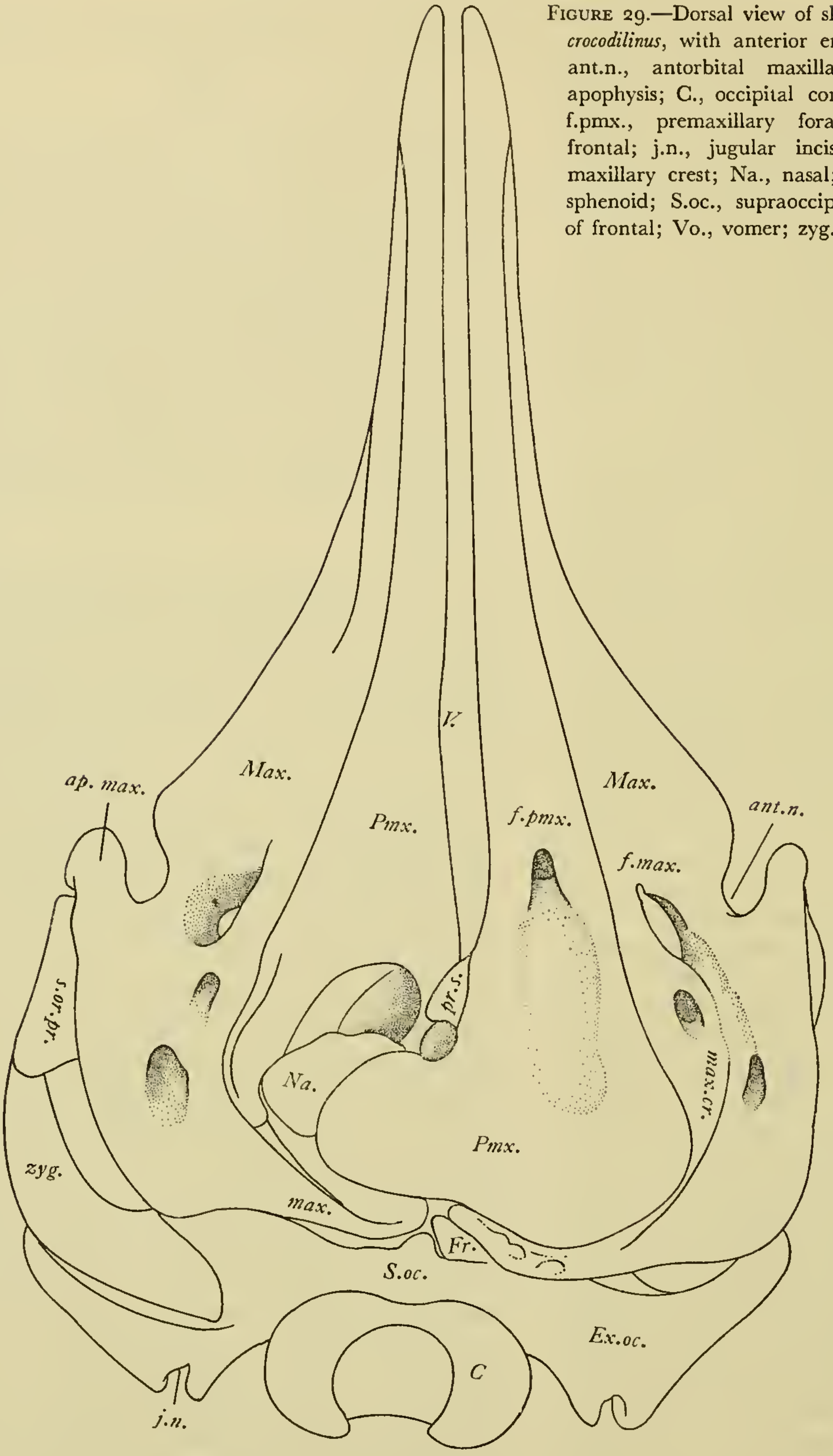

Figure 29.—Dorsal view of skull, USNM 22926, of *Orycterocetus crocodilinus*, with anterior end of rostrum restored. Abbrs.: ant.n., antorbital maxillary notch; ap.max., maxillary apophysis; C., occipital condyle; f.max., maxillary incisure; f.pmx., premaxillary foramen; Ex.oc., exoccipital; Fr., frontal; j.n., jugular incisure; Max., maxillary; max.cr., maxillary crest; Na., nasal; Pmx., premaxillary; pr.s., presphenoid; S.oc., supraoccipital; s.or.pr., supraorbital process of frontal; Vo., vomer; zyg., zygomatic process of squamosal.

The opposite premaxillaries of all known fossil and recent physeteroids are dissimilar in form. The upper surface of the right premaxillary in front of the premaxillary foramen is concave for a distance of about 150 mm. on two skulls (USNM 14729 and 14730) and convex on the other skull (USNM 22926). As a result of telescoping, the right premaxillary is extended backward on the upper surface of the cranium to the posterior borders of the maxillaries. Posterior to the nasal passages the right premaxillary expands into a broad, thin plate which is applied to the upper surface of the frontal, overlapping the maxillary externally and posteriorly. A large foramen pierces the right premaxillary anterior to the level of the maxillary incisure. On its internal border behind the nasal passages the right premaxillary overrides and partially conceals the flattened nasal bone except for a maximum 53 mm. wide exposure of its external border. The left premaxillary has been pushed outward by the enlargement of the left nasal passage and terminates 115 to 130 mm. behind the level of the posterior wall of this passage. No foramen is present on the left premaxillary anterior to the nasal passages. The inner borders of the premaxillaries are closely approximated in front of the presphenoid but do not completely roof over the mesorostral gutter on any one of the four fossil skulls. Anterior to the widest basal portion of the rostrum (fig. 30), the upper surfaces of the premaxillaries become progressively more convex and on USNM 22931 comprise one half or more of the vertical diameter on the distal 280 mm. of the lateral surface of the rostrum. Anterior to the widest basal portion of the rostrum the downward slope of the upper surface of the premaxillaries becomes more pronounced and is accentuated near the extremity. The premaxillaries (pl. 28 top) by themselves comprise the distal 75 mm. of the rostrum (USNM 22931) of the best preserved specimen. For more than half the length of the rostrum in front of the mesethmoid, the floor of the mesorostral gutter is formed by the anterior extension of the vomer and the sides and the roof by the premaxillaries; the distal 130 to 150 mm. is contributed entirely by the premaxillaries. The premaxillaries of this Calvert sperm whale skull resemble more closely those of *Diaphorocetus poucheti* than comparable cranial portions of any other described form, with the possible exception of the incompletely preserved skull (Abel, 1905, fig. 7) of *Thalassocetus antwerpiensis*. The side to side constriction of the anterior half or more of the rostrum resembles rather closely that of *D. poucheti*.

On one skull (USNM 14730) the distance from the posterior margin of the left nasal passage to the posterior face of the left occipital condyle is about half the distance from the anterior margin of the same passage to a point where the corresponding maxillary is no longer visible from a dorsal view.

The maxillaries are the largest elements in the rostrum and contribute the major portion of the palatal surface. The antorbital notches are deep and narrow. The rostrum is widest at the level of the anterior margin of the antorbital notches. As viewed from the dorsal side, the maxillaries are visible for a relatively greater distance toward the extremity of the rostrum on USNM 22926 than on USNM 22931. Unfortunately the extremity of the rostrum (pl. 22) of USNM 22926 is not preserved, and the left maxillary was broken off 410 mm. anterior to the level of the antorbital notches and was still visible some 180 mm. in front of the level of the anterior end of the vomer exposed on the palatal surface of the rostrum. On the better preserved rostrum (USNM 22931) each maxillary disappears from the dorsal view approximately 30 mm. in front of the level

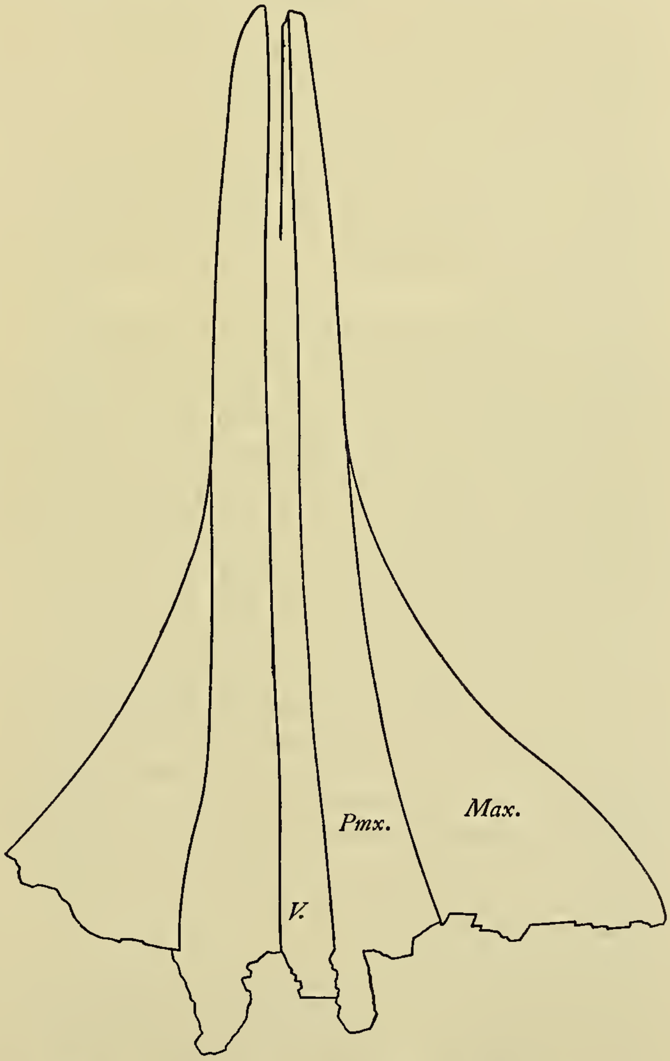

Figure 30.—Dorsal view of rostrum, USNM 22931, of *Orycterocetus crocodilinus*. Abbrs.: Max., maxillary; Pmx., premaxillary; Vo., vomer.

of the anterior end of the vomer. As will be observed from a palatal view (pl. 28 bottom) the premaxillaries comprise the distal 75 mm. of the rostrum (USNM 22931). It is obvious that little or no importance should be attributed to the dorsal exposure of the maxillaries as this bone is visible for a distance of 300 mm. anterior to the level of the antorbital notches on another skull (pl. 25, USNM 14730) and disappears from a dorsal view on USNM 14729 at least 200 mm. behind the broken extremity of the rostrum and 290 mm. anterior to the level of the antorbital notches.

Posterior to the antorbital notch, each maxillary is dorsoventrally thickened and contributes to the sloping outer wall of the supracranial basin. This posterior portion of the maxillary overrides the frontal, but leaves exposed a very narrow strip of the outer orbital portion of the supraorbital process. When the skull is viewed from above, the slender apophysis of the maxillary conceals the lachrymal (which is lost on all three crania) from a dorsal view. The maxillary incisure is quite variable in size and shape on the three skulls. A longitudinal depression is present on the dorsal surface of the maxillary in front of the maxillary incisure on one skull (USNM 22926) but is either absent or much less developed on the other two skulls. The posterior maxillary foramina although continuous internally with the maxillary incisure open into short posteriorly directed furrows.

The facial depression or supracranial basin (pl. 25), in which the spermaceti organ rests, occupies a large area on the dorsal surface of the skull. This supracranial basin is bounded posteriorly by the upturned and curved crestlike hinder borders of the two maxillaries which in turn are thrust backward against the upper border of the supraoccipital. The outer wall of the supracranial basinis contributed on the right side by the maxillary and on the left side by the premaxillary which overrides the corresponding portion of the maxillary. This basin is terminated anteriorly on the proximal portion of the rostrum.

Above the temporal fossa (pl. 27 top) the outer margin of the maxillary (USNM 14730), follows the underlying border of the frontal and does not project laterally beyond the latter. The postnarial portion of the right maxillary is separated by an interval of about 16 mm. from the left maxillary at the middle of the supraoccipital crest (USNM 22926). The depression of the supracranial basin has not modified the maxillaries to the same extent as the premaxillaries were altered.

The left respiratory passage (pl. 25) is bounded by the ethmoid on the inner side, by the left premaxillary in front and externally, and by the nasal and left premaxillary behind. Ventrally the vomer curves around the inside and back of each passage while the pterygoid and its hamular process (USNM 22926) contributes the remainder of the ventral border.

The laterally compressed presphenoid contributes the pluglike projection at the posterior end of the mesorostral gutter. Along with the enlargement of the left nasal passage, the presphenoid has been shoved leftward; laterally it slopes obliquely downward from left to right and its main axis forms an angle with the longitudinal axis of the rostrum. The mesethmoid is rather intimately coalesced with the presphenoid and apparently this bone contributes a portion of the posterior wall of the left nasal passage (USNM 14730). Each lateral wing of the presphenoid, the orbitosphenoid, is seemingly coalesced with the cranial portion of the corresponding supraorbital process of the frontal as in a young *Physeter* skull (Kellogg, 1925, pl. 6). The open furrow for the optic nerve on the ventral face of the supraorbital process of the frontal terminates internally. This portion of the frontal abuts posteriorly against the alisphenoid. No orifices for the olfactory nerves are present and hence the sense of smell has been lost. If ectethmoids are present they are coalesced with the mesethmoid which apparently contributes the most dorsal portion of the partition between the nasal passages.

Although a careful search was made on these three skulls for small foramina in the posterior walls of the nasal passages which would give passage for the ophthalmic division of the trigeminal nerve none were noted.

On these Calvert skulls the upwardly curved platelike portions of the frontals meet on the midline, roof over the braincase, and abut against the dorsal border of the supraoccipital. On the young skull (USNM 22930) and that of the oldest individual (USNM 22926) the posterior edge of the frontal underlying the right maxillary is exposed in front of the dorsal crestlike edge of the supraoccipital.

The zygomatic processes are more elongated and more outwardly bowed (pl. 23) than in *Diaphorocetus poucheti* (Lydekker, 1894, pl. 3). Each platelike exoccipital which abuts against the corresponding squamosal curves forward, but projects backward beyond the level of the supraoccipital shield when viewed from above.

Posterior view.—Since the occipital surfaces of two of these skulls are incomplete in one respect or another, the description of this surface (pl. 24 top) will be based on the largest skull (USNM 22926). The supraoccipital shield above the condyles slopes forward and is concavely curved from side to side; its relatively thin projecting flangelike external border contributes the posterior boundary of the temporal fossa. The exoccipitals (pl. 27 bottom) are relatively large, anteroposteriorly compressed bones, somewhat curved from side to side and partially conceal from a posterior view the corresponding zygomatic process. Anteriorly each exoccipital is suturally united with the squamosal, internally fused with the basioccipital, and dorsally merged imperceptibly into the supraoccipital. The deep jugular incisure (pl. 24 top) separates the internal margin of the exoccipital from the hinder end of the elongated falcate process of the basioccipital. Ventral to the occipital condyles and internal to the exoccipitals are the falcate processes of the basioccipital. The posterior ends of the hamular processes of the pterygoids are visible in front of and between the falcate processes. The foramen magnum is relatively large. The protuberant occipital condyles exhibit a greater transverse width dorsally than ventrally, and are convex from side to side. The internal borders of the condyles are concave; they are more closely approximated ventrally than dorsally.

Lateral view.—As seen from a lateral view, all three skulls are crushed to a varying degree. The largest skull (USNM 22926), although depressed somewhat, is the most complete. From about the middle of the length of the rostrum backward (pl. 24 bottom) the outer margin of the maxillary rises gradually to the antorbital notch. Beginning at the level of the fourteenth alveolus, counting backward from the anterior end of the maxillary tooth row, the oblique upward slope of the external face of the maxillary becomes accentuated so that it is nearly vertical in front of the ninth alveolus. Between the ninth alveolus and the antorbital notch the maxillary becomes progressively more compressed dorsoventrally. The apophysis of the maxillary is relatively large as compared to the supraorbital process of the frontal. The maxillary overrides the supraorbital process as well as the cranial portion of the frontal and ascends upward in a strong curve to the dorsal crest of the posterior face of the skull. The postorbital projection of the supraorbital process is more elongated than the postorbital portion and is turned downward and presumably came in contact with the anterior end of the zygomatic process.

On the type skull of *Thalassocetus antwerpiensis* (Abel, 1905, fig. 8) the slope of the outer border of the frontal and overlying maxillary above and behind the orbit is similar to that exhibited by the skull of *Orycterocetus crocodilinus* (USNM 22926), although the posterior extremities of these bones are less noticeably upturned.

The missing lachrymal was lodged in the gap between the antorbital portion of the supraorbital process and the apophysis of the maxillary.

The temporal fossa is relatively small, shortened anteroposteriorly, and bounded by the squamosal and its zygomatic process posteriorly and ventrally, and by the frontal dorsally and anteriorly. On one skull (USNM 14729) the almost vertical sutural contact of the ventrally situated alisphenoid with the squamosal at the rear is quite distinct. Careful examination of the temporal fossae of three skulls did not reveal the boundaries or relations of the parietal bone on the outer wall of the braincase. On the skull of the young *Physeter catodon* the parietal is in contact ventrally with the alisphenoid and meets the frontal anteriorly; dorsally it seems to be intimately coalesced with the frontal and may possibly be in contact posterodorsally with the external border of the supraoccipital. Similar relationships of these bones seem to exist on the *Orycterocetus* skulls. The parietal, however, is excluded from the top of the cranium behind the supracranial basin.

Abel (1905, p. 72) states that on the skull of *Thalassocetus antwerpiensis* the parietals are visible on the dorsal crest between the supraoccipital and the frontals. Judging from the relations of the cranial bones of the *Orycterocetus* skull it would appear that it is the posterior border of the frontal that is exposed between the overriding maxillary and the supraoccipital. If this is the correct interpretation, the parietal is shut off from the vertex and restricted to the temporal fossa. The alisphenoid extends forward to the supraorbital process of the frontal and contributes the posterior border of the optic furrow.

Both zygomatic processes are essentially complete on the largest skull (USNM 22926). They are relatively slender, but thickened dorsoventrally, with a curved concave glenoid articular surface. If not actually in contact, the postorbital projection of the supraorbital process at least overhung the anterior end of the zygomatic process. The actual contact between the exoccipital and the squamosal is revealed quite distinctly when this region is viewed from the side.

The rostrum is exceptionally well preserved on one specimen (USNM 22931). It is rather deep near the middle of its length (pl. 29, top), the maximum depth there slightly exceeding that of the proximal end. Commencing at the level of the fifteenth alveolus counting backward from the anterior end of the maxillary, the outer border of that bone becomes progressively thinner toward the antorbital notch. The maxillary itself, however, increases in vertical diameter anteriorly on the proximal half of the rostrum, and attains its maximum depth at the level of the twelfth alveolus counting backward from the anterior end of this bone. From this point forward the lateral surface of the rostrum becomes more nearly vertical and the dorsoventral diameter of the maxillary diminishes while that of the premaxillary increases. Anteriorly the premaxillary (pl. 28, bottom) projects forward beyond the maxillary, contributing the extremity of the rostrum, on which three teeth were present in the same number of very shallow alveoli.

Ventral view.—The general contour of the ventral aspect of the Calvert physeteroid skull (pl. 23) is somewhat pentagonal. As contrasted with the skull of *Diaphorocetus poucheti* (Lydekker, 1894, pl. 3, fig. 1), the more obvious distinctive characteristics of the ventral portion of the Calvert skull (fig. 31) are the more elongated zygomatic processes, wider and possibly more closely approximated hamular processes of the pterygoids, more protuberant occipital condyles, larger antorbital maxillary notches,

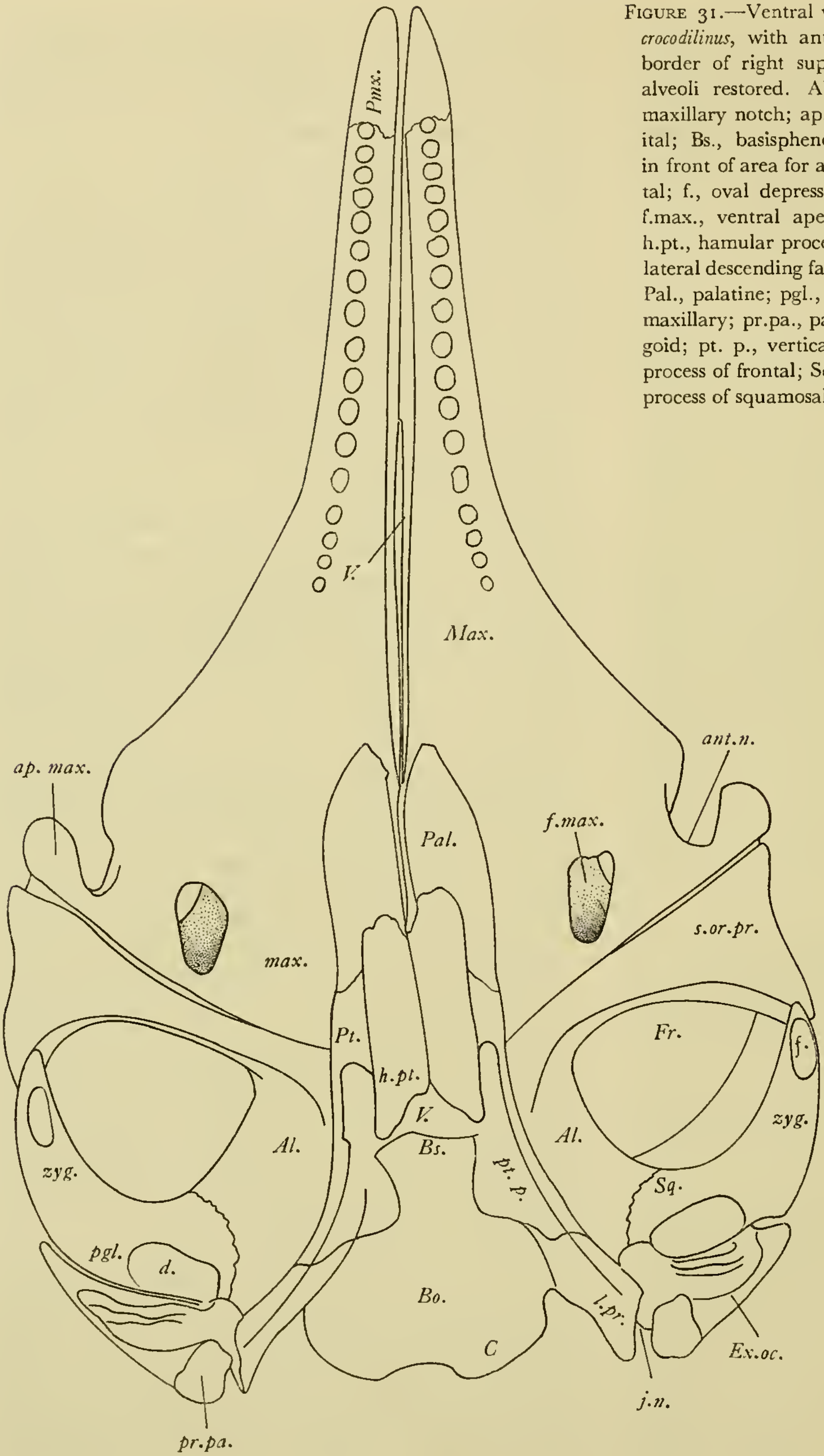

FIGURE 31.—Ventral view of skull, USNM 22926, of *Orycterocetus crocodilinus*, with anterior end of rostrum, incomplete orbital border of right supraorbital process, occipital condyles, and alveoli restored. Abbrs.: Al., alisphenoid; ant.n., antorbital maxillary notch; ap.max., maxillary apophysis; Bo., basioccipital; Bs., basisphenoid; C., occipital condyle; d., depression in front of area for attachment of spongy mass; Ex.oc., exoccipital; f., oval depression on anterior glenoid articular surface; f.max., ventral aperture of infraorbital system; Fr., frontal; h.pt., hamular process of pterygoid; j.n., jugular incisure; l.pr., lateral descending falcate plate of basioccipital; Max., maxillary; Pal., palatine; pgl., postglenoid process of zygoma; Pmx., premaxillary; pr.pa., paroccipital process of exoccipital; Pt., pterygoid; pt. p., vertical plate of pterygoid; s.or.pr., supraorbital process of frontal; Sq., squamosal; Vo., vomer; zyg., zygomatic process of squamosal.

and alveoli for maxillary teeth not extended as far toward the base of the rostrum. The right lachrymal is retained on the skull of *Diaphorocetus poucheti* attached to or wedged in between the apophysis of the maxillary and the antorbital portion of the supraorbital process. Seventeen alveoli for the teeth (pl. 28 bottom) implanted in each maxillary are readily discernible (USNM 22931). None of the alveoli exceed 15 mm. in depth and most alveoli are somewhat shallower, irregularly shaped and enclosed within cancellous or spongy bone. The four posteriormost alveoli, fourteenth to seventeenth inclusive counting backward from the anterior end of the palatal surface of the maxillary, are rather shallow and not sharply defined. Behind the posteriormost alveolus in the left maxillary and internal to it is a row of six shallow circular depressions for lodging the crowns of corresponding mandibular teeth. Four similarly located circular depressions are present on the right maxillary. The absence of similar depressions for mandibular teeth on the anterior palatal surface may possibly indicate that the mandible did not extend forward to the extremity of the rostrum. Presumably not more than three rather small, shallow alveoli were present in each premaxillary, the anteriormost alveolus on each side being the deepest. These alveoli must have lodged a very short root of a small nonfunctional tooth. The full complement of teeth on each side of the palatal surface of the rostrum is thus 20 teeth. On the constricted anterior portion of the rostrum the teeth were implanted along the outer border of the maxillary in distinct and fairly equally spaced alveoli, the interval between them varying from 7 to 15 mm. These alveoli do not follow the external border of the maxillary proximally beyond the narrowed distal portion of the rostrum, but do nevertheless diverge as the basal palatal portion of each maxillary increases in width. The location of the posterior maxillary alveoli on the skulls of *Idiorophus* (*Apenophyseter*), *Scaldicetus* and *Physeterula* is at present unrecorded.

On the skull of the largest individual (USNM 22926), the left maxillary tooth row terminates 90 mm. in front of the anterior end of the left palatine, or 160 mm. in front of the hinder margin of the antorbital maxillary notch. The four hindermost teeth were implanted in relatively shallow alveoli in the left maxillary; the alveoli located anterior to these four posterior alveoli become progressively deeper and slope obliquely inward and backward from the alveolar margin. No circular depressions for lodging the crowns of mandibular teeth were noted on the palatal surface of either maxillary.

The ventral or palatal surface of the rostrum (pl. 23) is formed largely by the maxillaries. Proximally the internal edges of the maxillaries become separated by the narrow keel of the vomer slightly behind the level of the anterior ends of the palatines and then spread apart distally to permit the premaxillaries to be visible between them. The vomer can be observed for a distance of 200 mm. between the maxillaries on the palatal surface of two skulls (USNM 22926 and USNM 22931) and for a somewhat variable distance on other skulls before it is entirely shut off on the anterior half of the rostrum by the close longitudinal contact of the opposite premaxillaries. The large single orifice for the infraorbital system is located internally to the antorbital notch on each maxillary (USNM 22926). Two ventral orifices for the infraorbital system, one anterior to the level of the antorbital maxillary notch and the other posterior to the level of this notch are present on the palatal surface of each maxillary of the Californian Miocene sperm whales, *Idiophyseter merriami* and *Aulophyseter morricei.*

Anteriorly, each premaxillary first becomes visible as a narrow strip on the palatal surface of the rostrum between the opposite maxillaries and the narrowly exposed keel of the vomer at the level of the anterior third of the latter.

The lachrymal bone has been dislodged and lost on all of these Calvert skulls. In its original position it was lodged in the narrow groove between the apophysis of the maxillary and the antorbital portion of the supraorbital process and apparently conformed to that of *Diaphorocetus poucheti* (Lydekker, 1894, pl. 3, fig. 1).

The palatine bones were fairly well preserved on the largest skull (USNM 22926), but are missing on the others. Each palatine is mortised into the ventral surface of the corresponding maxillary and projects forward considerably beyond the level of the large infraorbital system aperture. The anterior ends of the palatine bones are obtuse and the external margins are convexly curved. The palatines are overlapped posteriorly by the pterygoids. The relations of the palatines to the surrounding bones were thus essentially the same as on the skull of a young *Physeter catodon* (Kellogg, 1925, pl. 6, fig. 3).

The pterygoids meet on the midline and their hamular processes prolong the palate backward. The hamular processes (pl. 23) are large, relatively broad and completely conceal the nasal passages from a ventral view. The external margin of each hamular process does not overhang the vertical plate of the corresponding pterygoid. Both hamular processes project backward beyond the level of the furrow for the optic nerve. The internal edges of the hamular processes are in contact for most of their length, but diverge slightly behind the level of the nasal passages, forming obliquely truncated posterior ends. The vertical plate of each pterygoid merges posteriorly with the lateral descending falcate plate of the basioccipital.

The posterior end of the vomer is horizontally widened and overrides the basisphenoid and between the nasal passages forms the trough in the posterior end of which the presphenoid is lodged. The vomer contributes a portion of the lower half of the internal and posterior wall of each nasal passage, meeting the ethmoid dorsally.

The median region of the basicranium is bounded laterally by the deep vertical plates of the pterygoids (pl. 23) and posteriorly by the adjoining descending falcate plates of the basioccipital. The median basicranial region is relatively wide.

The flangelike falcate plates of the basioccipital descend obliquely and are directed outward and backward, but not projecting posteriorly beyond the occipital condyles (USNM 22926). Each falcate plate is thickened near its truncated extremity. The basioccipital is a relatively short bone, ankylosed anteriorly with the basisphenoid, and terminated posteriorly by the two condyles.

Between the descending falcate plate of the basioccipital and the thickened paroccipital process is the deep jugular incisure. The jugulo-acoustic funnel is bounded posteriorly by the exoccipital, internally by the basioccipital and anteriorly by the alisphenoid.

The horizontal flattening of the ventral surface of the alisphenoid and the adjacent surface of the squamosal seems to have resulted from the general widening of the basicranium (USNM 14729). The alisphenoid is relatively large and expanded horizontally. This bone is bounded anteriorly by the supraorbital process of the frontal, suturally united and in squamous contact posteroexternally with the squamosal, and in contact posterointernally with the basisphenoid and basioccipital. The horizontal expansion of the alisphenoid and the absence of a projecting glenoid process of the squamosal has as in other physeteroids resulted in the elimination of the tympanoperiotic recess which is a characteristic feature of delphinoids. The periotic and tympanic bones are thus excluded from the wall of the cranial cavity. No external reduplication of the pterygoid was developed on this Calvert sperm whale skull and this in conjunction with the closure of the area occupied on most odontocete skulls by the tympanoperiotic recess seem to represent a constant physeteroid basicranial characteristic. This basicranial modification was accompanied by the disappearance or relocation of some of the posterior foramina. The optic furrow (pl. 26) terminates internally on the ventral surface and the optic nerve makes its exit through a small foramen in the anterior wall of the braincase. The sphenoid fissure (USNM 14730) is bounded by the vertical plate of the pterygoid ventrally, by the alisphenoid posteriorly, and by the orbitosphenoid anteriorly and externally.

The foramen ovale pierces the internal portion of the alisphenoid and its ectal orifice is located near and external to the base of the more or less vertical plate of the pterygoid (USNM 22926 and USNM 14729). The foramen ovale for the mandibular branch of the trigeminal nerve on the young skull (USNM 22930) by the progressive closure of the elongated notch or fissure is now cut off from the edge of this bone; but its earlier condition is shown by the deep groove that marks the former position of the notch. Although the foramen ovale is located at the end of the conspicuous longitudinal notch at the posterior margin of the alisphenoid on the fetal *Physeter* skull, on the skull (pl. 29 bottom) of this very young Calvert Miocene physeteroid this elongated notch seemingly at an earlier growth stage was situated between the inner edge of the alisphenoid and the basioccipital.

The jugulo-acoustic funnel opens into the cranial cavity and is concealed from a ventral view by the descending falcate plate of the basioccipital. The deep jugular incisure is located external to this cranial opening. On the basicranium (pl. 29 bottom) of the very young Calvert sperm whale (USNM 22930) the oblique course of the jugulo-acoustic funnel is exposed, showing that it is directed forward and upward between the exoccipital, the basioccipital and the inner margin of the alisphenoid. In this region the base of the vertical plate of both pterygoids has been dislodged, exposing a narrower channel and foramen for the internal carotid, measuring 6 mm. in diameter, internal to and parallel below with the jugulo-acoustic funnel. This foramen pierces the basisphenoid in the region where it is embraced by the base of the vertical plate of the pterygoid. The jugulo-acoustic funnel opens into the cranial cavity on this young fossil basicranium some 53 mm. anterior to the articular face of the paroccipital process. The articular surface on the paroccipital process (pl. 23) of the exoccipital for attachment of the stylohyal is well defined on the largest skull (USNM 22926).

The squamosal contributes a relatively small area of the external wall of the braincase. A long curved irregular suture marks the union of the squamosal with the alisphenoid on the basicranium of the young fossil skull (USNM 22930). The squamous overlap of the squamosal by the alisphenoid is clearly delimited in the cranial cavity of this young fossil skull. Viewed from below the zygomatic process is rather slender; its glenoid articular surface is shallowly concave transversely, and concavely curved anteroposteriorly, but is not set off from the rest of the squamosal by an elevated internal margin. At the anterior end (fig. 31) of the ventral articular surface of the zygomatic process there is a distinct elliptical or elongated oval depression (15×40 mm.) whose function is not readily apparent. The glenoid articular surface of the zygomatic process is also fairly well defined on the young Calvert fossil skull. The postglenoid projection of the zygomatic process is rather short and thin. The squamosal is rather deeply excavated postero-internally to the glenoid articular surface of the zygomatic process to constitute a shallow depression in front of the area for attachment of the spongy osseous mass associated with the tympanic bulla. No remnant persists of the falciform process of the squamosal that articulated in other odontocetes with the alisphenoid. Posteriorly, the squamosal abuts against the exoccipital, whose posterior face curved convexly outward and forward.

Measurements in millimeters of the young Calvert sperm whale skull (USNM 22930) are as follows: Greatest breadth of skull across zygomatic processes, 292; greatest height of skull (basisphenoid to transverse supraoccipital crest), 215±; greatest breadth of right premaxillary opposite narial choanae, 58; greatest anteroposterior diameter of right supraorbital process at extremity, 50; least breadth of supraoccipital between temporal fossae, 205; greatest length of zygomatic process, 66; and distance across skull between outer margins of exoccipitals, 268.

Measurements (in mm.) of the skulls USNM 22926 (Zone 13, south of Parker Creek, Md.), USNM 14730 (Zone 12, south of Parker Creek, Md.), and USNM 14729 (Zone 11, south of Randle Cliff beach, Md.) are as follows:

	USNM 22926	*USNM 14730*	*USNM 14729*
Total length as preserved (condyles to tips of premaxillaries)	724+	631+	750+
Total length estimated (condyles to tips of premaxillaries)	830±	—	—
Length of rostrum as preserved (antorbital notches to extremity)	425+	384	500
Breadth of rostrum at antorbital notches	343	303	285
Breadth of rostrum at enlargement in front of antorbital notches	350	298	292
Greatest breadth of skull across maxillary apophyses	445	395	383
Greatest breadth of skull across zygomatic processes of squamosals	485	—	478+
Vertical height of skull (basisphenoid to transverse crest)	308	271	310
Vertical height of skull (hamular process of pterygoid to transverse crest of supraoccipital)	353	—	—
Greatest width of maxillary from a ventral view (internal margin to maxillary apophysis)	225	205	195
Greatest length of right premaxillary as preserved, in a straight line	640	580	637
Greatest breadth of right premaxillary at level of narial choanae	111	80	100
Greatest breadth of right premaxillary posterior to narial choanae	225	149	155+
Greatest anteroposterior diameter of supraorbital process of frontal at extremity	115	103	—
Greatest dorsoventral diameter of preorbital portion of supraorbital process of frontal	36	37	—
Elevation of lateral crest of supracranial basin above orbit	294	170	300±
Least breadth of supraoccipital between temporal fossae	207	218	172
Distance from summit of transverse crest of supraoccipital to upper margin of foramen magnum	251	196	232
Height of foramen magnum	63	60	—
Transverse diameter of foramen magnum	81	66	—
Greatest distance between outside margins of occipital condyles	150	122	—
Greatest vertical diameter of occipital condyle	107±		—
Greatest transverse diameter of occipital condyle	38	34	—
Distance across skull between outer margins of exoccipitals	456		438
Distance between anterior margin of maxillary apophysis and posterior face of condyle	397	314	332
Distance across basicranium between opposite foramen ovale	150	130	115
Length of vomer exposed on ventral face of rostrum	162	195	205
Greatest length of right palatine	150	—	—
Greatest breadth of right palatine	67	—	—
Greatest length of right pterygoid including hamular process	130	—	—
Greatest length of zygomatic process	145	—	125
Greatest diameter of right narial choanae	24	25	25
Greatest diameter of left narial choanae	53	55	54
Apex or crest of supraoccipital to extremity of rostrum, as preserved	660+	619+	661+
Right antorbital notch to apex or crest of supraoccipital shield (medially)	350	276	277
Inner margin of right premaxillary to inner margin of antorbital notch	158	138	130
Inner margin of right premaxillary to outer margin of maxillary apophysis	203	185	183
Distance between outside margins of opposite maxillary apophyses	446	398	380
Distance between outside margins of opposite preorbital portions of supraoccipital processes	456	413	—
Distance between opposite notches for jugular leash	245	—	200

Teeth

Seventeen teeth were lodged in each maxillary in distinct alveoli, three were present on each premaxillary, and an unknown number in each mandible. Sixteen teeth (pl. 30 top) were associated in the sandy clay enveloping the most mature skull (USNM 22926) and the posterior end of the left mandible. There is no certainty that these 16 teeth indicate either immaturity or that they were once embedded in the upper jaw. The skull of the Recent sperm whale (*Physeter catodon*) carries from one to eleven vestigial or very small curved teeth on each side of the upper jaw. These small teeth of *Physeter* are either completely hidden from a palatal view or their tips only cut through the gum. Larger and more robust teeth (pl. 30, figs. 11–14) characterized by annular lines of growth and an outer layer of cementum have also been recovered from the Calvert formation. These unquestionably represent teeth of mature individuals and are quite probably mandibular teeth.

The 16 teeth associated with the skull (USNM 22926) and the four isolated teeth (USNM 22933) are very similar in general conformation. These slender strongly curved teeth vary in length from 45 mm. to 78 mm. The general conformation of one of these teeth is an elongated curved cone, with either slightly flattened or longitudinally grooved sides, and with the posterior face less convex than the anterior curved surface. Three of these slender teeth (USNM 22933) and one associated with the skull (USNM 22926) have a completely closed pulp cavity at the end of the root (pl. 30, figs. 9–10). At the open base of the root of the other teeth, the funnellike pulp cavity which extends distally for one-fourth to one-third of the length of the root, is bounded by a very thin and fragile outer wall. Seven of these teeth (pl. 30, figs. 6, 7, 8, 9, 10) have an attenuated distal or apical end, but no trace of enamel. Four of these teeth have worn distal ends (pl. 30, figs. 1, 3, 4, 5). There exists no distinction between the apical portion which would be regarded as the crown and the root. Annular lines of growth are not visible on these slender teeth.

The largest tooth (pl. 30, fig. 12) recovered from the Calvert formation measures 92 mm. in length, while its greatest diameter (20.5 mm.) is at the base which is open, the pulp cavity extending distally for half the length of the root. The root is ovoidal in transverse section at the base. This tooth has retained some of its outer layer of cementum and displays annular rings of growth, but no enamel on the tip or crown. A portion of the tip is missing. The root is also indistinctly fluted or ridged longitudinally and is much less noticeably curved from end to end than the more slender teeth. This (USNM 22935) may possibly be a mandibular tooth.

The next largest tooth (USNM 22934) is strongly curved from end to end, rather deeply longitudinally fluted or grooved, and exhibits fine annular lines of growth. The outer layer of cementum is retained only on the proximal end and the pulp cavity is rather short, extending distally less than one-fourth the length of the root. The apical or crown end is worn and is ovoidal in transverse section; a small area on the tip is blackish and shining. At its base the root is more noticeably triangular in cross section. This tooth (pl. 30, fig. 13) measures 89 mm. in length, and its greatest diameter at the base is 15.5 mm. Some variation obviously exists in the length of the pulp cavity, which on the type tooth of *Orycterocetus crocodilinus* according to Cope

Measurements of Teeth:	*USNM 22926, pl. 30 fig. 8*	*USNM 22926, pl. 30 fig. 7*	*USNM 22926. pl. 30 fig. 6*	*USNM 22926, pl. 30 fig. 5*	*USNM 22926, pl. 30 fig. 4*	*USNM 22926, pl. 30 fig. 3*	*USNM 22926, pl. 30 fig. 2*
Greatest length of tooth as preserved in a straight line	68	62	56	53	51	52.7	49.6
Anteroposterior diameter of most expanded portion of root	7.5	9.5	8.8	10	8.9	8.9	8.3
Transverse diameter of most expanded portion of root	7.2	9	8.5	8	7.7	8	7.7

Measurements of Teeth:	*USNM 22926, pl. 30 fig. 1*	*USNM 22933, pl. 30 fig. 10*	*USNM 22933, pl. 30 fig. 9*	*USNM 22934, pl. 30 fig. 13*	*USNM 22935, pl. 30 fig. 12*	*USNM 1158, pl. 30 fig. 14*	*USNM 22932, pl. 30 fig. 7*
Greatest length of tooth as preserved in a straight line	44.7	78.6	68.3	89	92	70	64.5
Anteroposterior diameter of most expanded portion of root	9.5	11.5	10.5	15.5	20.5	18.4	13.7
Transverse diameter of most expanded portion of root	8.5	10.6	9.2	14	16	17.5	10.7

(1868, p. 145) extends distally for two-thirds of the length of the tooth.

Another tooth (USNM 1158) from the Miocene Choptank formation overlying the Calvert formation probably belongs to this species of sperm whale. The pulp cavity at the base of the root is closed, the thin annular lines of growth on the dentine are quite distinct, the outer layer of cementum is missing and the apical end or crown (pl. 30, fig. 14) is worn. The length of this tooth is 70 mm., and the greatest transverse diameter near the tip is 17.5 mm.

All of the teeth thus far recovered from the Calvert Miocene formation are less than half the size of those of *Scaldicetus caretti.* Rugose striated enamel on the crowns in part characterizes the teeth of *Scaldicetus caretti* and *S. grandis.* The skull of *Physeterula dubusii* was considerably larger than that of *Orycterocetus crocodilinus,* seemingly at least a third or more longer, and the mandibular teeth are also large. The teeth of this Antwerp species lack enamel on the crowns. The architecture of the skull is largely unknown. Abel (1905, p. 81) describes the articular surface of the zygomatic process as large, like that of *Physeter,* but the symphysis of the mandibles is shorter. No teeth were definitely associated with the skull of *Thalassocetus antwerpiensis.* Teeth, however, very similar to those of *Orycterocetus crocodilinus* are described and figured by Abel (1905, pp. 73–74, figs. 9–10). These slender curved teeth have an open pulp cavity and no enamel, but the dentine at the tip (or crown) of the teeth is black and shining. Abel suggested that they may be the teeth of *Thalassocetus* and also that the skull may have belonged to a young *Scaldicetus.*

Measurements (in mm.) of the teeth are tabulated opposite.

Periotic

One (pl. 31, fig. 3) of the five periotics here described was associated with the most mature and most completely preserved skull. Three of the periotics have the posterior process worn or eroded to varying degrees. One (USNM 22953) is exceptionally well preserved, possibly owing in part to its attachment to the corresponding tympanic bulla. The periotic of the Calvert sperm whale resembles in essential details that of the Tembler Miocene *Aulophyseter morricei* (Kellogg, 1927, pls. 8–9). The various structures of all described fossil physeteroid periotics are quite similar and are readily distinguishable from those of other odontocetes, Recent and fossil. The external portion of this periotic (pl. 32, fig. 2) comprising the anterior and posterior processes is very dense and heavy; the internal subhemispherical *pars cochlearis* and *pars vestibularis* is noticeably lighter.

The posterior process in an unworn condition (pl. 32, fig. 3) is characterized by projecting rugosities or spines that impart an irregular external and anterior emargination. Fine osseous ridges and grooves radiating outward from the base or internal margin of the posterior process mark the area of attachment of this concave surface with the corresponding surface of the tympanic bulla. This posterior articular surface is somewhat quadrangular in outline, the posterior edge being nearly straight. The anterior and posterior margins of this process on two of these periotics (USNM 11234 and USNM 22926) are slightly elevated above the concave articular surface and the ridges and grooves for attachment to the tympanic bulla are coarser. The ventrointernal border of the posterior process projects inward and its free edge contributes the floor of the facial canal for about half of its length. The dorsal surfaces of the posterior process are somewhat rugose when unworn. Four of these periotics (pl. 32) illustrate the variation that may be expected in the elongation and the shape of the posterior process.

There is a circular rugose or pitted depressed area (pl. 32, fig. 4) near the middle and on the internal border of the *pars cochlearis* on three of these periotics (USNM 11234, 22926 and 22953) behind the embraced accessory ossicle. The major area of the ventral face of the *pars cochlearis* is more or less flattened and slopes toward the anterior margin, with the most inflated portion in front of the fenestra rotunda. The internal face of the *pars cochlearis* is flattened and almost vertical. From a tympanic view three apertures are visible and of these the largest is the fenestra rotunda on the posterior face of the *pars cochlearis.* This fenestra is somewhat ovoidal in outline and is modified to a varying extent by the dimensions of the connecting aqueduct. The fenestra ovalis is ovoidal in outline and is situated near the center of the tympanic face of the periotic. On the outside the fenestra ovalis (pl. 32, fig. 4) is encircled by a narrow rim which is raised above the canal for the facial nerve and the fossa for the stapedial muscle. The foot plate of the small stapes is securely lodged in the fenestra and remains in place on one periotic (USNM 22953). A medium-sized internal aqueduct which leads away from the vestibule and two minute anteroexternal foramina which connect with the semicircular canals are visible within the fenestra ovalis. The minute aquaeduct leading from the foramen singulare has its aperture near the bottom of the vestibule on the internal wall and near the anterior angle. The epitympanic orifice of the *aquaeductus Fallopii* and the fenestra ovalis are situated in a depression, although the facial canal leading backward from the latter is partially concealed from a ventral view by the projecting ledge for the rather small circular *fossa incudis.* Posterior to this Fallopian orifice, the canal for the facial nerve is open along its whole length, sloping obliquely downward and curving around the posterior face of the posterior process (USNM 22953). Posteriorly, the facial canal forms a boundary for the large excavated fossa for the stapedial muscle. This fossa for the stapedial muscle is a rather deep concavity; the surface for the attachment of the muscle extends downward on the external face of the *pars cochlearis.* A thin-edged crest is developed on the ventroexternal angle of the cochlear region by the encroachment of the fossa for the stapedial muscle. Between the fenestra ovalis and the attachment of the accessory ossicle, there is a deep concavity for the reception of the head of the malleus which originates beneath the epitympanic orifice of the *aquadeuctus Fallopii* and extends downward on the anterior process and the external face of the *pars cochlearis* to its tympanic face.

Between the rounded swelling on the base of the anterior process and the anterior margin of the articular facet on the posterior process, the ventral surface of the external denser portion of the periotic is hollowed out, becoming distinctly grooved as it approaches the *fossa incudis.* This small shallow circular fossa is situated at the extremity of the thin ledge which projects inward below the facial canal. The *crus breve* of the incus is lodged in this *fossa incudis.*

The extremity of the anterior process is obtusely pointed and truncated, the cerebral face being rugose and irregularly pitted. The contour of the somewhat pyramidal tuberosity located external to the epitympanic orifice of the *aquaeductus Fallopii* is modified to a varying extent by the presence of small nodosities. The external face of the anterior process is rounded off between this tuberosity and the tip of this process. Anterior to the fossa for the head of the malleus, the ventral surface of the anterior process is deeply concave from end to end and more or less flattened from side to side. A relatively large accessory ossicle (pl. 32, fig. 3) or unciform process of the tympanic bulla is embraced in this fossa. This ossicle is preserved intact on two periotics (USNM 22926 and 22953) and detached on one (USNM 10860). This accessory ossicle is rather large, nearly egg-shaped and exhibits a longitudinal external groove that marks the line of ankylosis with the thin delicate plate that is fused with or is a continuation of the external lip of the tympanic bulla in its normal position this ossicle is embraced by the anterior process of the periotic along its posterointernal border. When the accessory ossicle is lodged in its normal position, it contributes the outer wall of the deep notch between it and the *pars cochlearis.*

A rather prominent pyramidal tuberosity (pl. 31, fig. 4) is present on the outer denser portion of the periotic external to the cerebral orifice of the *aquaeductus Fallopii* on two of the periotics (USNM 11234 and 22926), but is much less conspicuous on the other two periotics. On all four of these periotics the anterior process in front of the *pars cochlearis* is concavely depressed. From an external view (pl. 32, bottom) the posterior process is noticeably elongated in contrast to the rather robust anterior process. The bony partition between the entrance to the *aquaeductus Fallopii* and the more centrally located *tractus spiralis foraminosus* is somewhat variable in its development (pl. 31, fig. 2). The contour of the rim of the internal acoustic meatus is subpyriform, although on one periotic (USNM 11234) the rim of the above described bony partition is almost on a level with or continuous with the rim of the internal acoustic meatus.

The most anteriorly located orifice on the cerebral face of the *pars cochlearis* is that of the *aquaeductus Fallopii* (pl. 31, fig. 1) through which passes the facial nerve to emerge on the tympanic or ventral face slightly anterior to the fenestra ovalis. At the bottom of the large and relatively deep internal acoustic meatus is located the *tractus spiralis foraminosus* and the minute foramen centrale. The small compressed foramen sigulare is located on the external wall of this meatus about half way between the rim and the bottom. The orifice of the *aquaeductus vestibuli* is located outside of and posterior to the rim of the internal acoustic meatus, in a narrow slitlike depression or fossa (pl. 31, fig. 2). The cerebral orifice of the *aquaeductus cochleae* is also located posterior to the meatus, and is smaller than the orifice of the *aquaeductus Fallopii.* The interval between the orifice

Measurements of Periotics:	*USNM 11234, Right periotic*	*USNM 22926, Left periotic*	*USNM 22952, Left periotic*	*USNM 22953, Right periotic*	*USNM 10860, Right periotic*
Breadth of periotic at level of fenestra ovalis (as measured from external face above excavation to internal face of *pars cochlearis*)	24	25.4	20.8	23.6	21.8
Greatest length of periotic (tip of anterior process to tip of posterior process)	37.8	41.3	42	43.8	33.6
Greatest dorsoventral depth of periotic (as measured from most inflated portion of tympanic face of *pars cochlearis* and external excavation to most projecting point on cerebral face)	16.7	18.4	15.4	17.5	16.2
Distance between fenestra rotunda and tip of anterior process	19	22.6	24.8	23.8	22
Distance between fenestra rotunda and tip of posterior process	18.3	22.5	28.5	21.2	14.5
Distance between epitympanic orifice of *aquaeductus Fallopii* and tip of anterior process	17.2	17	16.7	18.7	16.3

of the *aquaeductus cochleae* and that for the *aquaeductus vestibuli* varies from 2.0 to 3.3 mm. As shown by the table of measurements the five periotics exhibit relatively slight dimensional differences, but one (USNM 22952) is abnormal in some respects (pl. 32, fig. 1).

The right and left periotics described and figured by Abel (1902, pp. 121–122, fig. 19; pl. 17, figs. 11–12) unquestionably belonged to one of the Miocene sperm whales (*Scaldicetus*, *Physeterula*, or *Thalassocetus*) whose skeletal remains were excavated in the deposits in the Antwerp basin. As a result of fortuitous proximity they were associated with a skull of *Eurhinodelphis longirostris* by Abel. The characteristics of the periotic bones of *Eurhinodelphis* are known with certainty, inasmuch as these ear bones have been found attached *in situ* to Calvert Miocene skulls belonging to this genus. These Antwerp periotics are not markedly unlike those of *Orycterocetus* and judging from the measurements given by Abel they are approximately the same size as one Calvert periotic (USNM 11234).

Measurements (in mm.) of the periotics are tabulated opposite.

Tympanic Bulla

No tympanic bulla was found associated with any of the Calvert sperm whale skulls in the national collections. Fortunately, a right tympanic bulla (USNM 22953) was attached to a right periotic when it was discovered in the block of sandy clay which had fallen from the face of the cliff. As is usually the case tympanic bullae of the fossil cetaceans are incomplete in one or another respect when found. The anterior end of the thin brittle outer lip which arches over the involucrum and the slender and rather delicate processus gracilis of the malleus normally attached to the sigmoid process, as well as the anterior process which forms the thin osseous connection with the accessory ossicle are missing.

In ventral aspect (pl. 31, fig. 6) the bulla is abruptly widened behind the middle of its length, its posterointernal end is rather angular and its posteroexternal end is rounded off. A broad shallow groove traverses the median area of the posteroventral surface of the bulla.

The dorsal aspect of the bulla (pl. 31, fig. 7) is characterized in part by the sinuous curvature of the rather narrow involucrum and the relatively large and wide backwardly projecting posterior pedicle. The anterior end of this bulla is not sufficiently complete to indicate the size and contour of the anterior outlet or tympanic aperture for the eustachian canal. The involucrum is widest posteriorly, constricted near the middle of its length and attenuated anteriorly. The dorsal surface of the involucrum is less convex posteriorly than anteriorly and faintly rugose, but anteriorly it is more noticeably convex from side to side and internally descends abruptly into the tympanic cavity.

The overarching thin outer lip of this bulla (pl. 31, fig. 7), when complete, curved from end to end. The thin anterior process of the bulla which forms the connection with the accessory ossicle is broken off at the level of the edge of the thin outer lip, and remains attached to this ossicle on the periotic (pl. 32, fig. 3). The large posterior pedicle projects upward, outward and backward; the contiguous portion of the outer lip and the involucrum furnish the supporting structures. No narrow vertical fissure separates the portion of this pedicle (pl. 31, fig. 5) which arises from the involucrum from the portion which projects from the outer lip. The articular surface (pl. 31, fig. 7) on this posterior pedicle is unusually broadened, emarginate on its edges and creased by outward radiating ridges and grooves. A distinct dorsoventral ridge marks the posterior limit of the external face of the bulla and terminates dorsally on the short posterior conical apophysis or tuberosity adjacent to the sigmoid process. This sigmoid process is twisted to the extent that its extremity is almost transverse to the long axis of the bulla. The groove on the outer lip of the bulla anterior to the sigmoid process is rather broad and is continuous with the median depressed area on the posterior portion of the ventral face of the bulla. The anterior face of the terminal portion of the sigmoid process is hollowed out and the posterior face is somewhat curved or convex.

The laminated spongy osseous mass (USNM 22953) found associated with the right periotic and attached tympanic bulla is unusually light in weight for a bone of this size. Its dimensions are approximately as follows: greatest length, 42 mm.; greatest width, 38 mm. These thin plates (pl. 31, fig. 8) are pressed together more compactly at the enlarged extremity than at the base where some are separated from adjacent plates by an interval of 1 to 2 mm. Flower (1868, p. 321) has described a similar laminated structure for the Recent sperm whale (*Physeter catodon*) where the rather large mass of thin plates is held together through their attachment to the mastoid or posterior process of the tympanic bulla. Furthermore, the posterior edge of each squamosal, which is visible between the exoccipital and the postglenoid process, has a laminated character, the ridges and grooves on the contiguous surface fitting into those of this laminated mass.

The edge of the squamosal exposed between the exoccipital and the postglenoid process of the skull of *Orycterocetus* (USNM 22926) exhibits a similarly laminated condition. Thus this condition or peculiar modification for the attachment of the petrotympanic to the skull had been developed certainly by Calvert Miocene time. Apparently, judging from the illustration of the skull of the lower Miocene Patagonian *Diaphorocetus poucheti* (Lydekker, 1894, pl. 3, fig. 1) the hinder edge of the squamosal exhibits a laminated appearance.

Measurements (in mm.) of the right tympanic bulla of USNM 22953 are as follows:

Greatest anteroposterior diameter without posterior pedicle, as preserved	31.5
Greatest dorsoventral diameter on internal side	14
Greatest transverse diameter	21.6
Greatest dorsoventral diameter on external side (ventral face to tip of sigmoid process)	23

Mandible

A relatively small fragment of the posterior end of the left mandible was associated with one skull (USNM 22926). This portion of the ramus is characterized by a relatively thin fragile shell; the dorsal and ventral borders are incomplete. The external face of this portion of the ramus is convex; the internal face is concave and the lower border is bent inward. The condyle (53+ x 41 mm.) is located at the posteroventral angle of the ramus; its ventral angle seemingly does not project beyond the level of the ventral face of the mandible. The major axis of the condyle is oblique to the vertical axis of the hinder end of the ramus. The external border of the condyle is rather thick and rounded, projecting outward beyond the outer face of this portion of the ramus, in contrast to its somewhat thinner and sharp-edged internal and ventral margins of the internal face. The condyle as a whole becomes progressively thinner toward the ventral margin of the ramus; its posterior articular surface is convex and its anterior face strongly concave. From the curvature of the thin outer wall it would appear that a large opening for a dental canal was located on the inside of the posterior portion of the ramus. The condyle of the Recent *Physeter catodon* is more noticeably elongated and its major axis more nearly vertical and not twisted inward.

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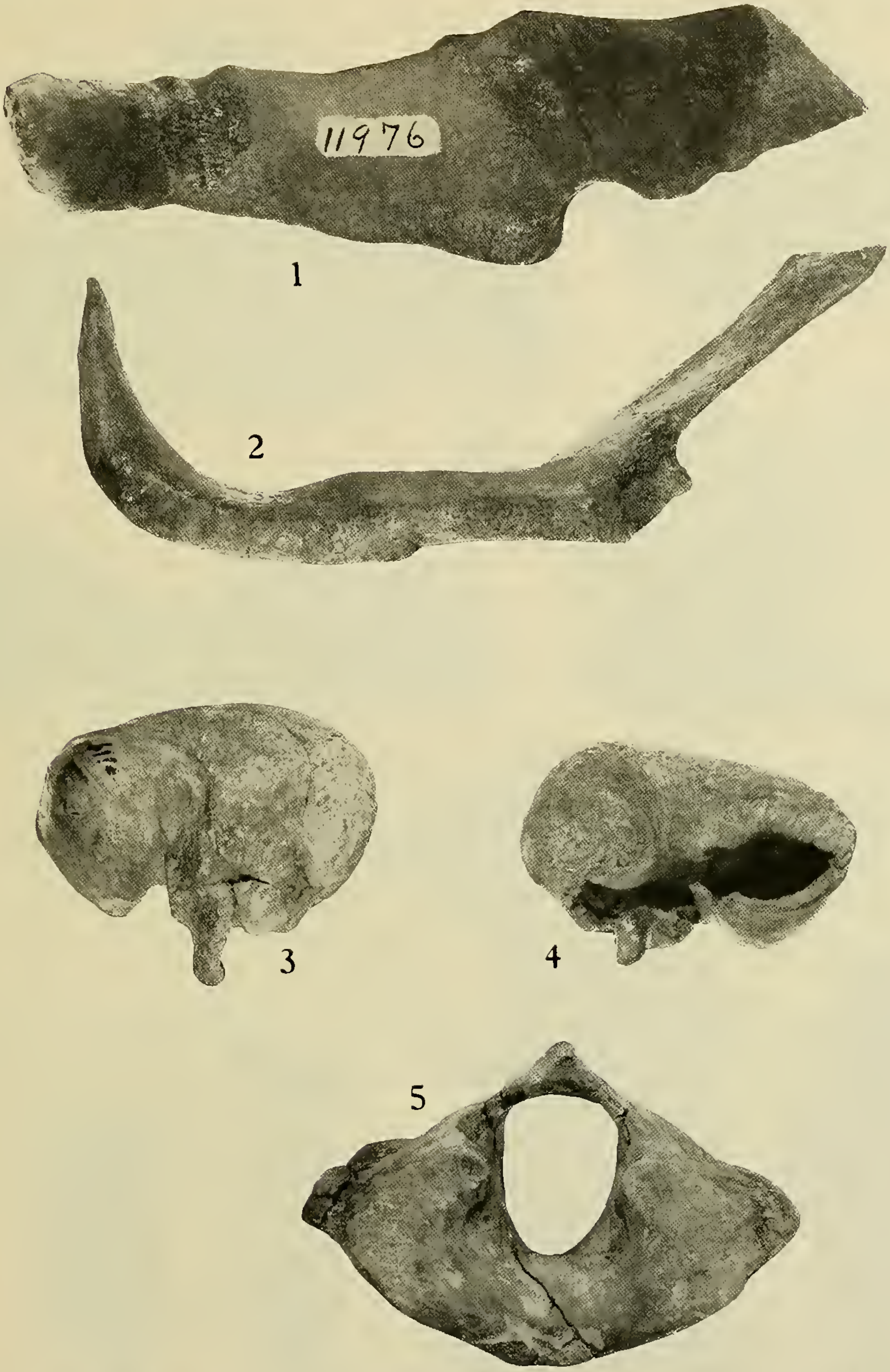
U.S. GOVERNMENT PRINTING OFFICE: 1965

Dorsal View of Skull, USNM 11976, Pelocetus calvertensis

VENTRAL VIEW OF SKULL, USNM 11976, PELOCETUS CALVERTENSIS

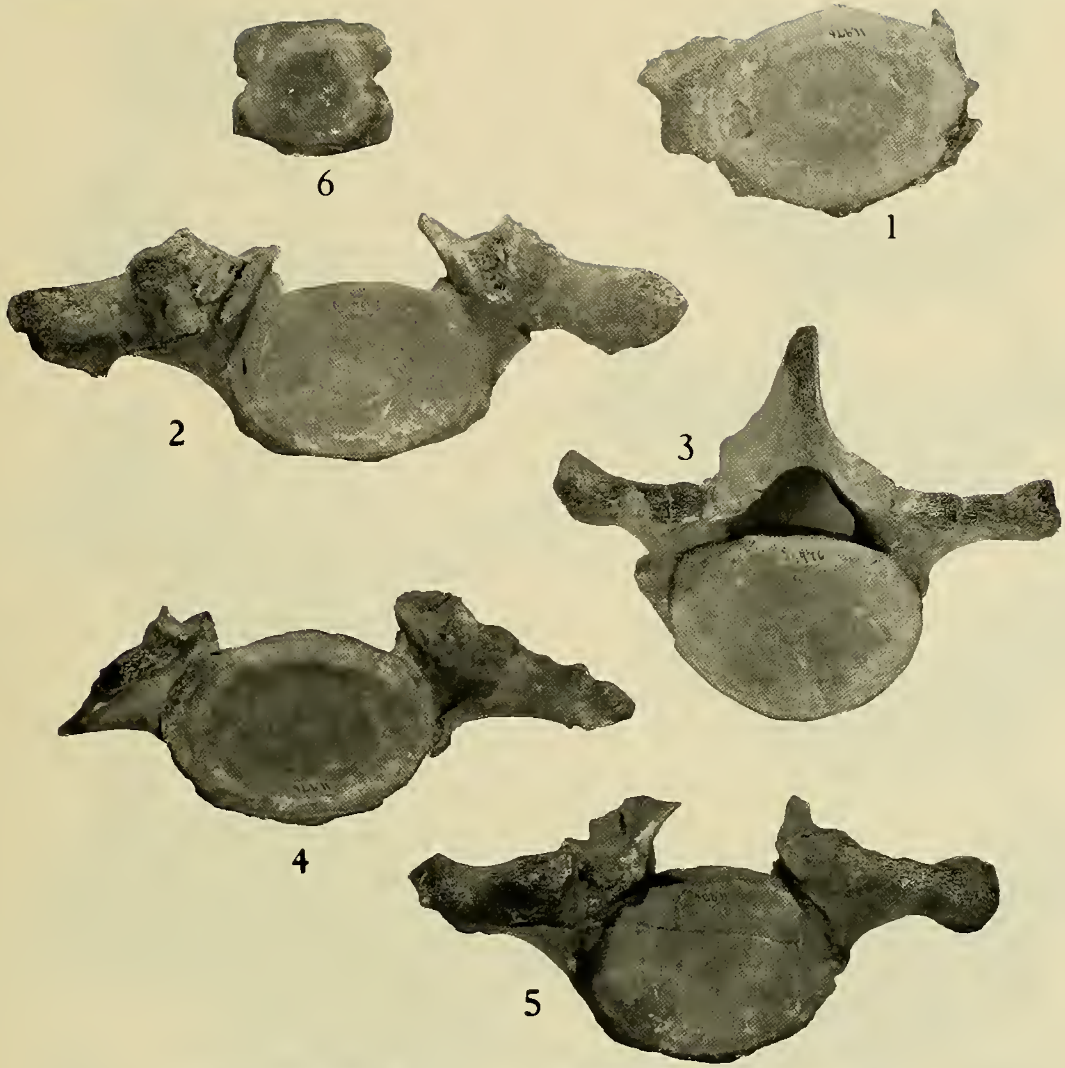


Left Jugal Bone and Right Tympanic Bulla, USNM 11976, Pelocetus calvertensis

1, Dorsal view of jugal; 2, lateral view of jugal; 3, external view of right tympanic bulla; 4, dorsal view of right tympanic bulla; 5, posterior view of atlas (USNM 23059).

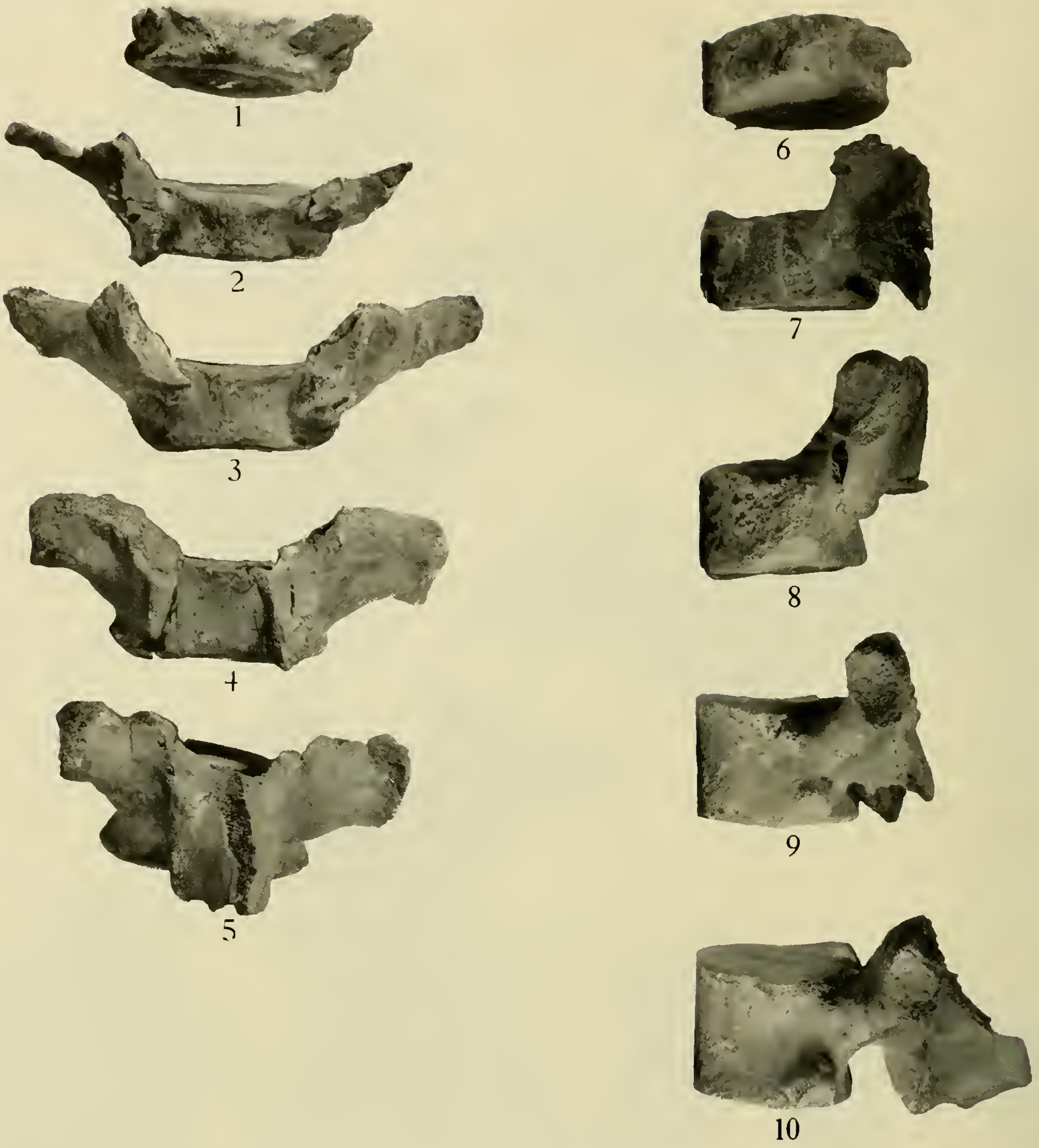
Cervical Vertebrae, USNM 11976, Pelocetus calvertensis

1–5, Anterior views: 1, Atlas; 2, axis; 3, fourth cervical; 4, sixth cervical; 5, seventh cervical. 6–10, Lateral views: 6, Atlas; 7, axis and third cervical, ankylosed; 8, fourth cervical; 9, sixth cervical; 10, seventh cervical.



Dorsal Vertebrae, USNM 11976, Pelocetus calvertensis

Anterior views: 1, First dorsal; 2, third dorsal; 3, sixth dorsal; 4, second dorsal; 5, fourth dorsal; 6, terminal caudal.



Dorsal Vertebrae, USNM 11976, Pelocetus calvertensis

1–5, Dorsal views: 1, First dorsal; 2, second dorsal; 3, third dorsal; 4, fourth dorsal; 5, sixth dorsal. 6–10, Lateral views: 6, First dorsal; 7, second dorsal; 8, third dorsal; 9, fourth dorsal; 10, sixth dorsal.

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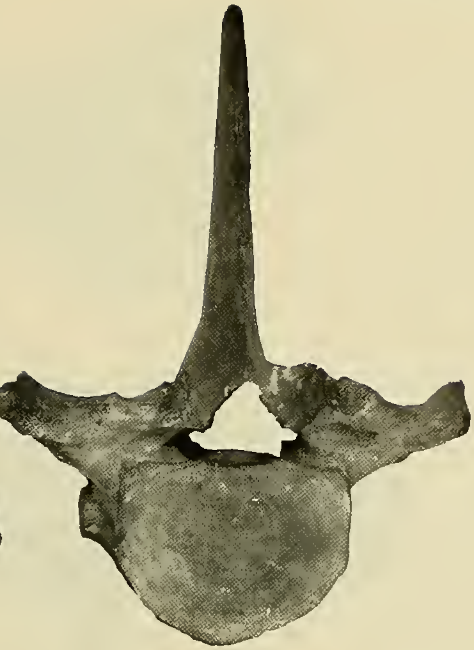

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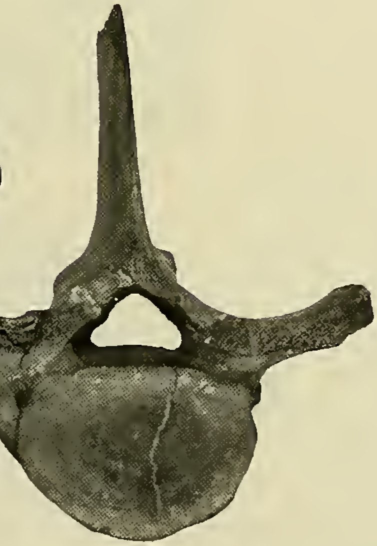

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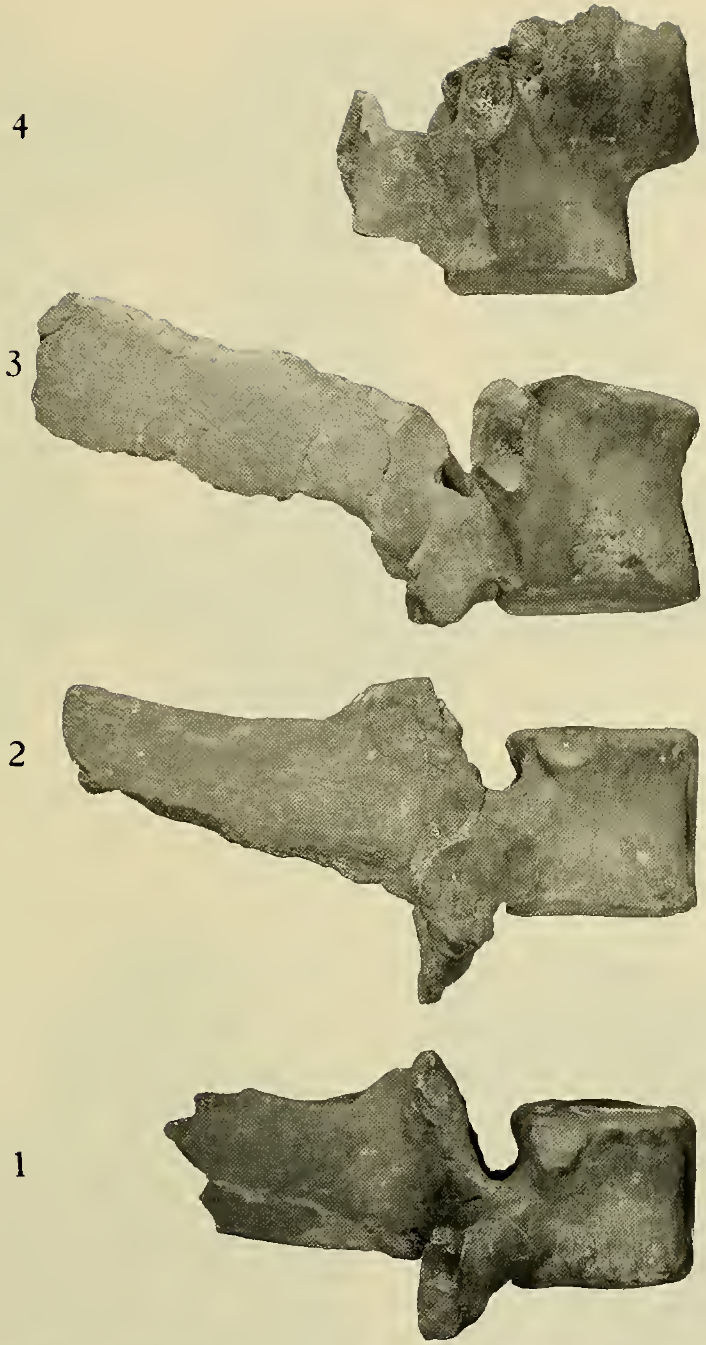
Dorsal Vertebrae, USNM 11976, *Pelocetus calvertensis*

Anterior views: 1, Tenth dorsal; 2, eighth dorsal; 3, eleventh dorsal; 4, seventh dorsal.

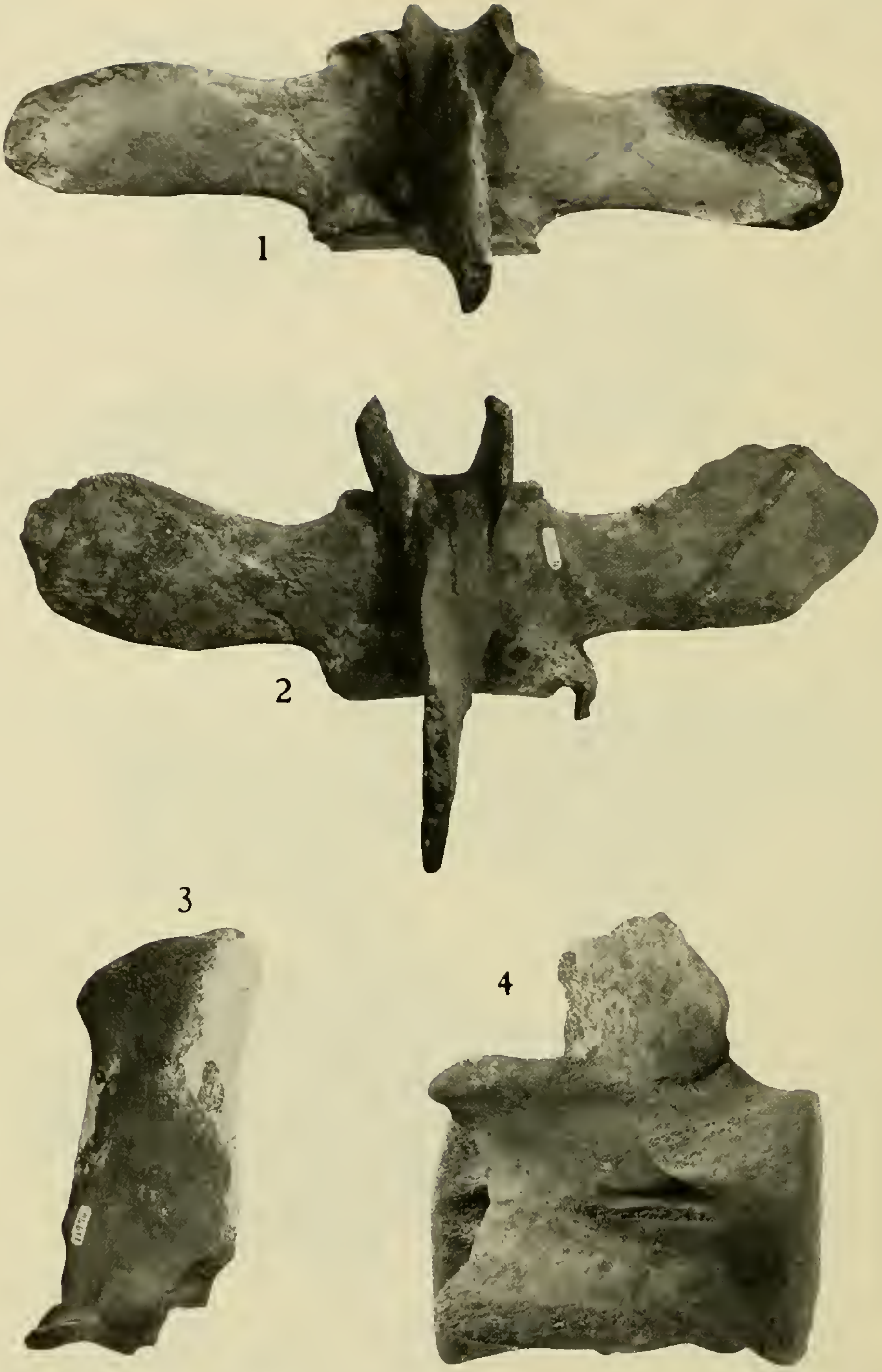
DORSAL VERTEBRAE, USNM 11976, PELOCETUS CALVERTENSIS

Dorsal views: 1, Eighth dorsal; 2, tenth dorsal; 3, seventh dorsal; 4, eleventh dorsal.



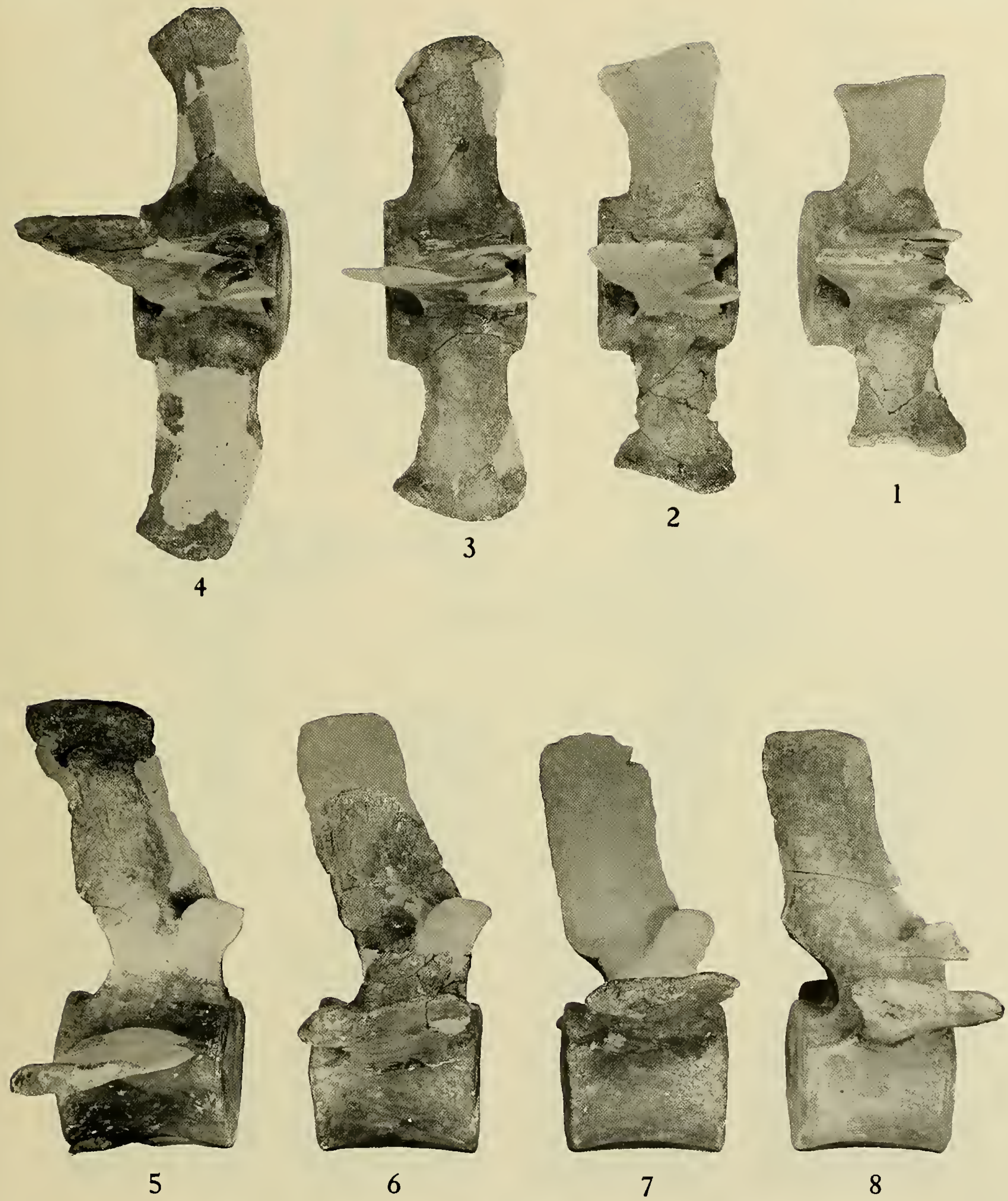
Dorsal Vertebrae, USNM 11976, Pelocetus calvertensis

Lateral views: 1, Seventh dorsal; 2, eighth dorsal; 3, tenth dorsal; 4, eleventh dorsal.



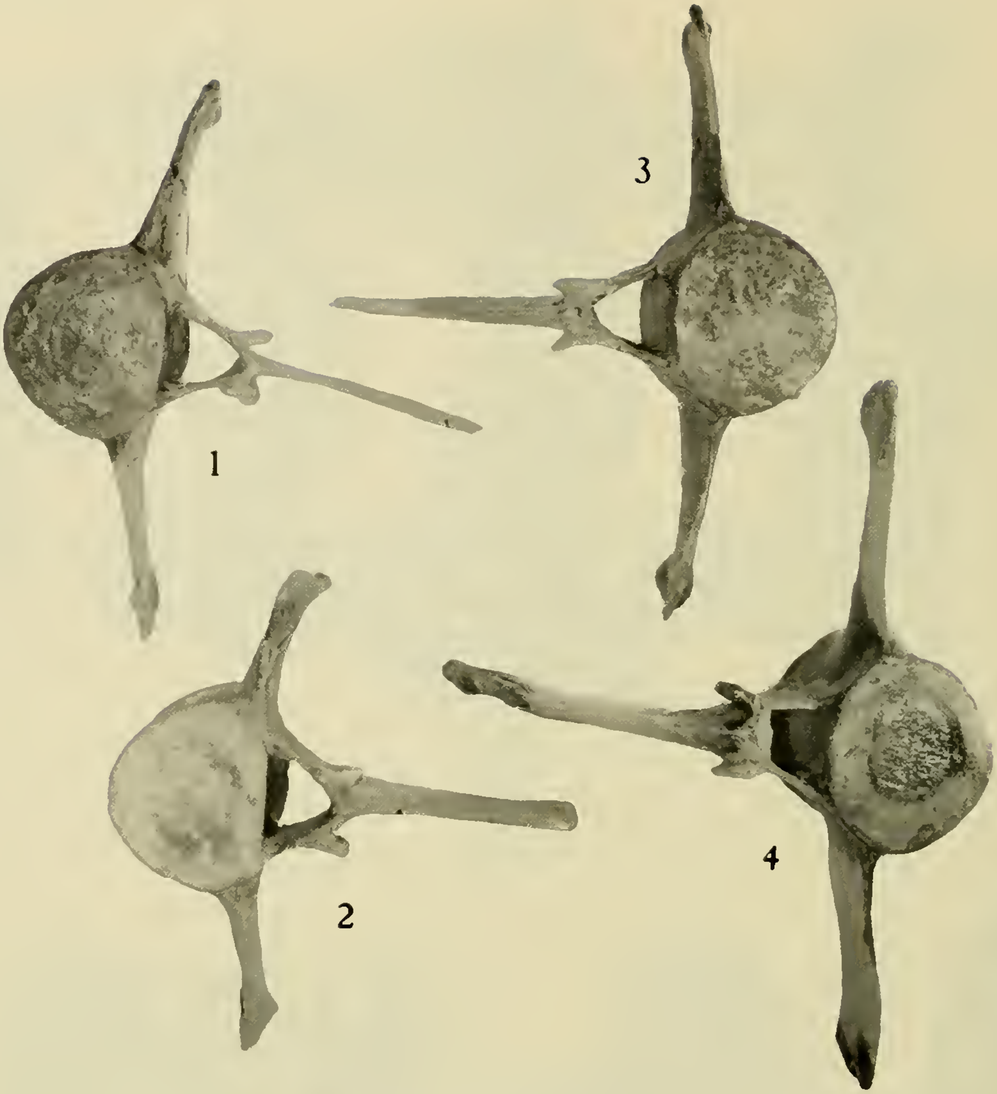
LUMBAR VERTEBRAE, USNM 11976, PELOCETUS CALVERTENSIS

Dorsal views: 1, Third lumbar; 2, fifth lumbar; 3, fourth lumbar, lateral view of neural spine; 4, anterior caudal vertebra, (?) species (USNM 11976).



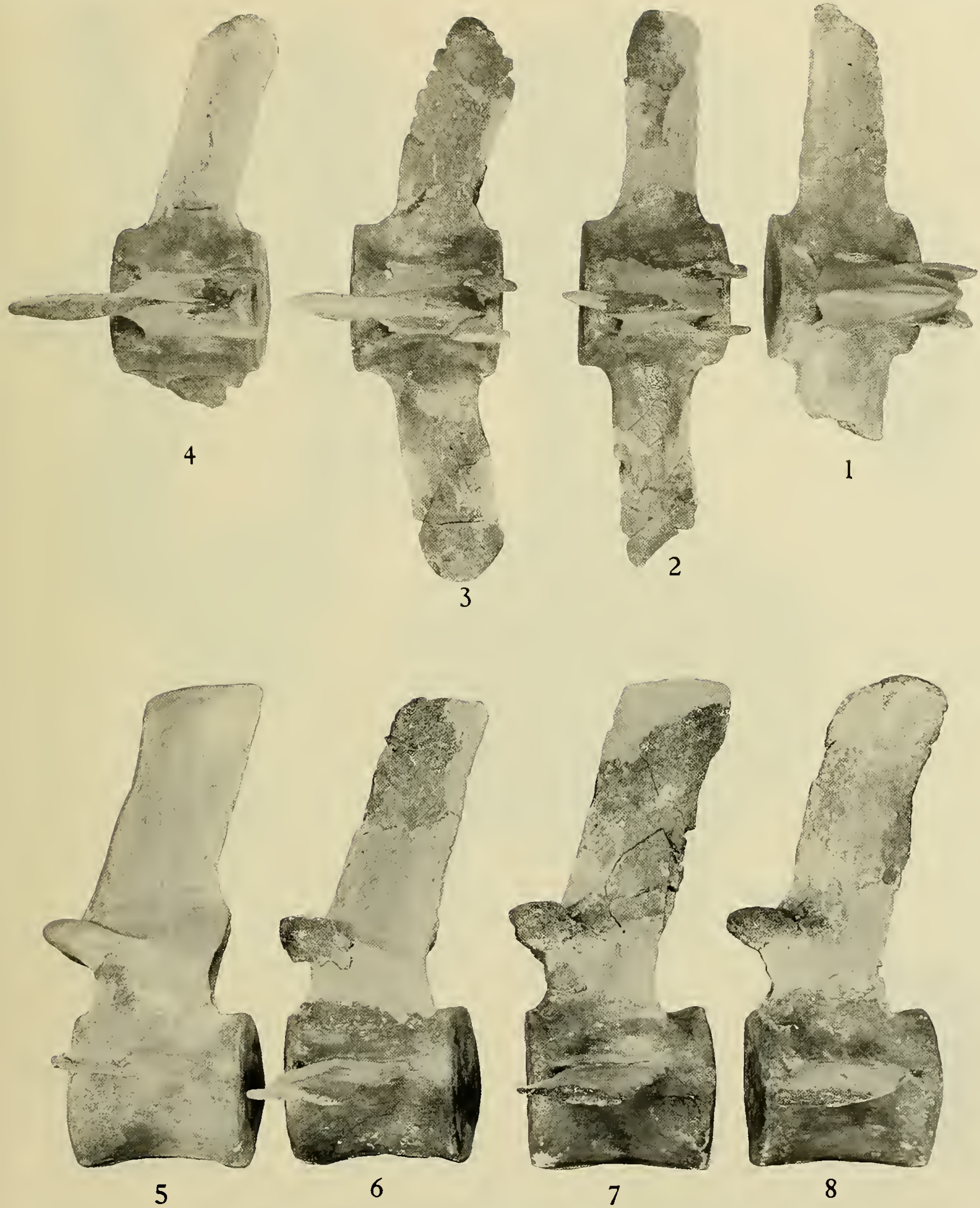
DORSAL VERTEBRAE, USNM 23058, PELOCETUS CALVERTENSIS

1–4, Dorsal views: 1, Ninth dorsal; 2, tenth dorsal; 3, eleventh dorsal; 4, twelfth dorsal. 5–8, Lateral views: 5, Ninth dorsal; tenth dorsal; 7, eleventh dorsal; 8, twelfth dorsal.



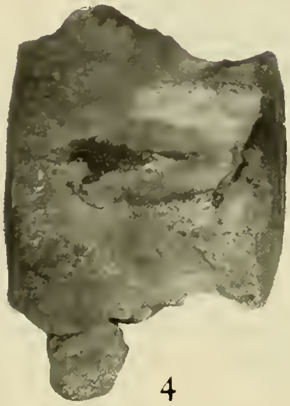
Dorsal Vertebrae, USNM 23058, Pelocetus calvertensis

Anterior views: 1, Tenth dorsal; 2, ninth dorsal; 3, eleventh dorsal; 4, twelfth dorsal.



Lumbar Vertebrae, USNM 23058, Pelocetus calvertensis

1–4, Dorsal views: 1, First lumbar; 2, second lumbar; 3, third lumbar; 4, fourth lumbar. 5–8, Lateral views: 5, First lumbar; 6, second lumbar; 7, third lumbar; 8, fourth lumbar.



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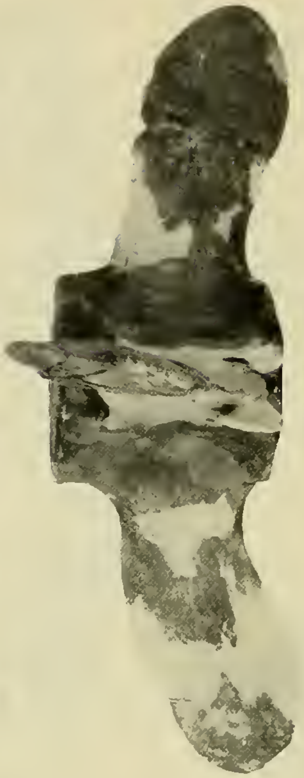

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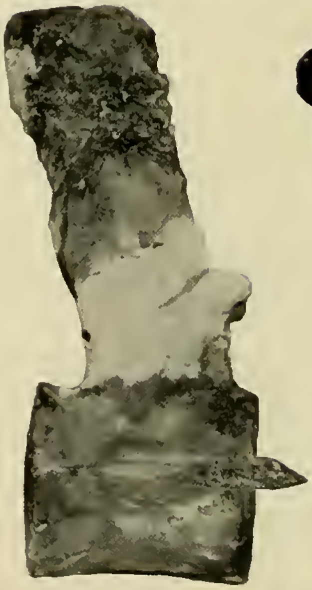

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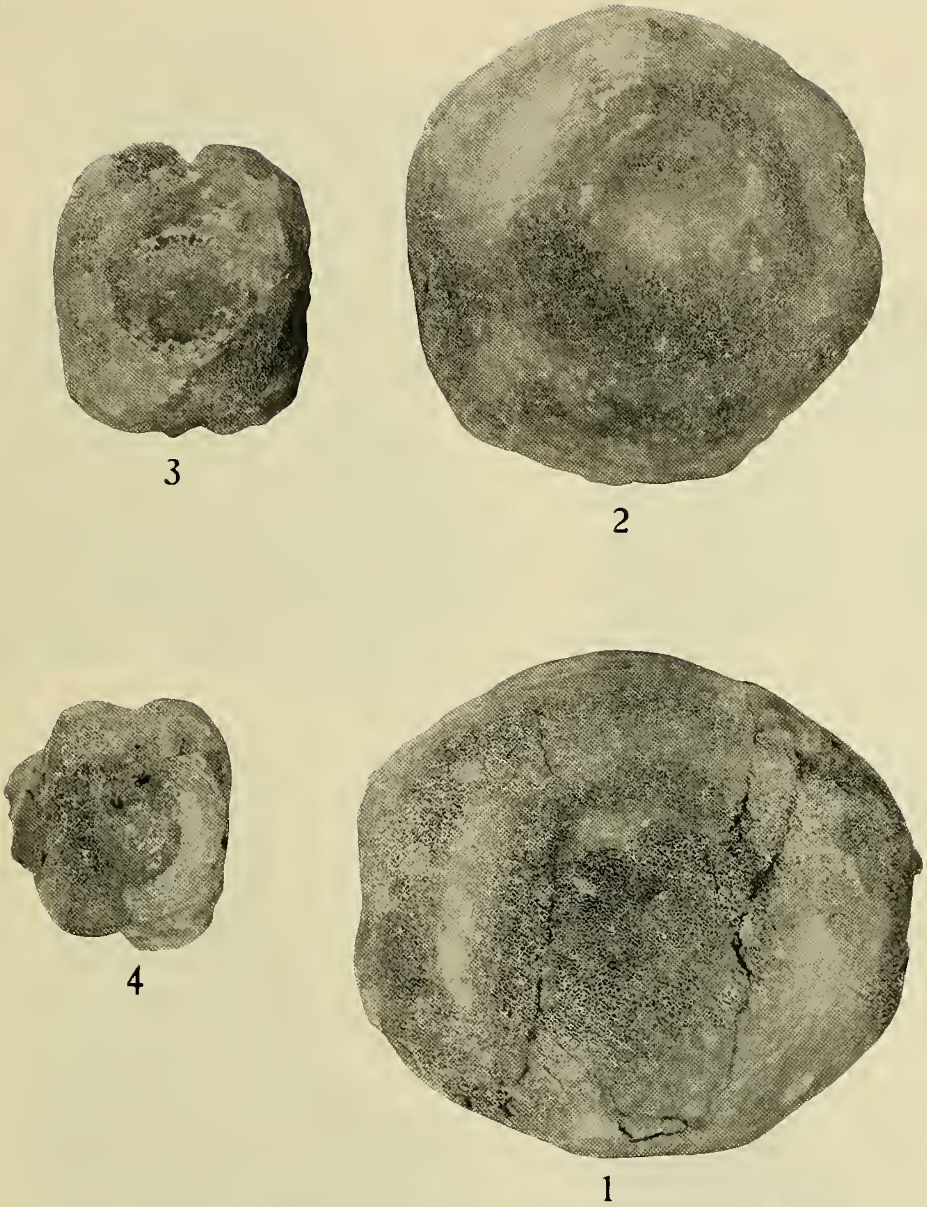
LUMBAR VERTEBRAE, USNM 23058, PELOCETUS CALVERTENSIS

1–4, Dorsal views: 1, Fifth lumbar; 2, sixth lumbar; 3, seventh lumbar; 4, anterior caudal vertebra (USNM 23059). 5–8, Lateral views: 5, Fifth lumbar; 6, sixth lumbar; 7, seventh lumbar; 8, anterior caudal vertebra (USNM 23059).

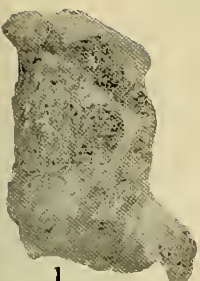


Terminal Vertebrae, USNM 23058, Pelocetus calvertensis

Anterior views.

Right Ulna and Left Periotic, USNM 23059, Pelocetus calvertensis

1, External view of right ulna; 2, tympanic view of left periotic; 3, cerebral view of left periotic.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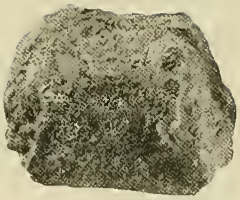
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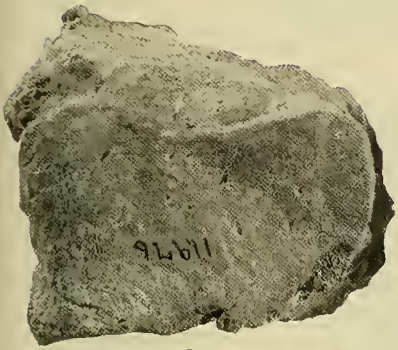
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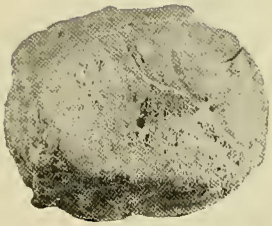
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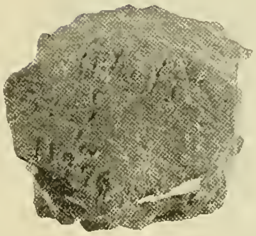
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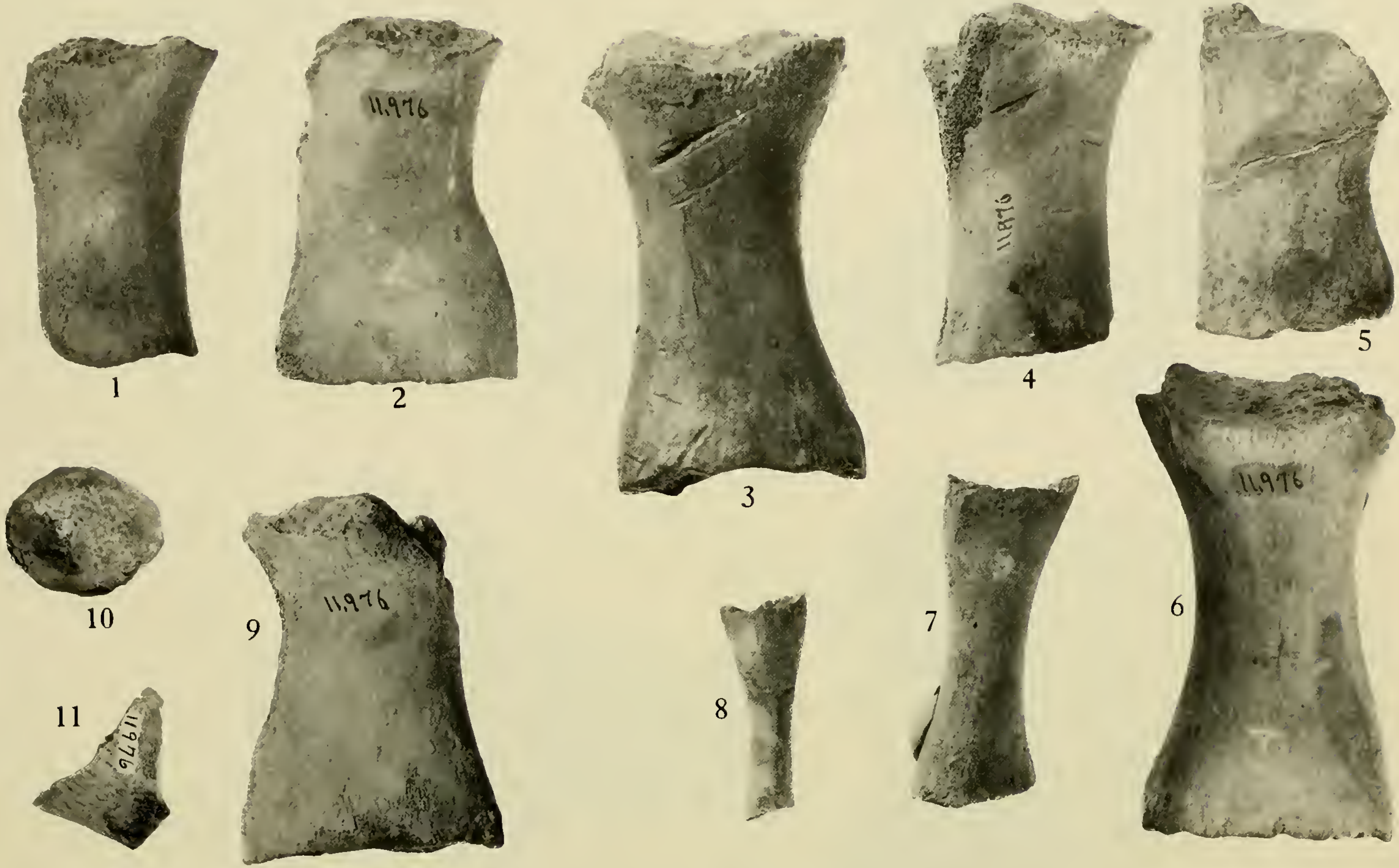
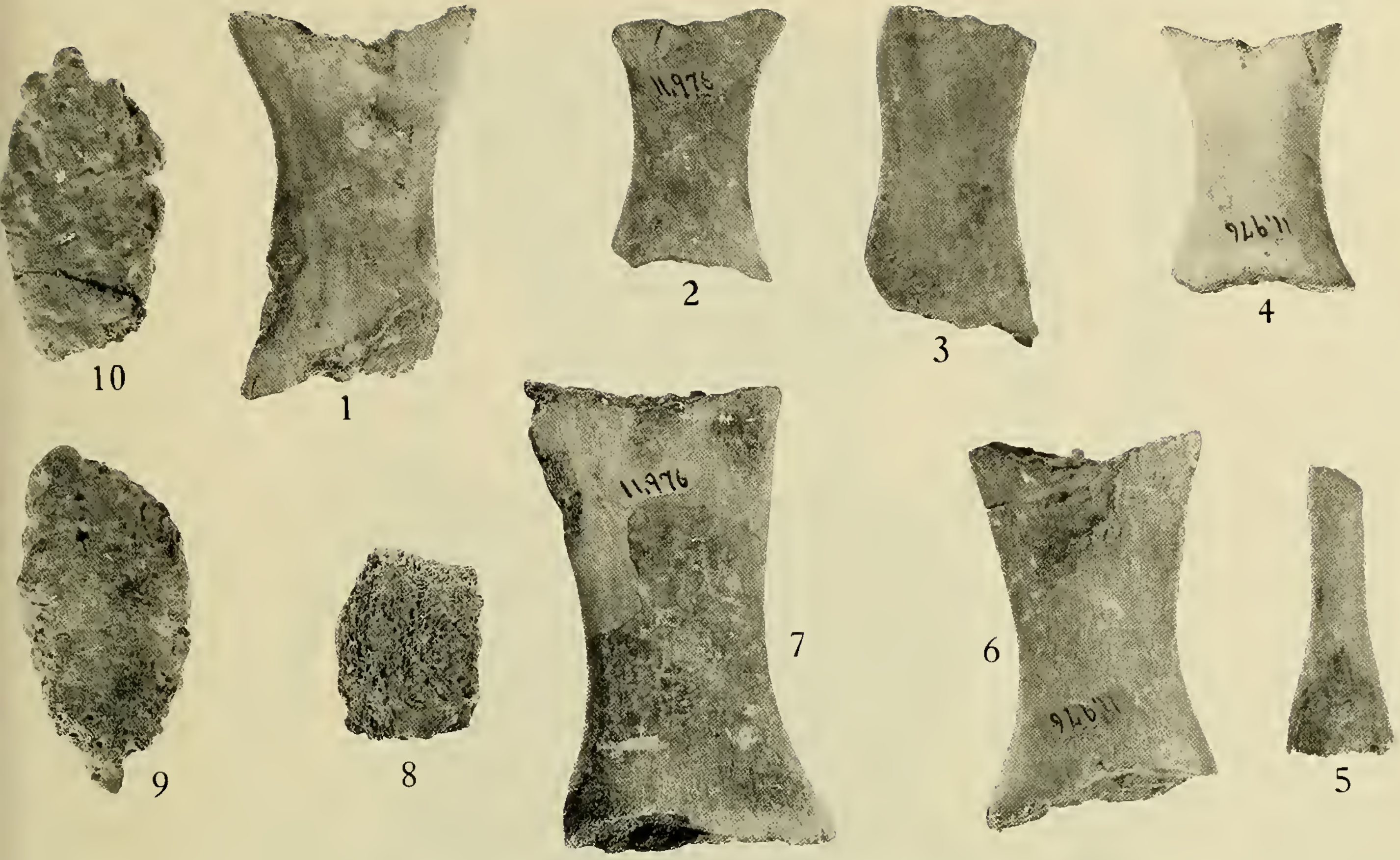
CARPAL BONES, USNM 11976, PELOCETUS CALVERTENSIS

1, Pisiforme; 2, carpal, second row; 3, carpal, second row; 4, carpal, second row; 5, carpal, second row; 6, radiale, one-half; 7, ulnare; 8, intermedium; 9, radiale.



METACARPAL BONES, USNM 11976, PELOCETUS CALVERTENSIS

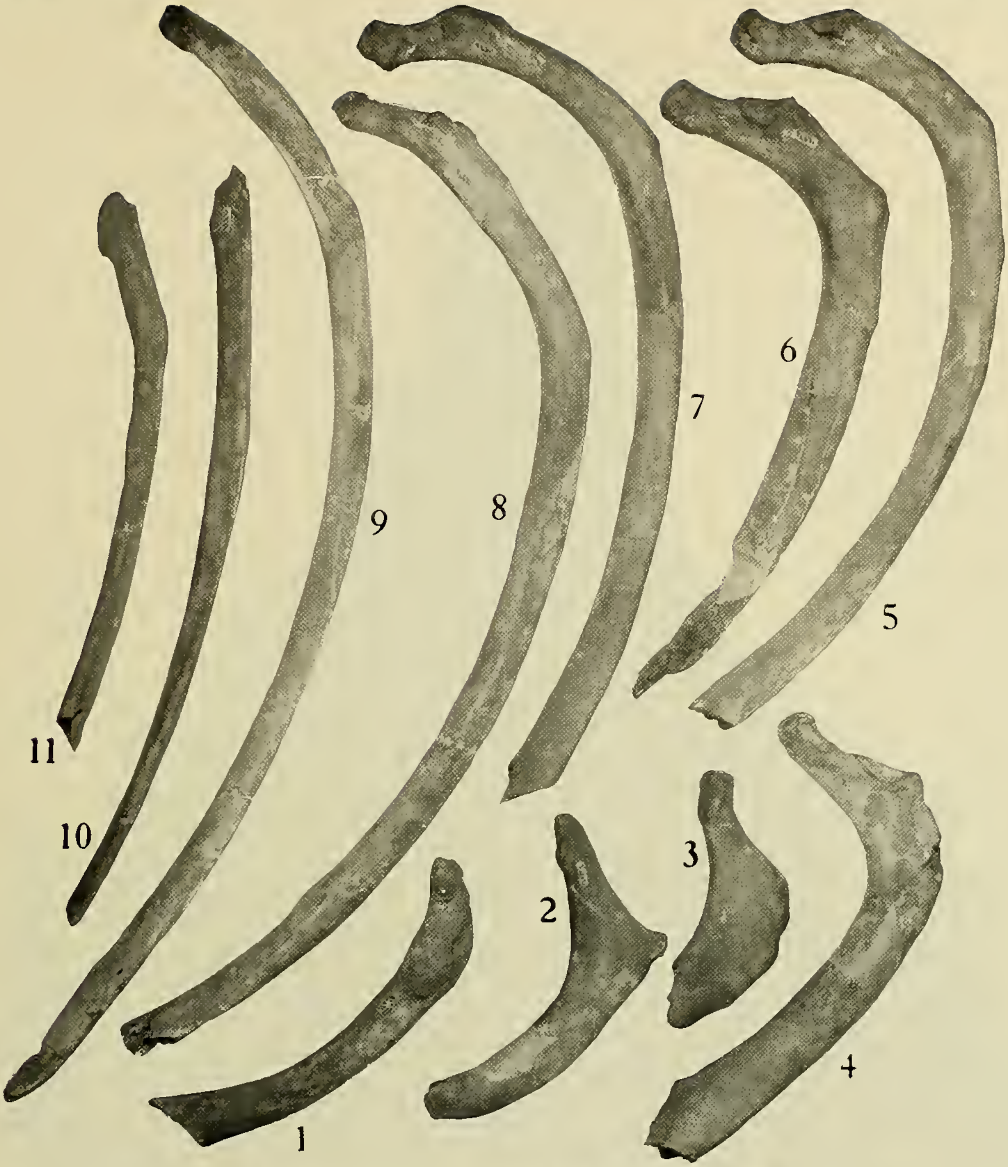
1, Metacarpal II, left; 2, metacarpal IV, right; 3, metacarpal III, right; 4, metacarpal II, right; 5, metacarpal I, right; 6, metacarpal III, left; 7, metacarpal V, right; 8, phalange, fifth digit, left; 9, metacarpal IV, left; 10, metacarpal V (?), left; 11, metacarpal, left.



Phalanges, USNM 11976, Pelocetus calvertensis

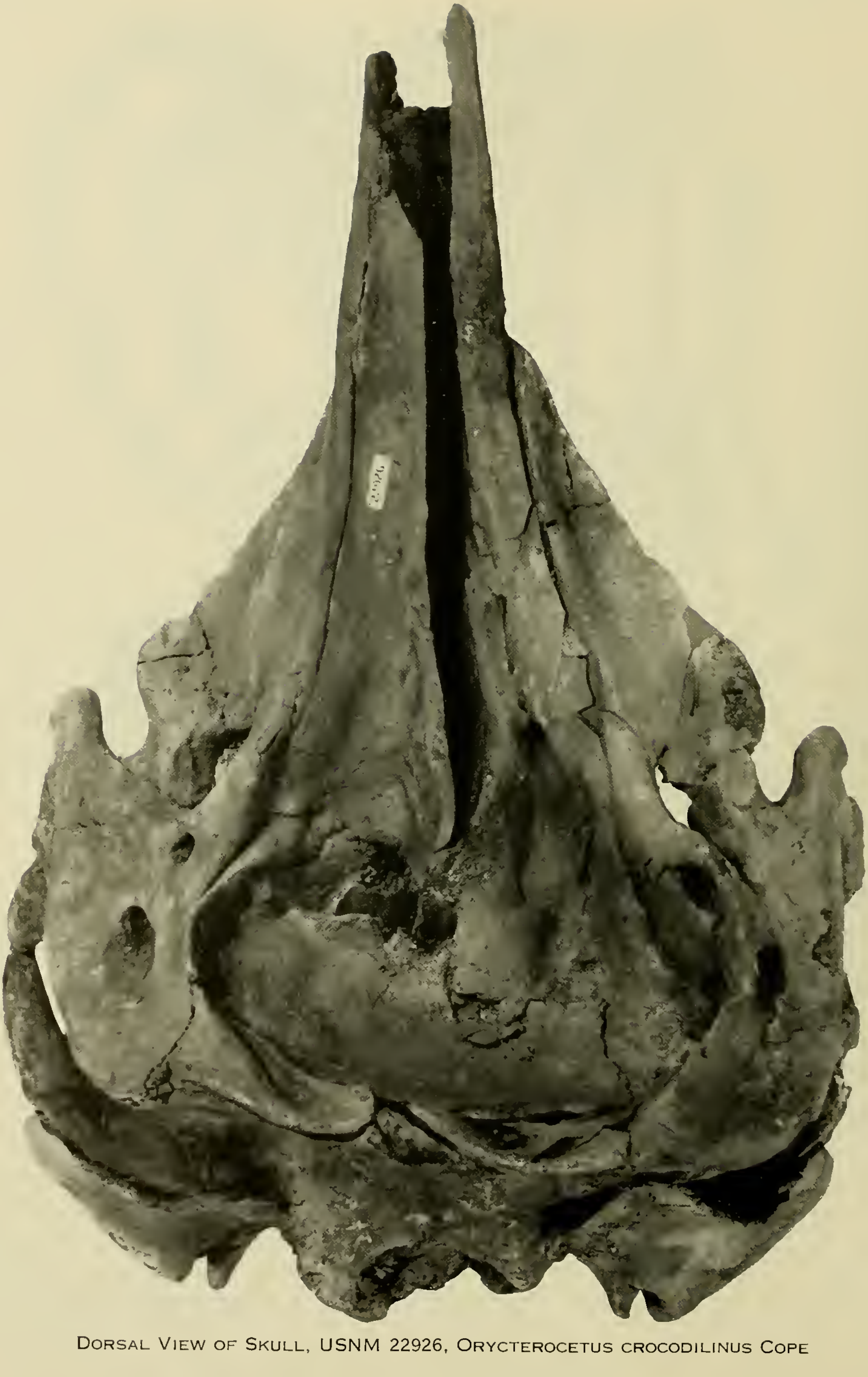
1–7, Tentative allocations: 1, Third digit, right; 2, fourth digit, right; 3, third digit, right; 4, second digit, right; 5, fifth digit, right; 6, fourth digit, right; 7, third digit, right. 8–10, Views of distal epiphyses (USNM 11976): 8 and 9, epiphyses of radii; 10, epiphysis of ulna.

BONES, USNM 11976, PELOCETUS CALVERTENSIS
Tentative identification as sternum.



Ribs, USNM 11976, Pelocetus Calvertensis

1, First rib, left; 2, second rib, left; 3, third rib, right; 4, fourth rib, right; 5, fifth rib, right; 6, sixth rib, right; 7, seventh rib, right; 8, eighth rib, right; 9, tenth rib, right; 10, eleventh rib, right; 11, twelfth rib, left.

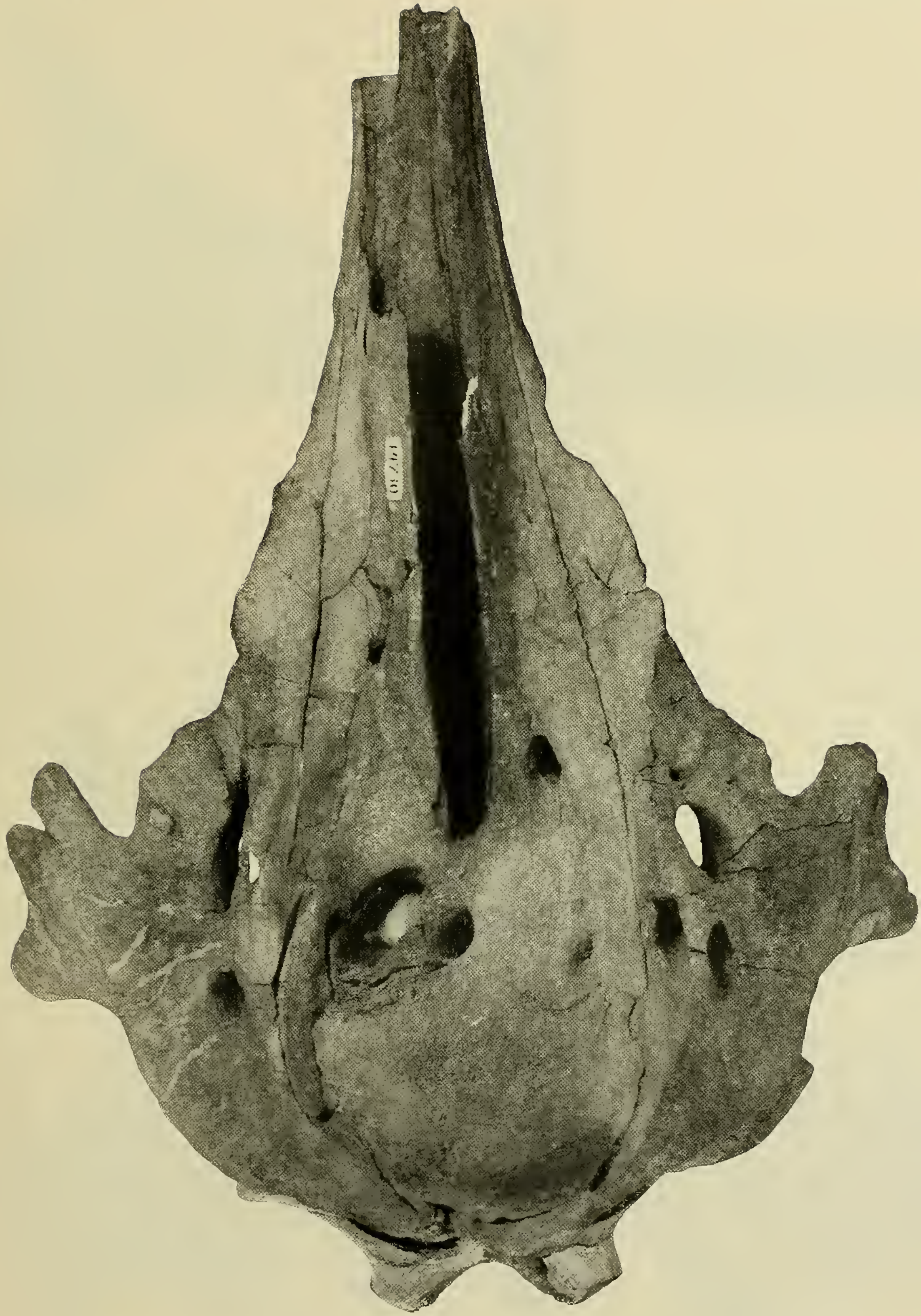


Dorsal View of Skull, USNM 22926, Orycterocetus crocodilinus Cope

Ventral View of Skull, USNM 22926, Orycterocetus crocodilinus Cope

Skull, USNM 22926, Orycterocetus crocodilinus Cope

Top: Posterior view. Bottom: Lateral view.

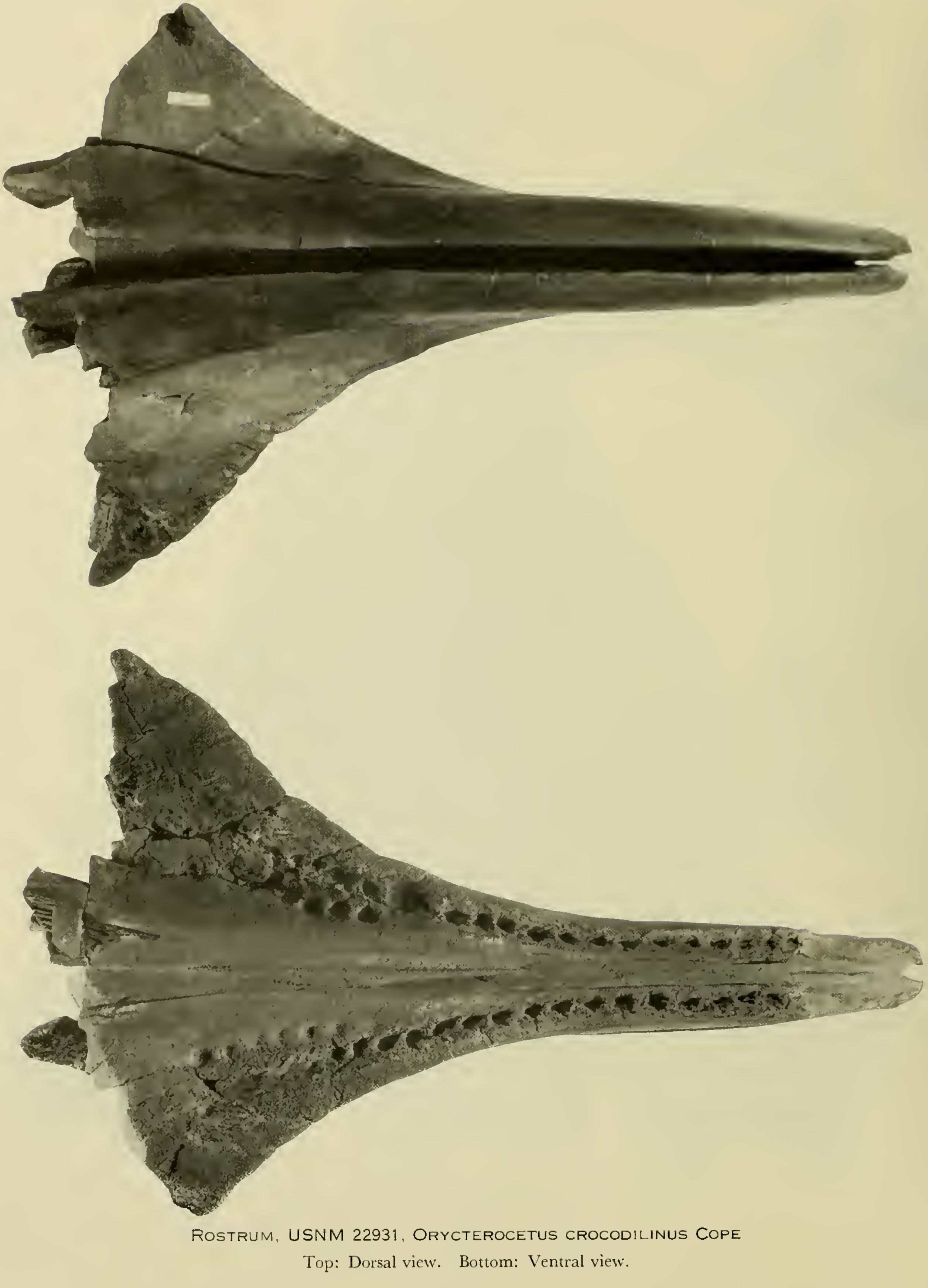


DORSAL VIEW OF SKULL, USNM 14730, CRYCTEROCETUS CROCODILINUS COPE

Ventral View of Skull, USNM 14730, Orycterocetus crocodilinus Cope

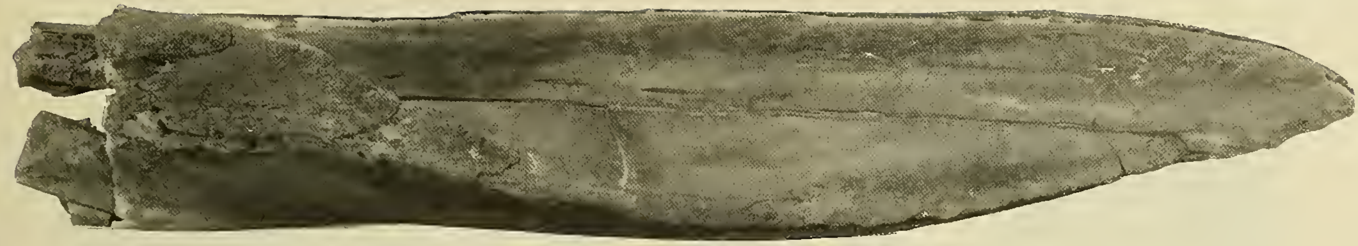
Skull, Orycterocetus crocodilinus Cope

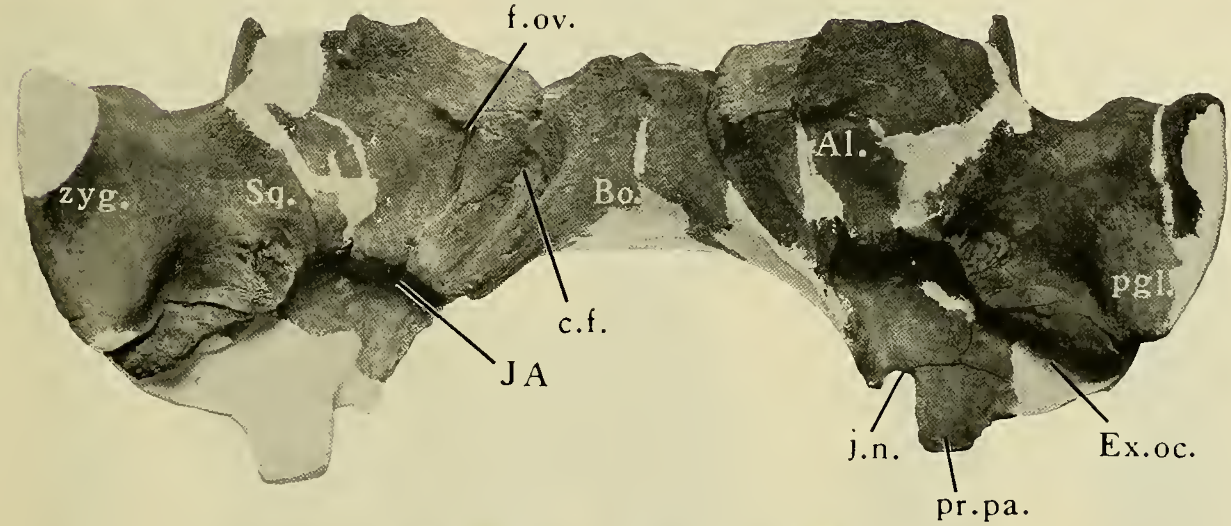
Top: Lateral view, USNM 14730. Bottom: Posterior view, USNM 14729.



Rostrum, USNM 22931, Orycterocetus crocodilinus Cope

Top: Dorsal view. Bottom: Ventral view.





ORYCTEROCETUS CROCODILINUS COPE

Top: Lateral view of rostrum (USNM 22931). Bottom: Ventral view of basicranium of young sperm whale (USNM 22930). Abbrs.: Al., alisphenoid; Bo., basioccipital; c.f., channel and foramen for internal carotid; Ex.oc., exoccipital; f.ov., foramen ovale; J.A., jugulo-acoustic funnel; j.n., jugular incisure; pgl., postglenoid process of zygoma; pr.pa., paroccipital process of exoccipital; Sq., squamosal; zyg., zygomatic process of squamosal.

LATERAL VIEWS OF TEETH, ORYCTEROCETUS CROCODILINUS COPE

1–8 (USNM 22926); 9 and 10 (USNM 22933); 11 (USNM 22932); 12 (USNM 22935); 13 (USNM 22934); 14 (USNM 1158).

ORYCTEROCETUS CROCODILINUS COPE

1–4: Cerebral or internal views of periotics: 1, right periotic (USNM 22953); 2, left periotic (USNM 22952); 3, left periotic (USNM 22926); 4, right periotic (USNM 11234).
5–8: Views of right tympanic bulla (USNM 22953): 5, posterior view; 6, external view; 7, dorsal view; 8, laminated spongy osseous mass.

Periotics Orycterocetus crocodilinus Cope

1–4, Tympanic or ventral views: 1, Left periotic (USNM 22952); 2, left periotic (USNM 22926); 3, right periotic (USNM 22953); 4, right periotic (USNM 11234). 5–8, External views: 5, left periotic (USNM 22952); 6, left periotic (USNM 22926); 7, right periotic (USNM 11234); 8, right periotic (USNM 22953).

UNITED STATES NATIONAL MUSEUM BULLETIN 247

FOSSIL MARINE MAMMALS

From the Miocene Calvert Formation of Maryland and Virginia

Parts 3 and 4

REMINGTON KELLOGG

Research Associate, Smithsonian Institution

MUSEUM OF NATURAL HISTORY
SMITHSONIAN INSTITUTION • WASHINGTON, D.C. • 1966

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3. New Species of Extinct Miocene Sirenia

4. A New Odontocete From the Calvert
Miocene of Maryland

3. New Species of Extinct Miocene Sirenia

SIRENIANS ARE CURRENTLY REGARDED as having an early Eocene, possibly Paleocene, derivation from a land mammal stock which gave rise also to the Proboscidea and Desmostylia. In the course of geological time their descendants have evolved as two readily distinguishable families, the dugongs (Dugongidae) and the manatees (Trichechidae).

Within historical times dugongs have been inhabitants of the Indian Ocean from Mozambique and Madagascar, north to Kenya and the Red Sea, the Malabar coast of southwest India, Ceylon, Andaman Islands and Mergui Archipelago in Bay of Bengal, North Pacific Ocean from Taiwan south to Philippine Islands, Malaysia and northern Australia. A markedly bent-downward rostrum and reduced dentition characterized, in part, the dugongs as early as the Miocene.

Manatees are restricted in the Recent fauna to the coast and coastal waters of the United States from Beaufort, N.C., to the Florida Keys, coasts of Gulf of Mexico, Caribbean coasts of Central America, coasts and lower reaches of rivers of northeastern South America, and the West Indies; occurring also in west African coastal waters and the larger rivers from Senegal to Angola. Reduplicated bilophid cheek teeth and a slightly deflected rostrum are readily recognizable characteristics.

Recorded antecedent geological history of the Sirenia commences with *Protosiren* and *Eotheroides* (middle Eocene of Egypt) and *Prorastomus* (Eocene of Jamaica). Later stages of development of structural modification of dugongids occur in the Oligocene of Germany, Belgium, and France; in the Miocene of Austria, Switzerland, Belgium, France, and Italy; and in the Pliocene of France and Italy. True dugongids were also present in the marine faunas of the western North Atlantic at least as early as the Oligocene and as late as the Pliocene.

Knowledge of the early geological history and geographic distribution of the Sirenia in the western hemisphere is limited to sporadic occurrences of somewhat divergent and apparently not closely related types. From the supposedly deep water lower Eocene (Manasquan formation) marl pits along Shark River, Monmouth Co., N.J., Cope (1869, pp. 190–191, pl. 5, fig. 6) described a portion of a tooth, which resembled the incisor tusk of a dugong, as *Hemicaulodon effodiens*. The identity and relationship of this tooth fragment will be dealt with in the description of the dentition of the Calvert sirenian.

Owen (1855, p. 543) bestowed the name *Prorastomus sirenoides* on the skull and mandibles of a primitive sirenian. This specimen was found embedded in a hard gray limestone nodule (Owen, 1875, p. 559) in the river bed on Freeman's Hall estate between the parishes of St. Elizabeth and Trelawney, Jamaica, possibly from the Richmond beds, lower Eocene. The type skull of *Prorastomus sirenoides* (BMNH 44897, Dept. Geology), measures 269 mm. from the incomplete posterior face of the occipital condyle to the worn anterior end of the premaxillary, and the estimated width across the postorbital angles of the supraorbital processes of the frontals is 86 mm. The length of the right mandible from the angle to the anterior end is 230 mm. and the length of the symphysis, 73.5 mm. On this partially prepared type specimen nine teeth are visible in the right mandible; in the right maxillary, six teeth occupy an interval of 69+ mm. The upper incisors are not enlarged as tusks. The molar teeth appear to be low crowned with cusps forming two transverse crests. The elongated premaxillaries enclose a short mesorostral fossa (50± mm.). The rostrum is narrow, measuring 45 mm. at the level of the anterior end of the mesorostral fossa. The mandibular symphysis is strongly compressed anteriorly (width, 21.5 mm.). No noticeable bending downward of the symphysial end of the mandibles is observable. An incomplete humerus from the island of Sombrero, Lesser Antilles, was later referred to the same species by Lydekker (1887). More recent geological studies assign a Miocene age to the sediments on this island.

From Tertiary calcareous shales in a bluff on the west bank of the Jacagnas River, 1 km. north and 1 km. west of Juana Diaz, Puerto Rico, Matthew (1916) described as

?*Halitherium antillense* a left mandible lacking the symphysis and the teeth anterior to the three molars. Middle Oligocene age is now attributed to these Juana Diaz shales. Another middle Oligocene Puerto Rican dugongid, *Caribosiren turneri*, but apparently younger in geological age, consisting of the skull, four dorsal vertebrae and ribs from the San Sebastian shales exposed on a hillside between Sebastian and Lares, has been described by Reinhart (1959, p. 8). The skull of this dugongid lacks incisors, M^3 is without posterior cingulum or hypoconule, rostrum is strongly bent downward anteriorly, and nasals are separated on midline by the frontals. A small sirenian, whose vertebrae and ribs exhibit some resemblance to the middle Oligocene (Stampian) *Halitherium schinzi* of Germany, has been recovered from the upper Oligocene Chichasawhay marl and limestone in Wayne County, Miss., and Clarke County, Ala.

Another dugongid represented by a considerable portion of the skeleton was excavated in a fuller's earth mine in Gadsden County, Fla. Simpson (1932a, p. 426) named this middle Miocene (Hawthorn formation) sirenian *Hesperosiren crataegensis*. The skull is characterized in part by the absence of incisors, slightly deflected rostrum, nasals separated in midline by frontals, and supraoccipital nearly or just meeting the foramen magnum.

At least one member of the family Dugongidae, *Felsinotherium ossivallense* (Simpson, 1932a, p. 448), persisted until the middle Pliocene on the Florida coast. Cranial and other skeletal elements were recovered in dredging the Bone Valley formation at Mulberry, Polk Co., Fla.

The oldest sirenian definitely identified as a trichechid thus far recorded is *Potamosiren magdalensis* (Reinhart, 1951) from the late Miocene La Venta fauna in Huila Dépt., Colombia. The left mandible and the posterior lower molar confirm this family allocation. This Miocene sirenian, however, may not be a direct ancestor of the living *Trichechus*.

Occurrences of indeterminate ribs and teeth of trichechids from Pleistocene deposits of North and South America have been reported in the literature. It would appear that the family Trichechidae had a long developmental history, the details of which remain largely obscure.

No reference to the Cenozoic developmental history of the Sirenia on the Pacific coast of North America was contemplated when this study was undertaken. Additional comments on some of the Cenozoic sirenians of the northern hemisphere will be made in the following text.

THE CALVERT MIOCENE DUGONG

The first recorded occurrence of sirenian vertebrae and a rib on the western shore of Maryland, although erroneous, was published by Harlan (1825, p. 236). Presumably these bones, at that time, had been deposited in the collections of the Academy of Natural Sciences of Philadelphia (ANSP); but, if such was the case, they have not since been recognized. The vertical diameter of the atlas of this supposedly gigantic species of fossil *Manatus* measured nine inches and its transverse diameter eleven inches. The measurements of the atlas indicate a species of mysticete, but as no locality was given there is no certainty that the bones were derived from a Miocene formation or even fossilized. Seventeen years later, DeKay (1842, p. 123) named these remains *M*[*anatus*] *giganteus*.

When preparing the mammalian text for the systematic paleontology of the Miocene deposits of Maryland, Case (1904, p. 56, pl. 26, fig. 1) referred an ankylosed radius and ulna from the Calvert formation at Fairhaven, Md., "evidently a small species," to (?) *Trichechus giganteus*. No further mention of fossil Sirenia appeared in the literature until Palmer (1917, p. 334) recorded the finding of the neural arch and spine of a fifth dorsal vertebra which he regarded as related to the extinct Steller's sea cow (*Hydrodamalis stelleri*). This vertebra is now referred to the Calvert sirenian herein described.

The first Calvert sirenian specimen was received for the national collections in 1905, and since then more adequate materials were added in 1936, 1939, and 1943. Portions of several individuals of this Miocene dugong have been recovered from the exposures of the Calvert formation on the western shore of Chesapeake Bay. Young, immature, and old adult individuals are represented by teeth and other skeletal parts, but articulated or otherwise complete skeletons have not been found. In many instances the bones are scattered in the stratum in which they were found. The occurrence in this formation of plant eating sirenians belonging to age classes from quite young to old adults suggests the existence of luxuriant growths of sea-water algae and succulent aquatic plants.

Dall in 1904 interpreted the Maryland Calvert molluscan assemblage to indicate shallow marine waters and somewhat warmer temperatures than at present in the Chesapeake Bay region. Analysis of the Calvert plants collected at Richmond, Va., led Berry in 1917 to conclude that the coastal region was low bordered by bald cypress (*Taxodium*) swamps.

Marine, fresh water and terrestrial inhabiting vertebrates comprise the Calvert fauna, indicating that one or more rivers discharged fresh water into a large estuary. Drowned land vertebrates may have been carried down stream in a river, especially during heavy precipitation resulting in the flooding of lowlands adjacent thereto. Animals of this kind may have been trapped wherever high banks prevented escape when the shore was flooded by high tides. The larger mammals may have been mired in the mud and sandy silt of tidal marshes and swamps. The occurrence in these deposits of land mammals, including the mastodont (*Gomphotherium*), the tapir (*Tapiravus*), rhinoceros (*Aphelops*), horses (*Archaeohippus* and *Merychippus*), peccaries (*Cynorca* and *Hesperhys*), and the dog (*Tomarctus*) may be attributed to some such fate. In most instances these occurrences are limited to teeth or isolated bones. The former presence of a hair seal (*Leptophoca*) is revealed usually by a single limb bone and more rarely by a vertebra. Innominate bones of three individuals have been added to the national collections.

When a marine mammal was washed ashore either dead or dying, its flesh and viscera would soon be removed by scavengers, leaving the at least partially disarticulated skeleton to be scattered by rising and ebbing tides, storm-driven waves, and washouts resulting from heavy rains. Articulated skeletons would seldom be preserved unless the carcass was tossed above the breaker zone and buried in the sand. Skeletons of some of the stranded carcasses on sand bars may also have been scattered by tidal surf, while the disassociation of those that sank in deeper water at death may have been affected by tidal scour (Kellogg and Whitmore, 1957, p. 1022).

With two exceptions all of the whalebone or mysticete specimens excavated have been young or immature individuals. Considerable portions of the skeletons of adult porpoises have been discovered, including the long-beaked *Zarhachis* and *Eurhinodelphis* and the short-beaked *Delphinodon* and *Kentriodon.* Skeletal elements, particularly vertebrae and ribs, have been found in normal sequence of relationship, relatively undisturbed and presumably were quickly covered with sediments after death. The majority of the odontocete remains found, however, have the epiphyses detached from the centra and are thus either young or immature individuals.

Crocodile (*Thecachampsa*) teeth are of fairly frequent occurrence and these reptiles were sufficiently numerous to play an important predatory role. Teeth of this Miocene crocodile like those of its notably aggressive Recent relative are not adapted for chewing. Although the crocodile can eat anything that can be swallowed whole, if the victim is too large the crocodile tows it away with its clamplike jaws to a hoarding spot where it will decay and become soft enough to be readily torn apart. Flesh and bones when swallowed are rapidly digested and no telltale remnants would survive to puzzle some future fossil hunter. The rather frequent intercalation of layers of sand in the Calvert formation should have provided suitable nesting habitats for the Miocene crocodile. Recent crocodiles lay their eggs in holes or depressions in sun-warmed sand where they remain covered until they hatch.

Many bones reveal clearly the gashes or scratches made by the teeth of sharks. Shark's teeth have been noted embedded in badly scarred vertebrae, limb bones, and mandibles. The presence of such a preponderance of immature or young marine mammals suggests that this region was the calving grounds for the mysticetes, the sperm whales and probably some of the smaller odontocetes. The apparent abundance of readily obtainable prey undoubtedly attracted the sharks. Teeth of sharks have been so plentiful along the beach in the tidal wash that many a young boy has filled a quart jar during the short stay at one of the Chesapeake summer vacation residences. Since their representatives in the Recent oceanic faunas are recognized voracious predators, it can be assumed that their Miocene forebears had similar habits. Among the kinds thus far identified are the cow shark (*Hexanchus*), the mackerel or mako shark (*Isurus*), the tiger shark (*Galeocerdo*), the requiem shark (*Hemipristis*), the gray shark (*Carcharhinus*), and the white shark (*Carcharodon*). The shark-toothed porpoise (*Squalodon*) undoubtedly was a predator.

Isolated or a few consecutive vertebrae of large fishes of the mackerel tribe or scombroids such as the tuna and bill fishes as well as other smaller bony fishes show they were also the victims of predators.

Of the fossil turtles thus far recognized in the Calvert fauna, the Miocene leatherback turtle (*Psephophorus*) and the green turtle (*Chelonia*) are undoubtedly pelagic types, the soft shell turtle (*Amyda*) and the side necked turtle (*Taphrosphys*) are fresh water, probably river, and the tortoise (*Testudo*) terrestrial.

Unless the way of life of the vertebrates comprising the Calvert fauna was materially altered in the course of subsequent geological time, typical pelagic seasonal migratory types such as the whalebone whales (Mysticeti), some of which resort to bays and lagoons at calving time, were associated with the marine green turtles and leatherbacks that deposit their clutch of eggs before the hatching season on sandy beaches, the clannish hair seals that congregate ashore or on offshore islands, and the dugongs and crocodiles that inhabit shallow bays as well as brackish and fresh water swamps.

It seems advisable to review the status of three genera that have been proposed for fossil dugongs that exhibit some rather close structural resemblances to the Calvert sirenian.

FELSINOTHERIUM Capellini

Felsinotherium Capellini, 1865, Atti Soc. Ital. Sci. Nat. Milano, vol. 8, p. 281. [Nomen nudum; no descriptive term except "grosso mammifero fossile."] Type species not named except for statement "dedica al Signor Foresti".

Felsinotherium Capellini, 1871, Mem. Accad. Sci. Inst. Bologna, ser. 3, vol. 1, p. 616.

Type Species: *Felsinotherium forestii* Capellini.

Type Locality: "Molassa giallastra," Riosto, Bologna, Italy. Astian, middle Pliocene.

The lower Pliocene (Plaisancian) *Felsinotherium serresii* has simple and primitive bunodont molars. These cheek teeth have six cusps in two rows modified by slightly more forward placement of the median posterior cusp (metaconule). Accessory cuspules are developed on the anterior and posterior cingulum. The length of the skull varies from 370 to 420 mm.

The middle Pliocene (Astian) *Felsinotherium forestii* is characterized by relatively high-crowned cheek teeth (Capellini, 1872, pl. 4), which are rather complex, in part resulting from the crowding of the cusps, which tends to mask the original two row arrangement pattern and the partial blocking or reduction of the transverse valley. The skull is large, length 540 to 620 mm., and massive; the rostrum is broadened, possibly more abruptly deflected than *serresii*, supraorbital processes of frontals are shorter and broader, and mesorostral fossa is elongate and narrow.

Minor and seemingly unimportant differences have been proposed to separate the genera *Metaxytherium* and *Felsinotherium*. Abel (1904, p. 217) contended that *Felsinotherium*, chiefly with reference to *F. forestii* and *Cheirotherium brocchii* (*Cheirotherium* Bruno, 1839, preoccupied by *Cheirotherium* Kaup, 1835, a genus of reptiles) was a more highly specialized type, as shown by the following characteristics: body size, form of skull roof and separation of temporal crests, relation of supraoccipital to foramen magnum, reduction stage of nasals, bending of jaw, development of tusks in premaxillaries, number of molars, form of molars, form of scapula, and geological age.

Depéret and Roman (1920, p. 48) distinguish *Felsinotherium* from *Metaxytherium* by the little more advanced reduction and the little more quadrate form of M^1, M^2, and Pm^4, and by the little more pronounced bending downward of the premaxillary of the rostrum. Comparison of the profiles of *Metaxytherium cuvierii* (Cottreau, 1928, pl. 1, fig. 2c) and *Felsinotherium serresii* (Depéret and Roman, 1920, pls. 1, 2, fig. 1a) does not confirm this mentioned difference in the bending downward of the rostrum.

Simpson (1932a, pp. 451, 469) in describing *Felsinotherium ossivallense* from the lower Pliocene Bone Valley formation at Mulberry, Fla., defends this generic allocation on the basis that the upper molariform teeth are wider relative to their lengths in *Felsinotherium* than in *Metaxytherium*, although no constant morphological differences were noted in isolated molars. He regarded *Felsinotherium* more progressive, but commented (op. cit., p. 469) "at present no single character can be relied on to separate all the species of this genus from all the species of *Metaxytherium*." Photographs were published by Simpson (1932a, fig. 12) of the rostral portion of a skull which was misplaced at the time of his study; its subsequent location has provided supplementary information. As regards the lengthening of the proximal portion of this rostrum, Gregory (1941, p. 39) observes that *Felsinotherium ossivallense* corresponds more closely with *Metaxytherium cuvierii* than with European species of *Felsinotherium* and stresses the doubtful value of the length-width ratio of M^3, inasmuch as the 1.24 ratio of this referred specimen agrees more closely with species of *Metaxytherium* than with *Felsinotherium*. These observations undoubtedly influenced Gregory to regard "the differences between Miocene and Pliocene Halitherinae as too slight and variable to be worthy of generic recognition," but he nevertheless concluded that until more adequate material was available a formal proposal would be premature.

The validity of the suggested diagnostic distinctions between *Metaxytherium* and *Felsinotherium* are far from being convincing. It would appear advisable, however, to defer further consideration of the status of these genera until additional species that exhibit some fairly close relationship to presently recognized forms are discovered.

HALIANASSA Studer

Halianassa Meyer, 1838, Jahrbuch für Mineralogie, Stuttgart, p. 667. [nomen nudum.] Type species: *Manatus studeri* Meyer (nomen nudum).

Halianassa Studer, 1887, Abhandlungen Schweizerischen paläontogischen Gesellschaft, Zurich, vol. 14, p. 10.

Type Species: *Halianassa studeri* Studer.

Type Locality: Muschelsandstein von Mäggenwyl bei Lensburg, Aargau Canton, Switzerland. Burdigalian, lower Miocene.

Manatus studeri was proposed by H. von Meyer (1837, p. 677), without description, for a portion of the left maxillary with four cheek teeth from the Burdigalian "Molassen-Sandstein" at Mäggenwyl, Switzerland. The name is unquestionably a nomen nudum. The following year, Kaup (1838, p. 319, pl. 2, figs. D1, D2) described briefly and illustrated a lower molar [=*Halitherium schinzi*, fide Lepsius, 1882, p. 161] from Flonheim, Rhineland-Palatinat, Germany, that measured 21 mm. in length and 17 mm. in width. This tooth was considered to belong to *Hippopotamus dubius* of Cuvier [=?*Protosiren dubia*, fide Sickenberg, 1934, p. 190] whose corresponding tooth measured 18 mm. in length and 14 mm. in width. The measurements of the same tooth of the middle Miocene (Helvetian) *Hippopotamus medius* of Cuvier were recorded as 28 mm. in length and width. This Flonheim molar has since been allocated to the Oligocene *Halitherium schinzi* Kaup.

In the same volume H. von Meyer (1838, p. 667) proposed the generic name *Halianassa* for the "widespread plant-eating" fossil of Flonheim (Kaup, 1838, p. 319), which was regarded as standing between *Halicore dugong* and *Manatus*. The sirenian tooth from Flonheim was identified by Kaup as the *Hippopotamus dubius* of Cuvier (ed. 2, 1824, vol. 5, pt. 2, p. 527 =?*Protosiren dubia*, fide Sickenberg, 1934, p. 190) from Blaye, Gironde, France. The *Hippopotamus medius* of Cuvier (ed. 2, 1821, vol. 1, p. 332, pl. 7, fig. 9) had been so named by Desmarest (1822, p. 388). To the same animal H. von Meyer (1838) referred the stone block with the Raedersdorf skeleton in the Strasburg Museum (Duvernoy, 1835a-b; Blainville, 1844, pp. 100–102, pl. 10, also refers to this specimen). H. von Meyer (1838) also stated that he did not doubt that *Halicore cuvieri* Christol, then also Cuvier's "*Hippopotamus medius* and *H. dubius*", as well as his *Manatus studeri* (a nomen nudum) belong thereto, which he then named *Halianassa studeri*, but again without a description. The portion of the left maxillary with four cheek teeth in place as well as the four root cavities of two missing anterior teeth from the Burdigalian sandstone at Mäggenwyl was neither described nor illustrated as the type of *Halianassa studeri* until 1887 (Studer, p. 10, pl. 1, fig. 4).

In 1843, Hermann von Meyer (p. 704) concluded that the sirenian mandibles excavated in the Aquitanian sand near Linz, Austria, and described as *Halitherium cristolii* by Fitzinger (1842, p. 61) belonged to the genus *Halianassa* which he (Meyer, 1838, p. 667) had proposed for the Flonheim sirenian and for which *Halitherium schinzi* Kaup is now recognized as the valid name. Four years later, in 1847, Hermann von Meyer (p. 189) employed the name *Halianassa collinii* for unlisted sirenian bones in the custody of Carl Ehrlich at the Linz Museum but published no description of them. Ehrlich (1848, p. 200) accepted the identification given by H. von Meyer and applied the name *Halianassa collinii* to the sirenian mandibles described by Fitzinger in 1842 as *Halitherium cristolii* as well as to a left scapula and two fragments of cranial roofs. This left scapula as well as ribs and vertebrae recovered in 1854 at Linz were also described as *Halianassa collinii* by Ehrlich (1855, pp. 11–21, figs. 5). All of these skeletal elements referred to *Halianassa collinii* are considered by Spillmann (1959, p. 17) to be identical specifically with the sirenian mandibles found in the Sicherbauer-Sandgestätten at Linz which Fitzinger (1842, p. 61) named *Halitherium cristolii*.

Thus, the generic name *Halianassa* is not available as a replacement for *Metaxytherium* under either of the above stated usages.

Depéret and Roman (1920, p. 33) while commenting on the inadequacy of our knowledge of *Halianassa studeri* suggest that this species is perhaps identical with *Metaxytherium beaumonti* (whose skull has been reported to be lost) and *M. krahuletzi*. The generic attributes of the species currently assigned to either *Halianassa* or *Metaxytherium* are so doubtful in the opinion of Simpson (1932a, p. 475) that he suggested the retention tentatively of both genera. Reinhart (1959, p. 23) in his excellent review of the Sirenia of the western hemisphere has employed the generic term *Halianassa*. This usage has been accepted by others. Nevertheless, should *Metaxytherium* Christol prove to be synonymous with *Halianassa* Studer, the former has at least 46 years priority and is valid. Whether or not the subquadrate upper molars of *Halianassa studeri* are sufficiently diagnostic to warrant generic recognition should await discovery of more adequate skeletal material.

The measurements (in mm.) of the cheek teeth of the type of *H. studeri* published by Studer (1887, pp. 11–12, pl. 1, fig. 4) are

	length	*width*
Pm^4	17	18.5
M^1	20	23
M^2	22	22
M^3	31	25

and on the basis of the illustration (pl. 43, fig. 3), the cheek teeth are characterized as follows:

M^1: narrow transverse lake between rim of anterior cingulum and the continuous rim encircling the protocone, protoconule, and paracone; transverse valley deflected by forward thrust of metaconule; continuous rim encircles metaconule, hypocone and posterior cingular lake; metacone conical, apex behind metaconule.

M^2: anterior cingulum wide, rolled over backward; anterior lake narrow, transverse; protocone, protoconule, and paracone almost in straight transverse row; transverse valley narrow, curved forward medially; hypocone prominent, continuous with metaconule and separated from smaller conical metacone by narrow curved cleft; apex of metacone behind metaconule; posterior cingulum minutely cuspidate.

M^3: apices of protocone, protoconule and paracone in straight transverse row; incipient parastyle on thick crest of anterior cingulum separated from paracone by a deep cleft; anterior transverse lake narrow, deep; transverse valley curved, similar to that of M^2.

METAXYTHERIUM Christol

Metaxytherium Christol, 1840, Compt. Rend. Acad. Sci., Paris, vol. 11, no. 12, p. 529; L'Institut, Paris, vol. 8, sect. 1, no. 352, p. 323, September 24, 1840; Ann. Sci. Nat., Paris, ser. 2, vol. 15, pp. 331–335, pl. 7, figs. 1–3, 5–6, 9–10, June 1841.

Type Species: Not mentioned. By restriction, *Metaxytherium medium* (Desmarest).

Type Locality: "Falun," vicinity of Doué, Maine-et-Loire, France. Helvetian, middle Miocene.

This genus was based on specimens from the departments of Maine-et-Loire, Gironde, and Herault, France. The specimens specifically mentioned by Christol were: (1) the top of the braincase (Cuvier, 1825, ed. 3, vol. 5, p. 267, pl. 19, figs. 22, 23) from the marine Miocene (Helvetian), vicinity of Doué, Maine-et-Loire, referred by Cuvier to the "lamantin" (sea cow); (2) the isolated upper molar teeth (Cuvier, 1825, ed. 3, vol. 1, pp.333–334, pl. 7, figs. 12–17, 18–20; referred subsequently to *Halitherium dubium* by Gervais, 1859, p. 282 [=?*Protosiren dubia*, fide Sickenberg, 1934, p. 190]) from the Eocene (Lutetian) "calcaire" near Blaye, Gironde, France, referred by Cuvier (1824) to *Hippopotamus dubius;* (3) the three lower molars in the left mandible (Cuvier, 1825, ed. 3, vol. 1, p. 332, pl. 7, figs. 9, 10, 11) from Doué referred by Cuvier to the "moyen hippopotame fossile" [=*Hippopotamus medius* Desmarest, 1822]; (4) The proximal and distal ends of the left humerus (Cuvier, 1825, ed. 3, vol. 5, p. 233, pl. 19, figs. 24–26, 28, 29; illustrations reversed by engraver, fide Christol, 1841, p. 328, footnote) from Doué referred by Cuvier to "deux phoques" (seals); (5) right radius and ulna (Cuvier, 1825, ed. 3, vol. 5, p. 268, pl. 19, figs. 19–21; illustrations reversed by engraver, fide Christol, 1841, p. 328, footnote) from Doué referred by Cuvier to the "lamantin" (sea cow); and (6) perhaps the rib and the vertebra (atlas) (Cuvier, 1825, ed. 3, vol. 5, p. 269, pl. 19, fig. 12A, 12B) from Doué referred by Cuvier at first to the "lamantin" and afterwards to the "morse" (walrus).

The specimens discovered in the Pliocene (Plaisancian) at Montpellier, Herault, included (1) most of the right mandible (except for the portion comprising the coronoid process and the condyle) with three molars in place and ankylosed at the symphysis with the anterior portion of the left mandible; (2) the skull; (3) the molars; (4) many ribs; and (5) many vertebrae.

The type species was not specifically fixed in the original description. Christol (1840, p. 529), however, recognized that his genus comprised two different species differing principally in size, the larger sirenian occurring in the Miocene of Maine-et-Loire and the smaller in the Pliocene of Montpellier.

Christol, however, in 1834 (p. 274 and p. 277 explanation for pl. 13) had referred the sirenian from Montpellier and the one from Doué to *Halicore cuvierii* nobis. Some years later, Christol (Blainville, 1844, p. 130) in a letter to Blainville concluded that his genus *Metaxytherium* comprised the following three species: *Metaxytherium cordieri* for the Loire Valley sirenian, *Metaxytherium cuvieri* for the Montpellier sirenian, and *Metaxytherium beaumonti* for the "molasse de Beaucaire" sirenian. The smaller Montpellier sirenian subsequently also became the type of *Halitherium serresii*, but Gervais (1849, vol. 2, expl. pls. 4, 5; 1849, vol. 1, pt. 1, p. 219; 1850, vol. 1, pt. 2, p. 406; 1859, p. 277, pl. 4, figs. 1–3, pl. 5, figs. 1–3, pl. 6, figs. 1–5) did not accept *Metaxytherium* as a valid genus in his review of European fossil sirenians.

The status of the Doué and the Montpellier sirenians remained in question for several years. Capellini in 1865 (p. 281) proposed *Felsinotherium* for an Italian Pliocene (Astian) sirenian, but did not formally name the species *Felsinotherium forestii* until 1871 (p. 617, pls. 1–8). Capellini (1871, p. 615), however, seems to have been the first to place *Halitherium serresii* Gervais among the species included in the genus *Felsinotherium*, but did not actually publish the combination. Zigno (1878, p. 944) discussed the Montpellier sirenian under the name *Felsinotherium serresii.* This removal of the Montpellier *serresii* to *Felsinotherium* restricted the application of *Metaxytherium* and also of *Halicore cuvierii* to the Maine-et-Loire specimens listed by Christol. The type species of *Metaxytherium* by this removal becomes *Halicore cuvierii* Christol (1834, p. 274 and p. 277, explanation for plate 13), which is antedated by *Hippopotamus medius* Desmarest (1822), based on the left mandible (MNHN 722, Laboratoire de Paléontologie) with three molars in place, but M_1 lacks the crown (Cuvier, 1821, ed. 2, vol. 1, p. 332, pl. 7, fig. 9; illustration reversed by engraver), and one isolated molar from Doué. The measurements of the molar teeth in the type mandible illustrated by Blainville (1844, pl. 9) are as follows: M_2, length, 26 mm., and width, 21.7 mm.; M_3, length, 28.7 mm., and width, 24 mm. The type species of *Metaxytherium* now stands as *Metaxytherium medium* (Desmarest).

Diagnosis: Incisors (tusks) present in premaxillaries of adult males; cheek teeth with enamel; upper cheek teeth reduced to three molars and one premolar (in young at least); one premolar and three molars comprise lower dentition; M^3 unreduced, complex, elongate with accessory cuspules; conules displaced, bunodont (unworn); roots of cheek teeth at least partially closed.

Skull: Braincase relatively long, high, and narrow; rostrum deflected downward to some degree; nasal bones separated at posterior end of mesorostral fossa on midline by the paired frontals; lachrymal present; no lachrymal duct; supraorbital processes of frontals relatively long, slender and little expanded; temporal crests lyriform, either well separated or closely approximated on parietals; median area of paired frontals flattened; supraoccipital narrowly reaching downward to foramen magnum; external palatal projection of maxillary suturally united with jugal as in *Dugong;* skull as long as 600 mm. Mandible deep and robust.

Anterior dorsal vertebrae with three pairs of facets for articulation with ribs, one at end of the diapophysis and the anterior and posterior demifacets on each centrum of the first nine dorsals; nineteen to twenty dorsal vertebrae, three lumbar vertebrae, one sacral vertebra, and possibly twenty or more caudal vertebrae; nineteen to twenty pairs of ribs; three processes present on vertebral end of first rib, two of which bear the articular surfaces of the capitulum and the tuberculum.

Radius and ulna of adults firmly ankylosed, rotation completely lost; radius bent forward, ulna inward; innominate bone reduced to elongated slender ilium, laterally compressed ischium, and pubis vestigial if retained; articular socket for head of femur shallow and small.

The diagnostic differences observable in the skull, scapula, and the maxillary and mandibular molars of the genera *Halitherium* and *Metaxytherium* have been tabulated by Spillmann (1959, p. 54).

METAXYTHERIUM CALVERTENSE, *new species*

Type Specimen: USNM 16757. Immature sirenian. Skull (lacking on left side: the maxillary, the entire series of cheek teeth, the jugal; also both palatines, right occipital condyle, and descending processes on each side of the pterygoid, and the coalesced alisphenoid and basisphenoid); right mandible and symphysial portion of left; both scapulae; both humeri; distal portion of left radius; axis and 3 cervical vertebrae; 16 dorsal vertebrae; neural arch and spine of 3 lumbar and 1 sacral vertebrae; 3 transverse processes of lumbar vertebrae; 40 ribs; sternum; right innominate. Collectors, W. E. Salter, A. C. Murray, and C. W. Gilmore; August 4, 1943.

Horizon and Locality: One-half mile south of Plum Point Road end, Calvert Co., Md. In compact blue clay at base of zone 11 (below shell band) and at tide level at base of cliff. Calvert formation, middle Miocene.

Referred Specimens: Ten, as follows: (1) USNM 9346: adult sirenian, left radius and ulna (figured by Case, 1904, pl. 26, fig. 1); Fairhaven, Anne Arundel Co., Md., diatomaceous earth, Calvert formation, middle Miocene. (2) USNM 12596: adult sirenian, 2 dorsal vertebrae, 8 more or less complete ribs and fragments of others; coll. Norman H. Boss and Remington Kellogg, June 19, 1932; at beginning of cliff south of Plum Point wharf, Calvert Co., Md., in zone 12 at contact between zone 12 and 11, 4 feet above shell band (zone 10), Calvert formation, middle Miocene. (3) USNM 16630: young sirenian, both mandibles, ankylosed anteriorly (4 cheek teeth in situ and 2 detached milk teeth), left occipital condyle, axis, 7 dorsal, 3 lumbar, 1 sacral, and 2 caudal vertebrae, 12 ribs, right scapula; coll. G. E. Marsh, Dec. 24, 1939; 646 yards south of mouth of Parker Creek, Calvert Co., Md., in bluish sandy clay, zone 12, Calvert formation, middle Miocene. (4) USNM 16715: young sirenian, left scapula; coll. William E. Salter, July 11, 1942; 1,400 feet south of mouth of Parker Creek (in second cliff), Calvert Co., Md., in blue clay of zone 11, about 3 feet below top of zone, Calvert formation, middle Miocene. (5) USNM 23213: adult sirenian, 8 dorsal and 2 lumbar vertebrae, portions of 2 scapulae, 2 incomplete ulnae, 1 incomplete left radius, left innominate, 2 rather complete ribs and portions of about 12 others; coll. R. Lee Collins, May 8, 1936; about 0.6 mile south of Randle Cliff Beach, Calvert Co., Md., in talus slope at foot of cliff (little doubt but that specimen came from zone 10), Calvert formation, middle Miocene. (6) USNM 23271: adult sirenian, second molar of left mandible; coll. A. Shaftsbury, Sept. 11, 1933; 1 mile south of Plum Point wharf, Calvert Co., Md., in lower part of zone 11 at shell layer, Calvert formation, middle Miocene. (7) USNM 23281: adult sirenian, third molar of right maxillary, worn; coll. T. E. Ruhoff, May 30, 1956; midway between Plum Point and Dare's wharf, Calvert Co., Md., in shell layer of zone 11 at base of cliff on farm of Mr. Andrews, Calvert formation, middle Miocene. (8) USNM 23348: adult sirenian, neural arch and spine of fifth dorsal vertebra (see Palmer, 1917, p. 234); coll. William Palmer, March 1916; 1 mile south of Chesapeake Beach, Calvert Co., Md., Calvert formation, middle Miocene. (9) USNM 23667: adult sirenian, axis; coll. R. Lee Collins, Apr. 7, 1934; about 1 mile south of Plum Point wharf, Calvert Co., Md., at shell layer at base of zone 11, Calvert formation, middle Miocene. (10) USNM 23409: adult sirenian, right third upper molar; coll. R. Lee Collins; Calvert Cliffs, Calvert Co., Md. (no other data), Calvert formation, middle Miocene.

Skull

This description is based on the skull (USNM 16757) of an immature individual, the sutural contact between the squamosal and the parietal being open on both sides of the braincase. On the left side the squamosal was displaced when the skull was found, but has since been partially corrected. On the left side, the maxillary, the anterior portion of the zygomatic arch, the entire row of cheek teeth, as well as the right occipital condyle are missing.

Dorsal view.—The skull (fig. 32) is characterized in part by elongation in conformity with the normal sirenian construction, the top of the braincase being narrower than the rostrum. The cerebral cavity as compared to that of the Recent dugong is more elongated, somewhat compressed from side to side, truncated at both ends, and rather flat dorsally.

The posterior or occipital face of the braincase is almost vertical and the elongated premaxillaries are bent strongly downward. The occipital condyles are not visible when viewed from above. The ovoidal mesorostral fossa is also noticeably elongated, widened near the middle of its length and extends backward beyond the orbit.

The somewhat horizontal dorsal surface of the braincase is slightly depressed longitudinally between the low flattened temporal crests. These crests strongly converge some 55 mm. anterior to the supraoccipital crest, where they are separated by a minimum 15 mm. interval; they then gradually diverge anteriorly until an interval of 50 mm. separates them, and these crests become indistinct.

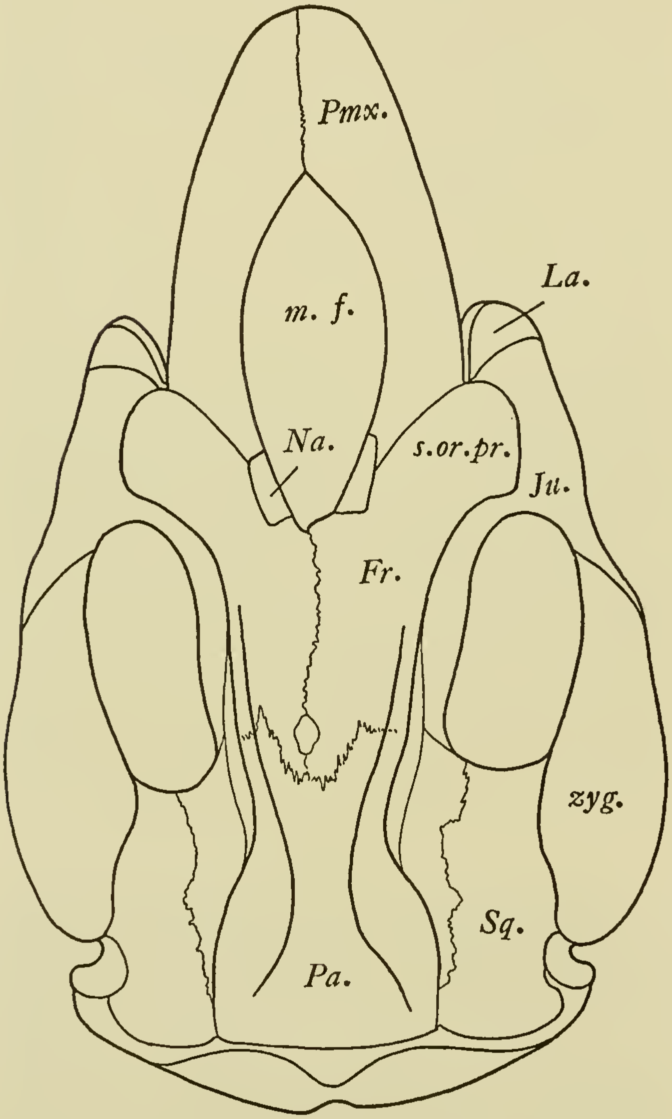

Figure 32.—Dorsal view of skull, USNM 16757, of *Metaxytherium calvertense*, with left jugal restored and rostrum corrected for distortion. Abbrs.: Fr., frontal; Ju., jugal; La., lachrymal; m.f., mesorostral fossa; Na., nasal; Pa., parietal; Pmx., premaxillary; s.or.pr., supraorbital process of frontal; Sq., squamosal zyg., zygomatic process of squamosal.

The elongated parietals are so intimately ankylosed to the supraoccipital that no sutural contact is discernible. At this contact posteriorly a low transverse crest is developed below which the occipital face abruptly descends to the foramen magnum. Anteriorly the parietals make a forklike sutural contact with the frontals. The narrowest part of the braincase roof is about 95 mm. anterior to the low transverse crest that marks the ankylosis of the supraoccipital and the parietals; at this point the width is 65 mm. The roof widens slightly toward its anterior end where its transverse width is about 75 mm. Inside the temporal crests on the top of the braincase the maximum length of the right parietal is 100 mm. and the maximum length of the right frontal is 88 mm. The maximum width of the intertemporal portion of the roof of the braincase is about 75 mm. The shape of the sutural contact between the parietals and the frontals is shown on plate 33.

In general configuration, the braincase (pl. 33, fig. 1) agrees with those of other forms of *Metaxytherium* and *Felsinotherium*. The anterior portion of the roof of the braincase is contributed by the elongated frontals, and the sutural contact between these bones medially is almost obliterated, except anteriorly, by ankylosis along the midline of the dorsal surface of the braincase. Anteriorly the frontals contribute the posterior margin of the mesorostral fossa and intervene between the opposite nasal bones. Each frontal bone is prolonged laterally to form a rather short and narrow, but bent downward supraorbital process which overhangs the orbital cavity. The maximum anteroposterior diameter (38 mm.) of the extremity of the right supraorbital process of the frontal does not exceed greatly the minimum diameter (35 mm.) of this process.

On each side above the olfactory chamber each frontal from a dorsal view is overlain by a relatively narrow nasal bone which in turn abuts anteriorly against the posterior end of the premaxillary. Between these nasals the narrowed anterior end of each frontal extends forward to the nasal or mesorostral fossa, thus separating these bones above the olfactory chamber.

The platelike nasal bones were found not fully preserved when this fossil skull was prepared in the paleontological laboratory. On each side of the posterior end of the mesorostral fossa, the narrow nasal bone was attached to or lodged in the excavation on the inner border of the corresponding supraorbital process of the frontal, and abutted anteriorly against the posterior end of the premaxillary. The length of each nasal exceeded its width on the dorsal surface of the skull.

At the posterior end of the mesorostral fossa of *Caribosiren*, *Hesperosiren*, *Metaxytherium*, *Thattatosiren* and *Felsinotherium*, the nasal bones are separated by the forward projecting wedge of the frontals above the nasal chamber. As a possible indication of some variability, it should be noted that the nasals are almost in contact medially on one skull of *Felsinotherium serresii* (Gervais, 1859, pl. 6, fig. 3). This relationship of the nasals and frontals was employed by Kretzoi (1941) to support his conception of phyletic relationship of genera. Kaltenmark asserts that on the cranium from Chazé-Henry, a photograph of which was published by Depéret and Roman (1920, pl. 7, fig. 3), the nasals meet on the midline, but Reinhart (1959, p. 61) questions this interpretation and believes that the right nasal is labeled as the premaxillary (Kaltenmark, 1942, vol. 6, p. 107, fig. 2).

As with all known sirenians, the slender premaxillaries are well developed and contribute the external borders of the mesorostral fossa. The left premaxillary is complete, but the right premaxillary has at least 20 mm. of the extremity broken off. At the anterior end of the mesorostral fossa, the premaxillaries are bent strongly downward and are closely approximated, forming a symphysis of about 84 mm. in length. No vestige of an alveolus even for a small incisor tusk is present in the extremity of the left premaxillary, but the internal surfaces of both premaxillaries are incomplete. This apparent absence of a tusk may indicate the female sex. Although the extremity of the rostrum projected obliquely downward and forward, the extent of its prolongation resembles *Metaxytherium cuvierii* (Cottreau, 1928, pl. 1, fig. 2c) more closely than *Felsinotherium serresii* (Depéret and Roman, 1920, pl. 2, fig. 1a).

In front of the supraorbital process of the frontal the external face of the premaxillary is in contact with the lachrymal. The lachrymal is also appressed against the anterodorsal end of the jugal.

The maxillary is not visible on the dorsal surface of the skull. The relations and shapes of the bones enclosing the mesorostral or nasal fossa correspond fairly closely with *Metaxytherium cuvierii* (Cottreau, 1928, pl. 1, fig. 2). The nasal passages enter this fossa from the rear and the pair of orifices of the olfactory nerves open into the same area. This mesorostral fossa is terminated anteriorly by the close approximation of the premaxillaries, which meet in the form of a symphysis to constitute the terminal portion of the rostrum. On each side the premaxillary constitutes the major portion of the downward directed rostrum which is supported posteriorly and ventrally by the corresponding maxillary. The sutural contact between each premaxillary and the corresponding maxillary commences on each side at the level of or near the posterior end of the incisive foramina and terminates at or near the level of the supraorbital process of the frontal.

Along the hinder portion of the mesorostral fossa, each premaxillary is applied externally to the anterior face of the supraorbital process of the frontal. At the posterior end of the mesorostral fossa each premaxillary also abuts against the anterior face of the corresponding nasal, thus excluding the maxillary from any share in the dorsal border of the mesorostral fossa. Each nasal bone is mortised into the internal face of the corresponding supraorbital process of the frontal.

Posterior view.—Viewed from the rear, this skull (fig. 33) resembles somewhat closely that of *Felsinotherium serresii* (Depéret and Roman, 1920, fig. 2(4)), its greatest width being above the level of the occipital condyles. The dorsal border of the supraoccipital is truncated horizontally and the rather sinuous curvature of the lateral lambdoid crest is concave dorsally and convex ventrally. The contour of the left occipital condyle is reniform, and the petrosal is visible in the gap between the supraoccipital, the exoccipital and the ventral projection of the squamosal. The foramen magnum is relatively large, higher than wide.

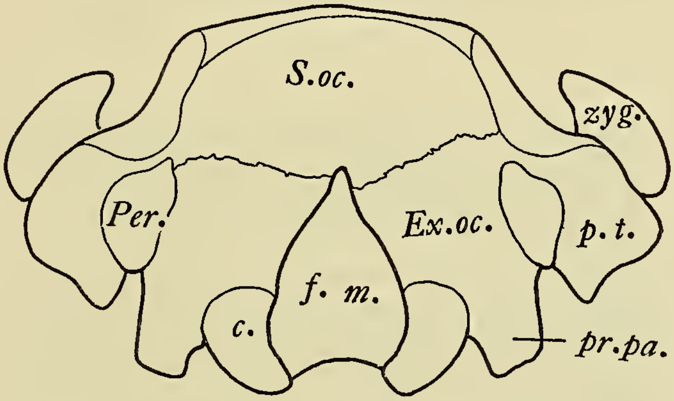

Figure 33.—Posterior view of skull, USNM 16757, of *Metaxytherium calvertense*, with right exoccipital and occipital condyle restored. Abbrs.: c., occipital condyle; Ex.oc., exoccipital; f.m., foramen magnum; Per., periotic; pr.pa., paroccipital process; p.t., posttympanic process of squamosal; S.oc., supraoccipital; zyg., zygomatic process of squamosal.

On this fossil skull, the exoccipital meets the thickened supraoccipital in sutural contact almost at the level of the top of the foramen magnum.

The posterior face of the braincase of *Metaxytherium*, new species, from Chazé-Henry figured by Kaltenmark (1942, vol. 6 p. 105, fig. 1) also has the supraoccipital extending downward to the foramen magnum. The lateral gap in the braincase wall between the squamosal, exoccipital and to a limited extent the supraoccipital, which is filled by the periotic, has a slightly different configuration either from that of the Calvert sirenian or from the Recent dugong. This gap is termed the supracondyloid fossa by Kaltenmark.

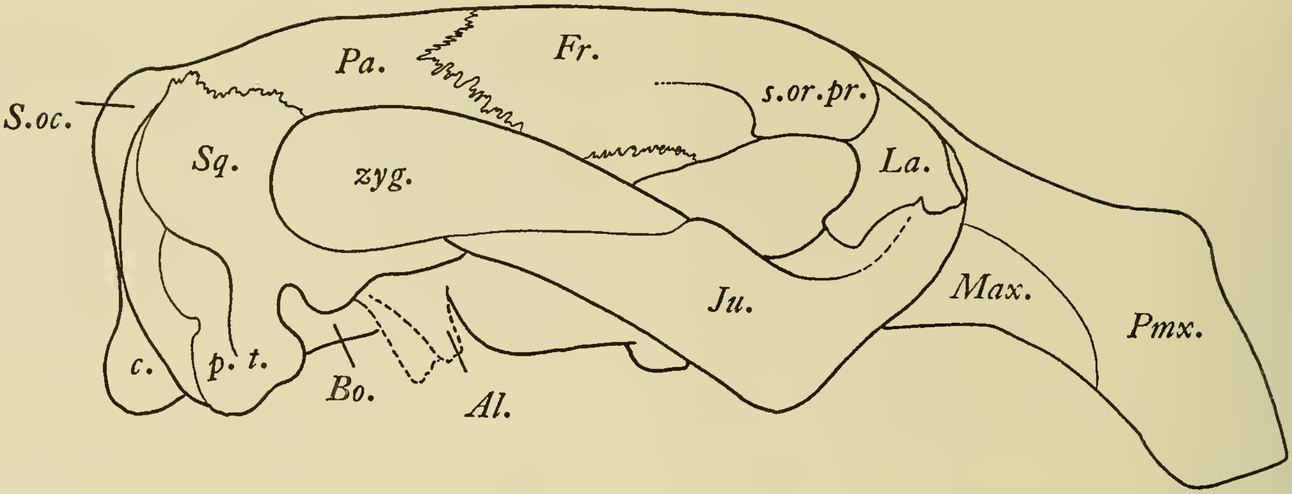

Figure 34.—Lateral view of skull, USNM 16757, of *Metaxytherium calvertense*, with rostrum corrected for distortion. Abbrs.: Al., descending pterygoid plate of alisphenoid; Bo., basioccipital; c., occipital condyle; Fr., frontal; Ju., jugal; La., lachrymal; Max., maxillary; Pa., parietal; Pmx., premaxillary; p.t., posttympanic process of squamosal; S.oc., supraoccipital; s.or.pr., supraorbital process of frontal; Sq., squamosal; zyg., zygomatic process of squamosal.

Lateral view.—The parietals and frontals constitute a major portion of the lateral walls of the elongated braincase (fig. 34). Both squamosals are fairly complete. Ventrally, in the temporal fossa, the squamosal anteriorly meets the alisphenoid edge to edge. From this point the sutural contact between the squamosal and parietal extends obliquely upward and backward to the level of the top of the braincase where this bone overlaps the anterior edge of the supraoccipital. The posttympanic process of the squamosal is prolonged ventrally beyond the level of the basicranium but apparently is not ankylosed to the paroccipital process, which is conjoined with the exoccipital.

The temporal fossa is also elongated and is continuous anteriorly with the orbital cavity. This temporal fossa is bounded externally by the zygomatic arch whose major portion is contributed posteriorly by the elongated and laterally compressed zygomatic process of the squamosal. The jugal underrides the anterior end of the zygomatic process.

Each frontal is produced anteriorly into a rather stout and narrow supraorbital process, directed obliquely forward and outward in front of the temporal fossa to form the roof of the orbit. The orbital cavity has an unusually thick rim in front and below, which is contributed by the large jugal. On this fossil skull no vestige of a postorbital process is developed to even partially delimit the orbit posteriorly. Underneath the zygomatic process of the squamosal, the attenuated posterior portion of the jugal is extended backward as far as the shallow glenoid fossa.

The jugal is a rather long bone (length 168 mm.), whose anterior portion is bent almost at right angles to the posterior horizontal portion. This bone constitutes the ventral rim of the orbit and its anterior end is intimately pressed against the external surface of the premaxillary.

On the right side, the small, tumid, reniform shaped lachrymal bone, 42 mm. long dorsoventrally and 18 mm. wide, is wedged (pl. 33, fig. 2) in against the dorsal end of the jugal, the premaxillary and the anteroexternal angle of the supraorbital process of the frontal. A tonguelike process of uncertain homologies projects backward into the orbital from the posterior face of the lachrymal.

On the left side of a dugong skull (USNM 284443) from Coburg Peninsula, Australia, the lachrymal is wedged in between the dorsal end of the jugal, the premaxillary internally, and the supraorbital process of the frontal posteriorly; anteroventrally behind the large infraorbital foramen, the lachrymal is unquestionably suturally in contact with the ascending posterior end of the maxillary. The sutural contacts of the several cranial bones on this skull are unusually distinct. Lachrymal bones of similar dimensions and relations to adjacent bones are retained on dugong skulls from east Africa (USNM 197900) and Australia (USNM $\frac{22481}{13721}$, USNM 28449). On other Australian skulls the gap corresponding to the position of the lachrymal bone is present, although the bone has been dislodged on both sides during maceration. Although greatly enlarged the relative position of the lachrymal on the Calvert skull (USNM 16757) is the same, except that the dorsal end of the jugal has been anteroposteriorly compressed.

Flot (1886, p. 510) describes the lachrymal of *Metaxytherium cuvierii* as a nearly triangular bone, 32 mm. long and 15 mm. high whose posterior border descends vertically from the supraorbital process of the frontal and joins in front the jugal and the maxillary. On the type skull of *Halianassa* [=*Metaxytherium*] *vanderhoofi*, according to Reinhart (1959, p. 33; see also pp. 57–58), the lachrymal is 30 mm. long dorsally and 32 mm. high anteriorly.

On the floor of the orbital cavity, the internal surface of the jugal is suturally united with the external palatal projection of the maxillary. The jugal of this fossil skull is relatively much longer and less semicircular in curvature than that of the Recent *Dugong dugon* (USNM 284443).

The temporal fossa is more elongated than that of the Recent dugong. The zygomatic process is robust, compressed from side to side, attenuated toward the anterior end and rounded posteriorly. The postglenoid process is short, blunt, and bent inward. The maximum vertical diameter of the right zygomatic process is 48 mm. On the anterior half of its length, the zygomatic process of the squamosal overrides and is applied ventrally to the jugal and is terminated anteriorly behind the level of the postorbital angle of the supraorbital process of the frontal.

As viewed from the right side the vertical diameter of the posterior half of the premaxillary is approximately one half the maximum diameter of the bent downward distal end. The external border of the maxillary portion of the palate is partially destroyed.

Ventral view.—The entire left maxillary (pl. 34, fig. 1) is missing. On the right side, although the internal border is eroded, the major remnant preserved shows that the maxillary extended forward to or slightly beyond the level of the presumed location of the incisive foramina. This anterior portion of the maxillary and its external palatal projection, and the jugal enclose the very large infraorbital foramen. Posteriorly each premaxillary rests upon a dorsal prolongation of the corresponding maxillary above the infraorbital foramen.

There is no evident roughening of the ventral surface of the right maxillary for attachment of a horny plate. The state of preservation of the adjacent bones does not permit accurate determination of the presence or extent of a median anterior palatal or incisive foramen.

The anterior narial apertures of the choanae are enclosed on each side of the midline by the ascending or posterior end of the dorsal extension of the maxillary which sheathes the undersurface of the premaxillary in front of the supraorbital process of the frontal. The anterior narial chamber was noticeably narrower than that of the dugong. The vomer forms the roof of the choanae, and sheathes as well the ventral surface of the presphenoid. The vomer apparently did not extend forward to the level of the anterior end of the row of cheek teeth. The olfactory chamber into which the olfactory nerves enter at the rear is greatly compressed from side to side and contains in this fossil skull remnants of the thin longitudinally arranged ethmoturbinals.

The palate, located between two parallel rows of 3 or 4 cheek teeth, seems to have been relatively wider than that of the dugong and is formed by the pair of maxillaries. The palatal portions of the maxillaries seemingly did not extend backward much beyond the posteriormost molar.

On the skull of the Recent dugong the pair of rather small palatine bones are visible in the palate between the posterior molars. This region is, however, missing on this fossil skull.

Behind each row of cheek teeth on the Recent dugong skull is a prominent and large descending process, formed by the coalescence of the palatine, with the more or less vertical platelike pterygoid and the pterygoid plate of the alisphenoid (external pterygoid of some authors). Each pterygoid bone is thus wedged in between the alisphenoid and a similarly descending process of the basisphenoid. The posterior face of each of this pair of descending processes is deeply grooved from base to extremity and this may correspond to a pterygoid fossa. On this fossil skull, however, this ventral extension of the basisphenoid, alisphenoid and pterygoid is broken off at the base on both sides, but the relations of the more dorsal portion of these bones are essentially the same as on the Recent dugong skull. No remnants of either the palatines or the projecting pterygoids are preserved.

On the roof of the choanae of this fossil skull, the vomer overspreads the presphenoid and extends relatively much farther forward than on the dugong skull. The anterior end of the presphenoid is broken off.

Length of skull, occipital condyle to extremity of premaxillary	340
Length of frontal (midline posteriorly to level of anterior angles of supraorbital processes)	137
Length of left premaxillary	190
Length of premaxillary symphysis	84
Length of mesorostral fossa	150
Maximum width of mesorostral fossa	53
Width across supraorbital processes of frontals	131
Least intertemporal constriction across frontals	67
Zygomatic width	215
Length of right zygomatic process	140
Maximum vertical diameter of right zygomatic process	57
Length of right jugal	164
Width across posttympanic processes of squamosals	186
Maximum width of supraoccipital	95
Maximum vertical diameter of occipital condyle	36
Maximum transverse diameter of occipital condyle	23
Maximum length row of three upper molars	68.5
Length of first upper molar	18.5
Width of first upper molar	19.6
Length of third upper molar	28.5
Width of third upper molar	18.5

The basicranial axis is thick and the suture between the basioccipital and basisphenoid is not ankylosed on this skull.

Behind each of the descending processes of the contiguous alisphenoid and basisphenoid, the constricted basioccipital internally, the alisphenoid anteriorly, the squamosal externally, and the exoccipital posteriorly enclose a large opening or recess which is only partially occupied by the tympanic half ring and the periotic.

The zygomatic process of the squamosal is rather massive and long, as well as flattened on the external and internal faces. Behind the level of its postglenoid process a robust downward-directed posttympanic process of the squamosal approximates the thickened exteroventral border of the exoccipital, forming a paroccipital area for the attachment of a stylohyoid. Internal to this posttympanic descending process, between the squamosal and the exoccipital, is a gap in the cranial wall which is filled by the periotic.

Measurements (in mm.) of the skull of USNM 16757 are as tabluated above, on page 75.

Ear Bones

Tympanic half ring.—On this Calvert sirenian skull both tympanic half rings are detached although on both periotics the point of attachment of the anterior limb is better developed than that for the posterior limb (see also description of sirenian middle ear by Robineau, 1965). The tympanic half ring (pl. 35, fig. 9) is solid and dense, and open dorsally; the short, broad, subtriangular, and nearly straight anterior limb is bent upward almost at right angles to the more slender curved posterior limb, forming an obtuse-produced angle at the bend. In general configuration this half ring resembles that of *Halitherium schinzi* (Lepsius, 1882, pl. 2, figs. 12–13). This tympanic half ring was apparently rather feebly attached at both ends to points near the external border of the periotic. Both half rings were preserved with this skull, although the left one lacks the extremity of the posterior curved limb.

Periotic.—The right periotic is well preserved but the internal half of the left one is broken off and missing. This somewhat peculiar periotic (pl. 36, fig. 3) is a large and dense bone which is not ankylosed to any of the bones surrounding the tympanoperiotic recess. It consists of a hemispherical inner protuberance, the *pars labyrinthica* (*cochlearis*), a rounded dorsoventrally compressed anterior portion, which is lodged in a cavity in the squamosal, and a posteroexternal mastoid portion, which bridges the gap between the exoccipital, the supraoccipital, and the squamosal, and thus forms part of the posterior wall of the braincase.

Externally, the periotic is abruptly truncated, and thickened dorsoventrally (39 mm.), constituting the mastoid portion. A well developed transverse ridge merging internally with the *pars labyrinthica* and postero-externally with the mastoid portion of the periotic separates the vestibular recess from the rather large depression in which the *fenestra rotunda* opens on the posterior face of the labyrinthine portion. The *fenestra ovalis* is situated on the anterior side of this ridge at the base of the *pars labyrinthica.* The periotic is lodged securely anteriorly and externally by the projecting rim of the squamosal and its descending posttympanic process. The anterior portion of the periotic to which the anterior limb of the tympanic half ring was attached is markedly compressed dorsoventrally as contrasted with the posterior enlargement or mastoid portion to which the posterior curved limb of the tympanic half ring was attached. The anterior portion of the periotic is partially set off from the postero-external mastoid portion by a deep notch, similar to the condition observable on the dugong periotic, where this notch or groove is situated external to the point of attachment of the anterior limb of the tympanic half ring. The maximum transverse diameter of the right periotic is 53 mm.

Auditory Ossicles

As regards these small bones of the inner ear, the malleus was not preserved for either ear region. The right and left incus are present as well as the right stapes.

Incus.—The right incus (pl. 36, fig. 3) is still lodged on the tympanic face of the right periotic in contact with the stapes. The left incus (pl. 35, fig. 10) was detached when found. In configuration this incus is quite similar to that of *Halitherium schinzi* (Krauss, 1862, pl. 6, fig. 5). The body of the incus is prolonged into the bent or curved *crus longum* which articulates with the head of the stapes by an ovoidal flat facet located on the side below its extremity. The *crus breve* is short, conical, and projected upward; the small facet on its extremity should rest in the *fossa incudis* which, however, was not recognized on the tympanic face of the left periotic. A short blunt nipple-like tubercle is located internal to the small concavity which serves for reception of the head of the malleus. From the head of the *crus longum* to the base of the body the incus measures 13 mm., and the greatest diameter of the flattened base is 10 mm.

Stapes.—The stapes (length, 9 mm.) has the same form as in *Halitherium schinzi* (Krauss, 1862, pl. 6, fig. 5). The small intercrural aperture is located above the footplate and opens into an ovoidal cavity, presumably on both sides. The footplate of the stapes, which is lodged in the *fenestra ovalis* (pl. 36, fig. 3), is about three times as wide (7 mm.) as the extremity (2.5 mm.) of this little ear bone. A scar or roughened area is discernible on the posterior surface below the articular facet on the extremity or head and may represent the area for attachment of the stapedius muscle.

The facet for contact with the facet on the *crus longum* of the incus seems to be placed obliquely on the head of the stapes.

Mandible

As compared to *Dugong* this mandible (pl. 37, fig. 10) is more elongated and the coronoid process, which is likewise inclined forward, is more elevated. Hatt (1934, p. 553) has noted that high variation in the shape of the coronoid process occurs among *Trichechus* mandibles and hence due allowance for variability should be made for mandibles of *Metaxytherium*. The condyle, which is broken off, apparently was rather narrow. The length of the right mandible is 255 mm. The ventral profile of the horizontal ramus is broadly concave. An increase in the depth of the symphysis of an old adult would undoubtedly accentuate the curvature of the ventral profile.

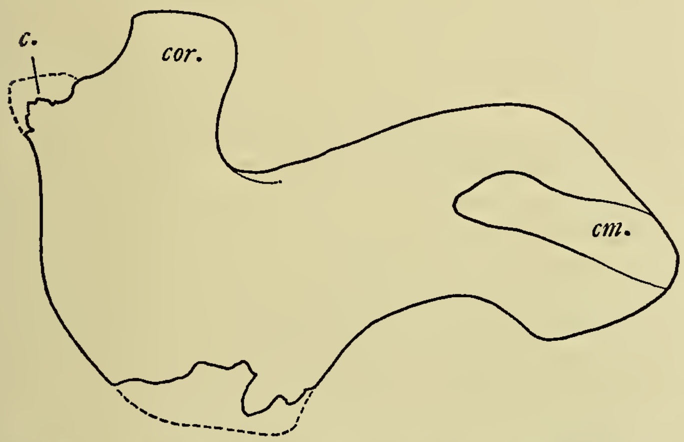

Figure 35.—Right mandible, USNM 16757, of *Metaxytherium calvertense*. Abbrs.: c., condyle; cor., coronoid process; cm., external orifice of mandibular canal.

The anterior ends of the two mandibles of this immature sirenian were not ankylosed firmly on the symphysis. This thickened symphysis, however, is truncated obliquely at the extremity. Internally the large mandibular canal is open to within 32 mm. of the posterior margin of the symphysis. Externally the same broad canal is open for a distance of 85 mm. to the extremity of the symphysis.

Alveoli for the roots of at least three cheek teeth are partially preserved on the mandible of the immature sirenian (USNM 16757). Juvenile Recent dugongs have four pairs of slender conical teeth lodged in alveolar cavities which are concealed beneath the horny plate covering the downward deflected and squarely truncated symphysial ends of the mandibles. These teeth are absorbed before maturity. Immature and even old adult dugongs retain these alveoli partially filled with osseous replacement. Three dorsal pairs and one ventral pair at the end of the symphysis is the normal complement. One specimen (USNM 284458) has four dorsal pairs and one ventral pair and another (USNM 284456) has three alveoli on the right side and four on the left side of the dorsally placed alveoli and the usual one ventral pair. The ventral pair of alveoli are located at or below the level of the external orifice of the large mandibular canal.

The large capsule (anteroposterior diameter, 24 mm.) below the alveolar surface of the horizontal ramus, above the mandibular canal and in front of the anterior border of the coronoid process serves as a receptacle for the roots of the large M_3 (pl. 37, fig. 10). Alveoli for one premolar and three molars are present on both mandibles for the young individual (USNM 16630). The four pair of partially closed alveolar cavities present on the anterior face of the symphysis of the young individual (USNM 16630) and present as well on the symphysis of the Recent *Dugong* (USNM 284441) are partially obliterated by surface disintegration on the symphysis of the immature sirenian (USNM 16757). Although the ventral portion of the symphysial region of this immature sirenian is missing, there is exposed in each mandible below these anteriorly located alveoli an anteroposteriorly directed groove approximately 15 mm. in width which opens on the anterior face of the symphysis. Openings for this pair of grooves, however, are not present on the anterior face of the symphysis of the young individual (USNM 16630), but seem to correspond in position to the partially closed ventral pair of alveoli on the end of the symphysis of the Recent *Dugong* (USNM 284441). Alveoli for two incisors at the end of the mandible of *Halianassa* [=*Metaxytherium*] *vanderhoofi* are mentioned by Reinhart (1959, p. 30).

The depth of the horizontal ramus is proportionately greater for the mandible (pl. 39, fig. 8) of the young individual than for the immature sirenian (fig. 35). Furthermore, the configuration of the mandible of the young individual resembles more closely that of the adult *Dugong* than that of the immature sirenian (USNM 16757). The mandibles of this young individual (pl. 39, fig. 8) are dense and heavy and thus differ from those of other young mammals. Measurements of the left mandible of the young individual (USNM 16630) are as follows: Length, 169 mm.; depth, condyle to posteroventral angle, 101 mm.; minimum depth of left horizontal ramus, 49 mm.; depth of symphysis, 70 mm.

Measurements (in mm.) of right mandible of USNM 16757 are as follows:

Anteroposterior diameter (condylar region to extremity)	255
Minimum vertical diameter of horizontal ramus	65
Length of symphysis	80
Vertical diameter of symphysis	75

Dentition

Although no enclosed alveolus for a tusklike incisor is recognizable at the anterior end of either premaxillary (USNM 16757), the curvature of the internal face of each premaxillary does suggest that if these bones were in a better state of preservation internally the presence or absence of a tusk could have been ascertained. Consequently, there is no certainty that tusklike incisors were either present or absent. No conclusive evidence is available either to demonstrate that the absence of incisors is not in this sirenian a sexual character.

Dugongids that possessed large incisor tusks were present in the western North Atlantic Ocean as early as the Miocene. Attention is here directed to five individuals with large tusks: (1) the type right premaxillary of *Dioplotherium manigaulti* Cope; (2) a left premaxillary (YPM 21334) obtained during phosphate dredging operations on the Wando River, S.C.; (3) a heavily worn incisor tusk (USNM 9457; length, 88 mm.; maximum width, 37 mm.) from beds mapped as Calvert formation at Tar Bay, James River, Prince George Co., Va.; (4) a tusk (AMNH 9852; length, 170 mm.; maximum width, 40 mm.), probably from left premaxillary, dredged up by "Western Chief" on the west coast of Florida near Fort Myers; and (5) a tusk (USNM 23110; length, 166 mm.; maximum width, 38 mm.) from pit near city limits of Savannah, Ga., presumably Miocene Duplin marl.

The loss of incisors is regarded by Simpson (1932a, p. 427) as a character acquired by at least four sirenians. Absence of incisors is ascribed by Simpson as an outstanding peculiarity of the middle Miocene Hawthorn *Hesperosiren crataegensis.* Presence of incisor tusks in the skull has been regarded by some as a diagnostic character of the Miocene *Metaxytherium,* although recently at least one exception has been recorded. According to Reinhart (1959, p. 31) the Californian *Halianassa* [=*Metaxytherium*] *vanderhoofi* lacks incisor teeth at the anterior ends of the premaxillaries.

On the incomplete tusk (length, 150 mm.; maximum width, 74 mm.; least width, 45 mm.) of *Hemicaulodon effodiens* (Cope, 1869, pl. 5, fig. 6), the compressed pulp cavity is open at the basal end; the cross section at the broken end shows the osteodentine filling the pulp cavity, which is surrounded by a thick layer of dentine and it in turn by a thin circumferential layer of cementum. Annuliform ridges on the circumference of the dentine core are exposed by the flaking off of an area of external cementum. A single large longitudinal groove is present on the external face of the tusk. All of the above described characteristics, with exception of the dimensions, can be matched by a Calvert tusk (USNM 8457) as well as by a Florida Tertiary tusk (AMNH 9852). It is now suggested without hesitation that the type tooth was not derived from the middle Eocene Shark River marl. Tusklike incisors of similar dimensions and configuration made their appearance in sirenian developmental history at a time later than the Eocene. Inasmuch as the Miocene Kirkwood formation overlaps the Shark River marl (Manasquan formation), the association of any specimen picked up on the surface alongside or in a marl pit being worked could readily be misinterpreted. The dimensions of the type tusk of *Hemicaulodon effodiens* [1] correspond more closely with those of the Aquitanian *Rytiodus capgrandi* than with those of other American extinct dugongids.

On the right side of the skull (USNM 16757)M^1 has a well worn crown (pl. 34, fig. 2), alveoli for three roots indicate the size of M^2, and the more elongated M^3 is not fully erupted. If Pm^4 was present in the young, its alveolus has now been obliterated by closure. The length of the maxillary molar row is 68.5 mm.

It should be noted, however, that the young of the Pliocene (Plaisancian) *Felsinotherium serresii* (Depéret and Roman, 1920, p. 8) possessed five upper cheek teeth, two premolars and three molars, but Pm^3 disappeared in the adult and its alveolus is completely obliterated.

The Tortonian *Thallatosiren petersi* (Sickenberg, 1928, p. 315) has retained in the upper dentition two premolars and three molars.

Adults of the Helvetian *Metaxytherium medium* (*cuvierii*) have four upper cheek teeth, one premolar and three molars (Flot, 1886, p. 509) and this formula is recorded also in two maxillaries obtained at Doué, France (Cottreau, 1928, p. 10). The number of upper cheek teeth present in the middle Miocene (Hawthorn formation) *Hesperosiren crataegensis* is known with less certainty, not more than five and possibly only four (Simpson, 1932a, p. 428).

On the palate of the lower Miocene (Burdigalian) *Halianassa studeri* four cheek teeth are in place in addition to four root cavities of one or two missing anterior teeth. The upper dental formula of this sirenian has been interpreted to be: Pm^2, Pm^3, Pm^4, M^1, M^2, M^3 (Depéret and Roman, 1920, p. 33).

Seven upper cheek teeth, three premolars and four molars, were retained by the middle Oligocene (Stampian) *Halitherium schinzi* (Krauss, 1862, p. 20, pl. 6, fig. 2).

An indentation on the lingual and buccal sides of the well-worn crown of M^1 marks the location of the transverse valley. It is obvious then that the anterior portion of the crown (pl. 34, fig. 2) is slightly larger than the posterior, and that the latter is narrower. An incompletely closed enamel ridge marks the location of the buccal paracone. A

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[1] The type specimen of *Hemicaulodon effodiens* was purchased in March 1886 from the Reverend Samuel Lockwood, Keyport, N.J., by Professor O. C. Marsh for the Peabody Museum, Yale University. This specimen cannot now be located in the museum collection.

large deep lake is present in the area occupied by the protocone and protoconule. An enamel rim encircles the deep lake occupied by the hypocone and metaconule before they were obliterated by excessive wear. A very small lake with complete enamel rim represents the remant of the metacone. Wear has not completely reduced the cingular cusps.

The length (28.5 mm.) exceeds the maximum width (18.5 mm.) of M^3 anteriorly. The protocone (pl. 34, fig. 2) is the largest cusp and projects beyond the level of the apices of the protoconule and paracone. At the apex the protoconule and paracone are almost equal in size. An anterior crest connects the protocone, the antero-internal cusp, with the anterior cingulum. A low parastyle on the anterior cingulum is separated from the paracone by a shallow cleft. Between these elevations on the anterior cingulum and the transverse row, the protocone, protonconule and paracone, is a deep lake. From a posterior view, both the paracone and the protoconule are seen to be inclined obliquely toward the protocone, and are separated by a deep unobstructed transverse valley from the cusps on the posterior half of the crown.

The metaconule, although in advance of the hypocone, is actually situated much nearer the lingual than the buccal side of the crown. A narrow almost vertical reentrant oblique cleft separates these two cusps on the medial or external side, although they appear to be confluent on the lingual side. The buccal metacone (pl. 35, fig. 2) is situated opposite the hypocone, but set off from the latter by a deep anteroposterior cleft, and is inclined obliquely inward. A rather large cusp, which may represent another conule, is not completely separated from the metacone in front of it. In addition a sharp-pointed low smaller cuspule is situated medially on the posterior cingulum. A cleft of varying depths, incompletely obstructed between opposite cusps, extends backward obliquely from the transverse valley to the deep lake in front of the posterior cingulum.

This Calvert M^3 does not resemble very closely the corresponding molar of the Helvetian *Metaxytherium cuvierii* [=*M. medium*] from Chazé-Henry, France (Flot, 1886, p. 502, pl. 27, fig. 2). The illustration of the three molars published by Flot seems to have been reversed by the engraver. Measurements (in mm.) given for these three molars (Flot, 1886) are:

	length	*width*	*page*
M^1	18	20	503
M^2	26	21	502
M^3	23	22	503

Any close resemblance to the Calvert sirenian in the placement of the cusps on the crowns of these molars is not readily apparent.

Simpson (1932a, p. 449) and Gregory (1941, p. 36) have both commented on the excessive wear of the M^1 on a skull of *Felsinotherium ossivallense* before the M^3 had fully erupted. A similar condition exists on this Calvert skull. It will be observed (pl. 34, fig. 2) that this incompletely erupted third upper molar is implanted in an alveolus at the posterior end of the maxillary, and that space for a more posteriorly situated alveolus can not be developed in this portion of the maxillary in view of its sutural contact with the descending process of the pterygoid.

In the tabulation below are compared the measurements (in mm.) of the molar teeth of *M. calvertense* (USNM 1675), *M. medium* (Flot, 1886, pp. 502–503), *F. ossivallense* (Fla. V. 5454), and *M. floridanum* (USNM 7221).

Reentrant angles in the encircling enamel rim on the buccal side of the well worn isolated left M^3 (USNM 23281) are interpreted as indicative of the boundaries of original cusps. The upper reentrant angle (pl. 35, fig. 3) on the buccal side separated the paracone and the small anterior parastyle. Between this reentrant angle and the median wider one the enamel rim follows the outer contour of the paracone. The wider median reentrant angle is the

Molar Teeth:	Metaxytherium calvertense (*USNM* 16757, *type*)	Metaxytherium medium (*Flot*, 1886, *pp.* 502–503)	Felsinotherium ossivallense (*Fla. V.* 5454)	Metaxytherium floridanum (*USNM* 7221, *type*)
Length M^1 to M^3	68.5	68	78	78±
Length M^1	18.5	18	10+	—
Width M^1, across protocone	19.6	20	12+	—
Width M^1, across hypocone	15.5	14	—	—
Length M^2	—	23	28	—
Width M^2, across protocone	—	22	26.2	—
Width M^2, across hypocone	—	17	—	—
Length M^3	28.5	26	30.1	27.5
Width M^3, across protocone	18.5	21	24.2	26.4
Width M^3, across hypocone	18.5	—	22	21.5
Length M^3/width M^3, across protocone	1.54	1.24	1.24	1.04

remnant of the transverse valley, which limited the metacone anteriorly. A much narrower reentrant angle separated the metacone from the cuspidate posterior cingulum. The lingual side of the crown, however, is worn down below the level of the former reentrant angles. This M^3 has three roots, one anterior and two posterior but united for most of their length. Measurements of this right M^3 are as follows: length, 27 mm.; width across protocone, 22 mm.; width across hypocone, 17.5 mm.; length-width ratio, 1.227.

Another detached left M^3 (USNM 23409) has the roots completely sheared off at the level of the base of the enamel crown. The dentine within the enamel crown has not been resorbed and there remain exposed a pair of cavities for the nerves and vascular vessels which were within the roots. This tooth (pl. 35, fig. 1) appears to have been in the permanent dentition since this sheared off crown does not possess the characteristic appearance of the hollow enamel crown of the shed deciduous molar teeth of the young sirenian (USNM 16630) hereinafter described.

A large unworn paracone is separated by a thin cleft from the worn apex of the protoconule, the rim of which is continuous with the rim of the abraded protocone. A large deep narrow lake lies between the anterior cingulum and the three cusps in the transverse row. The narrow and deep transverse valley is deflected by the forward thrust of the worn apex of the hypocone beyond the worn apices of the metaconule and the worn rim of the metacone. The cleft behind the hypocone and the metaconule is continuous posteriorly with the constricted lake in front of the cuspidate posterior cingulum. The measurements of this molar are as follows: length, 25.2 mm.; width across protocone, 21 mm.; width across hypocone, 18.5 mm.; length-width ratio, 1.20. A constant crown pattern is not readily discernible when comparison is made of the third upper molar of three individuals (USNM 16757, 23281, 23409).

An isolated left M_2 (USNM 23271) discovered in zone 11 of the Calvert formation one mile south of Plum Point wharf, Md., has two wide roots, one anterior and the other posterior. This molar (pl. 35, fig. 4) has a crown width anteriorly of 15 mm. and a length of 21 mm.; the height of the crown and posterior root is 36 mm. Wear has commenced on the enamel on the crown, obliterating a transverse valley between the protoconid and metaconid anteriorly, and the hypoconid and entoconid posteriorly. The metaconid projects forward slightly in advance of the protoconid. The summits of the protoconid and metaconid are worn down effacing the usual separation between them and the more centrally located anteromedian cuspule or plica. On the buccal side the anterior talon is greatly reduced.

Between the hypoconid and the entoconid, the posteromedian cuspule is situated centrally across the original transverse valley. On the buccal side the hypoconid is also smaller than the entoconid on the lingual side. At the rear of the crown of the left M_2 tooth on the buccal side is a worn conule which is regarded as the hypoconulid. Internal to this cusp are two worn secondary conules on the posterior border of the cingulum. Depéret and Roman (1920, pl. 7, fig. 2a) illustrated the cheek teeth in the right mandible of *Metaxytherium cuvierii* [=*M. medium*] excavated at Chazé-Henry, Maine-et-Loire, France. Differences seemingly not of generic importance between the M_2 of *Metaxytherium medium* and the Calvert sirenian are observable.

In the left mandible (pl. 35, fig. 7) of the young sirenian (USNM 16630) the anteriormost cheek tooth is represented by an empty alveolus for a single root; two roots of the second cheek tooth, sheared off at the alveolar level, are lodged in the alveolus for the second lower cheek tooth; the crown of the two-rooted penultimate cheek tooth is very slightly abraided, and the alveolus for two wide roots of the posteriormost tooth is empty. In the right mandible the anteriormost alveolus is essentially obliterated by closure, the alveolus for the two roots of the second tooth is empty, the enamel crown of the penultimate cheek tooth is slightly worn, and the enamel crown of the posteriormost cheek tooth is certainly unworn. One hollow crown of the deciduous molar, which was being shed, overlay the unworn crown of this posteriormost cheek tooth in the right mandible. The large osseous cuspule which later in life will contain the roots of the lower M_3 was empty in both mandibles; the dorsal aperture of this cuspule is small and irregular in outline.

On the right penultimate lower cheek tooth (pl. 35, fig. 8) a transverse valley separates the anterior portion of the crown with its large metaconid and smaller protoconid from the posterior worn portion of the crown with confluent hypoconid, entoconid and posteromedian cuspule or plica. The posterior talon is large and minutely cuspidate; this portion of the crown is less abraded. The length of the crown of this tooth is 13.5 mm., and its width, 11 mm.

The posteriormost cheek tooth measures 17 mm. in length and 12 mm. in width. The crown of this cheek tooth (pl. 35, fig. 8) shows no evidence of wear. The summits of the protoconid and metaconid are not confluent; this anterior portion of the crown is likewise sharply separated from the posterior portion by a deep transverse valley. This transverse valley is partially bisected centrally by the low longitudinal ridge that connects the anterior and posterior median cuspules. The posteromedian cuspule is located in part anterior to the hypoconid, which in turn is separated by a narrow cleft from the entoconid on the lingual side of the crown. On the buccal side the posterior talon seems to give origin to a hypoconulid, which is separated by a deep cleft from the hypoconid (fig. 36).

The upper and lower molars have few trenchant differences, usually the anterior lake of the posterior upper molars is rather large and the main cusps are well developed. The anterior lake of the posterior lower molars is reduced and the main cusps are less prominent.

Regressive processes associated with the erupting permanent or succeeding cheek tooth resulted in the entire absorption of each milk tooth except the hollow cuplike enamel crown. The enamel crowns (pl. 35, figs, 5, 6) of the two opposite deciduous cheek teeth each measure 18 mm. in length and 13 mm. in width. They are here regarded as the third lower deciduous cheek teeth. For these milk teeth (USNM 16630) the terminology of the permanent molar is applied topographically in view of the uncertain homologies of the cusps on the crowns of the deciduous cheek teeth.

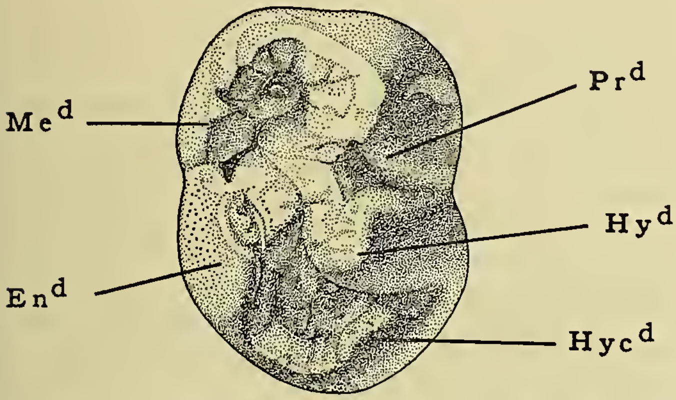

Figure 36.—Posteriormost lower cheek tooth, right mandible, USNM 16630, of *Metaxytherium calvertense*. Abbrs.: En^d, entoconid; Hy^d, hypoconid; Hyc^d, hypoconulid; Me^d, metaconid; Pr^d, protoconid.

The buccal protoconid and the opposite metaconid are both bluntly conical and are partially separated by a shallow narrow cleft. The small anteromedian cuspule is pressed against the protoconid and also partially obstructs the deep transverse valley centrally. The entoconid is slightly smaller than the hypoconid; these two conids are so closely approximated that they tend to conceal the posteromedian cuspule. The large buccal hypoconulid is cut off from the hypoconid by a deep cleft. The posterior talon located on the lingual side of the hypoconulid is noticeably cuspidate.

No plausible explanation has been advanced to support the contention of Lepsius (1882, p. 106) that sirenian cheek teeth increase in size during advancing age. It is generally accepted that once the enamel crown is fully formed any size increase of cheek teeth is terminated. Thomas and Lydekker (1897) have described and figured the continuous succession of cheek teeth in the Recent manatee (*Trichechus*). They have shown that as regards the mandibles of *Trichechus senegalensis* the anterior eroded cheek teeth are thrown off during growth, with the consequent increase in the length of the upper and lower jaws, and that the replacement teeth developing in the jaw at the posterior end of the row will be erupted sequentially (see also Heuvelmans, 1941). This method of replacement of worn off and shed cheek teeth may suggest at least one explanation of the diminutive size of the teeth of the young Calvert sirenian, which are so much smaller than those in the immature skull or isolated teeth of adults.

As regards the Oligocene *Halitherium*, however, the described specimens (Krauss, 1862, pl. 6; Lepsius, 1882, pl. 10, fig. 96) also show an observable tendency toward progressively heavy wear of the upper cheek teeth from before backwards. Nevertheless, on these mentioned skulls the posteriormost cheek tooth is fully erupted and wear has commenced, but no indication of a developing replacement molar is visible. On a left mandible (Lepsius, 1882, pl. 4, fig. 32), however, similar progressive wear of the lower cheek teeth from before backwards is observable, but the hindmost molar has not fully erupted. Mention should be made that no small young individual of *Halitherium* of a size comparable to the young Calvert sirenian has been illustrated or described. Related observations according to Abel (1906, pp. 59–60) show that the fourth milk molar is retained unusually late in life by the Halitheriidae and is sometimes intercalated between the posteriormost successional premolar and the first true molar (see also Heuvelmans, III, 1941, p. 6). By this interpretation Abel explains the presence of eight postcanine teeth in the mandible of *Halitherium schinzi*, an interpretation which does not require budding from the tooth germ of the third molar to form an additional molar.

It is quite possible that the observed cheek tooth replacement of *Trichechus* represents an advanced stage in the adaptation of the dentition to the excessive wear and that cheek teeth succession in the Calvert sirenian may have at least conformed to an intermediate condition that enabled this vegetable feeding animal during growth toward maturity to replace the small cheek teeth that succeeded the milk deciduous dentition, by larger molars compatible in size with adequate mastication requirements. In accordance with such an interpretation, during this sirenian's growth the cheek teeth at the anterior end of each jaw may have been worn out and shed before the posteriormost cheek teeth were fully developed and erupted.

As an alternative interpretation, the suggestion is here made that the total number of cheek teeth that erupted during the life of this Calvert dugongid exceeded the number that would be required in the majority of mammals for replacement in the usual diphyodont dentition, a first or milk dentition and the second or permanent dentition. In support of this assumption attention is called to the presence of the large osseous capsule below the alveolar surface of the horizontal ramus for enclosure of the roots of the posterior lower molar. This capsule in the mandible (USNM 284441) of the living dugong contributes a complete osseous shell or wall around the roots of M_3 except for the ventral opening for the nutritive vessels and nerves. The internal wall of this capsule (pl. 37, fig. 10) on the right mandible of the immature Calvert sirenian (USNM 16757) has been broken off and destroyed though remnants of the rims of the alveoli are visible. On each of both mandibles of the young sirenian (USNM 16630) this capsule is not enclosed by an osseous wall ventrally, and it does have a dorsal opening which, during growth or ensuant lengthening of the mandibular ramus, would increase in size, permit eruption of the molar and serve as the receptacle for the roots of the permanent M_3. Since both deciduous crowns of the posteriormost lower cheek teeth were preserved with these ankylosed mandibles of the young sirenian, the rooted lower cheek teeth that remain lodged in the respective alveoli would necessarily be displaced and replaced subsequently by molars of appropriate dimensions.

Scapula

Incomplete right and left scapulae were associated with this skeleton, although the right one lacks only a portion of the anterior border. The vertebral border of the anterior half of the left scapular blade, a considerable portion of the prescapular fossa, the basal portion comprising the glenoid articular fossa and the coracoid are not preserved. From the vertebral margin to the end of the acromion the left scapula measures 243 mm. and the right 242 mm.

The high spinal crest is very well developed, extending more than half the height of the blade of the scapula (pl. 43, fig. 1) and terminating in the relatively large, slightly bent-backward acromion. This spinal crest provides a rigid support for the blade. The prescapular fossa is relatively large, exceeding the postscapular fossa in area. The curvature of the posterior profile is somewhat similar to that of *Felsinotherium serresii* (Depéret and Roman, 1920, pl. 2, fig. 2).

The basal end of the right scapula of an adult individual (USNM 23213) is complete. Between the spinal crest and the glenoid cavity the neck (width, 42 mm.) is narrowed and a little compressed (28 mm.) exterointernally. The glenoid cavity is deeply concave and measures 55 mm. anteroposteriorly and 40 mm. exterointernally. The stout coracoid process is rather short and bent inward, but is narrower and more strongly exterointernally compressed than the enlarged and blunt-nosed process of the right scapula of the immature individual (USNM 16757).

A left scapula (USNM 16715) of a young individual measures 199 mm. in vertical diameter and its prescapular fossa is slightly larger in area than the postscapular area. The vertebral profile of this scapula (pl. 43, fig. 2) is more convexly curved than that of the immature individual (USNM 16757). The spinal crest, coracoid and glenoid cavity are not materially unlike the immature scapula. The blade is relatively narrow and curved backward.

Measurements (in mm.) of the scapulae of USNM 16757, 16630, and 16715 are as follows:

	USNM 16757 (Right immature)	*USNM 16630 (Right young)*	*USNM 16715 (Left young)*
Vertebral margin to anterior edge of glenoid articular cavity	280	198	199
Dorsoposterior angle of blade to posterior edge of glenoid articular cavity	205	150	153
Posterior edge of glenoid articular cavity to extremity of coracoid	74	47	46
Vertebral margin of blade to extremity of acromion	242	—	184
Anteroposterior diameter of glenoid articular cavity	57	38	35

Humerus

Both humeri of this immature sirenian have the distal or trochlear extremity damaged; the inner trochlea and capitellum are broken off as are the outer condyle of the left and the inner condyle of the right humerus, as well as the major portion of the coronoid fossa on both. The detached head of one humerus is preserved but the proximal epiphysial ends of both, comprising the greater tuberosity and the lesser tuberosity, were not found.

Viewed from in front, the shaft of each humerus (pl. 41, fig. 3) is noticeably narrowed below the greater tuberosity, the inner profile being more concave than the outer and it also flares out at the distal end to form the inner condyle.

The deltoid crest increases in prominence from the coronoid fossa to the broad greater tuberosity and tends to fold over toward the outer face. This crest forms the sharp anterior edge of the shaft. The rounded internal face of the shaft contrasts strongly with the opposite face which is limited posteriorly by the supinator ridge which, however, is not sharp edged.

The olecranon fossa (pl. 41, fig. 4) on the posterior face at the distal end of the right humerus is deep and rather broad. The bicipital groove on the proximal end between the greater and lesser tuberosities is relatively broad and deep. The detached cap or head is relatively small, as on other sirenian humeri.

Measurements of left humerus (USNM 16757) are: length as preserved, 155 mm.; extero-internal diameter of proximal end, 77 mm.; anteroposterior diameter of proximal end, 67 mm.; minimum diameter of shaft, 29 mm.

Radius and Ulna

The distal three-fourths of the left radius alone was recovered when the skeleton (USNM 16757) was excavated. The left radius and ulna of a slightly larger individual (USNM 23213) were separated when found and were subsequently united (pl. 41, fig. 1) by a museum preparator. Old adults seemingly have the radius and ulna ankylosed at the proximal and distal ends (USNM 9346). The shaft of the radius is bent forward. In cross section the shaft of two of these radii varies from ovoidal to subcircular. One radius (USNM 23213), however, has its posterior face flattened and the anterior face raised longitudinally into a ridge. A shorter internal crest extends downward half the length of this shaft. The rugose distal extremity of two of these radii is subtriangular in cross section and the third is nearly circular.

The shaft of one ulna (USNM 23213) below the olecranon is subtriangular in cross section, and a sharp edged longitudinal crest extending downward from the olecranon constitutes the posterior face. On another ulna (USNM 9346) this crest is not developed. The olecranon process of the ulna (pl. 41, fig. 2) is short, rather thick and is occupied anteriorly by the transversely placed sigmoid cavity for articulation with the trochlear end of the humerus. This sigmoid articular cavity is continuous with the shallowly concave articular surface on the proximal end of the radius. A smaller dorsal or ulnar articular portion of the sigmoid cavity on one ulna (USNM 23213) is set off from the wider and larger portion by a groove. A slight torsion toward the distal end is observable in the almost straight shaft of the ulna. The interosseous space between these two forearm bones is wide and open on one (USNM 9346) and slitlike on the other (USNM 23213).

The firmly ankylosed radius and ulna (USNM 9346) from Fairhaven, Md., was described and figured by Case (1904, p. 56, pl. 26, fig. 1) under the designation *Trichechus giganteus* (?) (DeKay).

Pelvis

A right innominate bone (USNM 16757) was associated with the skull and other skeletal elements. A left innominate bone (USNM 23213) that lacks the anterior end of the ilium as well as much of the ischium behind the acetabulum was found among mingled ribs of a somewhat older individual. Lepsius (1882, pl. 7, figs. 80, 81, 82, 84, 85) has illustrated the variation in the configuration of this bone and also in the position of the acetabulum observed among several specimens. Judging from the two Calvert innominate bones, similar variability prevailed. The most complete innominate bone (pl. 41, fig. 5) has a rather slender ilium, compressed from side to side, slightly expanded at the anterior end and feebly curved inward. The crista lateralis, if present, is indistinctly developed. An ovoidal scar on the anterior end of the ilium may indicate a rather close ligamentous attachment to the extremity of the sacral vertebra. At the level of the acetabulum, the shaft of the innominate bone is widened, resulting in the development of a ventrally directed enlargement which may represent the reduced pubis. A shallow ovoidal articular facet for the head of the femur is situated on the ventral angle of this enlargement. The area where the acetabular notch was located is deeply abraded. The ischium is represented by the dorsoventrally widened and side to side compressed posterior portion of this bone. The irregular contour of the roughened hinder end of the ischium may indicate attachment of a cartilage. Measurements of USNM 16757 are as follows: length, 184 mm.; diameter of distal end of ilium, 20 mm.; and diameter of end of ischium, 34 mm.

On the left innominate bone (USNM 23213), the ilium is less compressed from side to side, somewhat oval in cross section and retains more distinctly the crista lateralis. The shallow, oval articular facet (pl. 41, fig. 6) for the head of the femur is located on the external face of the pubic enlargement, and a distinct acetabular notch is visible on its internal or ventral border. The surface of the bone surrounding the acetabulum, although porous and roughened, is apparently not abraded. Just behind the acetabulum the inner surface of the ischium is flattened and this portion of the innominate bone may have been less widened dorsoventrally.

The pelvis of the Calvert sirenian has degenerated much farther than in the Miocene *Metaxytherium krahuletzi* (Abel, 1904, pl. 7, figs. 3, 4) and also in a slightly different direction than in *Thallatosiren petersi* (Abel, 1904, pl. 7, fig. 2a). As compared to *Halitherium schinzi* (Lepsius, 1882, pl. 7; Abel 1904, fig. 24), the acetabulum has migrated downward to or near the ventral face of the pubic enlargement of the innominate bone.

Sternum

The sternum of *Metaxytherium cuvierii* is described and figured by Cottreau (1928, p. 16, pl. 2, fig. 2) as a single piece of bone, the manubrium being fused with the xiphisternum, The sternum (pl. 41, fig. 7) of the immature

Calvert sirenian has the manubrium (presternum) separate from the posterior segment.

The anterior portion of the sternum is spatulate, compressed dorsoventrally at the distal end, the truncated end being pitted and rugose for a cartilaginous attachment, and becoming progressively thicker and more convex on the upper and the lower surfaces. A low longitudinal ridge is developed on both of these surfaces. This anterior portion of the sternum also is curved from end to end. A lateral tuberosity on one side and a roughened area on the other seem to represent the region of attachment of the first pair of ribs, as in the Recent dugong. Behind these rib attachment areas the sternum becomes ovoidal in cross section (28 × 44 mm.); the posterior end and the lateral surfaces adjacent to it are irregularly rugose and porous. This end may have been contiguous to an intermediate ossified segment to which the second, third and fourth pair of ribs were attached as in the Recent dugong, or to the xiphisternum. No other segments of the sternum were recognized among the associated skeletal elements. Lepsius (1882, pl. 6, figs. 73–75) describes and figures three segments of the sternum of the Oligocene *Halitherium schinzi.*

Vertebrae

Skeletons of several extinct dugong genera have been reconstructed for exhibition purposes, including *Halitherium schinzi* (Brussels); *Metaxytherium medium* (Paris; Cottreau, 1928, pl. 1); *Felsinotherium serresii* (Lyon; Depéret, 1914); and *Hesperosiren crataegensis* (New York; Simpson, 1932b). Estimated lengths of some of these skeletons are as follows: *Halitherium schinzi*, 2.58 m., or 8.44 feet (Depéret and Roman, 1920, p. 37); *Metaxytherium medium*, 3 m., or 9.8 feet (Cottreau, 1928, p. 7); *Miosiren kochi*, 3.53 m., or 11.54 feet (Depéret and Roman, 1920, p. 25); *Hesperosiren crataegensis*, 3.045 m., or 10 feet (Simpson, 1932b, p. 7); *Metaxytherium jordani*, 4.48 m., or 14.66 feet (Kellogg, 1925, p. 58); and *Felsinotherium serresii*, 2.45 m., or 7.98 feet (Depéret and Roman, 1920, p. 22). The estimated length of the skeleton of this immature Calvert sirenian is 3.054 m., or 10 feet.

CERVICAL VERTEBRAE.—Seven cervical vertebrae comprise the neck of the Recent dugong although the manatee has only six. Since only an axis and three other cervical vertebrae in varying states of preservation were associated with this skeleton, the number in this vertebral series remains uncertain.

Axis: The configuration of the axis (USNM 16757) is quite similar to that of *Metaxytherium cuvierii* (Cottreau, 1928, pl. 2, fig. 1) and its preservation is somewhat better than the other cervicals. The blunt nipple-like odontoid process projects forward at least 25 mm. beyond the flat anterior articular facets for the atlas, which are subcircular in outline and slope obliquely backward from internal to external margins. The neural canal (pl. 39, fig. 5) is higher (41 mm.) than wide (35 mm.) and rather flat at the base. The pedicles of the neural arch are almost triangular in cross section and give origin posteriorly to the postzygapophysial facets for articulation with the third cervical. The roof of the neural arch is thick, bluntly truncated dorsally and notched posteriorly, but no vestige persists of a neural spine. The posterior articular face of the centrum is concave or depressed and is wider (50 mm.) than high (28 mm.). Other measurements are: maximum height, 90 mm.; maximum width, 81 mm.; distance between outer margins of postzygapophysial facets, 71 mm.; and maximum width of neural canal, 35 mm.

Fourth Cervical: This cervical has a thin centrum (thickness, 12 mm.), its anterior face concave and its posterior face convex, its width posteriorly (67 mm.) greater than its height (30 mm.), and has its large winglike transverse processes (pl. 39, fig. 6) pierced near the base by the vertebrarterial canal. These transverse processes project more outward than downward and are curved slightly backward externally and bent forward ventrally below the level of the centrum. The pedicles of the neural arch are slender and compressed anteroposteriorly. The right postzygapophysial facet on the undersurface of the prezygapophysial facet is ovoidal; the flat prezygapophysial facet is located dorsally on the right pedicle and slopes obliquely downward from external to internal margin. The maximum width of the neural canal is 48 mm. The distance between external angles of the transverse processes is 121 ± mm.

Fifth Cervical: A portion only of the centrum of this cervical is preserved. The height of the centrum is 33 mm. and its thickness 12 mm. The origin of the transverse process on the lateral surface of the centrum is lower than on the sixth cervical.

Sixth Cervical: The thickness (16 mm.) of this cervical has increased slightly over the preceding centra. The width (62 mm.) of the centrum posteriorly is nearly twice its height (32 mm.). The broad and rather thin transverse processes, which are projected more outward and forward than upward, actually curve backward toward the extremity. Each process (pl. 39, fig. 7) has its origin considerably higher on the lateral surface of the centrum than on the preceding cervical and is pierced dorsally below the prezygapophysial facet by a large vertebrarterial canal. An interval of 72 mm. separates the opposite prezygapophysial facets. Each prezygapophysial facet slopes slightly downward from external to internal margin, terminates posteriorly in a depression on the neural arch and projects forward beyond the level of the transverse process which contributes to its support. The roof ofthe neural arch is thin, weak and bent backward. No vestige of the neural spine persists. Each postzygapophysial facet is situated for the most part on the undersurface of the corresponding prezygapophysial facet. The width of the neural canal is 51 mm.; and height 43 mm. The distance between the external angles of the transverse processes is 139 mm.

Dorsal vertebrae.—Forty ribs, representing the right and left sides of the thorax, were excavated in association with this skeleton although sixteen dorsal vertebrae were located. Nineteen vertebrae (Cottreau, 1928, p. 13) comprised the dorsal series of the Loire Valley sirenian *Metaxytherium cuvierii* [=*M. medium*].

The contour of the anterior end of the centrum of consecutive dorsals becomes altered from the transversely widened outline of the first dorsal to a less noticeably dorsoventrally compressed subcordate outline near the middle of this series. A keel is developed or at least becomes more noticeable on the ninth dorsal. The increase in the length of the centra behind the eighth dorsal is rather slight and on all sixteen dorsals excavated the transverse diameter exceeds the vertical diameter of the anterior end. A few of these dorsals have the roughened anterior and posterior ends of their centra coated partially at least with a thin veneer of bone which may later in life develop as an epiphysis. No distinct epiphyses are discernible on the dorsal vertebrae of the young of Recent sirenians.

The genera *Halitherium*, *Metaxytherium*, *Miosiren*, *Hesperosiren*, and *Felsinotherium* are now represented in collections by sufficient portions of the vertebral column to show that some of the anterior dorsal vertebrae have three pairs of facets for ribs; a facet at the end of the diapophysis for the tuberculum of each articulating rib, and two external demifacets. The anterior demifacet articulated with the posterior half of the capitulum of the corresponding rib and the posterior demifacet with the anterior half of the capitulum of the following rib. Anterior demifacets are present on the first to the eighth dorsal vertebrae of this Calvert sirenian. On the first dorsal (pl. 37, fig. 1) the shallowly concave anterior demifacet is located at the anteroexternal angle of the centrum below the base of the pedicle of the neural arch. This anterior demifacet is elevated progressively on succeeding dorsals until on the seventh and eighth it is located wholly on the lateral surface of the pedicle of the neural arch. This demifacet also increases in size and depth. The posterior demifacets likewise shift upward in position from the postero-external angle of the centrum of the first dorsal to the posterobasal portion of each pedicle of the neural arch on the eighth to tenth dorsal (pl. 39, fig. 1). Notwithstanding the presence of these well-defined posterior demifacets on the tenth dorsal, no recognizable anterior demifacet on the lateral surface of the pedicle of the neural arch of the ninth and tenth dorsals was detected.

The first nine dorsal vertebrae of *Metaxytherium medium* (*cuvierii*) possess anterior and posterior demifacets for articulation with the heads of ribs according to Cottreau (1928, p. 13) and the posterior demifacet disappears after the tenth dorsal. The posterior demifacet was well developed on the tenth dorsal (pl. 39, fig. 1) of the Calvert sirenian, but was not present on the twelfth dorsal, the eleventh being represented solely by the neural arch and neural spine.

The facet for articulation with the tuberculum of the corresponding rib on the end of the diapophysis becomes less sharply defined behind the fourth (pl. 37, fig. 4) in the dorsal series, although it is quite deep on the tenth dorsal.

On the first (pl. 37, fig. 1) and second (pl. 37, fig. 2) dorsals, the neural spine is relatively slender, subacuminate and inclined backward. The five anterior dorsals (pl. 37) have higher neural spines than those near the middle of this series, where they tend to become more erect. The neural spines progressively increase in width anteroposteriorly from the first to the fourth (pl. 37, fig. 4) and then become more noticeably triangular in cross section, wider posteriorly and more strongly obliquely truncated at the distal end. On the fifth dorsal (pl. 37, fig. 5) a low, thin, anteroposterior median ridge or crest makes its appearance on the distal end of the neural spine, but further development or accentuation seems to have been retarded behind this vertebra.

The longest transverse processes (diapophyses) are developed on the first dorsal (pl. 38, fig. 1). On all the dorsals these processes project outward from the pedicle of the neural arch. The extremity of the diapophysis increases in thickness as well as in anteroposterior diameter and is bent more noticeably upward behind the second dorsal (pl. 38, fig. 2) as far backward as the eighth. From the ninth to the sixteenth dorsal, the extremity of the diapophysis is progressively reduced in prominence and tends toward atrophy on the fifteenth and sixteenth dorsals (pl. 39, fig 4). A deep irregular depression for attachment of the rib occupies the undersurface of the reduced or vestigial diapophysis and the pedicle of the neural arch of the fifteenth (pl. 37, fig. 8) and sixteenth dorsals.

The pedicles of the neural arch become more massive behind the fourth dorsal (pl. 38, fig. 4), the minimum anteroposterior length of the tenth dorsal being 46 mm. The neural canal decreases in width from the first to the sixteenth dorsal (pl. 39, fig. 4) and also in height; it becomes more nearly hexagonal on the twelfth dorsal and the dorsal notch or groove commences its development on the fifth dorsal (pl. 38, fig. 5).

On the first seven dorsals, the prezygapophysial facet is more or less horizontal although it curves upward on its external borders. On the eighth dorsal to the sixteenth dorsal of this series this articular facet definitely slopes obliquely downward from external to internal margin, and the anteroposterior ridge or crest delimiting its outer margin increases in prominence. This shift in the inclination of the facet culminated on the eighth dorsal with the incipient development of the metapophysis which progressively increases in size and height toward the posterior end of the dorsal series and projects forward beyond the level of the anterior face of the centrum. The width of the gap between the prezygapophysial facets decreases from the first to the sixteenth dorsal and presumably to the end of this series. On the fourth (pl. 38, fig. 4) to and including the sixteenth dorsal a deep groove extending backward to the base of the neural spine bounds the prezygapophysial facet internally.

The distance between the outer margins of the postzygapophysial facets decreases from 77 mm. on the first dorsal to 46 mm. on the sixteenth. These postzygapophysial facets become narrower and slope more obliquely downward from external to internal margin toward the hinder end of the dorsal series.

Lumbar vertebrae.—Four neural arches and their neural spines associated with this skeleton (USNM 16757) were presumably detached from centra of lumbar and sacral vertebrae since the slope and length of the lateral surface of the pedicle of the neural arch seems to exclude the existence of even a vestige of the diapophysis. One lumbar certainly is represented by a detached transverse process.

Three lumbar, one sacral, and two caudal vertebrae were associated with the young Calvert sirenian skeleton (USNM 16630). Cottreau (1928, p. 13) states that three lumbar and one sacral vertebrae are present in the nearly complete skeleton of *Metaxytherium medium* (*cuvierii*) excavated at Doué-la-Fontaine, France.

The anterior and posterior ends of the centra of these three lumbar vertebrae (USNM 16630) are transversely widened and depressed dorsally; two are somewhat flattened ventrally. All three possess ventrally a median longitudinal ridge which is rather wide on the first lumbar and quite narrow on the third lumbar. The elongated transverse processes (pl. 40, fig. 4) are dorsoventrally compressed and bent forward near the middle of their length; they project outward horizontally or slightly downward. The neural canals (pl. 40, fig. 3) are subtriangular in outline and the thin pedicles of the neural arch occupy more than half the length of the centrum.

Rather slender metapophyses with elongated prezygapophysial facets on the first and ovoidal on the third lumbar project forward beyond the level of the anterior face of the centrum. The distally rounded neural spines are rather short, their height above the roof of the neural canal being less than the distance from the dorsal face of the metapophysis to the ventral face of the centrum. Measurements of the third lumbar are as follows: distance between ends of transverse processes 222 mm.; tip of neural spine to ventral face of centrum, 108 mm.

Sacral vertebra.—The sacrum is reduced to one vertebra (USNM 16630) which is distinguished from the third or last lumbar by the dorsoventrally thickened and bent downward transverse processes (pl. 40, fig. 1), each of which is expanded at the extremity to provide a flattened surface for contact with the innominate bone. Otherwise, this sacral vertebra (pl. 40, fig. 2) is quite similar in general configuration to the last lumbar vertebra. Measurements of the sacral are as follows: distance between ends of transverse processes, 210 mm.; tip of neural spine to ventral face of centrum, 105 mm.

Caudal vertebrae.—The two caudal vertebrae (USNM 16630) possess shorter transverse processes than any of the three lumbars or the sacral vertebra. The rather broad transverse processes are directed obliquely downward and their extremities are rounded. Thin epiphyses are attached to the posterior ends of their centra and remnants of the anterior epiphysis are preserved on one caudal. The ends of the centra are somewhat hexagonal in outline. Below each transverse process the lateral surface of the centrum is depressed and the ventral surface is traversed by a broad median longitudinal trough which is bounded anteriorly and posteriorly by low almost triangular facets for articulation with the chevron bones. The neural canal of each of these caudals is subtriangular in outline and higher than wide; the pedicles of the neural arch and the neural spines are reduced in anteroposterior length. As compared to the sacral vertebra, the height of the neural spine (48 mm.) of this caudal is almost identical, the vertical diameter of the neural canal has diminished and the vertical diameter of the centrum has increased slightly, yet the distance from the tip of the neural spine to the ventral face of the centrum (105 mm.) remains unchanged. The slender metapophyses are smaller than those of the preceding vertebrae, but project forward also beyond the level of the anterior face of the centrum.

The caudal series of the Recent dugong is comprised of 20 to 27 vertebrae and this suggests that more than 20 caudals may have been present in the vertebral column of this Calvert sirenian.

Measurements (in mm.) of dorsal vertebrae of USNM 16757 are given in the tabulation on opposite page.

Ribs

The Loire Valley *Metaxytherium medium* has nineteen pairs of ribs. It is certain that the skeleton of the Calvert sirenian has one additional pair of ribs. Forty ribs were excavated with this skeleton (USNM 16757). All of the ribs are dense, hard and heavy; no internal marrow cavity is recognizable.

Three processes, two of which bear articular facets, are present on the vertebral ends of the ribs of the first pair; two facets are present on the second to twentieth, inclusive. On the second to the tenth or eleventh pairs of ribs, the

USNM 16757—Dorsal Vertebrae:	*D.1*	*D.2*	*D.3*	*D.4*	*D.5*	*D.6*	*D.7*	*D.8*	*D.9*	*D.10*	*D.11*	*D.12*	*D.13*	*D.14*	*D.15*	*D.16*
Anteroposterior diameter of centrum	31	36	39	43	46	48	52	56	54	55	—	59	55	59	59	58
Transverse diameter of centrum anteriorly including demifacet for capitulum	91	81	80	76	75	77	77	78	81 ±	77+	—	89	88	88 ±	90	90
Vertical diameter of centrum anteriorly	30	30.5	32.5	33	35	38	38	38	50	50	—	55	50	55	48	52
Minimum anteroposterior length of pedicle of neural arch	16	19	19.5	25	34	42	42	43	44	46	—	46	41	45	43	42
Transverse diameter of pedicle of neural arch	31.5	28	29	27.5	28	28	29	28	28	28	—	28	28	29	24	28
Vertical diameter of neural canal, anteriorly	40	42	42	44	42	43	39	39	39	37	—	35	33	34	30	30
Transverse diameter of neural canal, anteriorly	44	42	38	37	33	35	31	35	34	33	—	32	34	31	33	33
Distance between ends of transverse processes (diapophyses)	165	158	154	155	150	145	137	130	125	123	117	118	114	113	108	111
Dorsal face of metapophysis to ventral face of centrum, anteriorly	66	79	85	91	96	95	91	95	106	107	—	105	101	105	100	98
Tip of neural spine to ventral face of centrum, anteriorly	146	163	163	161	161	155	151	153	162	161	—	166	158	166	159	160
Roof of neural arch anteriorly to tip of neural spine	82	93	93	92	86	81	81	80	80	80	75	78	79	77	79	82
Transverse diameter centrum posteriorly across demifacets for capitulum	81	80	84	86	89	91	95	95	85+	87 ±	—	84	86	87	87	84+
Vertical diameter of centrum, posteriorly	29.5	31	32.5	35	37	37	38	43	52	51	—	54	53	56	48	54 ±

capitulum at the vertebral end of the rib is lodged in part in the posterior demifacet on the external face of the preceding dorsal and in part in the anterior demifacet on the same face of the centrum of the vertebra to which the tuberculum is attached. The tuberculum of the rib articulated with the facet at the end of the diapophysis. Behind the eleventh vertebra, the rib is in contact with an articular surface on only one dorsal vertebra. The anteroposterior compression of the neck at the vertebral end of the rib is terminated on the fifth rib, and an obvious dorsoventral compression of the neck commences with the seventh rib. The internal face of the shaft of the fourth to twentieth rib is flat, the external at least slightly convex and the width of each rib exceeds the thickness. Behind the first pair the ribs progressively increase in length (in a straight line) to the eleventh or twelfth pair and then decrease; behind the eleventh pair the distal attenuation of the shaft becomes more pronounced, and the distance between the articular face of the capitulum and the tuberculum is shortened. The lower extremity of each rib is more or less roughened, presumably for attachment of a ligamentary connection with a costal rib.

While dissecting a male dugong carcass, Owen (1838, p. 41) found that the first four pair of ribs had a cartilaginous attachment to the sternum; the remainder of the ribs terminated freely in the mass of abdominal muscles.

In view of the close association of these forty ribs with the skull, vertebrae and other skeletal elements, one can be assured that only one individual is represented. Furthermore, the ribs belonging to the right and left sides of the thorax constitute a consecutive series. Attention is directed to the disparity in the lengths of the ribs of the first, third, fifth and sixth pairs, which otherwise appear normal.

The first pair are the shortest of the ribs in the thorax, the anteroposteriorly compressed vertebral end is abruptly bent inward, and the transversely flattened distal or sternal end of the shaft is twisted almost at right angles to the vertebral end. There are three processes or facets on the vertebral end of the first rib (fig. 37), the knoblike upper one, the tuberculum, is attached to the end of the diapophysis; the second, the capitulum, is at the end of a slender neck; and a third ventral knoblike process may have been connected by ligament with a cervical rib. The first rib of a skeleton of the dugong (USNM 20861) mounted for display in the Museum of Natural History has a short piece of a dried ligament still attached to this lower process. This ligament may have formed a ligamentary connection with the very rudimentary cervical rib which is loosely articulated with the seventh cervical on this mounted skeleton. This cervical rib is bifurcated or at least has two heads; the upper head articulates with the diapophysis of the seventh cervical, the lower head articulates with the centrum of the sixth cervical. As regards the occurrence of rudimentary ribs in certain whalebone whales, Turner (1871, p. 360) states that the cervical rib possesses neither capitulum nor neck, nor does it take the place of the ventral transverse process of the seventh cervical, and it is articulated with the upper transverse process of this cervical. This lower process is not developed on the vertebral end of the first rib of the American manatee (*Trichechus manatus latirostris*). The absence of this process on the first rib of the manatee may bear some relationship to the reduction of the cervicals to six vertebrae. Depéret and Roman (1920, p. 16, pl. 4, fig. 6) illustrated the first rib of *Felsinotherium serresii* and mentioned the third ventral process below the capitular facet, but offer no suggestion of its functional significance.

The capitular facet of the first rib articulates with the anterior demifacet on the external face of the first dorsal vertebra. On the internal face of the shaft (pl. 42, fig. 6) is a thick oblique crest extending inward and upward from the posterior face which may demarcate the area for insertion of the scalenus muscle.

A much less prominently developed crest can be recognized on the first rib of the dugong. The right and left first ribs measure respectively in a straight line 250 and 237 mm., and their greatest width (42 mm.) is below the middle of their length. From the notch behind the tubercular facet to about the middle of their length, the posterior face of the shaft can best be described as a crest.

Comparison of the first rib of the Calvert sirenian revealed a rather close resemblance to the first rib of the *Halitherium schinzi* (Lepsius, 1882, pp. 138–139, pl. 7, fig. 78) in the general configuration of the vertebral end and the position of the thick oblique internal crest; this Calvert rib, however, is otherwise readily distinguished by the slender shaft and no enlargement of the sternal end. The similarity of the peculiar configuration of the vertebral end of this rib is quite close, however, to the first rib of the dugong. Both possess a slender shaft.

Although somewhat larger, the ribs of the second pair (pl. 42, fig. 5) have a noticeably thickened shaft. Each rib is curved from end to end, the sternal end is abruptly truncated, the area for attachment to the sternum being markedly reduced, and the vertebral end is turned forward. An anteroposteriorly compressed neck separates the blunt-nosed ovoidal capitulum from the low knoblike tuberculum, the interval between these articular surfaces being 25 mm. The distal half of the shaft is flattened internally and the external is convex, though there is an obvious constriction of the proximal third of the shaft. The maximum width of the shaft is 47 mm. The lengths of the right and left ribs, respectively, are 308 and 307 mm.

The ribs of the third pair (pl. 42, fig. 4) are more curved and longer, the right and left measuring respectively 345 and 365 mm. No noticeable constriction of the vertebral portion of the thick shaft is observable, the maximum width of the upper portion of the shaft being 45 mm. and the lower half 47 mm. The external and internal faces of the shaft are flattened and the attenuation of the lower or sternal end is abrupt. A less compressed and thicker neck separates the low flattened tuberculum from the capitulum, the distance from the capitular articular face to the posterior edge of the tubercular facet being 65 mm.

The weight of the ribs of the fourth pair (pl. 42, fig. 3) has increased and the width of the shaft has become more

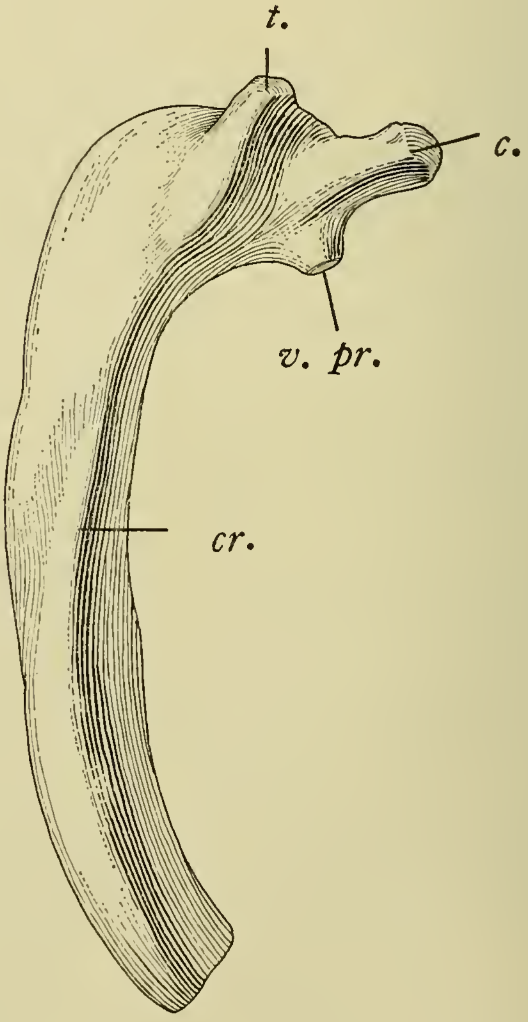

Figure 37.—First left rib, USNM 16757, of *Metaxytherium calvertense*. Abbrs.: c., capitulum; cr., crest of shaft; t., tuberculum; v.pr., ventral process.

uniform from end to end. The lengths of the right and left ribs are, respectively, 405 and 404 mm. At the vertebral end of the shaft, the neck between the small, low, oval tuberculum and the enlarged capitulum (24 x 20 mm.) is thicker than that of the third rib, although the distance (68 mm.) from the capitular articular face to the posterior edge of the tuberculum has increased imperceptibly. The beveling of the attenuated sternal end is quite similar to the third rib.

The tendency toward flattening of the shaft which is progressively accentuated toward the posterior end of the thorax seems to have been initiated with the fifth pair of ribs (pl. 42, fig. 10). These ribs are larger than the fourth pair, the right and left ribs measuring respectively 430 and 443 mm., though the end to end curvature of the shaft is about the same. Both external and internal surfaces are rather flat, the width of the shaft (maximum, 48 mm.) changes very little until within 90 mm. of the slightly attenuated sternal end. At the vertebral end of the shaft, the tuberculum is a rather large saddle-like depression.

The ribs of the sixth pair (pl. 42, fig. 11) are longer than the fifth, the right and left measuring, respectively, 443 and 455 mm., the width of the shaft has not changed except for a more gradual attenuation of the beveled sternal end. External and internal faces of the shaft are flattened; the depression external to the tuberculum is more elongated than on the fifth. An obliquely truncated capitulum is located at the vertebral end of the bent forward neck, but the dorsoventral compression of the attenuated neck does not develop until the seventh rib. The maximum distance between the articular face of the capitulum and the posterior edge of the tuberculum is 72 mm.

Backward deflection of the gradually attenuated sternal end of the shaft becomes more apparent on the seventh pair of ribs which are slightly wider (maximum width, 54 mm.) than the preceding. The external and internal faces of the shaft are unmistakably flattened. The inward curvature of the vertebral end of the shaft is accentuated and the dorsoventrally compressed neck is wider than on the sixth, though the distance between the capitulum and the tuberculum has not been altered. The depression external to the tuberculum, however, is more elongated and somewhat deeper. The lengths of the right and left ribs are, respectively, 460 and 470 mm.

The length of the right and left ribs of the eighth pair (pl. 42, fig. 2) are, respectively, 463 and 460 mm. At the widest point, the breadth of the shaft is 50 mm. and the attenuation to the truncated sternal end is gradual. There is a noticeable deflection backward of the sternal end and a more abrupt bending inward and forward of the vertebral end of the curved shaft. The external and internal faces of the shaft are flattened. The dorsoventrally compressed goosebeak-like neck diminishes in width from 44 mm. across the tubercular facet to 24 mm. across the capitular facet. The elongated depression external to the low tuberculum is rather deep.

The right and left ribs of the ninth pair measure, respectively, 466 and 470 mm. in a straight line; the maximum width of the shaft is 51 mm. The attenuation of the sternal end of the curved shaft is more gradual than on the eighth and the backward deflection has increased. The neck is wide and thick, the capitulum is broad and the tuberculum is a low flattened knob. The distance (68 mm.) between the posterior edge of the tuberculum and the anterior face of the capitulum on the vertebral end of the shaft is greater than on the preceding rib (64 mm.); no increase in the forward and inward curving of the vertebral end of the shaft is noticeable.

Of the tenth pair of ribs, the left rib lacks the capitular end of the neck; these ribs measure 473 and 475 mm. in length in a straight line. The tenth, eleventh, and twelfth pairs of ribs are the most massive components of the thorax. The maximum width (51 mm.) is below the vertebral one-third of the laterally flattened shaft; below this point the shaft tapers gradually to the sternal end. The backward deflection of the sternal end of the attenuated shaft is no greater than that of the ninth and the forward and inward curvature of the vertebral end is quite similar. External to the reduced flattened tuberculum the usual depression has increased in breadth but decreased in depth. The neck behind the capitulum is strongly compressed dorsoventrally and rather gradually attenuated.

Each of the eleventh pair (pl. 42, fig. 1) of ribs, measuring 473 and 475 mm. in length, has the sternal end of the shaft strongly deflected backward and the vertebral end curved inward and bent forward. The curved shaft tapers gradually from about the middle of its length (maximum width, 49 mm.) to the small sternal end (18 mm.). The dorsoventrally compressed neck between the blunt-nosed capitulum and the low flattened tuberculum resembles the tenth rib, but the depression external to the tuberculum is reduced to a deep but rather short (20 mm.) and narrow pit. The internal face of the curved shaft is more noticeably flattened than the external face.

The twelfth pair of ribs, measuring 445+ and 473 mm., respectively, in length, are similar in conformation to the thirteenth pair, except for a larger bluntnosed capitulum at the vertebral end of the dorsoventrally compressed and somewhat triangular neck. The neck of the right rib is broken off and missing. The limits of the flattened tuberculum are indistinct. External to the tuberculum is the usual depression or groove, which is at least four times as long (23 mm.) as wide and is rather deep. The limits of the flattened tuberculum are indistinct. The curved shaft tapers from a maximum width of 46 mm. near the middle of its length to the sternal end and is bent forward and inward more abruptly at the vertebral end than deflected backward at the sternal end. It is as uniformly curved from end to end as the eleventh rib.

Each of the thirteenth pair of ribs, measuring 452 and 460 mm., respectively, in length in a straight line, has an obliquely truncated capitulum on the end of a short subtriangular dorsoventrally compressed neck and a relatively low tuberculum. The depression external to the tuberculum resembles the groove on the twelfth rib. The tapering of the shaft toward the distal end is gradual and the backward deflection of the sternal end as well as the inward curvature of the vertebral end corresponds with the twelfth rib. The maximum width of the curved shaft is 44 mm.

The fourteenth pair of ribs, measuring 450 and 445 mm., respectively, in a straight line, are curved from end to end; the shaft of each is deflected backward at the sternal end and curved inward and forward at the vertebral end. The shaft gradually tapers from about the middle of its length (width 43 mm.) to the blunt sternal end (width 16 mm.). The capitulum at the end of the short subtriangular neck seems more functionally modified for articulation than the small flattened tuberculum. A narrow groovelike depression is located external to the tuberculum.

The fifteenth pair of ribs, measuring 435 and 440 mm., respectively, in a straight line, are characterized in part by a more rounded capitulum separated from the low tuberculum by a short, dorsoventrally compressed subtriangular neck. A shallow elongated groove is present external to the tuberculum. The sternal or distal third of the curved shaft is as strongly deflected backward as the fourteenth rib, and the vertebral end is curved inward, but the neck is less noticeably bent forward. The shaft is widest (41 mm.) near the end of the proximal or vertebral one-third and then tapers to the small distal end; the inner face of the shaft continues to be flattened; the external face is slightly convex.

The distance from the articular face of the capitulum to the posterior margin of the tuberculum is 45 mm. on both the fifteenth and sixteenth ribs. A narrow groove is present external to the tuberculum. The tuberculum is a low prominence similar to the facet on the fifteenth rib. The capitulum remains acuminate and the dorsoventrally compressed neck is subtriangular. The right and left ribs of the sixteenth pair measure 422 and 424 mm. in length. The end to end curvature of the shaft is rather uniform, the distal one-third is deflected backward and the neck bent forward. A gradual taper of the shaft, commencing below the vertebral one-third where the maximum width is 41 mm., continues to the small oval distal end.

Except for the shortening of the shaft the general configuration of the seventeenth rib is almost a replica of the sixteenth rib, the right and left ribs measuring, respectively, 405 and 408 mm. in length. The distal two-thirds of the curved shaft tapers to the small oval end. A similar backward deflection of the distal portion of the shaft exists and the neck is slightly bent forward. The subtriangular neck is short but less dorsoventrally compressed and the distance from the articular face of the capitulum to the posterior edge of the low knoblike tuberculum is 40 mm. The groove which is present behind the tuberculum on the preceding rib has been replaced by a small shallow depression.

Except for the more abrupt taper of the distal 80 mm. of the shaft and the shortening of the neck, the ribs of the eighteenth pair (pl. 42, fig. 9) resemble the seventeenth. The maximum width (43 mm.) of the shaft of the right rib exceeds the left (38 mm.); the neck of the right rib is also malformed. The right and left ribs measure, respectively, 382 and 392 mm. in length. The short triangular neck is not dorsoventrally compressed, the tuberculum is somewhat protuberant, and the distance from the articular face of the capitulum to the posterior edge of the tuberculum is 36 mm. A shallow depression is present external to the the tuberculum. The vertebral end of the shaft is twisted slightly and the distal end deflected backward. The internal face of the shaft is flat and the external convex.

The vertebral ends of both ribs of the nineteenth pair (pl. 42, fig. 8) appear to be malformed. The right rib has a very short and broad triangular neck, and an ill-defined tuberculum. A small acuminate capitulum but no distinct depression external to the posterior edge of the tuberculum is present. The maximum width of the curved shaft is 40 mm. near the middle of its length; the tapering of the shaft becomes more gradual beginning 130 mm. above the small (width 17 mm.) oval distal end. The curvature of the shaft is accentuated on the vertebral one-third and the distal end is deflected backward. On the left rib the vertebral end is markedly compressed dorsoventrally, the relatively small capitulum is separated from the similarly reduced tuberculum by a deep notch which reduces the diameter (12 mm.) of the connecting neck. The right and left ribs of this pair measure, respectively, 378 and 368 mm. in length.

Culmination of the progressive shortening of the ribs behind the twelfth occurs in the twentieth pair (pl. 42, fig. 7), where the right and left ribs measure, respectively, 343 and 348 mm. in length. At a point about 140 mm. above the distal extremity the attenuation of the curved shaft commences, although the taper of the distal 100 mm. is very gradual; this end is very little if at all deflected backward beyond the long axis of the shaft. The maximum width of the shaft is 38 mm. External and anterior to the small knoblike tuberculum, there is an ill-defined shallow depression. Between the tuberculum and the small blunt-nosed capitulum, the short neck is creased obliquely by a notch or groove.

THE SOUTH CAROLINA MIOCENE DUGONG

DIOPLOTHERIUM MANIGAULTI Cope

The mammalian fossil specimens obtained during the phosphate dredging operations on the Wando, Ashley, and other rivers in South Carolina unquestionably were derived from overlying deposits of successive geological ages, seemingly extending in time from the upper Eocene to the Pleistocene. Included among such specimens are teeth and cranial fragments of the upper Eocene archaeocete *Dorudon serratus.* Pleistocene land mammals are represented by *Megatherium, Elephas, Equus, Tapirus, Procamelus, Bison,* and *Castoroides.* Some, at least, of the varied assortment of beaked whale or ziphioid rostra, including *Choneziphius, Eboroziphius, Dioplodon,* and *Proroziphius,* are thought to have been in existence in Carolina coastal waters in the Miocene, as well as the shark toothed porpoise *Squalodon.* Hence proper caution is required in the appraisal of the age of the sirenian fossils.

The small cranial specimens representing the dorsal portion of the braincase, which Glover Allen (1926, p. 455, pl. 2, figs. 1–2) identified as *Halitherium antiquum* (Leidy) and Simpson (1932a, p. 445) as *Halitherium alleni* are considered here to possess features characteristic of either *Felsinotherium* or *Metaxytherium.* At least one cranial roof (USNM 23394) is sufficiently complete to show that the nasal bones are separated medially by the forward projection of the paired frontal bones. The least parietal width of this specimen is 60 mm. The cranial roof (fig. 38) of this specimen corresponds rather closely in its dimensions with the skull of the lower Pliocene (Plaisancian) *Felsinotherium serresii* (Depéret and Roman, 1920, p. 6; fig. 1b; pl. 2, fig. 1b).

Braincase roofs, having similar dimensions and configurations, demonstrate the variable degree of convergence of temporal crests. Among ten specimens recovered by dredging the degree of convergence of these crests varies from wide separation to close approximation on the longitudinal axis of the paired parietals. These examples may represent either growth stages or possibly sexual differentiation.

Associated in the phosphate derived collections with these small specimens, here referred to *Felsinotherium alleni,* are portions of skulls of a somewhat larger sirenian. At the request of Gabriel Manigault, the then director of the Charleston Museum, Cope (1883, pp. 52–54) described the anterior symphysial end of a sirenian right premaxillary containing a large tusk lodged in the alveolus which he named *Dioplotherium manigaulti.* Cope mistakenly asserted that a second tusk was lodged in the premaxillary external to the first tusk and that the presence of a second tusk distinguished this form from all other sirenians. A critical examination of the type specimen from the phosphate beds of the Wando River northeast of Charleston, S.C., failed to corroborate this assumption. The overall length of this portion of the premaxillary (Cope, 1890, pl. 25) is 168 mm., and the bent downward anterior end is quite broad, the maximum anteroposterior diameter being 105 mm. Other measurements are: vertical diameter from dorsal face of premaxillary near posterior end of symphysis to ventral alveolar border, 128 mm.; length of symphysis, 126+ mm.; length of tusk, 176 mm. (present condition, 153 mm.); anteroposterior diameter near base, 50 mm.; transverse diameter, 27 mm. The longitudinal fluting of the tusk is most pronounced on the internal face.

Cope stated that the premaxillary symphysis of *Dioplotherium manigaulti* was shorter than that of *Rytiodus capgrandi* (Delfortrie, 1880, pl. 6), which was a rather large sirenian, the complete skeleton measuring 5 meters and the skull 700 mm. The type tusk of *R. capgrandi* (Lartet, 1866, p. 682) was found in the lower Miocene (Aquitanian) "calcaire marin coquillier" at Bournic, near Sos, La Gélise Valley, Dépt. Lot-et-Garonne, France. The largest of the two incisor tusks from Bournic in the Laboratoire de Paléontologie, Museum National d'Histoire Naturelle, Paris, which is labeled as the type and as having been

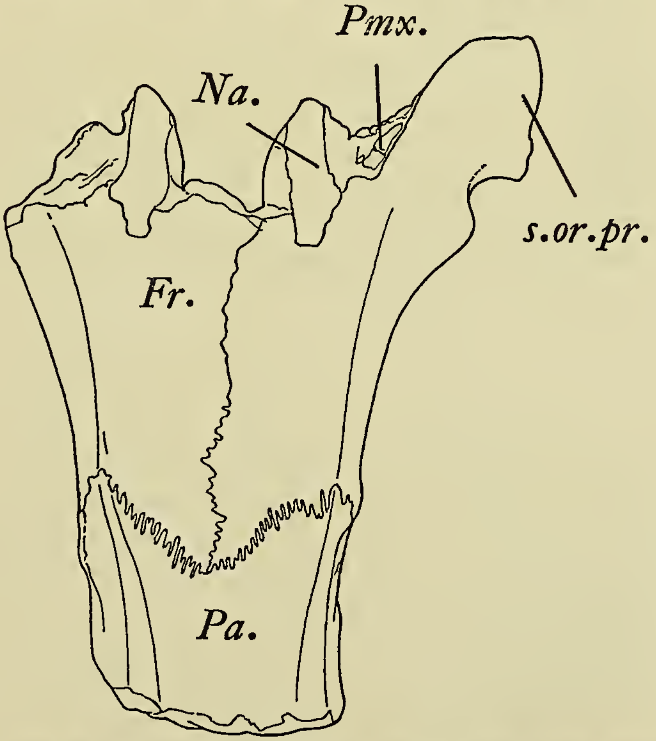

FIGURE 38.—Cranial roof, USNM 23394, of *Felsinotherium alleni.* Abbrs.: Fr., frontal; Na., nasal; Pa., parietal; Pmx., premaxillary; s.or.pr., supraorbital process of frontal.

donated by the Nérac Museum in 1866, measured 260.4 mm. in length and 77.5 mm. in greatest width. The skull described and figured by Delfortrie was excavated in the lower Miocene "marnes sableuse" at Saint-Morillon, Labrède Canton, Dépt. Gironde, France. According to the measurements published by Delfortrie (1880, p. 143), the length of the tusk is 300 mm., and the width, 56 mm. No cheek teeth have as yet been identified as belonging to *D. manigaulti.* The length of the roof of the braincase of *R. capgrandi* was about the same as that of *Metaxytherium jordani* (Kellogg, 1925, p. 66). The premaxillaries of *R. capgrandi* were, however, greatly elongated, measuring 450 mm., and the length of the premaxillary symphysis was 240 mm. The zygomatic width of the skull of *R. capgrandi* was 300 mm., and the width across the supraorbital processes of the frontals, 240 mm., as contrasted with the corresponding measurements of 317 and 192 mm., respectively, of *M. jordani.* Four cheek teeth (Delfortrie, 1880, pl. 8, fig. 3) are in place in each maxillary, the molariform series in the right maxillary being noticeably abraded and those in the left maxillary strongly abraded on the lingual side and relatively little worn on the buccal side. These four cheek teeth are regarded as Pm^4, M^1, M^2, and M^3; the length of the molariform series is 95 mm., and the length of M^3 is 30 mm., and width, 25 mm. The crown pattern of the *Rytiodus* cheek teeth does not correspond very closely with teeth of *Metaxytherium.*

A left premaxillary (YPM 21334) in the Scanlon collection of the Peabody Museum of Yale University, which is broken off about 75 mm. in front of the anterior end of the mesorostral fossa, also has a large tusk lodged in the alveolus. The measurements of this rostral fragment are as follows: overall length, 220 mm.; maximum diameter of premaxillary about 50 mm., in front of posterior end of symphysis, 95+ mm.; transverse diameter of premaxillary near middle of mesorostral fossa, 32 mm.; maximum diameter of tusk in cross section (presumably about 50 mm. from base), 51 x 25 mm. Near its commencement the maximum dorsoventral diameter of the symphysial sutural contact is 56 mm. on both the type of *D. manigaulti* and the Peabody Museum specimen. Both of these premaxillaries have the ventral surface strongly striated or ridged for reception of the palatal extension of the corresponding maxillary. The bent downward anterior end of the maxillary, which overlapped the exteroventral surface of the premaxillary, terminated about 20 mm. in front of the anterior end of the mesorostral fossa. The estimated maximum width of the mesorostral fossa is 80 mm. and its length 150 mm.

Specimens consisting usually of the supraoccipital ankylosed to the parietals appear separable into two size categories. On the largest specimen (YPM 21333), the width of the supraoccipital is 105 mm. and the least parietal width is 85 mm. Of those in the smaller size category, the width of the supraoccipital ranges from 65 mm. to 90 mm. (USNM 8198), and the least parietal width from 50 mm. (YPM 21335) to 70 mm. The narrowest braincase has high, closely approximated temporal crests. The edges of the supraoccipital are abraded to some extent on all specimens examined.

Two size categories of humeri likewise occur in these collections. The smaller humeri are as short as 150 mm. (USNM 23256) and these specimens are characterized in part by a narrow bicipital groove. The largest humerus examined measured 210 mm. in length and has a broad open bicipital groove. Neither of these humeri were physically mature since the proximal epiphysis was detached and missing on both.

Notwithstanding the uncertainty of age determinations of components of mixed assemblages, it is suggested that the small sirenian should be considered to be *Felsinotherium alleni* and the large form *Metaxytherium manigaulti.*

THE COLOMBIA TERTIARY DUGONG

As a gift from the Instituto de la Salle, Bogotá, Colombia, a number of Cretaceous invertebrates and a fragment of a fossil sirenian skull were presented to Dr. John B. Reeside, Jr., United States Geological Survey, by Brother Ariste Joseph in 1923. The mandible of a fossil manatee (*Potamosiren magdalensis*) discovered farther south in the present Magdalena valley in the Miocene La Venta fauna of the El Libano sands and clays near Villavieja, Departamento del Huila, has been described by Reinhart (1951). These two occurrences demonstrate that during the interval when the Central American isthmus was submerged pelagic dispersal enabled representatives of the Dugongidae and Trichechidae to reach the American region now designated as Colombia, South America. The occurrence of fossil vertebrates in the upper Tertiary of the municipality of Ortega, Dept. Tolima, without an indication of either the precise locality or the species, has been recorded in the literature (Botero, 1936, p. 44; Royo y Gomez, 1946, p. 499).

E. D. Ackerman, International Petroleum Company, Ltd., has advised that the company's geologists in Colombia report that Ortega as a locality is not sufficiently precise to permit determination of the specific geologic formation from which this fossil dugong was derived. He has kindly furnished the following statement (personal communication):

"The geologic description 'gray to green black speckled sandstone' suggests the Honda formation, outcrops of which are present in the general area of Ortega. Palynologic evidence indicates that this unit belongs to the middle Miocene. Both lithologic and micropaleontologic evidence, however, suggest the Honda formation to be of continental origin. Furthermore, Professor R. A. Stirton in his report to the Servicio Geologico Nacional, Bogotá, does not appear to record marine vertebrates from the Honda. These data seem to preclude the occurrence of marine vertebrate fossils in the unit."

As will be noted in the descriptive portion of the text, the reduction of the upper cheek teeth row to three molars would be an unusual accomplishment as early as the lower Miocene. On the basis of present recorded geologic occurrences of fossil dugongs this reduction to three upper molars would logically have been expected in the upper Miocene.

METAXYTHERIUM ORTEGENSE, *new species*

Type Specimen: USNM 10870. Adult sirenian. Palatal portion of left maxillary containing M^1, M^2, and M^3. Collector, Brother Ariste Joseph, August 1920.

Horizon and Locality: Ortega, north of mouth of Río Saldana, Departamento Tolima, Colombia. Gray to green black speckled sandstone; upper Miocene.

Dentition

These three molars (pl. 36, figs. 1–2) are uncrushed and exceptionally well preserved. Crown wear is minimal; no cusps have been noticeably reduced by occlusal abrasion. The length of the maxillary molar series is 80.5 mm. The molars of the Ortega dugong are larger than those of *Felsinotherium serresii* (Depéret and Roman, 1920, p. 12, pl. 2, fig. 2) and smaller than those of *Felsinotherium gastaldi* (Zigno, 1878, p. 946, pl. 4). The first and second upper molars of *F. serresii* are more subquadrangular than the same molars of the Ortega sirenian; the placement of the cusps, however, is quite similar, but the anterior lake between the cingulum and the paracone on the Montpellier molars is very narrow. M^3 on the Gennevaux specimen of *F. serresii* seems not fully erupted. The worn left M^3 on the skull (Depéret and Roman, 1920, pl. 2, fig. 1d) in the Hortolès collection is less elongated, though the arrangement of the cusps on the crown is not materially different. Lengths of the molar teeth on the right and left maxillaries of the specimen in the Gennevaux collection, Université de Lyon, published by Depéret and Roman (1920, p. 12) are as follows: M^1, 18 mm.; M^2, 21 mm.; M^3, 22 mm.

On the buccal side two separated roots are visible for M^1, M^2, and M^3; on the lingual side M^1 has a single root and the other two molars appear to have two roots.

Each of these molars has the anterior half of the crown separated from the posterior half by a deep transverse valley which is only slightly obstructed by the metaconule. An obvious indentation on the buccal side of the crown of M^1 marks the external end of the deep, narrow transverse valley. The front portion of the crown is truncated obliquely anteriorly from buccal to lingual side. This first molar has the enlarged paracone connected with the anterior faintly cuspidate cingulum by a short cuspule and is continuous medially with the small protoconule which in turn is not cut off from the crescentric rim of the lingual protocone. A deep transverse lake intervenes between the anterior crest of the cingulum and the continuous enamel connecting isthmus or forward wall of the paracone, protoconule and protocone occlusal surface. The anterobuccal rounded angle of the crown projects beyond the level of the metacone. On the hinder half of the crown of M^1, a thin cleft separates the metacone from the centrally placed metaconule; the occlusal surface of the latter is, however, continuous with that of the obliquely worn anterior face of the hypocone. A deep triangular lake intervenes between the buccal metacone, the lingual hypocone, and the rather thick liplike posterior cingulum. Measurements of M^1 are as follows: width across protocone, 19.5 mm.; width across hypocone, 17.5 mm.; length, 22 mm.

M^2 is longer (length, 26 mm.) and wider than M^1; the portion of the enamel crown in front of the deep transverse valley is larger than the posterior portion, the width across the protocone being 23 mm. and across the hypocone 21.2 mm. On the buccal side a thin cleft separates the paracone from the antero-external parastyle, which in turn is separated in similar manner from the rather broad anterior cingulum. The large protoconule is wedged in between the more elevated and less abraded paracone and the protocone. The deep anterior lake between these three cusps and the anterior cingulum is relatively small. The metaconule is likewise wedged in between the buccal metacone and the hypocone. On the buccal and lingual sides of the posterior cingulum there is a low blunt-edged cuspule. These cuspules constitute the posterolateral borders of the hexagonal lake and are separated by a cleft from the metacone and hypocone, respectively.

M^3 is the largest and longest of the three maxillary cheek teeth. Measurements of the enamel crown are as follows: width across protocone, 25 mm.; width across hypocone, 21 mm.; length, 29.5 mm.; length-width ratio, 1.18. The paracone is slightly smaller than the protocone; its apex, however, is elevated above the centrally placed protoconule and the protocone. The dimensions of the anterobuccal parastyle are comparable to those of this cusp on M^2 and this style is likewise separated from the rather broad anterior cingulum by a thin cleft. On the lingual side the cingulum has an enlargement whose dimensions are the same if not larger than those of the parastyle. The quadrangular anterior lake is larger than that of M^2.

The deep transverse valley is deflected slightly forward centrally by the more forward placement of the rather large median posterior cusp (metaconule). The unworn apices of the metacone and hypocone are not elevated above the metaconule; the hypocone is, however, pressed more closely against the metaconule than is the metacone. In contrast to M^2 there are three distinct cuspules on the posterior cingulum; the apices of the buccal and lingual cuspule are, however, elevated above the smaller medial cuspule. The buccal and lingual cuspules are also separated from the metacone and hypocone respectively by a thin cleft. The lake in front of the posterior cingulum is smaller than that of M^2.

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4. A New Odontocete From the Calvert Miocene of Maryland

In February 1965, Howard W. Hruschka while searching for fossil bones along the Chesapeake Bay shore north of Governors Run, Md., found the mandibles hereinafter described. They were near the tide level in a mass of marl which had been dislodged from the face of the cliff during a previous storm. These mandibles belonged to a toothed cetacean somewhat larger than any of the previously recorded Calvert odontocetes that are characterized by an elongated rostrum. Mr. Hruschka generously presented the specimen to the United States National Museum.

HADRODELPHIS, *new genus*

Type species: *Hadrodelphis calvertense*, new species.

Diagnosis: Mandibles thick, robust, ankylosed anteriorly by symphysial fusion; mandibular alveoli large, anteroposterior diameter 18–23 mm., separated by 5–8 mm. septa or interspaces; mandibular teeth with black enamel crowns; crowns of posterior teeth with anastomosing fine striae and with apical portion of subconical crown bent inward, overhanging broad internal basal shelf; enamel crown of more anterior mandibular teeth nearly conical and with internal shelf progressively reduced.

Type specimen: USNM 23408. Portion of right mandible ankylosed anteriorly to a shorter portion of the left mandible at symphysis. Collector, Howard W. Hruschka, February 13, 1965.

Horizon and Locality: Marl in a fall at base of cliff, 900 feet north of road end at Governors Run, Calvert Co., Md. Calvert formation, middle Miocene.

Teeth

The incomplete right mandible (length, 388 mm.) has five teeth (pl. 44, fig. 1) with crowns in situ, 1 root only and 7 empty alveoli. The shorter portion (length, 233 mm.) of the left mandible has two teeth with worn crowns in situ and 4 empty alveoli. In the symphysis of these mandibles the alveoli are larger than those at the posterior broken end of the right ramus which suggests that the lower teeth were progressively slightly diminished in size toward the posterior end of this tooth row. In the right mandible (pl. 45, fig. 1) the five posterior alveoli with teeth in situ occupy an interval of 120 mm. The five anterior alveoli with complete rims in the right mandible occupy an interval of 140 mm. The largest alveolus in the symphysial portion of the left mandible measures anteroposteriorly 23 mm. at the rim and the smallest posterior alveolus in the right mandible 18.5 mm. The walls of the alveoli are not quite vertical, although the backward slope is not very pronounced. Judging from the dimensions of the alveoli, the anterior teeth were slightly larger than those at or near the posterior end of the tooth row.

The fourth tooth (pl. 45, fig. 2) in front of the broken posterior end of the right mandible (tenth tooth behind broken anterior end) was removed from its alveolus for examination and illustration. No appreciable variation in the configuration of the enamel crown of the five posterior teeth in the right mandible is noticeable. The apex of the subconical crown curves inward, overhanging the broad internal basal shelf. The black enamel on the crown of these posterior teeth is lightly roughened with irregular and anastomosing fine striae which are almost imperceptible except under magnification. No cingulum is developed. There is no distinct neck below the enamel crown, although the rounded ventral rim is pinched-in or turned inward. The internal basal shelf is progressively diminished toward the anterior end of the tooth row and is barely visible on the posteriormost of the two teeth retained in the left mandible. The conical apices of these two teeth are worn down transversely. The basal margin of the enamel crown seems to extend ventrally farther on the internal face than on the external face, although the distance from the conical apex to the ventral rim is approximately the same on both faces. None of the teeth possess any vestige of accessory cusps or tubercles nor an anterior or posterior cutting edge (carina). The teeth preserved in the two mandibles show no evidence of lateral occlusal wear.

The root of the extracted mandibular tooth (pl. 45, fig. 3) is widest near the middle of its length, bent backward distally, and compressed from side to side on the distal one third. The extremity of the root is rugose, with at least six tubercles; the pulp cavity is closed at the extremity. Accidental breakage of the root revealed the existence internally of an open pulp cavity. These mandibular teeth are larger and have relatively lower crowns than those of *Lophocetus pappus* (Kellogg, 1955, p. 120).

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

Greatest length	52
Least length of root	38
Greatest anteroposterior diameter of root	14
Greatest transverse diameter of root	16
Greatest height of crown	13
Greatest anteroposterior diameter of crown at base	10
Greatest transverse diameter of crown at base	12

Mandibles

The posterior portions of both mandibles are broken off; the right ramus is more complete than the left. The anterior extremities of both mandibles (pl. 44, fig. 1) are also missing. Both mandibles are firmly ankylosed at their broken-off anterior ends. In their present condition they diverge behind this symphysial union, but, for a distance of 80 mm. anterior to the commencement of the outward curvature, the internal surface of each ramus is straight. This may indicate a more posterior extension of the symphysis. The posterior portion of the right ramus exceeds 55 mm. in depth anterior to the missing coronoid process, and anteriorly the vertical diameter of the symphysis becomes less than 39 mm. The symphysial portion of the ankylosed rami also tapers toward the anterior extremity, the transverse diameter becoming less than 45 mm. The opposite alveoli are rather closely approximated in the symphysial region and the narrowed dorsal surface of the symphysis between these opposite teeth rows is relatively smooth and flat. No pits for the reception of the apices of the teeth in the rostrum are present.

Dorsoventral diameter of ankylosed symphysis at broken anterior end, 39 mm.; dorsoventral diameter of symphysis at level of fourth alveolus counting backward from anterior end, 46 mm.

The outer surface of the right mandible is nearly vertical near the broken-off posterior end and anteriorly becomes more convex and gradually shifts to a more oblique slope from the alveolar edge to the midline ventrally. Seven external mental foramina (pl. 44, fig. 2) are present on the preserved portion of the right mandibular ramus. The two posteriorly located foramina are the largest of these seven; the hindermost one opens into a backward extending groove, but the larger foramen 33 mm. in front of it is not associated with a groove. The five smaller anterior foramina open into anteriorly directed grooves varying in length from 10 to 60 mm. The mandibular rami are rather thick and sturdy. At the posterior broken end of the right ramus, the internal mandibular canal measures 32 mm. vertically and 15 mm. transversely.

From *Macrodelphinus kelloggi* (Wilson, 1935, p. 28), excavated in the middle Miocene Pyramid Hill sand, Kern Co., Calif., this Calvert odontocete is distinguished readily by considerably fewer and larger teeth, much larger and more widely spaced alveoli, as well as thicker and more robust mandibular rami.

Although the rostrum has not as yet been recorded, the width of the mandibular symphysis of the Florida middle Miocene genus, *Megalodelphis magnidens* (Kellogg, 1944, p. 445), indicates a skull of somewhat larger dimensions, particularly the width of the rostrum, than the Calvert Miocene odontocete. The transverse diameter (60 mm.) of the combined rami (USNM 23408) at the level of the posterior end of the symphysis is not more than 27 percent of the corresponding measurement of the symphysis of the Florida Hawthorn formation odontocete. The anteroposterior diameter (18–20 mm.) of alveoli located posterior to the symphysis (USNM 23408) is slightly smaller than the corresponding alveoli (23–25 mm.) of *Megalodelphis magnidens* (MCZ 17883) and the interspaces or septa (5–8 mm.) between the alveoli are much narrower than those (10–12 mm.) of *magnidens.*

The rostral fragment which constitutes the type of *Champsodelphis valenciennesii* (see Kellogg, 1944, pp. 448, 449, 451) from the Helvetian shell marl at Sort, 8 kilometers from Dax, Département Landes, France, should correspond in general configuration and dimensions to the missing rostrum of this Calvert odontocete. It is obvious that the teeth of this Helvetian species represent a somewhat different type of dentition. The Helvetian species *valenciennesii*, however, does not belong in the genus *Champsodelphis.*

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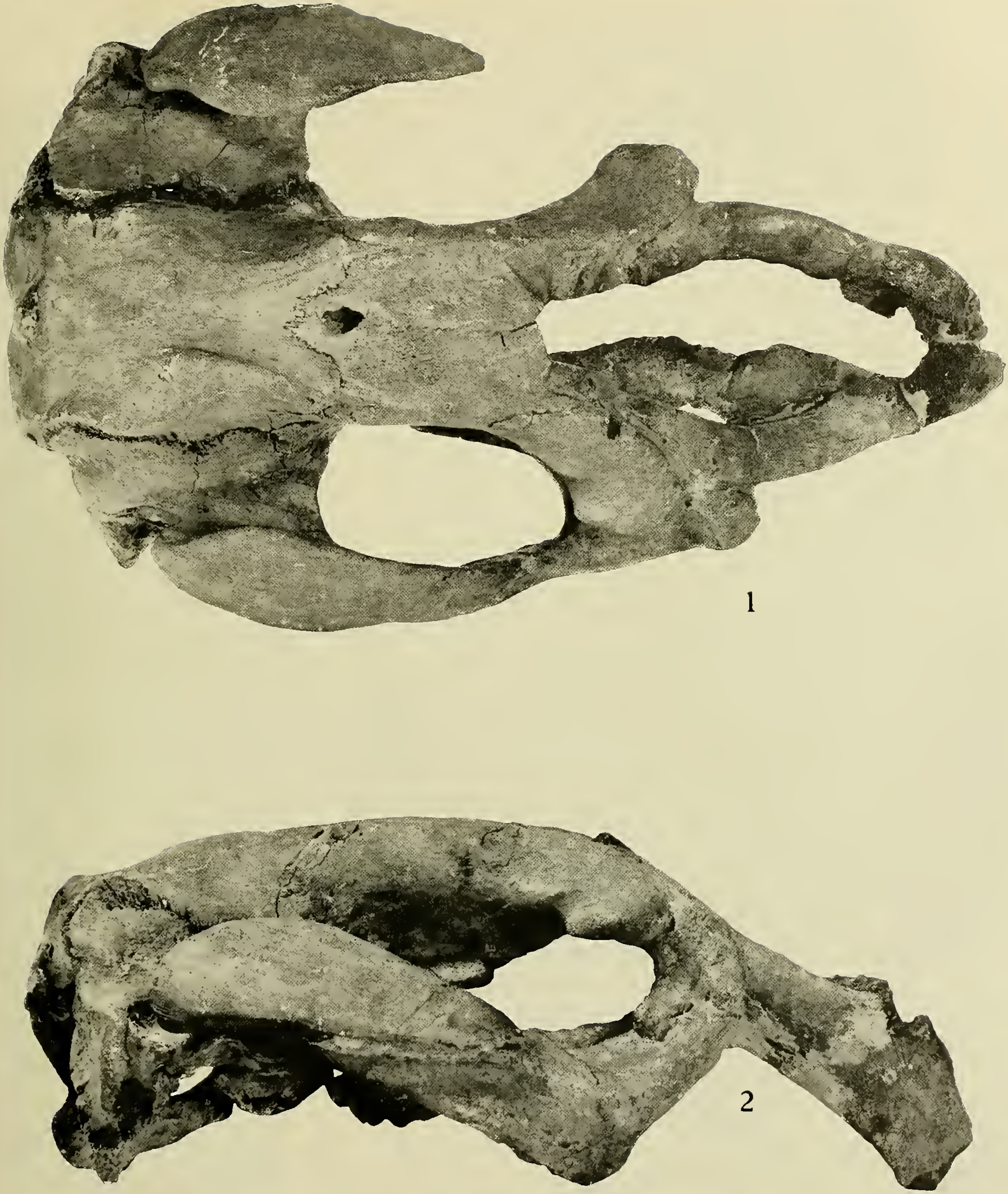
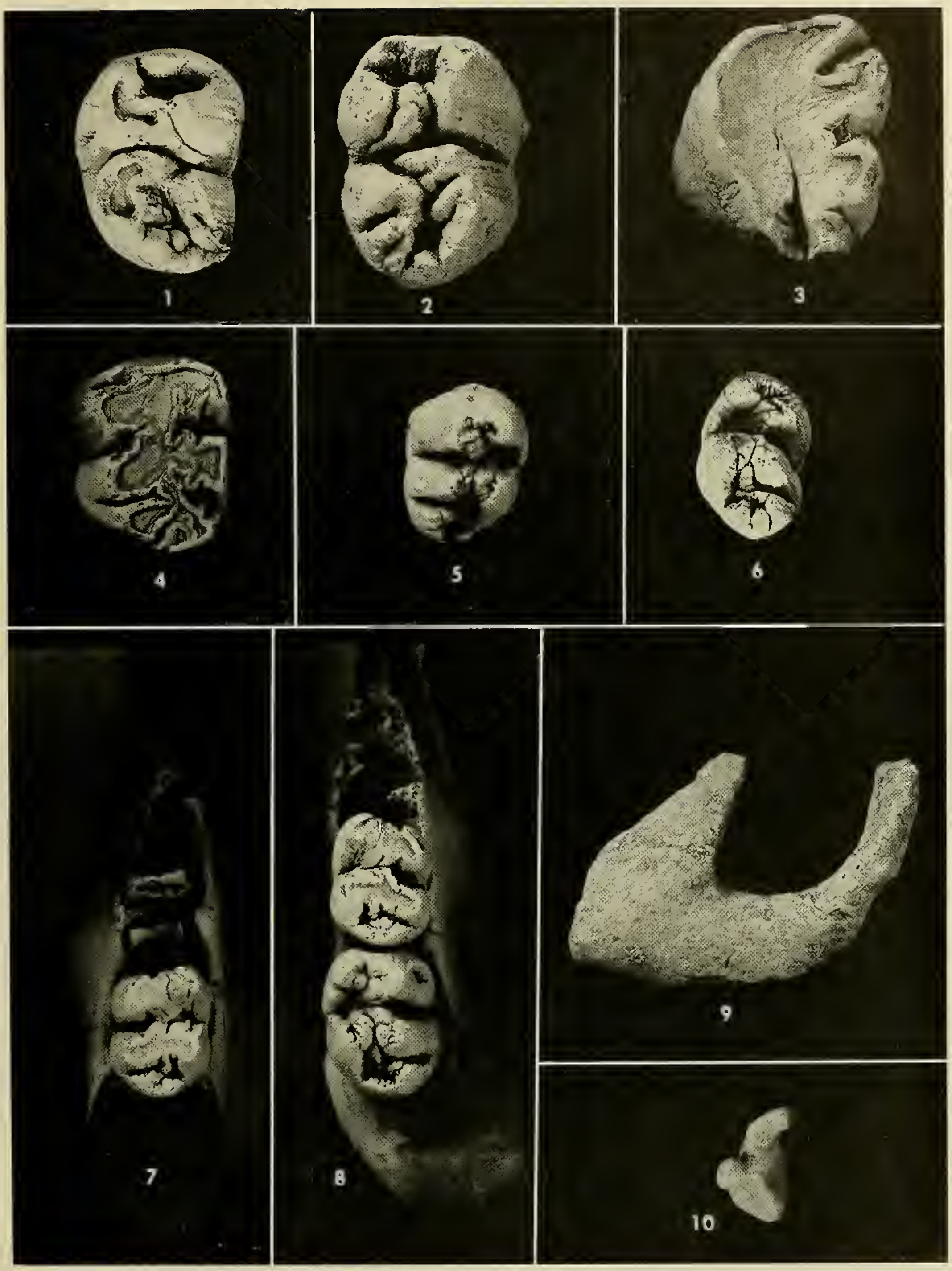


Skull, USNM 16757, Metaxytherium calvertense

1, Dorsal view; 2, lateral view.

SKULL, USNM 16757, METAXYTHERIUM CALVERTENSE

1, Ventral view; 2, right maxillary cheek teeth.



Metaxytherium calvertense

Teeth: 1, right upper third molar (USNM 23409); 2, right upper third molar (USNM 16757); 3, left upper third molar (USNM 23281); 4, left lower second molar (USNM 23271); 5, left posterior molar milk tooth (USNM 16630); 6, right posterior molar milk tooth (USNM 16630); 7, left penultimate lower cheek tooth (USNM 16630); 8, right penultimate and posterior lower cheek teeth USNM 16620). Ear bones, USNM 16757: 9, Right tympanic half ring; 10, left incus.

Left maxillary cheek teeth, USNM 10870, of *Felsinotherium ortegense:* 1, ammonium chloride treated; 2, not treated. Right periotic, incus and stapes, USNM 16757, of *Metaxytherium calvertense:* 3, posttympanic process of squamosal removed.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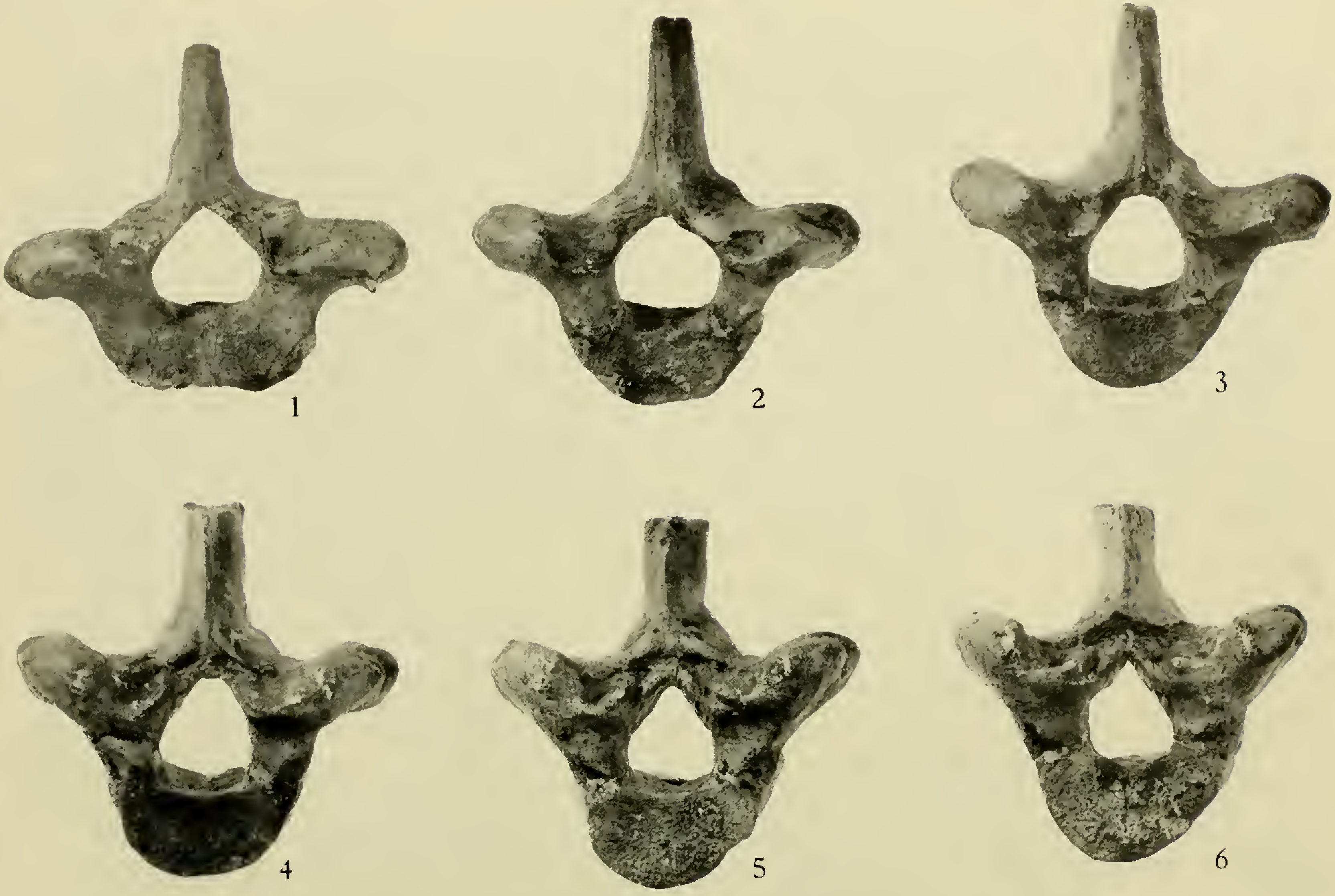
USNM 16757, METAXYTHERIUM CALVERTENSE

Dorsal vertebrae, lateral views: 1, first dorsal; 2, second dorsal; 3, third dorsal; 4, fourth dorsal; 5, fifth dorsal; 6, sixth dorsal; 7, thirteenth dorsal; 8, fifteenth dorsal; 9, sixteenth dorsal. Right mandible: 10, internal view, showing capsule for molar.

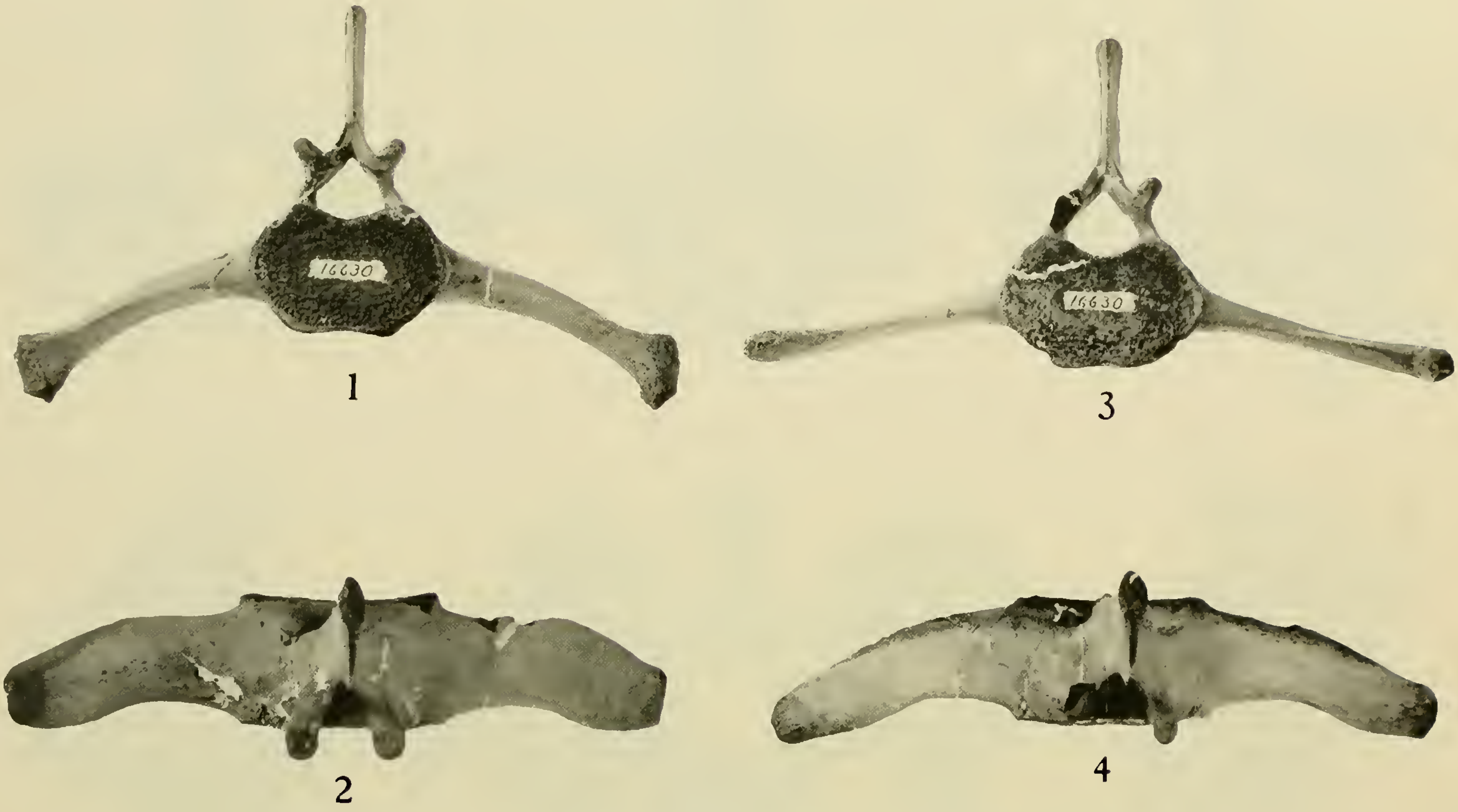


Dorsal Vertebrae, USNM 16757, Metaxytherium calvertense

Anterior views: 1, first dorsal; 2, second dorsal; 3, third dorsal; 4, fourth dorsal; 5, fifth dorsal; 6, sixth dorsal.

Dorsal and Cervical Vertebrae, USNM 16757, Metaxytherium calvertense

1, Tenth dorsal, posterior view; 2, tenth dorsal, anterior view; 3, thirteenth dorsal, anterior view; 4, sixteenth dorsal, anterior view; 5, axis, anterior view; 6, fourth cervical, posterior view; 7, sixth cervical, posterior view. Left mandible, USNM 16630: 8, external view.

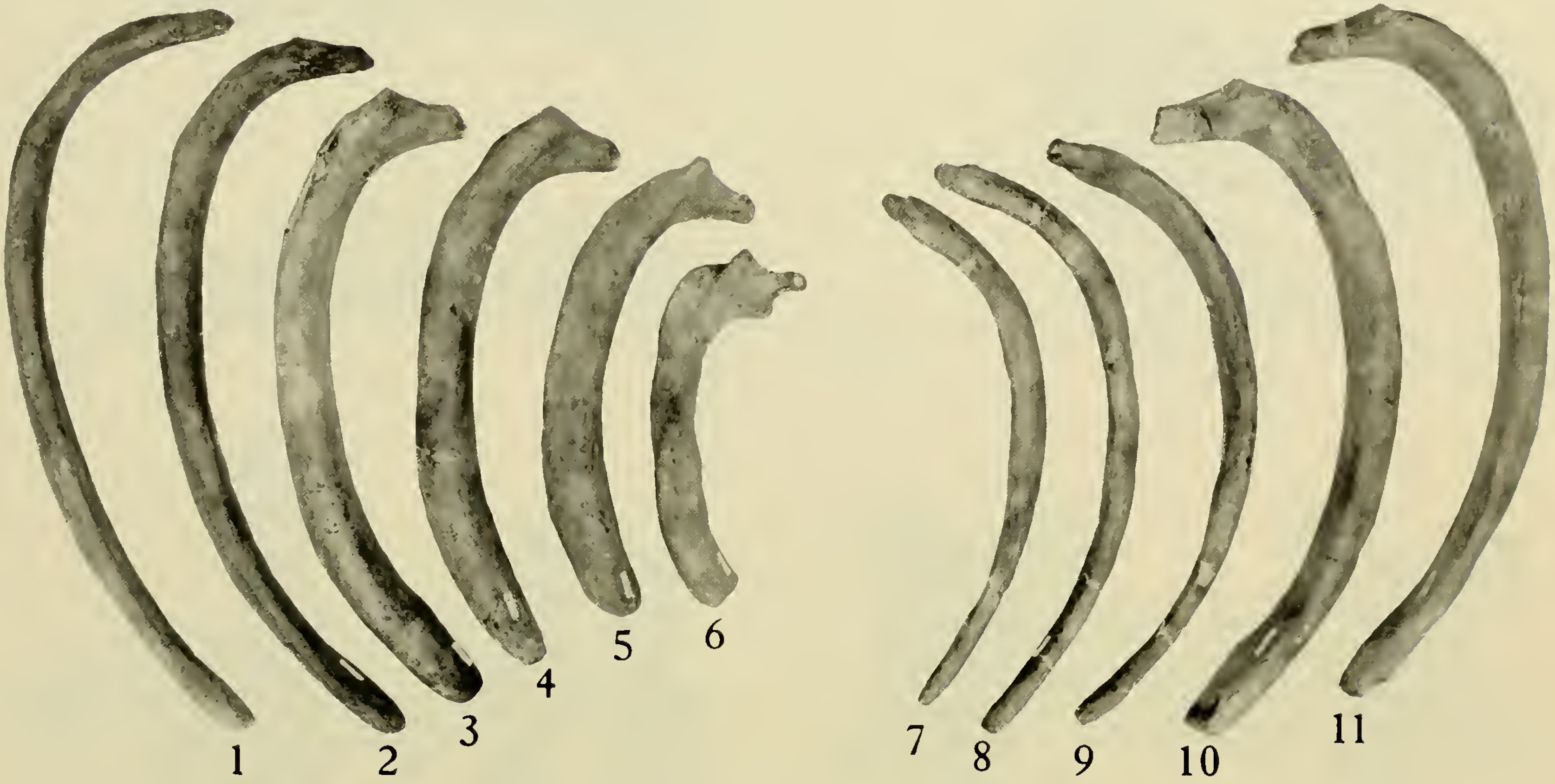


LUMBAR AND SACRAL VERTEBRAE, USNM 16630, METAXYTHERIUM CALVERTENSE

1, Sacral vertebra, anterior view; 2, sacral vertebra, dorsal view; 3, lumbar vertebra, anterior view; 4, lumbar vertebra, dorsal view.

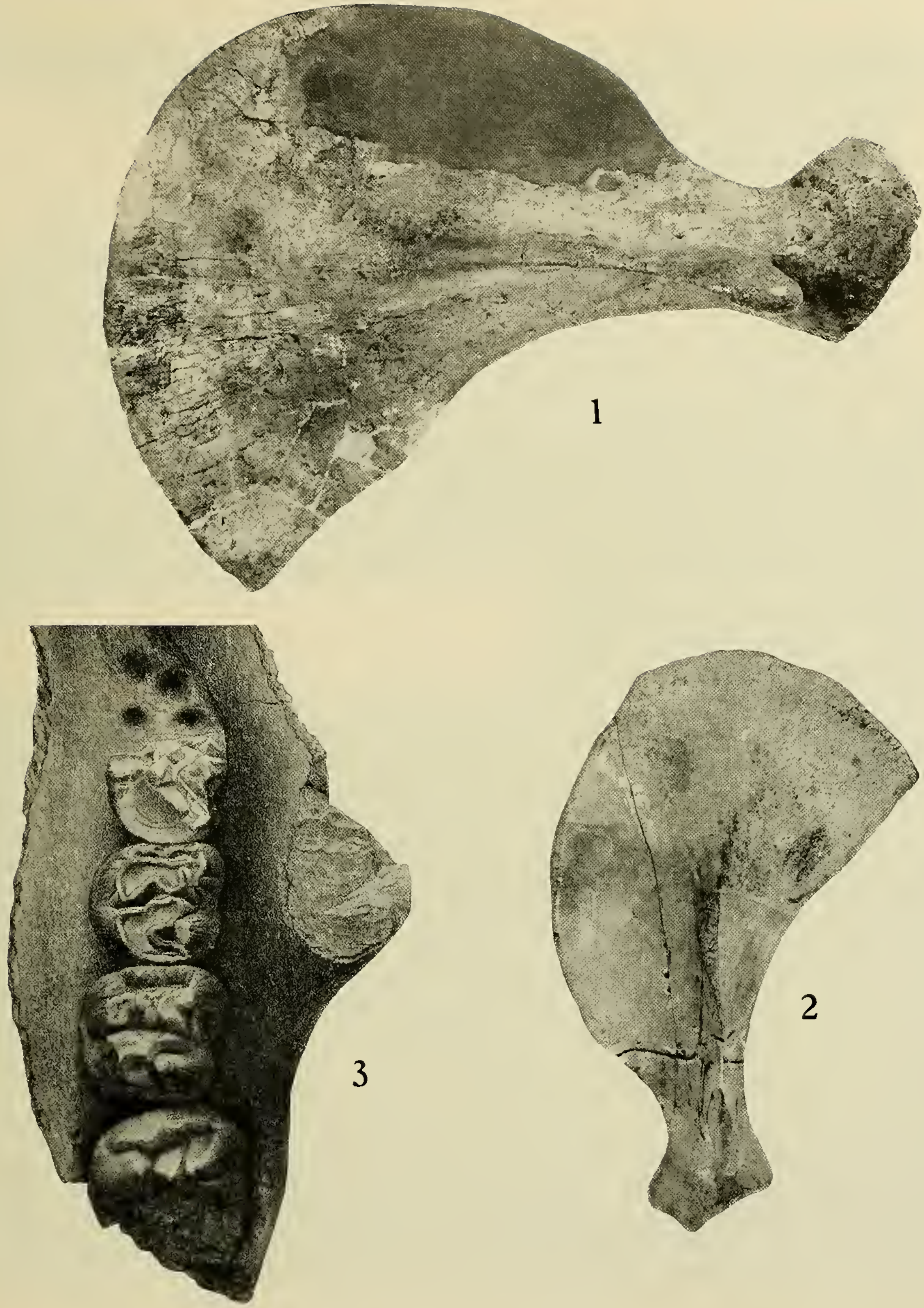
Limb Bones, Pelvis and Sternum, Metaxytherium calvertense

1, Left radius and ulna (USNM 23213); 2, left radius and ulna (USNM 9346); 3, left humerus, anterior view (USNM 16757); 4, left humerus, posterior view (USNM 16757); 5, right innominate bone (USNM 16757); 6, left innominate bone (USNM 23213); 7, sternum (USNM 16757).



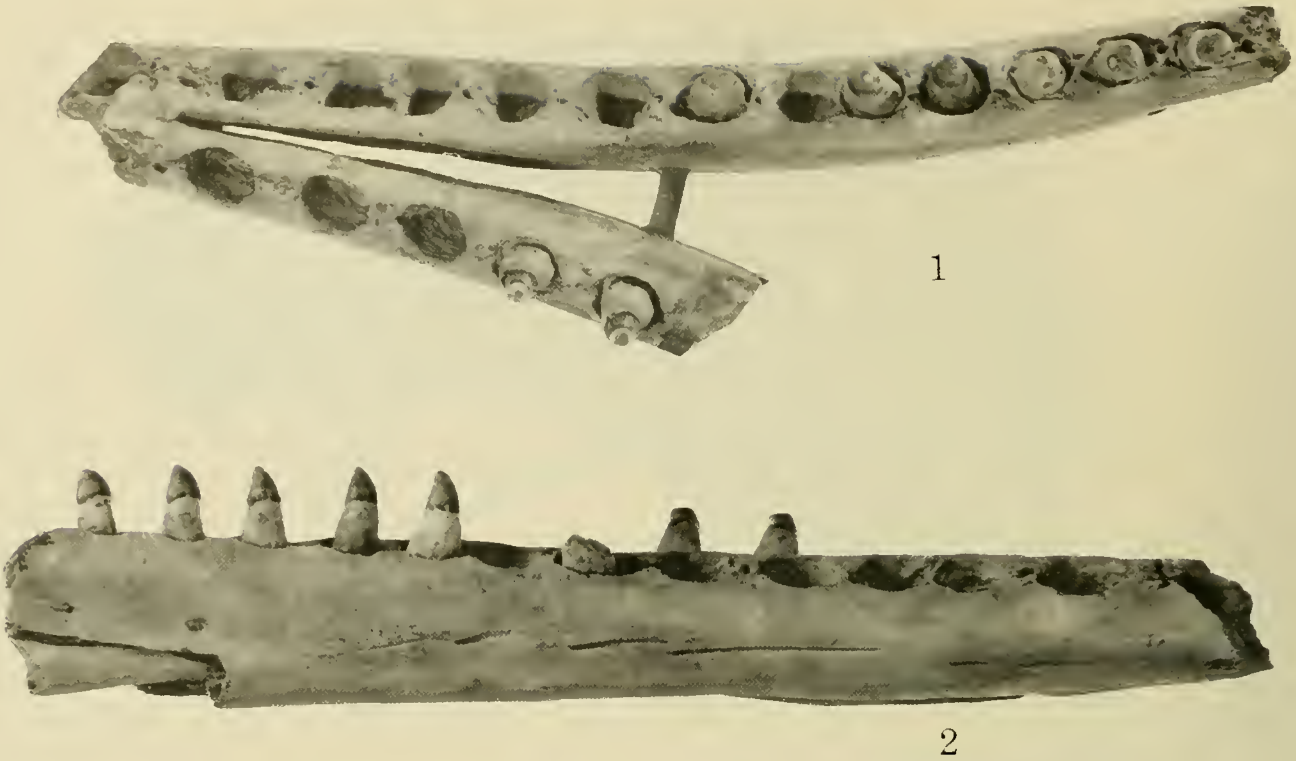
RIBS, USNM 16757, METAXYTHERIUM CALVERTENSE

1, Eleventh rib, left; 2, eighth rib, left; 3, fourth rib, left; 4, third rib, left; 5, second rib, left; 6, first rib, left; 7, twentieth rib, right; 8, nineteenth rib, right; 9, eighteenth rib, left; 10, fifth rib, right; 11, sixth rib, right.



SCAPULAE AND CHEEK TEETH

Metaxytherium calvertense: 1, right scapula, external view (USNM 16757); 2, left scapula, external view (USNM 16630). *Halianassa studeri:* 3, left maxillary cheek teeth (type, Studer, 1887, pl. 1, fig. 4).



MANDIBLES, USNM 23408, HADRODELPHIS CALVERTENSE

1, Dorsal view; 2, lateral view, right mandible.

POSTERIOR MANDIBULAR TEETH, USNM 23408, HADRODELPHIS CALVERTENSE

1, Internal view of posterior teeth, right mandible; 2, anterior view of posterior tooth; 3, internal view of posterior tooth.

UNITED STATES NATIONAL MUSEUM BULLETIN 247

FOSSIL MARINE MAMMALS

From the Miocene Calvert Formation of Maryland and Virginia

Parts 5–8 (end of volume)

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MUSEUM OF NATURAL HISTORY
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5. Miocene Calvert Mysticetes Described by Cope

6. A Hitherto Unrecognized Calvert Cetothere

7. A Sharp-nosed Cetothere From the Miocene Calvert

8. Supplement to Description of PARIETOBALAENA PALMERI

5. Miocene Calvert Mysticetes Described by Cope

Methods of collecting and preserving fossil cetacean remains were less than satisfactory during the past century. Inexperienced or untrained persons were picking up at waters edge bones from the fallen debris of the marine formations exposed along the western shore of the Chesapeake Bay, the Patuxent River, and the cliffs on the Potomac River. The novelty and supposed rarity of such finds seemingly influenced Leidy and Cope to seek the assistance of workers in marl pits and helpers on farms in the recovery of all such curiosities. Broken and otherwise imperfect vertebrae and mandibles of fossil cetaceans received from such sources were the usual kind of accessions to museum collections. Such inadequate and often nondiagnostic specimens became the basis for generic and specific names. With few exceptions these species were based on skeletal elements other than portions of skulls. In view of present knowledge based on more complete skeletal materials, the proposal during the past century of generic and specific names for imperfect, nonassociated vertebrae and portions of mandibles may be attributed, in part, to unawareness of the probable extent of individual variation and growth changes. Except in a rather few instances determinable comparisons with type specimens of this nature have not been rewarding. Although a conscientious effort has consistently been made during the past forty years to identify or associate Cope's cetacean types with more completely preserved specimens, this has so far proven impractical for several of his fossil mysticetes.

Since Winge (1909) concluded that the upper Miocene (Anversien) *Mesocetus* Van Beneden was equivalent to the lower Pliocene (Diestien) *Plesiocetus* Van Beneden, and that *Metopocetus* Cope was probably also equivalent thereto, consideration should be given to the availability of this generic name for a particular kind of fossil mysticete. As regards *Mesocetus*, True (1912) concurred with Winge, but thought that *Metopocetus* was questionably valid.

Three species, *hupschii*, *burtinii*, and *garopii*, based on skeletal materials from the Diestien "sables" (lower Pliocene) at Saint Nicolas, Belgium, in the Musée de l'Université Catholique, Louvain, were included when the generic name *Plesiocetus* was established by Van Beneden (1859, p. 139). Some twelve years later Van Beneden (1872, p. 15) decided to restrict the application of the generic name *Plesiocetus* to *P. garopii*, a large species very near the living *Balaenoptera*. In this article, *Plesiocetus hupschii* and *P. burtinii* were referred to *Cetotherium* Brandt and two additional fossil mysticetes *Cetotherium brevifrons* and *C. dubium* were described.

After having had his attention directed by Brandt to the elongated lumbars and the absence of capitular articulation[1] with the centrum by anterior as well as posterior ribs of related mysticetes, Van Beneden (1882, p. 59), in September 1872, was not quite so certain of the generic distinctness of *Plesiocetus garopii*.

Van Beneden and Gervais (1874–1880, p. 273) state that recognition of the genus *Plesiocetus* was based on notable differences that exist in the bones of the skull, particularly the tympanic bulla and the cervical vertebrae as contrasted with others. Four species, *Plesiocetus garopii* (Van Beneden and Gervais, 1874–1880, pl. 16, figs. 1–9), *P. burtinii*, *P. hupschii*, and *P. gervaisii*, were recognized. In his revised diagnosis, Van Beneden (1880, p. 17) stated that *Plesiocetus* was nearest to the living balaenopterines, that the articular condyle of the mandible was round

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[1] The second, third, and fourth pair of ribs of *Balaenoptera* (*Sibbaldus*) *musculus*, *B. physalus*, *B. borealis*, and *B. acutorostrata* have the tuberculum separated from the capitulum by a well-defined neck, although the capitulum seemingly does not articulate with the centrum of a dorsal vertebra. As regards the Calvert Miocene cetotheres, the capitulum on each of the seven or eight anterior pairs of ribs articulates in a definite demifacet on the posteroexternal surface of the centrum of the preceding vertebra.

(like the head of the humerus) similar to that of true balaenids, that the tympanic bulla was distinctive, and that especially great importance was attached to the distance between the (supra) occipital and the nasals which determined more or less the length of the skull. The species of *Plesiocetus* recognized by Van Beneden were, *brialmontii*, *dubius*, *hupschii*, and *burtinii*. No mention of *Plesiocetus garopii* is made in Van Beneden's final review (Van Beneden, 1885) of the genus *Plesiocetus*. Omission of *P. garopii* seems to imply that Van Beneden no longer accepted as valid the characteristics he previously assigned to this species, but regrettably he failed to comment on its actual relationships. The type species of *Plesiocetus* has been fixed (Kellogg, 1925, p. 51) as *P. hupschii*.

Diagnostic portions of skulls, if in existence, have neither been described nor illustrated by Van Beneden (1885) for *Plesiocetus brialmontii*, *P. dubius*, or *P. burtinii*. The tympanic bullae assigned to *P. brialmontii* (Van Beneden, 1885, pl. 2) and to *P. dubius* (op. cit., 1885, pl. 14) are balaenopterine. The condyle of the mandible (op. cit., 1885, pl. 22, fig. 9) and the periotic (op. cit., 1885, pl. 21, figs. 2–7) of the referred specimen of *P. hupschii* are also balaenopterine. These species were rather large mysticetes, the length of the humerus as illustrated is 300 mm. for *P. hupschii* (Van Beneden, 1885, pl. 24, figs. 2–3), 315 mm. for *P. dubius* (op. cit., 1885, pl. 15, fig. 6), and 350 mm. for *P. brialmontii* (op. cit., 1885, pl. 4, fig. 1). The length of the radius of *P. hupschii* (op. cit., 1885, pl. 25, figs. 4–5) is 435 mm., of *P. dubius* (op. cit., 1885, pl. 16, fig. 3) 475 mm., and of *P. brialmontii* (op. cit., 1885, pl. 5, fig. 3) 510 mm. These skeletal details do not indicate a close relationship of these Belgian species with the Calvert Miocene genera which were discussed by Winge (1909) and True (1912).

Uncertainties in the allocation of isolated bones uncovered during excavation to any one of several related species must always be considered. Reference to the dispersal of bones in the sediments of the Antwerp basin has been made by Van Beneden (1886, p. 34). Furthermore, the sequence of the catalog numbers assigned to skeletal elements of the above-mentioned four species does not lend creditability to the accuracy of such attributions. Sufficient diagnostic criteria for the recognition of *Plesiocetus* as a valid genus are not presently known.

Winge (1909, p. 25) thought that *Siphonocetus* Cope was probably equivalent to *Cetotherium* Brandt, while True (1912, p. 3) regarded this opinion as doubtful. An upper and lower aqueduct shown in the cross section of the mandible of *Cetotherium rathkii* illustrated by Brandt (1873, pl. 1, fig. 9) lead Winge to conclude that this division of the internal mandibular canal was not different from that described by Cope for *Siphonocetus priscus* (Leidy).

It has not been feasible to identify the type mandibular fragment of *Siphonocetus priscus* with mandibles associated with Calvert Miocene skulls. The architecture of the skull of *Cetotherium rathkii* is quite unlike that of any of the North American species of fossil mysticetes, with the possible exception of *Cetotherium furlongi* (Kellogg, 1925, fig. 1). The overriding of the central interorbital region by the posterior ends of the rostral bones (ascending processes of the premaxillaries and maxillaries and the nasals) on the skull of *Cetotherium rathkii* (Brandt, 1873, pl. 1, fig. 1) is decidedly more pronounced than on skulls referred to *Parietobalaena palmeri*. The location on this Sarmatian cetothere skull of the nasal bones entirely behind the level of the preorbital angles of the supraorbital processes of the frontals, as well as the unusually narrow and presumably strongly attenuated rostrum, are quite different. The genus *Cetotherium* unquestionably represents a more advanced stage in the general process of modification of the mysticete skull by telescoping.

A more detailed discussion of each of Cope's Calvert Miocene mysticetes follows.

For permission to study specimens in their respective collections, I am indebted as follows: the type of *Mesocetus siphunculus* Cope to Dr. Walter Granger, The American Museum of Natural History (AMNH) in New York City; the types of *Balaena prisca* Leidy, *Megaptera expansa* Cope, *Eschrichtius pusillus* Cope, and *Eschrichtius cephalus* Cope, to Dr. Horace G. Richards of the Academy of Natural Sciences of Philadelphia (ANSP); the types of *Tretulias buccatus* Cope, *Ulias moratus* Cope, *Metopocetus durinasus* Cope, *Balaenoptera sursiplana* Cope, and *Parietobalaena palmeri* Kellogg to Dr. C. Lewis Gazin of the United States National Museum (USNM) in Washington, D.C.; and the mysticete types from the Antwerp basin described by Van Beneden to Dr. Victor Van Straelen, Director, Musée royal d'Histoire naturelle in Brussels (MNHB), Belgium. Through continued assistance of the late Sydney Prentice, line drawings were prepared some twenty years ago for the Miocene specimens here illustrated, as well as those in part one of this bulletin. Assistance in the preparation of illustrations was also received from Lawrence B. Isham. These illustrations as well as the outline drawings included in this part are true projections made with a pantograph.

ESCHRICHTIUS Gray

Eschrichtius Gray, 1864, Ann. & Mag. Nat. Hist., London, ser. 3 vol. 14, no. 83, p. 350.

Type Species: *Megaptera*? *robusta* = *Balaenoptera robusta* Lilljeborg, 1861, Föredrag vid Naturforskaremötet i Köpenhamm, 1860, p. 602.

Type Specimen: Right and left mandibles, stylohyal, atlas and 3 cervicals, 7 dorsals, 8 lumbars, 14 caudals, 4 chevrons, 22 ribs, sternum, right scapula, left humerus, right radius and ulna, 6 carpals, 4 metacarpals, and 4 phalanges. Mineralogisk-geologiska institut, Kungliga Universitetet i Uppsala, Sweden. Collectors, Dr. J. O. von Friesen, F. M. von Friesen, and W. Lilljeborg; 1859.

Type Locality: Skeleton dug up on Gräsö (Grassisle) in Roslagen, Upland, Sweden.

Diagnosis: This genus was established by Gray for the sub-Recent *Balaenoptera robusta* Lilljeborg. Gray (1866, p. 132, fig. 21) published line drawings forwarded to him by Lilljeborg of a cervical vertebra, mandible, scapula, and sternum of this whale. Gray's generic diagnosis directed attention to the scapula with a distinct acromion and coracoid process, mandible with a low, but little developed coronoid process, and a cervical vertebra with the neural canal broad in comparison with the centrum. This genus was regarded by Gray as a close relative of *Megaptera* (the humpback). The discovery in Holland of skulls, mandible, periotics, axis, scapula, humerus, radius, and ulna enabled Van Deinse and Junge (1937) to demonstrate that the Recent gray whale now restricted to the North Pacific Ocean was present at that time in the North Atlantic Ocean. Cope's articles published during this decade provide no evidence that he had consulted the British Museum catalog of seals and whales (Gray, 1866) and seemingly he was not aware of the characteristic shape of the *Eschrichtius* mandible whose vertical diameter in front of the coronoid process is not appreciably greater than near the anterior end. Otherwise, considering his usual perspicacity, it is difficult to explain the initial application of the generic term *Eschrichtius* to a large Calvert mysticete (Cope, 1868a, p. 131). The skeletal parts of *Eschrichtius cephalus* Cope (Cope, 1868a, p. 148; type, ANSP 12691, 12692, 12941) included both mandibles and four cervical vertebrae, but no scapulae. Both of these mandibles are elongated and markedly attenuated toward the anterior end, but on both the coronoid process is broken off and the condyles are missing. The configuration of these Calvert mandibles is quite close to that of a young *Balaenoptera physalus* (USNM 16039).

Cope (1868b, p. 147) observed later that *Eschrichtius* differs in part technically from *Megaptera* in the presence of an acromion on the scapula, but since this skeletal element is not represented among his fossil materials, he relied on the "great size of the neural canal as compared with the vertebral centra" in describing a second cervical vertebra without epiphyses from eastern Virginia as *Eschrichtius leptocentrus* (type, ANSP 12693).

ESCHRICHTIUS CEPHALUS Cope

Eschrichtius cephalus Cope, 1868a,b, Proc. Acad. Nat. Sci. Philadelphia, vol. 19, pp. 131, 144, 148.
Cetotherium cephalus Cope, 1890, American Nat., vol. 24, no. 283, pp. 612–615, figs. 7, 8, pl. 22.

Type Specimen: ANSP 12691. Right and left mandibles with hinder ends destroyed behind level of coronoid processes, both premaxillary bones incomplete, a portion of the maxillary, a portion of the vomerine trough, portions of both squamosals, left humerus, left radius, two carpals, and one phalange. Collector, James T. Thomas; October 27, 1867.

Fourth, fifth, sixth, and seventh cervical vertebrae. ANSP 12692. Collector, James T. Thomas; October 27, 1867.

One half of the atlas, 3 lumbar vertebrae, and 2 caudal vertebrae. ANSP 12941. Collector, James T. Thomas; October 27, 1867.

Type locality: In the bed and opposite bank of a small run, not far from the home of James T. Thomas, near the Patuxent River, about one mile east of site marked Patuxen (U.S.G.S. Brandywine sheet), 2 miles east of Hughesville, Charles County, Maryland. Calvert formation, middle Miocene.

Referred Specimens: (1) AMNH 9846: right tympanic bulla; no locality data. (2) AMNH 1750: left periotic; (?) Yorktown, Va., Yorktown formation, upper Miocene. (3) USNM 23749; right ulna, incomplete; coll. Thomas G. Gibson, April 1963; National Military Park, Petersburg, Prince George Co., Va., Calvert formation, middle Miocene.

Diagnosis: In the fall of 1867, Cope accepted an invitation to visit the home of Oliver N. Bryan at Marshall Hall Charles County, Maryland. With Bryan, Cope examined exposures of the Miocene formations in southern Maryland between the Patuxent and Potomac Rivers. From an old man, James T. Thomas, living near the Patuxent River, Cope on October 27, 1867 (Osborn, 1931, p. 148) obtained two mandibles seven feet in length, portions of the premaxillary and other pieces of the skull, four cervical vertebrae, a humerus, a radius, 2 carpals, and one phalange of a large mysticete, which he subsequently named *Eschrichtius cephalus*. Included with these skeletal elements were one half of the atlas, 3 lumbar and 2 caudal vertebrae. This specimen now is the property of the Academy of Natural Sciences of Philadelphia. One year later, Cope (1868d, p. 184) stated that this specimen was found in the bed and opposite bank of a small run near the Thomas residence, which was located about one mile east of Patuxent, near Hughesville, Charles County, Maryland.

From these few remains Cope (1890, pl. 22) attempted a restoration of the skeleton. Other skeletal material collected during the past ten years shows that this reconstruction is remarkably accurate when one considers the scanty evidence on which it was based. Cope estimated that the length of the skeleton of this mysticete was about 31 feet and that the skull comprised about one-third of the total length.

Cope was impressed by the great length of the mandible as compared with the length of the cervical series. This condition exists, however, in most of the Recent whalebone whales. Cope seemingly overlooked the fact that the depth of the mandibular ramus in front of the coronoid process as compared with the anterior end is relatively greater than has been noted for any other Calvert mysticete and that it bears a much closer resemblance to the mandible of a young *Balaenoptera physalus* (USNM 16039) than to any known cetothere.

It may appear illogical to conclude in the absence of the precise details of construction of the braincase and of the condyle of the mandible that *cephalus* is referable to an existing genus. Nevertheless, the portions of the skeleton herein described indicate a close affinity if not identity with *Balaenoptera.*

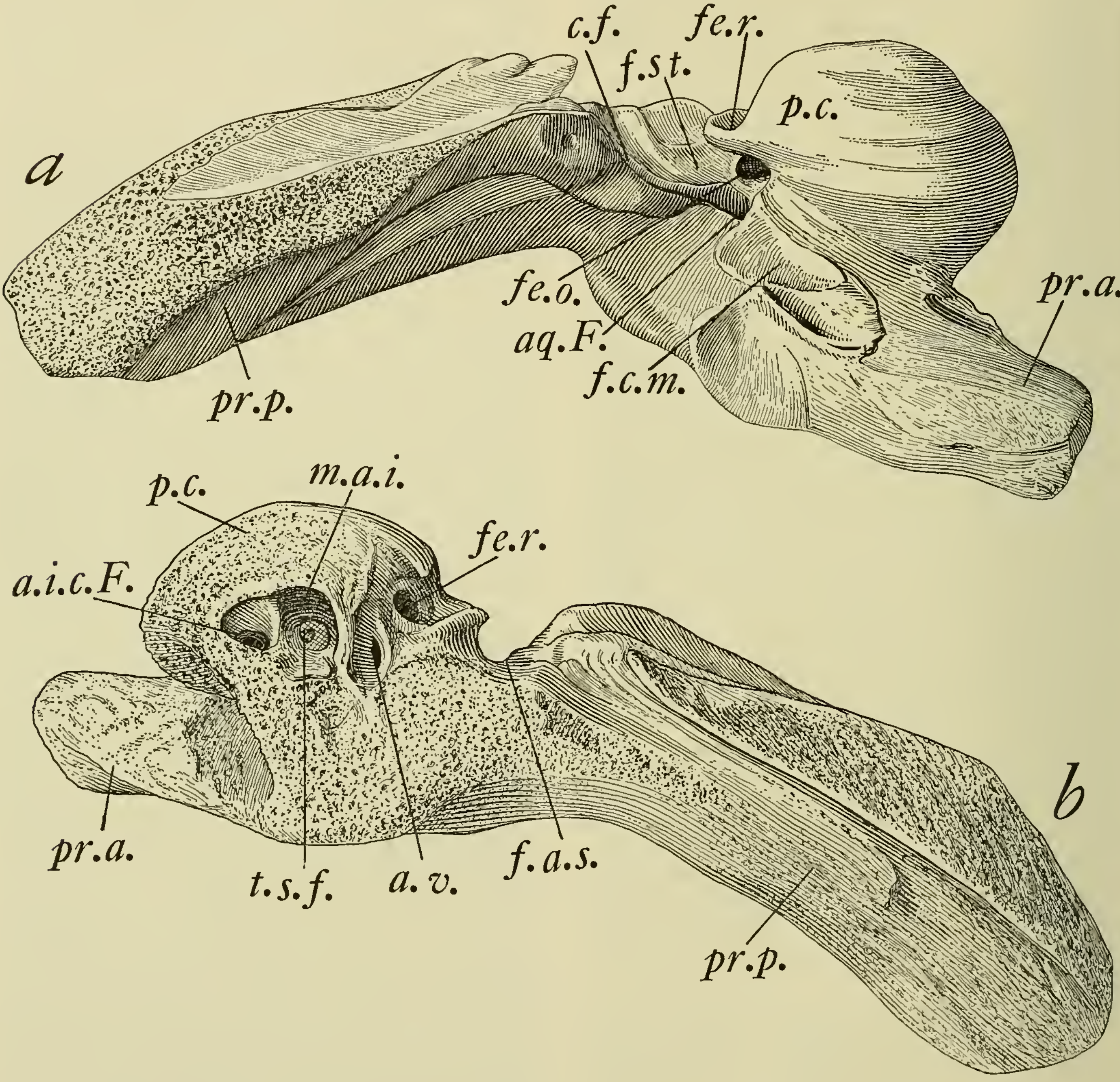

Figure 39.—Views of left periotic, AMNH 1750 of (?)*Balaenoptera sursiplana* Cope: *a*, ventral or tympanic view; *b*, internal or cerebral view. Abbrs.: a.i.c.F., internal aperture of aquaeductus Fallopii; aq.F., epitympanic orifice of aquaeductus Fallopii; a.v., aperture of aquaeductus vestibuli; c.f., channel for facial nerve; f.a.s., fossa for extension of air sac system; f.c.m., fossa for head of mallus; fe.o., fenestra ovalis; fe.r., fenestra rotunda; f.st., fossa for insertion of stapedial muscle; m.a.i., internal acoustic meatus; p.c., pars cochlearis; pr.a., anterior process or pro-otic; pr.p., posteri or process or opisthotic; t.s.f., tractus spiralis foraminosus.

Skull

Cope does not state whether the rostrum was complete when it was found. If the skull (ANSP 12691) was fairly complete, it must have been largely destroyed during excavation, for all that exists today is the incomplete right and left premaxillary bones, a portion of the maxillary, a section of the vomerine trough, and portions of both squamosals.

Measurements (in mm.) of portions of skull, ANSP 12691, are as follows:

Premaxillary, greatest length as preserved, proximal end missing	1000
Greatest width near proximal end	63
Maxillary, greatest length as preserved, in a straight line	735+
Vomer, greatest breadth as preserved	68
Squamosal, Greatest transverse diameter of zygomatic process, from margin of tympanoperiotic recess to external margin of squamosal	295
Greatest length of external edge of zygomatic process, approximately	310

Tympanic Bulla

The incomplete right tympanic bulla (AMNH 9846) which Cope (1890, p. 612, fig. 7) described as being "noticeably compressed, somewhat incurved, and with a nearly parallelgrammic outline from the side" measures 71.5 mm. in length and 37 mm. in width. These dimensions are matched by the tympanic bulla of a much smaller Calvert cetothere (USNM 23494) whose mandible measures in a straight line 1480 mm. as contrasted with 2326+ mm. for the mandible of *Eschrichtius cephalus*. Either fortuitous association at the same locality with the type skeletal remains or subsequent presumptive allocation may explain this later referal by Cope, since no tympanic bulla was included in the material received by the Academy from James T. Thomas.

Periotic

One of the periotic bones (AMNH 1750) mentioned by Cope (1868a, p. 132) as previously presented to the Academy quite certainly represents a balaenopterine whale and is now regarded as belonging to a species different from *Eschrichtius cephalus*. The bone is most probably derived from the Yorktown formation, near Yorktown, Virginia, and not from Tarboro, North Carolina. This is probably the periotic bone sent to Cope by Edwin Holway of Yorktown, Virginia. The dimensions of this left periotic are compatible with those of the left tympanic bulla (length, 101 mm.) of *Balaenoptera sursiplana* (Cope, 1895a, p. 151; USNM 9347, type).

On this left periotic (fig. 39b) the internal acoustic meatus and the Fallopian aqueduct open in close proximity on the internal (cerebral) face. The *fenestra rotunda* is large and within it a portion of a semicircular canal is visible from the posterior view. There is no internal opening for the *aquaeductus cochleae*, and only a portion of the shallow open groove or canal which marks its former course is present. The orifice of the *aquaeductus vestibuli* lies just above and internal to the *fenestra rotunda* in a slit-like depression, but is situated much more internally than in any of the living whalebone whales. The internal acoustic meatus is deep, circular in outline, and at its base is a minute foramen, the foramen centrale. The cerebral opening of the Fallopian aqueduct is about one half the size of the internal acoustic meatus. The partition between this aqueduct and the internal acoustic meatus does nor attain the level of the cerebral face of the periotic. The entire cerebral surface of the *pars labyrinthica* is porous. The rather short anterior process is compressed from side to side; the posterior process is rather slender and elongated; and the *pars cochlearis* is inflated.

On the tympanic or ventral face (fig. 39a) the anterior pedicle of the tympanic bulla is fused with the anterior process of the periotic; behind this attachment the head of the malleus is lodged in a somewhat elongated depression which in turn lies below the tympanic orifice of the Fallopian aqueduct. Behind the *fenestra ovalis* is the rather large excavation for the attachment of the stapedial muscle. Alongside this excavation and external to it the facial nerve occupies the narrow groove which has its origin at the orifice of the Fallopian aqueduct, and extends backward to the posterior edge of the *pars labyrinthica;* on its outward course this nerve then occupies the broad groove on the ventral face of the posterior process.

Measurements (in mm.) of the left periotic (AMNH 1750) are as follows:

Greatest length, tip of anterior process to tip of posterior process	150.8
Length of posterior process (opisthotic), external wall of the groove for the facial nerve to tip of posterior process	89
Greatest anteroposterior diameter of posterior process	30
Greatest vertical diameter of posterior process	50
Width of periotic from internal face to external face	59.6
Anteroposterior distance from tip of anterior process (prootic) to posterior face of *pars labyrinthica* behind groove for stapedial muscle	86
Anteroposterior diameter of *pars cochlearis,* from antero-internal angle to anterior edge of *fenestra rotunda*	43

Mandible

The mandibles of the type specimen (ANSP 12691) are larger than those of all cetotheres found in the Calvert formation and exhibit a rather close resemblance to the mandibles of a young finback (*Balaenoptera physalus*).

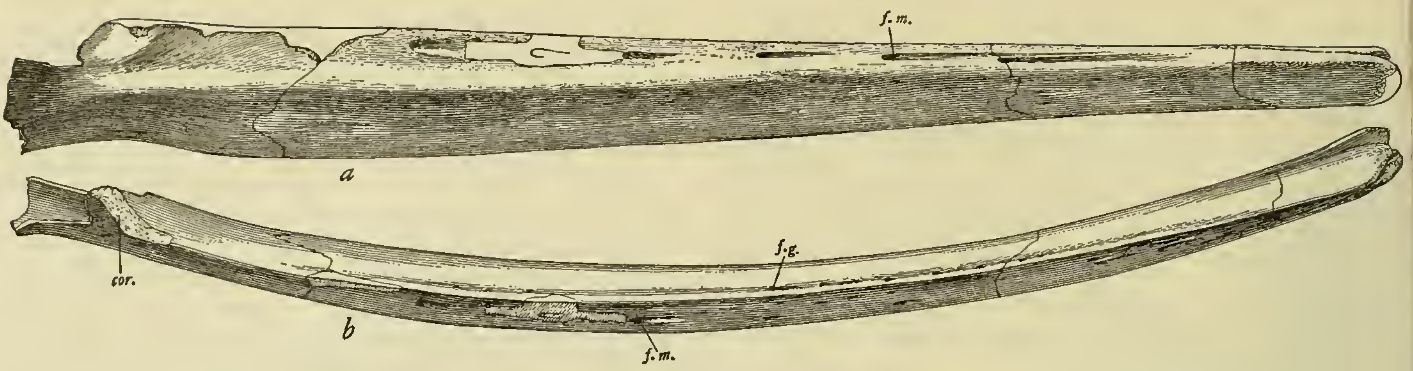

Figure 40.—Views of right mandible, ANSP 12691, of *Eschrichtius cephalus* Cope: *a*, external view; *b*, dorsal view. Abbrs.: cor., coronoid process; f.g., gingival or alveolar foramen; f.m., mental foramen.

They also differ from mandibles of Calvert cetotheres in having the vertical diameter of the ramus (fig. 40a) strongly diminished from in front of the coronoid process toward the anterior end. Both of the type mandibles are broken transversely at several places, the right one being broken at the following distances from the anterior end: 200 mm., 700 mm., 1950 mm., and 2325 mm. The anterior end of the right mandible is complete, but most of the coronoid process and a portion of the ramus behind the latter, including the condyle, is destroyed. The missing portion of the ramus did not exceed 300 mm. in length.

The horizontal ramus of the mandible (fig. 40b) is bowed outward, most conspicuously in front of the middle of its length, and the maximum distance between the alveolar margins of the opposite rami is probably greater than the width of the rostrum at corresponding levels. Cope (1869, p. 10) described the mandibles as being "much depressed, outer face little convex; superior margin a narrow ridge without any truncation, with a series of foramina on each side, the inner extending for a very short distance only; no marginal groove; inferior edge narrow. Very large." Actually the internal surface of each mandibular ramus is distinctly flattened but the external surface, however, is rather strongly convex (see fig. 41; also, Cope, 1896, pl. 12, figs. 2–3). The relatively short symphysial region is not pitted for the attachment of ligaments. The curved internal ledge at the anterior end of the ramus, which on the right mandible is located about 50 mm. below the corresponding point of the dorsal margin anteriorly and 96 mm. posteriorly, is discernible for a distance of 290± mm. At the anterior end of the ramus, 25 mm. below the dorsal edge, there is a deep groove that leads backward to the large trumpet-shaped orifice of the mandibular canal.

The external mental foramina are relatively large, the hindermost one on the left mandible being 14 mm. in diameter, 37 mm. below the dorsal ridge, and 155 mm. behind the next anterior foramen. Each of these foramina opens into a deep groove, which not only is directed anteriorly, but also increases in width from its point of origin to the point where it becomes indistinct. The internal gingival foramina are small, 3 to 4 mm. in diameter, and posteriorly are located about 25 mm. below the dorsal ridge and from 30 to 80 mm. apart. These internal gingival foramina run up onto the dorsal surface on the anterior

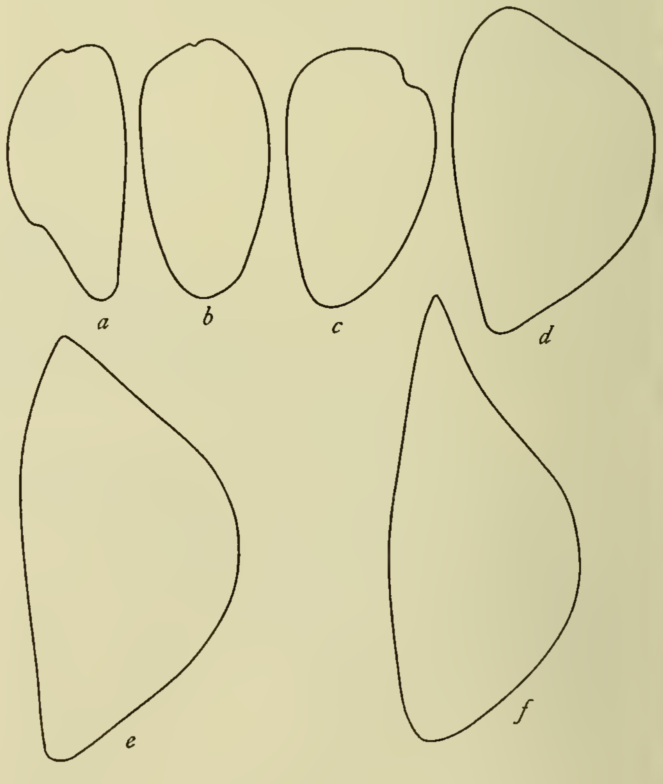

Figure 41.—Cross sections of right mandible, ANSP 12691, of *Eschrichtius cephalus* Cope; *a*, 100 mm. behind anterior end; *b*, 300 mm. behind anterior end; *c*, 500 mm. behind anterior end; *d*, 1000 mm. behind anterior end; *e*, 1500 mm. behind anterior end; *f*, 2000 mm. behind anterior end.

one fourth of the ramus. The anteriormost one of these small internal gingival foramina is located on the dorsal edge about 165 mm. behind the anterior end of the ramus, but the succeeding ones gradually drop down to a lower level, the hindermost one being at least 25 mm. below the dorsal ridge and at least 470 mm. anterior to hinder edge of the coronoid process.

The coronoid process, judging from the basal portion, when complete may have resembled somewhat closely the same process on the mandible of a 45-foot long *Balaenoptera physalus* (USNM 16039). Apparently, the coronoid process was outwardly curved, with apex anterior to anteriormost edge of entrance to the large mandibular canal. It should be noted, however, that Cope (1868 b, p. 149) stated that the coronoid process was broken off when received, but the base indicated that it was compressed and not elevated. The outer wall of the ramus between the coronoid process and the condyle was, apparently, merely a very thin shell (thickness 5 to 25 mm.) in contrast to the swollen and conspicuously thickened hinder portion (thickness 98 mm.) of the ramus of the young *Balaenoptera physalus.*

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

	Eschrichtius cephalus		*Balaenoptera physalus*
	ANSP 12691 Right	*ANSP 12691 Left*	*USNM 16039 Right*
Greatest length of mandible as preserved, in a straight line	2326+	2325+	2610
Greatest length of mandible as preserved, along outside curvature	2370+	2385+	2720
Greatest vertical diameter of mandible, 100 mm. behind anterior extremity	117	119	126
Greatest transverse diameter of mandible, 100 mm. behind anterior extremity	56	54	72
Greatest vertical diameter of mandible, 300 mm. behind anterior extremity	118	120	130
Greatest transverse diameter of mandible, 300 mm. behind anterior extremity	59	58	82
Greatest vertical diameter of mandible, 500 mm. behind anterior extremity	119	118	131
Greatest transverse diameter of mandible, 500 mm. behind anterior extremity	70	70	84
Greatest vertical diameter of mandible 1000 mm. behind anterior extremity	151	149	147.5
Greatest transverse diameter of mandible, 1000 mm. behind anterior extremity	92	91	105
Greatest vertical diameter of mandible, 1500 mm. behind anterior extremity	199	192	192.5
Greatest transverse diameter of mandible, 1500 mm. behind anterior extremity	102	111	117
Greatest vertical diameter of mandible, 2000 mm. behind anterior extremity	209	205	204
Greatest transverse diameter of mandible, 2000 mm. behind anterior extremity	87	86	119
Greatest vertical diameter of mandible through coronoid process	212+	216+	330
External mental foramen (mm. behind anterior extremity)			
First	—	100	—
Second	705	740	710
Third	897	1115	1045
Fourth	1108	1398	1190
Fifth	1331	1565	1410
Sixth	1480	1661	1495
Seventh	1679	1842	1546
Eighth	1911	—	1604
Ninth	—	—	1815

Vertebrae

Cervical vertebrae.—Four (ANSP 12692) of the five cervical vertebrae described by Cope as having been found in association with the mandibles and the skull fragments have well-preserved centra, but lack most of their processes. The axis and the third cervical were not found. All of these vertebrae have both epiphyses attached to the centra.

Atlas: The atlas (ANSP 12941), as mentioned by Cope (1868b, p. 148), exhibits a rather close resemblance to the corresponding cervical of *Balaenoptera acutorostrata.* This resemblance is most marked in the relative transverse diameter of the neural canal, the ventral position of the transverse processes, and the obliquity of the cuplike anterior articular face of the centrum. These anterior articular facets are separated ventrally by an interval of 25 mm. In this interval, there is a transverse, very obtuse *tuberculum atlantis.* The transverse process is compressed

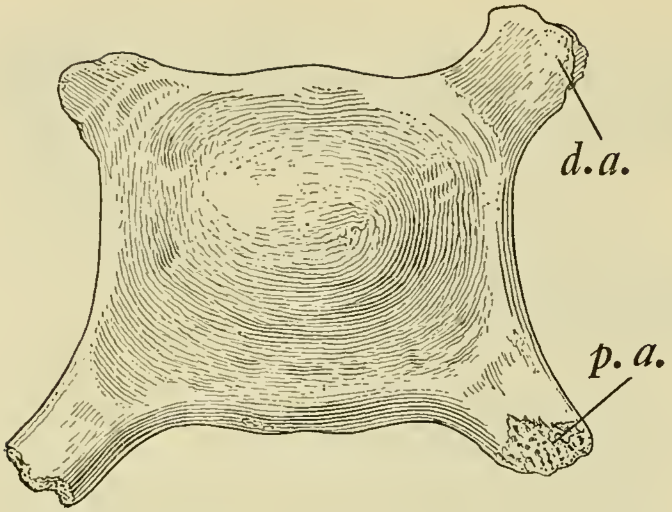

Figure 42.—Anterior view of fourth cervical, ANSP 12692, of *Eschrichtius cephalus* Cope. Abbrs.: d.a., diapophysis; p.a., parapophysis.

anteroposteriorly and perforated at the base by a vertebrarterial canal. The neural spine is not developed. The measurements (in mm.) are as follows: greatest vertical diameter, tip of vestigial neural spine to ventral face of centrum, 163; and greatest vertical diameter of neural canal anteriorly, 95.

Fourth Cervical: The centrum (ANSP 12692; fig. 42) is subrectangular in outline, convex anteriorly and concave posteriorly. The neural arch is destroyed except for the basal portion of the left pedicle and of the anteroposteriorly compressed left diapophysis. The obliqueness of the downward slope of the exteroventrally directed parapophyses renders it improbable that the para- and diapophyses were connected distally to inclose the vertebrarterial canal. The slender parapophyses are anteroposteriorly compressed. The maximum diameter of the neural canal is 101 mm. The anterior profile of the centrum of the corresponding cervical of *B. acutorostrata* (USNM 256498) is a flattened elliptical oval.

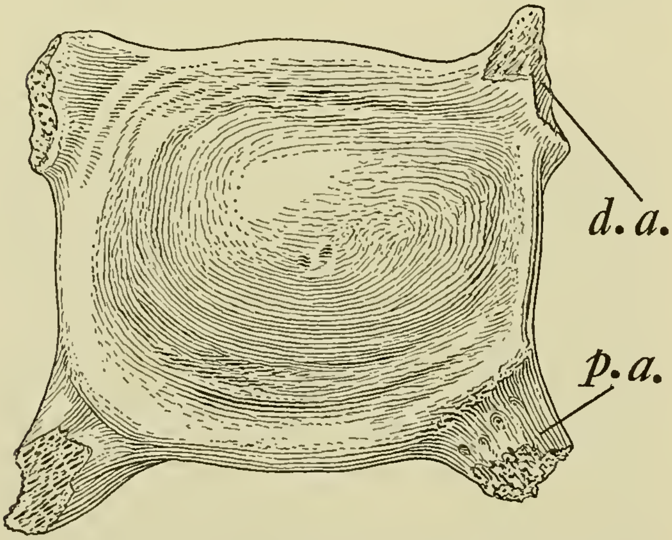

Figure 43.—Anterior view of fifth cervical, ANSP 12692, of *Eschrichtius cephalus* Cope. Abbrs.: d.a., diapophysis; p.a., parapophysis.

Fifth Cervical: The anterior face of the centrum is more subquadrate in outline (ANSP 12692; fig. 43) than the preceding, convex anteriorly and concave posteriorly. The neural arch is destroyed except for the basal portion of the left pedicle; the anteroposteriorly compressed base of the right diapophysis is also preserved. The parapophyses are directed more downward than those on the fourth cervical and probably were not connected distally by an osseous isthmus with the diapophysis. The floor of the neural canal is more flattened than on the sixth and seventh cervicals. The anterior profile of the centrum of *B. acutorostrata* is more nearly elliptical.

Figure 44.—Anterior view of sixth cervical, ANSP 12692, of *Eschrichtius cephalus* Cope. Abbrs.: d.a., diapophysis.

Sixth Cervical: The centrum (ANSP 12692; fig. 44) is ovoidal in outline viewed from in front, convex anteriorly, and concave posteriorly. Except for the basal portions, the pedicles of the neural arch and the conjoined anteroposteriorly compressed diapophyses are destroyed. The diapophyses appear to have been bent backward to some extent. No vestige of the parapophysis persists. The broad floor of the neural canal is elevated medially. The width of the elliptical anterior face of the centrum of the corresponding cervical of *B. acutorostrata* is relatively greater than the transverse diameter of the centrum of this fossil cervical.

Seventh Cervical: The profile of the anterior face of the centrum (ANSP 12692; fig. 45) is broadly subovate and the broad floor of the neural canal is less elevated medially than on the preceding cervical. All of the neural arch,

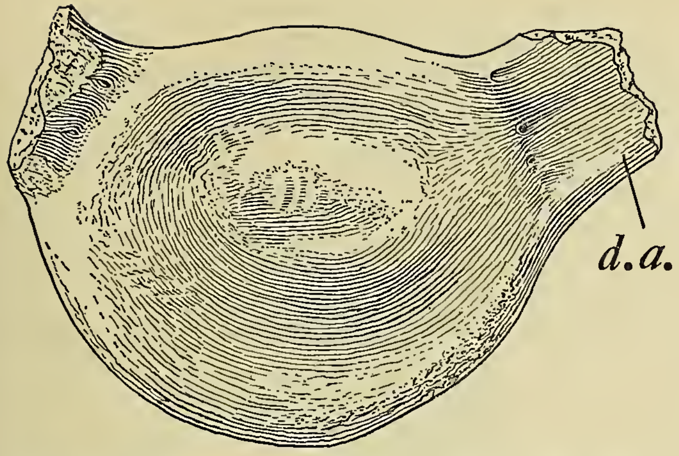

FIGURE 45.—Anterior view of seventh cervical, ANSP 12692, of *Eschrichtius cephalus* Cope. Abbrs.: d.a., diapophysis.

except the basal portions of its pedicles, is missing. The anterior face of the anteroposteriorly compressed basal portion of the diapophysis is excavated and is inclined slightly forward. The parapophysis was not developed. A greater relative width and a more elliptical anterior outline of the centrum distinguish the same cervical of *Balaenoptera acutorostrata* from the seventh cervical of this fossil mysticete.

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

	C.4	*C.5*	*C.6*	*C.7*
Anteroposterior diameter of centrum	20	22	22	29
Vertical diameter of centrum anteriorly	103	108	110	108
Transverse diameter of centrum anteriorly	118	120	120	137

CAUDAL VERTEBRAE.—Neither of the two caudal vertebrae listed by Cope (1868b, p. 149) are structurally unlike those of other mysticetes. The larger caudal, possibly the fourth or fifth, has the anterior and posterior haemal tubercles on either side of the longitudinal groove or channel for the caudal artery connected by an osseous isthmus. The distally eroded lateral tansverse processes projected outward more than 40 mm. beyond the centrum.

The measurements (in mm.) of this caudal (ANSP 12941) are as follows: anteroposterior diameter of centrum, 131; transverse diameter of centrum anteriorly, 143; and vertical diameter of centrum anteriorly, 121.

Forelimb

The forelimb is relatively short, the combined length of the humerus and radius being slightly more than 27¼ inches (692 mm.) Cope states (1868b, p. 150) that the "forelimb was remarkably short, approaching the species of *Balaena*, and differing from *E. robustus*, still more from the Sibbaldii and Balaenopterae and most from *Megaptera longimana*."

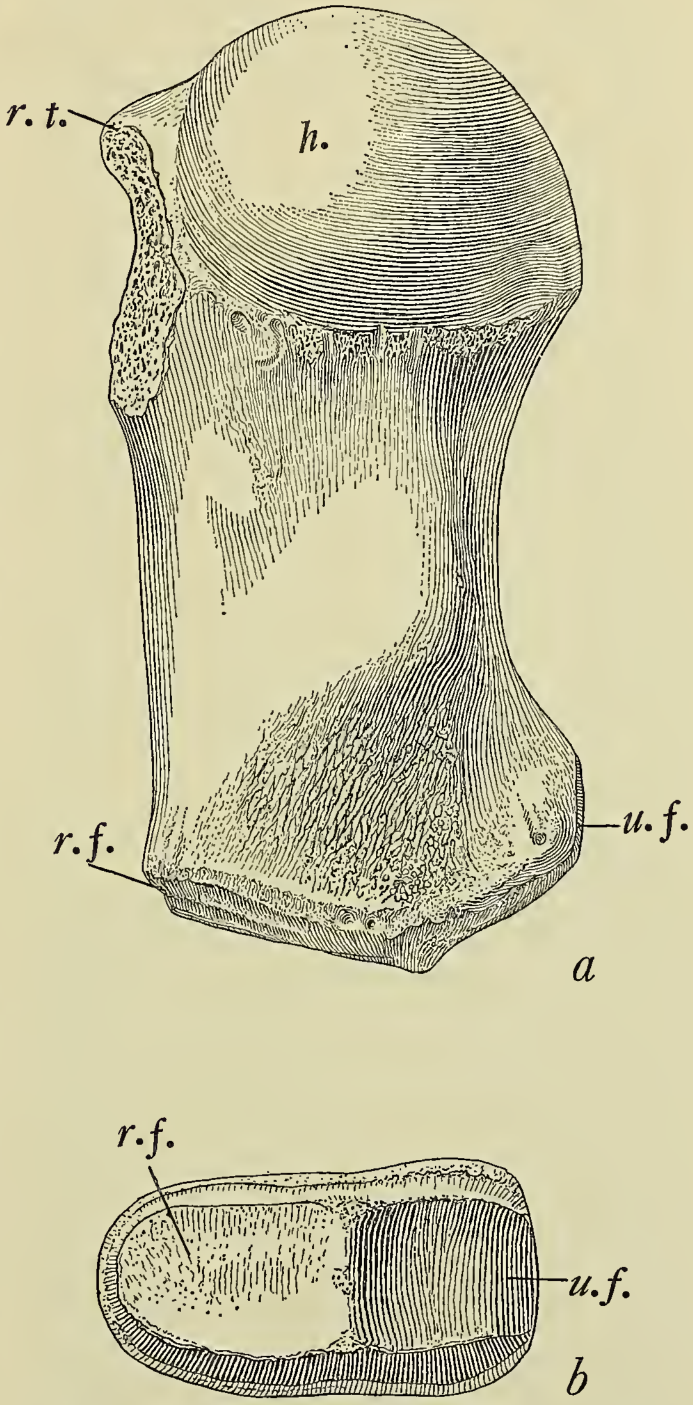

FIGURE 46.—Views of left humerus, ANSP 12691, of *Eschrichtius cephalus* Cope: *a*, external view; *b*, view of distal end. Abbrs.: h, head; r.f., radial facet; r.t., radial or greater tuberosity; u.f., ulnar facet.

HUMERUS.—The type left humerus (ANSP 12691) is complete with the exception of eroded areas on the proximal end. The greater tuberosity (fig. 46a) is eroded and a considerable portion is missing. On the proximal end there is a large circular eroded area at least 80 mm. in diameter and 10 to 15 mm. in depth which commences on the anterior border of the head and extends forward about half way across the internal face of the shaft. A similarly eroded area of approximately half the diameter of the above-mentioned area is present on the internal face below the greater tuberosity.

An unassociated left humerus (USNM 180) tentatively referred to this mysticete has the internal face of the head eroded, the greater or radial tuberosity is more noticeably worn, and a considerable portion of the distal facet for the olecranon of the ulna is eroded.

The anteroposterior width of the side to side flattened type left humerus exceeds the corresponding measurement of recorded Miocene cetotheres. Although it differs from the left humerus of the lower Pliocene Belgian *Plesiocetus hupschii* figured by Van Beneden (1885, pl. 24, figs. 2–3) in important details, the main dimensions of the Calvert humerus are approximately the same as the latter. On the humerus of *P. hupschii* there is a large triangular facet on the posterior face of the distal end of the shaft for articulation with the olecranon process of the ulna; the external face lacks the elevation for muscular attachment, and the greater tuberosity is reduced and does not project dorsal to the level of the articular head but is obliquely truncated in a dorsoanterior direction.

Both epiphyses of the type left humerus are firmly fused with the shaft. The head (fig. 46a) is subelliptical in outline, placed obliquely on the shaft, facing outward and backward. The rough and pitted articular surface on the head is set off from the shaft by bone of a quite different texture; the general appearance of the head suggests that it was enveloped by capsular cartilage. The greater tuberosity is imperfectly preserved on the type humerus as well as on the referred humerus (USNM 180), but enough remains to indicate that it was well developed.

Both of these humeri have an elevation near the middle of the external face for muscular insertion, possibly the short head of M. triceps. Viewed from the external side (fig. 46a), the anterior profile, with the exception of the greater tuberosity, is nearly straight, while the posterior profile is strongly concave, with the deepest indentation at level of the above-mentioned elevation. At the proximal end of the shaft on the internal face between the head and the greater tuberosity is a large rounded protuberance, possibly in part for the insertion of M. supraspinatus. The anterior or radial face of the shaft is rather thick and convexly curved from side to side. The hinder face of the shaft is somewhat broader and more flattened. The distal end of the shaft is more strongly expanded anteroposteriorly on the type humerus than on the larger referred left humerus. On the distal end of the shaft (fig. 46b) the ulnar articular surface is slightly larger than the radial facet and these two facets are separated by a low transverse crest. The ulnar facet has the shape of an unsymmetrical saddle and extends upward on the hinder face of the distal end of the shaft for a short distance. It is slightly concave from side to side and meets the radial facet at an obtuse angle. Both the radial and ulnar facets are deeply pitted.

Measurements (in m.m.) of the humerus are as follows:

	Eschrichtius	*cephalus*	*Plesiocetus hupschii*
	ANSP 12691 Left	*USNM 180 Left*	*MHNB 99 Left*[1]
Greatest length of humerus	296	318	300
Greatest anteroposterior diameter of proximal end	155	177+	—
Greatest anteroposterior diameter of head	130.5	140	136
Greatest exterointernal (transverse) diameter of head	116	133	—
Least anteroposterior diameter of shaft	112	131	108
Least exterointernal (transverse) diameter of shaft	76.5	75	—
Greatest anteroposterior diameter of distal end	136	162	135
Greatest exterointernal (transverse) diameter of distal end	74	91.5	82
Greatest anteroposterior diameter of radial facet	77	92	—
Greatest anteroposterior diameter of ulnar facet	80	99±	—

[1] Measurements from Van Beneden, 1885, pl. 24, figs. 2–3.

RADIUS.—At the proximal end the epiphysis is firmly ankylosed to the shaft of the left radius (ANSP 12691); a portion of the distal end of the shaft is broken off and lost. This limb bone (fig. 47a) when complete was longer than that of *Pelocetus calvertensis* (Kellogg 1965, p. 39, fig. 23a) and the anteroposterior diameter (89.5 mm.) of the proximal end exceeded slightly the corresponding measurement (84 mm.) of the right radius of *P. calvertensis.* The somewhat flattened shaft is most strongly bent backward on the proximal third of its length. The proximal facet (fig. 47b) which articulated with the radial facet of the humerus is shallowly concave and its anteroposterior diameter is greater than

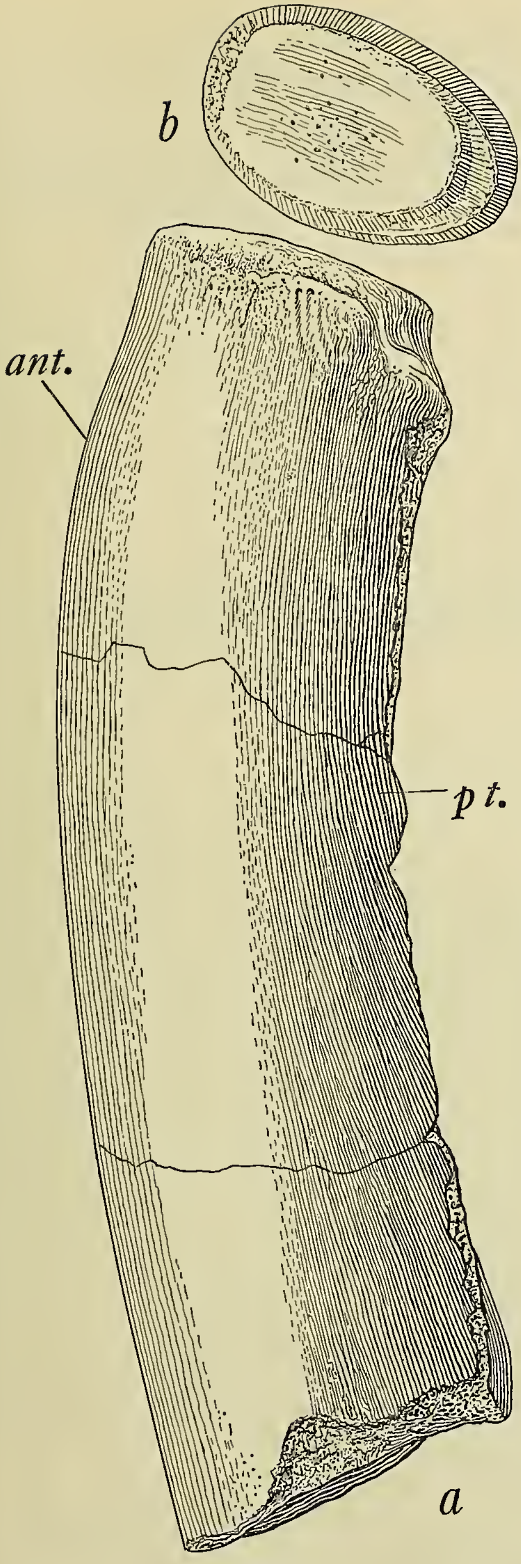

Figure 47.—Views of left radius, ANSP 12691, of *Eschrichtius cephalus* Cope: *a*, internal view; *b*, view of proximal end. Abbrs.: ant., anterior face; pt., posterior face.

its transverse diameter. An indentation on the posterior face of the proximal end marks the location of the articular area for its contact with the ulna. The internal and external faces of the shaft are slightly convex.

Measurements (in mm.) of left radius, ANSP 12691 are as follows: Greatest length, 396; anteroposterior diameter of proximal end, 89.5; transverse diameter of proximal end, 64.5; anteroposterior diameter of distal end, 110; transverse diameter of distal end, 53.

Ulna.—A large right ulna (USNM 23749) that has the shaft broken off 280 mm. below the horizontal articular surface of the olecranon fossa and a considerable portion of the posterior border of the olecranon process eroded is tentatively referred to this mysticete. This ulna is more massive, larger, and presumably longer than those of all other Calvert Miocene mysticetes and probably belonged to a larger individual than the type. Viewed from the side, the posterior profile is slightly more curved than the anterior profile. In cross section the shaft is ovoidal and not transversely compressed; the minimum anteroposterior diameter of the shaft is 66 mm., and the minimum transverse diameter is 48 mm. The enlarged and thickened olecranon process is bent inward and this curvature modifies the direction of the upper, more vertical portion of the articular surface of the greater sigmoid cavity. The transverse diameter of the horizontal articular surface is 64 mm., and the width of the upper articular surface is about 50 mm.

Manus.—The position and homologies of the two carpal bones (ANSP 12691) associated with the humerus and radius are uncertain. The preservation of these two indicates that some if not all of the five or six carpal bones comprising the manus were ossified. These carpal bones have their flexor and extensor surfaces flattened and their irregular circumferential borders pitted and roughened for attachment of the intervening cartilaginous tissue which normally in Recent mysticetes occupies the interspaces between them. The greatest dimension of the largest carpal is 63.5 mm.

The single phalange is noticeably flattened, slightly constricted near the middle of its length, and widened distally. Both ends are roughened for the attachment of the cartilaginous tissue that connects the phalanges of each finger enclosed within the integument of the flipper. This finger bone measures 80.5 mm. in length and 57 mm. in width.

ESCHRICHTIUS PUSILLUS Cope

Balaenoptera pusilla Cope, 1868c, Proc. Acad. Nat. Sci. Philadelphia, vol. 20, no. 3, p. 159. [*Nomen nudum.*]

Eschrichtius pusillus Cope, 1868d, Proc. Acad. Nat. Sci. Philadelphia, vol. 20, no. 3, p. 191

Cetotherium pusillus Cope, 1890, American Nat., vol. 24, no. 283, pp. 612, 616. [Antedated by *Cethotherium pusillus* Alexander von Nordmann, Palaeontologie Südrusslands, p. 348, pl. 28, figs. 6, 6a, 1860; a second cervical from Taman and the vicinity of Kertsch, Bessarabia.]

Cetotherium parvum Trouessart, Catalogus mammalium tam viventium quam fossilium, Berlin, fasc. 5, p. 1071, 1898. [To replace *C. pusillus* Cope, antedated.]

Type Specimen: Many vertebrae, "of which one dorsal, six of the lumbars, and one caudal may serve as types," ANSP 12769; and a fragment of a right mandible (length, 381 mm.), not since located in the collection of the Academy of Natural Sciences of Philadelphia. Collector, James T. Thomas.

Type Locality: Presumably excavated in a marl bed on the De la Brooke estate, about 1 mile east of site marked Patuxent (U.S.G.S. Brandywine sheet), 2 miles east of Hughesville, Charles County, Maryland. Calvert formation, middle Miocene.

Diagnosis: Cope (1868c, p. 159) announced the presentation to the Academy of Natural Sciences of Philadelphia of a portion of the mandible of the smallest known finner whale whose length was about 18 feet which he named *Balaenoptera pusilla*, and commented that "some vertebrae in the collection were also supposed to belong to the same." Later the same year, when Cope (1868d, pp. 191–192) published the detailed description and measurements of this right mandible (length, 15 inches [381 mm.]; depth, 2 inches [50.8 mm.]; circumference, 5 inches 2.5 lines), he referred to this mysticete under the designation *Eschrichtius pusillus*. Cope (1868d, p. 191) also stated that "this species is indicated by many vertebrae of which one dorsal, six of the lumbars, and one caudal may serve as types." Some years later at least 28 cetacean vertebrae which were available for examination, when the descriptions of both *E. pusillus* and *Megaptera expansa* were published, were assigned the same catalog number (ANSP 12769). Among these vertebrae were the centra of a first dorsal, a posterior dorsal, four lumbars, and 2 caudals which presumably were regarded as belonging to *Eschrichtius pusillus* by Cope. The measurements published by Cope (1868d, p. 192) were relied on in selecting one dorsal, one lumbar, and one caudal from this assemblage for allocation to *E. pusillus*.

No dorsal vertebra having dimensions that correspond precisely to those published by Cope (1868d, p. 192) was recognized among the vertebrae (ANSP 12769) listed under this species in the catalog of the Academy. Converted measurements (in mm.) are as follows: length, 125; height of articular face, 89; width of articular face, 108; width of neural canal, 34. There is in this lot a posterior dorsal, probably the tenth or eleventh, with epiphyses firmly ankylosed to the centrum that has the anterior articular end ovoidal in outline, but only basal remnants of the pedicles of the neural arch and the transverse processes. Measurements (in mm.) of this dorsal (pl. 46, fig. 3) are as follows: anteroposterior diameter of centrum, 128; vertical diameter of centrum posteriorly, 88; transverse diameter of centrum posteriorly, 109; and transverse diameter of neural canal, 34+.

The "depressed oval" shape of the end and regular curvature of the centrum ventrally, mentioned by Cope, apply equally well to this vertebra. A dorsal vertebra of these dimensions would indicate a cetothere comparable in size to *Pelocetus calvertensis*.

The lumbar (pl. 46, fig. 1) is described by Cope as having the usual ventral longitudinal keel, the articular end "not quite so transverse," and small not noticeable venous canals. The measurements (converted in mm.) are given as follows: length, 125; height articular surface, 99; width articular surface, 106; and width of neural canal, 21. One lumbar of a mature individual that retains remnants of the pedicles of the neural arch and of the rather broad transverse processes can be described in the above terms; its measurements, however, are less in agreement. They are as follows: anteroposterior diameter of centrum, 127; vertical diameter of centrum anteriorly, 100; transverse diameter of centrum anteriorly, 119; and transverse diameter of neural canal, 26±. A large, but a slightly smaller whale is indicated than the one that had the preceding dorsal.

As regards the caudal vertebra, Cope states that the transverse processes are not perforated at the base, the ventral longitudinal keels are very slight, and the neural arch occupies three-fifths the length of the centrum. The published measurements (converted in mm.) are as follows: length, 102; height articular surface, 96; width articular surface, 101; height to zygapophyses, 131. One caudal (ANSP 12769; pl. 46, fig. 2) in the Academy's collection has quite similar measurements (in mm.), as follows: anteroposterior diameter of centrum, 102; vertical diameter of centrum anteriorly, 99; transverse diameter of centrum anteriorly, 100; and zygapophyses to ventral face of centrum, 131. This caudal vertebra, however, belonged to a somewhat smaller whale than either the lumbar or the dorsal; it lacks both epiphyses, the transverse processes are broken off at the base, as are also the metapophyses and the neural spine. This fourth or fifth caudal lacks developed anterior haemapophyses; the rather broad posterior haemal tubercles bound the shallow longitudinal haemal groove. The profile of the posterior face of the centrum approaches hexagonal more closely than that of the anterior face.

Two at least and possibly three different species of cetotheres are represented among the eight vertebrae which presumably were referred to *E. pusillus* by Cope (1868d, pp. 191–192).

There is no certainty that the following description published by Cope (1869, p. 11) was based on the type

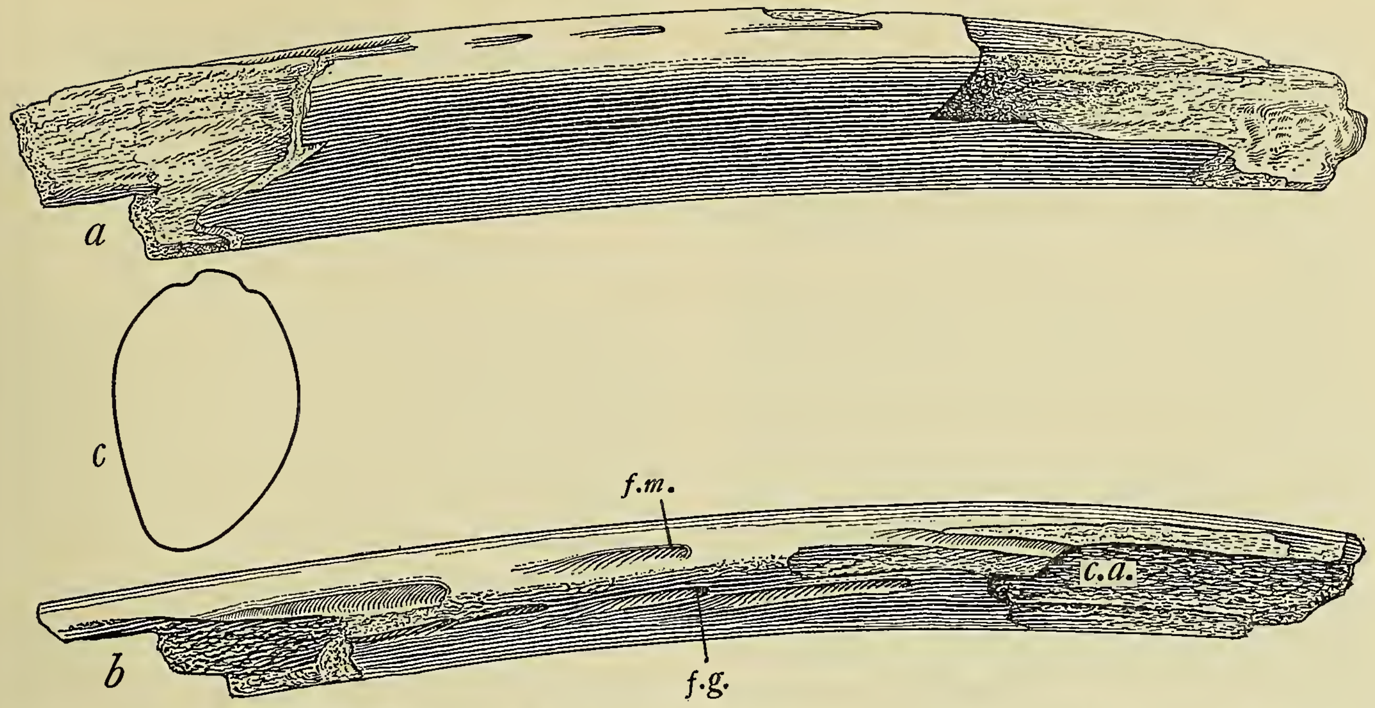

FIGURE 48.—Views of right mandible, ANSP 12912, labeled *Eschrichtius pusillus* Cope: *a*, external view; *b*, dorsal view; *c*, cross section 210 behind broken anterior end. Abbrs.: c.a., alveolar or mandibular canal; f.g., gingival or alveolar foramen; f.m., mental foramen.

mandible: "upper edge nowhere broad and with a deep or shallow groove below it on inside; less decurved; less convex externally; small."

The mandible from the mouth of the Patuxent River corresponding to the cited measurements and referred by Cope (1869, p. 11) to this species was not located in the collections of the Academy. This mandible, according to Cope (1869, p. 11), "differs from the type in having the inner groove on the superior margin much less marked." On the preceeding page, Cope (1869, p. 10) attributes provisionally to *E. pusillus* a portion of a black cranium (St. Marys fm.) which "serves to confirm the affinities expressed in the name established on the ramus of the mandible."

There is, however, a section of a right mandible (ANSP 12912; figs. 48a, b, 463 mm.) in length from Charles County, Maryland labelled "*Cetotherium pusillum* Cope, Type," which is black in coloration and undoubtedly was derived from the St. Mary's formation in that region. At a point 210 mm. behind the broken anterior end of this mandible (fig. 48c), the vertical diameter is 67 mm. and the transverse 44.5 mm. Right and left mandibles (ANSP 12918), measuring respectively 1107 mm. and 1063 mm. in a straight line as preserved, are also labelled as from near the mouth of the Patuxent River and presumably were found either in the Calvert or the Choptank formation. Nevertheless, neither of these mandibles (ANSP 12912 and ANSP 12918) are specifically mentioned in the several references made to this species by Cope.

In review it should be noted that although Cope (1868c, p. 159) originally applied the name *Balaenoptera pusilla* to a portion of the right mandible; vertebrae in the collection of the Academy were "supposed" to belong to the same species. Writing in the next month of the same year, Cope (1868d, p. 191) specifically designated eight vertebrae which "may serve as types," and commented that vertebrae of several small species were procured by J. T. Thomas; and since they are "the most abundant and therefore characteristic of the beds, I think best to describe them from these." A year later Cope (1869, pp. 10–11) unequivocally stated that the name *pusillus* was "established on the ramus of the mandible." This mandible, however, belonged to a smaller species of mysticete than the vertebrae. The vertebrae of the type series of *E. pusillus* are devoid of all processes and hence any allocation must be made on the configuration and comparative demensions of the centra.

Subsequent acquisition of additional specimens led Cope (1869, p. 10) to recognize six species of *Eschrichtius*, "whose characters offer nothing as yet to separate them from the scarcely extinct type *E. robustus* Lillj." and of these five were characterized by their mandibles as set forth in an accompanying table. It is now certain that not one of the mandibular types of the fossil mysticetes referred to *Eschrichtius* by Cope exhibits even a remote resemblance to the mandible of *Eschrichtius robustus*.

More than twenty five years later, Cope (1895a, p. 145) shifted his generic allocation of this mysticete to *Cetotherium* *pusillus* and commented on an incomplete mandible "longer than any that have come under my observation, which now number five individuals. Its length is 723 mm., and the diameters at a fracture near the middle are as follows: vertical, 71 mm.; transverse, 47 mm. It is a little larger than those that I have seen hitherto, but agrees with them in every respect." This mandible, USNM 9351, is recorded as from near the mouth of the Patuxent River, Maryland.

The original 381 mm. long portion of a right mandible was described by Cope (1868d, p. 192) as differing from the type mandible of *Balaena prisca* Leidy by the presence of a median dorsal ridge paralleled by a groove on the internal side into which the small gingival or nutritious foramina open. This groove has no especial significance since it is present on several mandibles of obviously different cetotheres. Furthermore, this ramus was moderately convex on both faces, the outer face more so than the inner, and its size was about "one third the same portion of the jaw of *B. prisca*." A vertical diameter of two inches (50.8 mm.) is given by Cope for this type mandible of *E. pusillus*, which is about two thirds of the corresponding measurement (72 mm.) of the type mandible of *B. prisca*.

In summary, the nondiagnostic characterization of the type mandible (apparently lost) and of the eight vertebrae mentioned by Cope and the uncertainty relative to the particular vertebrae selected by Cope for specific designation among the mixed assortment of 28 vertebrae, which may represent two or possibly three different cetotheres, render it difficult if not impractical to formulate a satisfactory diagnosis by which this species could be discriminated. Since the validity of *Eschrichtius pusillus* can not be satisfactorily demonstrated by critical comparisons with a rather unusual varied assemblage of Calvert cetothere skeletal materials, the name should be ignored and discarded.

MEGAPTERA Gray

Megaptera Gray, 1846, Ann. Mag. Nat. Hist., London, ser. 1, vol. 17, no. 10, p. 83. February 1846.

Type Species: *Megaptera longipinna* Gray (=*Balaena longimana* Rudolphi = *Balaena novae angliae* Borowski, 1781 Gemeinnmüzzige Naturgeschichte des Thierreichs . . ., vol. 2, pt. 1, p. 21).

Type Specimen: Based on *Balaena novae angliae* Brisson, 1762, Regnum Animale, Leyden, p. 221. The Pflokfisch, the humpback whale. New England.

Diagnosis: This genus was characterized by Gray (1864, p. 350) as follows:

"The hunchbacked whales have a very low broad dorsal, a very long pectoral fin; arm bones strong, broad; fingers very long, joints 3 to 10; the cervical vertebrae are often anchylosed; the neural canal high, triangular, with angles rounded, as high as broad.

The pectoral fin about one-fifth of the entire length of the animal. The second cervical vertebra with two short, truncated, subequal lateral processes. Ribs 14, first single-headed. Vertebrae 54 or 55."

MEGAPTERA EXPANSA Cope

Megaptera expansa Cope, 1868d, Proc. Acad. Nat. Sci. Philadelphia, vol. 20, no. 3, p. 193.

Eschrichtius expansus Cope, 1869, Proc. Acad. Nat. Sci. Philadelphia, vol. 21, no. 11, p. 11.

Cetotherium expansus Cope, 1890, American Nat., vol. 24, no. 283, p. 616.

Siphonocetus expansus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 140, pl. 6, fig. 5.

Type Specimen: Cervical vertebrae, ten dorsal vertebrae, and several lumbar vertebrae. The following are co-types in Cope's original description: (1) numerous vertebrae collected by James T. Thomas, (2) several vertebrae collected by Oliver N. Bryan, and (3) some vertebrae from Virginia in the collection of the Academy. The anterior and median dorsal vertebrae, for which measurements are published by Cope (1868d, p. 193), are now designated as the lectotype, ANSP 12769.

Type Locality: Not designated: original description based on vertebrae from three localities, including (1) "numerous vertebrae" found near the Patuxent River, not far from the home of James T. Thomas, which was located about 1 mile east of site marked Patuxent (U.S.G.S. Brandywine sheet), 2 miles east of Hughesville, Charles County, Maryland, Calvert formation; (2) "several vertebrae" from Nomini Cliffs, Westmoreland County, Virginia, presented to the Academy by Oliver N. Bryan [of Marshall Hall, Charles County, Maryland] and probably from Calvert formation; and (3) vertebrae from Virginia.

Diagnosis: The diagnostic criteria for *Megaptera* quoted by Cope (1868b, p. 147) are "transverse processes and parapophyses of second and succeeding cervical vertebrae always separate and not united at their extremities;" and those of second cervical usually very broad at their origins. Cope (1868d, p. 193) did not describe the cervicals of *M. expansa* which he remarked were not in his possession at that time. These cervicals are characterized, however, by Cope, as having a greater anteroposterior diameter than those of *Eschrichtius*, but possessing quite similar di- and parapophyses. Two dorsal vertebrae (ANSP 12769) alone among the 28 vertebrae acquired for the collections of the Academy before and during 1868 exhibit sufficiently close agreement with the measurements and brief description published by Cope (1868d, p. 193) to be regarded as the original specimens. The measurements (in mm.) of these two vertebrae, which agree most closely with the fifth and ninth in the dorsal series, are as follows, respectively: anteroposterior diameter of centrum, 70, 82; transverse diameter of centrum anteriorly, 103+, 93; vertical diameter of centrum anteriorly, 68, 77; and transverse diameter of neural canal, 46, 31. On the vertebra regarded as the fifth dorsal, the diapophysis projects outward from the pedicle of the neural arch; each posterodorsal lateral demifacet is large and protuberant. Concave lateral surfaces accentuate the projecting circumferential rims of articular ends of the centrum. The transverse process of the ninth projects from the dorsolateral surface of the centrum, the normal condition. Various mysticetes have vertebral centra with more or less subcordate articular ends. Among the European species those of *M. expansa* seem to exhibit the nearest resemblance to those of *Mesocetus longirostris* (Van Beneden, 1886, pl. 40), with which several agree rather closely in size. Cope's comments on the dorsal and lumbar vertebrae have no special significance except to indicate size and general appearance.

In 1869, Cope transferred this species to the genus *Eschrichtius* and referred to it some limb bones and three pieces of mandibles of two individuals from the mouth of the Patuxent River, in Maryland, incorrectly stated to belong to the collection of P. T. Tyson of the Geological Survey of Maryland. He did not describe the limb bones, but gave a description and measurements of one mandibular fragment from which it appears that the chief peculiarity of the ramus was the flat upper surface of the proximal portion in which the internal gingivalforamina were located. According to Cope (1869, p. 11) "the inferior margin is a rather obtuse angle; the general form is not compressed, nor much convex externally, as in *E. priscus*." In the comparative table of the diagnostic features of four species referred to *Eschrichtius* the mandible of *E. expansa* was characterized as having "upper edge broad behind only and these bearing only the inner series of foramina. Elsewhere with a median ridge and rows of foramina below on each side; much decurved; less convex externally. Medium." The mention made here to the "median ridge [anterior to the broad flat upper surface] and the rows of foramina below on each side" indicates in that year Cope attributed some significance to the position of the lateral rows of foramina.

At a later date Cope (1895a, p. 140) again revised the generic allocations of some of the Calvert mysticetes and transferred *expansus* to the new genus *Siphonocetus* which was characterized by having the alveolar groove and dental canal distinct, and also the alveolar groove roofed over and perforate. True (1912, p. 5) suspected that "these characters are of no value." Further critical comments are cited under *Siphonocetus*.

Cope (1895a, p. 140) also remarks that the two mandibular fragments first described (Cope, 1869, p. 11) were the property of the Maryland Academy of Sciences, and that there was another smaller fragment (Cope, 1895a, pl. 6, fig. 5) in the collection of Johns Hopkins University. This right mandible fragment was labeled *Cetotherium expansum* in Cope's handwriting and marked "15," formerly in the Johns Hopkins University collection (now USNM 12722), and measures 175 mm. in length. It is more convex externally at the anterior end than shown in the illustration published by Case (1904, pl. 25, fig. 3). There are no external mental foramina, but the internal single gingival row is about 10 mm. below the dorsal margin. One cannot be certain whether or not there are separate mandibular and gingival canals, although at the anterior end there is a grayish indurated sandy filling about 7 mm. broad below the dorsal border of the ramus and below the filling, but separated by a bony layer, is a deep concavity not so filled. The latter is certainly the mandibular canal. The blackish color of this short mandibular fragment suggests that it was derived from the St. Marys formation of St. Marys County, southern Maryland.

Inasmuch as the fossil remains on which *M. expansa* was established consisted solely of vertebrae, the allocation of portions of mandibles from several sources in the absence of associated skeletal elements would appear to require more justification than advanced by Cope. Accumulated materials have since shown that some of the original type vertebrae of *M. expansa* (although part of an obviously mixed assortment) are questionably separable from those of *Eschrichtius pusillus*. The fact that the internal gingival foramina are described as being located on the dorsal flattened surface of the mandible would indicate that Cope, at that time, did not attach much significance to their being below the median dorsal ridge in other specimens. These internal foramina usually begin proximally on the internal side and gradually approach or rise to the dorsal margin, ending by crossing over the margin at the distal extremity of the mandibular ramus. One would expect, therefore, to find these foramina close to or on the margin in some pieces of the mandible and lower down on others. The Belgian species *Mesocetus pinguis* (Van Beneden, 1886, pl. 44, figs. 1, 2) shows this kind of an arrangement. If one takes into consideration the extent of erosion on this mandibular fragment, a more plausible interpretation of the location of these foramina becomes obvious. The wearing down of the median longitudinal ridge has flattened somewhat the dorsal surface of the ramus; the gingival foramina were, however, actually below this surface when the ramus was unworn.

Among the ten dorsal vertebrae mentioned by Cope (1868d, p. 193) as originally included among the numerous vertebrae in the Thomas collection from Charles County, Maryland, and from the Nomini Cliffs, Westmoreland County, Virginia, presented by Oliver N. Bryan, are two dorsals whose measurements were given in the type description of *Megaptera expansa*. One of these two dorsals, the ninth (pl. 46, fig. 6), agrees fairly closely in the dimensions and shape of the centrum to the corresponding dorsal vertebra of USNM 23494. The other, now regarded as the fifth dorsal (ANSP 12769; pl. 46, fig. 5), however, belongs in the dorsal series of another Calvert cetothere, since it has a wide dorsoventrally compressed subcordate anterior end on the centrum and is quite obviously different in profile. Another vertebra, the eighth dorsal (pl. 46, fig. 4), in this collection of ten, is smaller than its counterpart in the USNM 23494 skeleton. At least two different cetotheres are thus represented among the dorsals designated by Cope as type vertebrae. All of these vertebrae possess mere basal remnants of their processes and they do not exhibit other features on which a precise characterization may be based. The identification of the original type vertebrae of *M. expansa* is further complicated by the association under one catalog number (ANSP 12769) of 28 or more vertebrae, in part at least originally included among the many vertebrae on which Cope (1868d, p. 191) based *Eschrichtius pusillus*, a somewhat larger mysticete. No justification exists either on the basis of the supposed diagnostic characters listed by Cope or on the shape, characteristics and dimensions of any of the vertebrae then available to him for referring *Megaptera expansa* either to *Megaptera*, *Eschrichtius*, *Siphonocetus*, or *Cetotherium*. The species *Megaptera expansa* is, therefore, held to be indeterminable and to be ignored henceforth.

MESOCETUS Van Beneden

Mesocetus Van Beneden, 1880, Bull. Acad. roy. Sci., Lettres et Beaux-Arts Belgique, Bruxelles, ser. 2, vol. 50, no. 7, p. 22.

Type Species: *Mesocetus longirostris* Van Beneden. (Type fixed by Hay, Bull. no. 179 U.S. Geol. Surv., Dept. Interior, 1902, p. 600).

Diagnosis: Van Beneden's rather brief generic diagnosis of *Mesocetus* (1880, p. 22) is limited to the relations of bones that comprise the top of the cranium—the well-developed parietals and the long space between the [apex of] supraoccipital and the frontals. Subsequently from Croatia [Yugoslavia] under the generic name *Mesocetus*, Van Beneden did describe and illustrate as *M. agrami* a posterior end of a left mandible (1884, pl. 2, fig. 10) and also a basicranium with attached tympanic bulla and periotic. Comments in this memoir apparently led Cope (1895a, p. 153) to state that Van Beneden established *Mesocetus* for mysticetes that resemble odontocetes in having the transverse widening of the condyle situated at the middle of the relatively thin and laterally compressed posterior end of the mandible. The articular condyle is thus situated below the dorsal rim of the posterior portion of the ramus behind the coronoid process. Van Beneden observes that the condyle of *M. agrami* is flattened and widened with projecting lateral edges, but is not set off from the ramus like the head of a femur, and is adapted to articulate almost vertically with the glenoid surface of the squamosal. As a result of his own observations, Van Beneden (1884, p. 18) attached great importance to the condyle for the establishment of the generic sections among mysticetes.

MESOCETUS SIPHUNCULUS Cope

Mesocetus siphunculus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 153.

Type Specimen: AMNH 22665. Anterior portion of right mandible and its detached condyle; coronoid process and the portion of the ramus between coronoid process and condyle destroyed. Collector, E. D. Cope; April 1895.

Type Locality: Pamunkey River, probably near Hanover, Hanover County, Virginia. Associated with a turtle (*Syllomus crispatus* Cope), vertebrae of at least four Calvert odontocetes and the anterior ends of two mandibles of a smaller cetothere. Marl,[2] Calvert formation, middle Miocene.

Referred specimens: (1) Left humerus, essentially complete, and (2) the first dorsal and centra of two other anterior and one middle dorsal vertebrae (pl. 47); Pamunkey River, Hanover County, Virginia, AMNH 22669, coll. E. D. Cope, April 1895.

Diagnosis: Cope (1895a, p. 153) states that the mandibular ramus "has no large dental canal, but it is almost entirely filled with spongy bone of moderate coarseness. The gingival canals united into a single tube, which is not larger than one of the external gingival canals, and which runs about opposite to them or a little distance below the superior edge. In this disposition of the canals *Mesocetus* differs from any of the genera of Mystacoceti referred to in the preceding pages." This mandible was fractured while being excavated and subsequently repaired under Cope's supervision. It is not now possible to ascertain the actual internal structure. Close scrutiny, however, of similar mandibles confirms the belief that the type mandible of *Mesocetus siphunculus* does not differ appreciably from the internal canal arrangement described under *Siphonocetus priscus*.

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[2] A sample of matrix attached to the type specimen was submitted for heavy mineral analysis to Dr. Lincoln Dryden, Bryn Mawr College. Since the percentage of staurolite exceeded that of tourmaline and zircon, Dr. Dryden was inclined to believe that Cope collected this fossil material from a horizon near the base of the Calvert formation, possibly a foot or so above the contact with the Eocene.

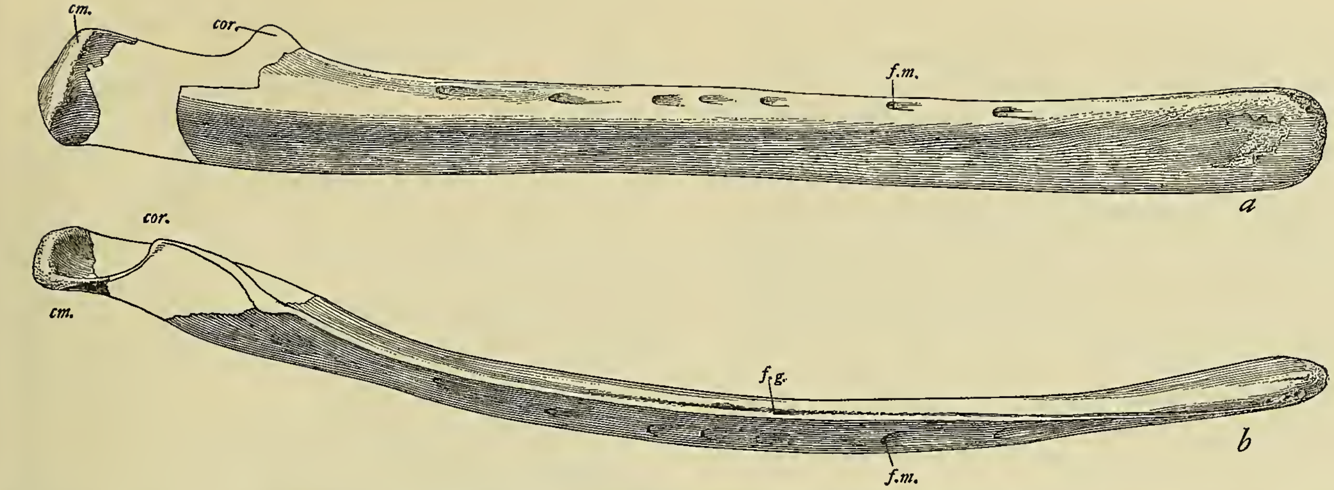

FIGURE 49.—Views of right mandible, AMNH 22665, of *Mesocetus siphunculus* Cope: *a*, external view; *b*, dorsal view. Abbrs.: cm., condyle; cor., coronoid process; f.g., gingival foramen; f.m., mental foramen.

Mandible

The type right mandible of *Mesocetus siphunculus* (fig. 49a) represents a larger cetothere than the left mandible of *Isocetus depauwii* (Van Beneden, 1886, pl. 70; length, 1128 mm.) whose vertical diameter at the distal end is 84 mm. in contrast to 99.5 mm. for the Virginia Calvert species, and 76 mm. 440 mm. behind the anterior end versus 89 mm. 500 mm. behind the anterior end for *M. siphunculus.* The vertebrae associated with the type mandible of *I. depauwii* have the epiphyses loose or detached from the centra, indicating physical immaturity. The type mandible of *M. siphunculus* is also smaller than that of *Mesocetus pinguis* (Van Beneden, 1886, pl. 44, fig. 10; length, 1642 mm.) and is intermediate in size between the latter and *Isocetus depauwii.* If not identical with *I. depauwii* it appears rather closely allied to this Belgian species. Both *M. siphunculus* and *I. depauwii* possess much narrower condyles on the mandibles than *M. pinguis.* The transverse diameters of the mandibular condyles are respectively: 61.5 mm. for *M. siphunculus,* 55 mm. for *I. depauwii,* and 96.5 mm. for *M. pinguis.* The shape of the condyle of *M. siphunculus* (pl. 47, fig. 2) is also somewhat similar to that of *I. depauwii* (Van Beneden, 1886, pl. 70, fig. 8). In making any comparison, it should be noted that the angle of the mandible is broken off below the level of the groove for the internal pterygoid muscle. The internal gingival foramina are not clearly recognizable on the mandible of *I. depauwii* (Van Beneden, 1886, pl. 70, fig. 1); they are situated normally on the internal face of the mandible of *M. siphunculus* (fig. 49b).

Although Cope states that the type mandible of *M. siphunculus* is not strongly convex either on the internal or external side, his diagrammatic figure (Cope, 1896, pl. 12, fig. 6) does not bear this out. The convexity of the external face does, however, exceed that of the internal.

Measurements (in mm.) of the type left mandible are as follows: greatest length in straight line when complete, estimated, 1200±; greatest length as preserved in a straight line, 1128; distance from anterior end to center of coronoid process along outside curvature, 1040; vertical diameter 100 mm. behind anterior end of ramus, 99.5; transverse diameter at same point, 32; vertical diamter 700 mm. behind anterior end of ramus, 89.5; transverse diameter at same point, 58; greatest vertical diameter of hinder end including condyle, 115; greatest transverse diameter of condyle, 61.5.

Humerus

Another skeletal element mentioned by Cope (1895a, p. 154) in his description of *Mesocetus siphunculus,* but not definitely referred to it, is a left humerus (AMNH 22669) which was found near the excavated anterior ends of two right mandibles (lengths, respectively, 167 and 225 mm.) which represent a somewhat smaller cetothere than the type mandible, since the vertical diameter near the anterior end of the longest specimen is 56 mm. This humerus has been split lengthwise but subsequently repaired and the greater tuberosity is eroded; both epiphyses are fused with the shaft. Cope remarks (1895, p. 154) that "the tuberosity is not produced beyond the head, and the olecranar facet is not distinguished by an angle from the remainder of the ulnar facet." Although worn, the conformation of the greater tuberosity does not differ materially from other larger and smaller Calvert humeri. The shape of the ulnar facet is not unusual. The articular surface of the horizontal portion merges with the vertical portion of the ulnar facet in a gradual curve. The features cited by Cope would not be regarded as diagnostic for Calvert cetotheres. Comparison cannot be made with *Isocetus depauwii* as the Belgian humerus was not illustrated by Van Beneden. Whether or not this humerus really belongs to *M. siphunculus* is uncertain.

This left humerus (fig. 50a) has a large, convex head, whose greatest diameter is 107 mm. As in other Calvert cetotheres, the head is placed obliquely on the shaft, facing outward and backward. Between the head and the radial or greater tuberosity there is a shallow groove on the external face that limits the articular surface of the former anteriorly. The small rugose area on the external face below this groove may have served for the attachment of M. mastohumeralis. There is also a large central swelling or knob at the proximal end of the internal face (fig. 50b). The rugose internal surface of the greater tuberosity presumably served as the area for insertion of M. infraspinatus and M. subdeltoideus, and the protruding knob below on the anterointernal angle for a portion of the insertion of M. deltoideus.

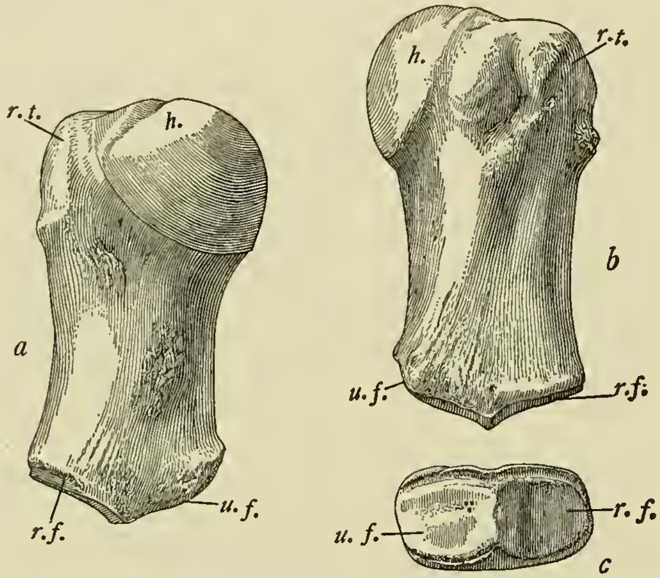

Figure 50.—Views of left humerus, AMNH 22669, of *Mesocetus siphunculus* Cope: *a*, external view; *b*, internal view; *c*, distal view. Abbrs.: h, head; r.f., radial facet; r.t., radial or greater tuberosity; u.f., ulnar facet.

Since the shaft was split lengthwise the median rugose area on the outer surface shown on the line drawing (fig. 50a) may have been over emphasized. This median rugose area may have served for attachment of the short head of M. triceps or M. teres major. A right humerus (USNM 23708) of similar dimensions from the Calvert formation, 1½ miles south of Plum Point, Calvert County, Maryland, lacks this rugose area.

The thick shaft is slightly constricted near the middle of its length, but is flattened exterointernally toward its distal end. At the transversely compressed distal end of the shaft (fig. 50c) the ulnar facet is approximately the same width as the radial facet and is extended upward on the posterior face of the shaft for a short distance. A low transverse crest separates the ulnar facet from the shorter radial facet.

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

	AMNH 22668 Left	*USNM 23708 Right*
Greatest length of humerus	233.5	229
Greatest anteroposterior diameter of proximal end	128	123
Greatest anteroposterior diameter of articular head	107	104
Greatest exterointernal (transverse) diameter of articular head	95	91
Least anteroposterior diameter of shaft	88	87
Least exterointernal (transverse) diameter of shaft	55.5	56
Greatest anteroposterior diameter of distal end	107.5	105
Greatest exterointernal (transverse) diameter of distal end	56.8	56
Greatest anteroposterior diameter of radial facet	57	55
Greatest anteroposterior diameter of ulnar facet (in a straight line)	69.5	65

Vertebra

Dorsal vertebra.—Cope (1895a, p. 154) assigned provisionally to this species a "first dorsal" vertebra (AMNH 22669) "found in immediate contact with the posterior part of the ramus," that is, with the type specimen. The measurements published by Cope (1895a, p. 155) for the "first dorsal" are somewhat at variance with those of the sole anterior dorsal (pl. 47, fig. 1), which lacks both epiphyses, now associated with the type mandible. These measurements (in mm.) are as follows: anteroposterior diameter of centrum, 35; vertical diameter of centrum anteriorly, 56.5; transverse diameter of centrum anteriorly across demifacets, 87.5; greatest vertical diameter of neural canal anteriorly, 30.5; greatest transverse diameter of neural canal anteriorly, 49; and distance between outer ends of diapophyses, 159.5.

Consecutive series of dorsal vertebrae of at least three different Calvert cetotheres, ranging in size from the small *Parietobalaena palmeri* to the larger *Pelocetus calvertensis* are represented in the United States National Museum vertebrate paleontological collections. Structurally all the dorsal series of these Calvert cetotheres conform to one basic pattern. On each side of the anterior dorsals the pedicle of the neural arch is coalesced basally with the corresponding portion of the diapophysis; this combined structure is transversely widened and projects outward as much from the lateral as from the dorsal surface of the centrum on the first, second, and third, and, to a lesser extent, on the fourth dorsal. With the exception of the width (49 mm.) of the neural canal anteriorly, the vertebra (pl. 47, fig. 1) regarded by Cope as the "first dorsal" does not conform either in location or construction of the pedicle of the neural arch with either one of the first three dorsals, and the greatest distance between the outer margins of the postzygapophyses (55.5 mm.) would preclude allocation to any dorsal behind the fourth. The separation of the postzygapophyses is abruptly diminished behind the fourth dorsal.

As regards dimensions and essential characteristics, this dorsal vertebra resembles more closely the fourth dorsal of a smaller cetothere whose mandibles correspond in size with the anterior ends of the two mandibles mentioned previously. Rather frequently in these Calvert marls, bones of more than one individual are found associated in close proximity and at the same stratigraphic level.

Our present knowledge of the range of variation of skeletal elements of younger than physically mature fossil mysticetes does not permit a diagnostic generic characterization of this species which is based solely on one mandible, a doubtfully allocated humerus, and a dorsal vertebra. There is a strong probability, however, that this Calvert cetothere should be assigned to *Isocetus* rather than *Mesocetus* and tentatively bear the name *Isocetus siphunculus* (Cope).

METOPOCETUS Cope

Metopocetus Cope, 1896, Proc. American Philos. Soc., Philadelphia, vol. 35, no. 151, p. 141.

Type Species: *Metopocetus durinasus* Cope.

Diagnosis: Backward thrust of rostrum has carried median rostral elements (ascending processes of premaxillaries and the nasals) backward beyond level of center of orbit; exposure of frontals on median interorbital region eliminated; thin anterior process of parietal, which overrides basal portion of supraorbital process of frontal, extended forward beyond level of hinder ends of median rostral elements; attenuated posterior end of each ascending process of premaxillary mortised into median interorbital portion of underlying frontal, in close contact if not fused with corresponding nasal, and in contact laterally with the narrow projecting ledge contributed by the outward bent dorsal border of thin anterior process of parietal; nasal bones fused or coossified along median longitudinal line of contact, but each is elongated and attenuated toward posterior end; intertemporal region narrow.

The diagnostic characters of the genus *Metopocetus* were described in the key by Cope (1896, p. 141) as follows: "A temporal ridge; maxillaries little produced posteriorly; nasals not produced beyond frontal, coossified with the frontal and with each other." In the preceding descriptive text Cope cites other characters that also require attention, including lateral occipital (lambdoidal) crests continuous with anterior temporal crests which diverge forward. "Frontal bone elongate, not covered posteriorly by the maxillary, coossified with the nasals. Nasals short, coossified with each other, not projecting anterior to frontals." Cope's interpretation of the relationships of these bones will be reviewed under the diagnosis for the type species.

METOPOCETUS DURINASUS Cope

Metopocetus durinasus Cope, 1896, Proc. American Philos. Soc., Philadelphia, vol. 15, no. 151, p. 141.

Type Specimen: USNM 8518. An incomplete cranium with right periotic *in situ*. Deposited by Goucher College, Baltimore, in Division of Vertebrate Paleontology, U.S. National Museum. Collector, Arthur Bibbins.

Type Locality: Nomini Cliffs near mouth of Potomac River, Westmoreland County, Virginia. Marl, Calvert formation, middle Miocene.

Diagnosis: In reviewing the proposed generic characters, the presumed ankylosis of the frontal and nasal bones may first be given consideration. Winge (1909, pp. 27–28) very properly makes the point that this character is an indication of advanced age rather than a generic distinction. This is quite true, but it should be noted that such ankylosis appears to be rather unusual among mysticetes, at least, so far as can be observed among specimens in museum collections or those illustrated by various authors. While this peculiarity may not be of much importance, if correlated with others the tendency to ankylosis might possibly be regarded as a convenient distinguishing feature.

Should there exist any doubt regarding the validity of Cope's interpretations, a critical review of the cranial architecture of other Miocene mysticetes that either resemble or are closely related to *Metopocetus* should serve a useful purpose.

Skull

The supposed relations of the frontals and maxillaries are of somewhat greater significance than the temporal ridge and the lateral occipital crests. If the actual relationships of these bones were as Cope interpreted them, *Metopocetus* would be quite different from other genera of whalebone whales. By referring to Cope's illustration (1896, pl. 11, fig. 3) of this type cranium, one will note that the anterior borders of the broken off bones, labeled as frontals, were considered by Cope to represent the sutural contacts with the hinder ends of the premaxillaries and maxillaries and, accordingly, that these two last mentioned bones terminated opposite the anterior ends of the nasal bones. The actual relations of these bones are most certainly quite different.

Two alternative interpretations of the relations of the posterior ends of the premaxillaries and maxillaries may be considered. Assuming that the contact margins of each of the normally narrow attenuated posterior ends of the premaxillaries have been obliterated by coalescence with the corresponding nasal, the narrowed posterior end of each maxillary has then been thrust backward beyond the level of the posterior ends of the nasals.

The other assumption would be that the posterior ends of the premaxillaries have been broken off fortuitously opposite or barely posterior to the level of the anterior ends of the nasals. Breakage is clearly evident when one examines under a binocular microscope the eroded and broken bone surfaces. Each underlying frontal is then overlaid by the ascending process of the corresponding premaxillary and its posterior extremity extends backward to the short intertemporal region and almost to the vertex. The backward overriding of the frontal by the nasal and premaxillary in a similar manner may also be observed on the cranium of *Mesocetus longirostris* (Van Beneden, 1886, pl. 34, fig. 1).

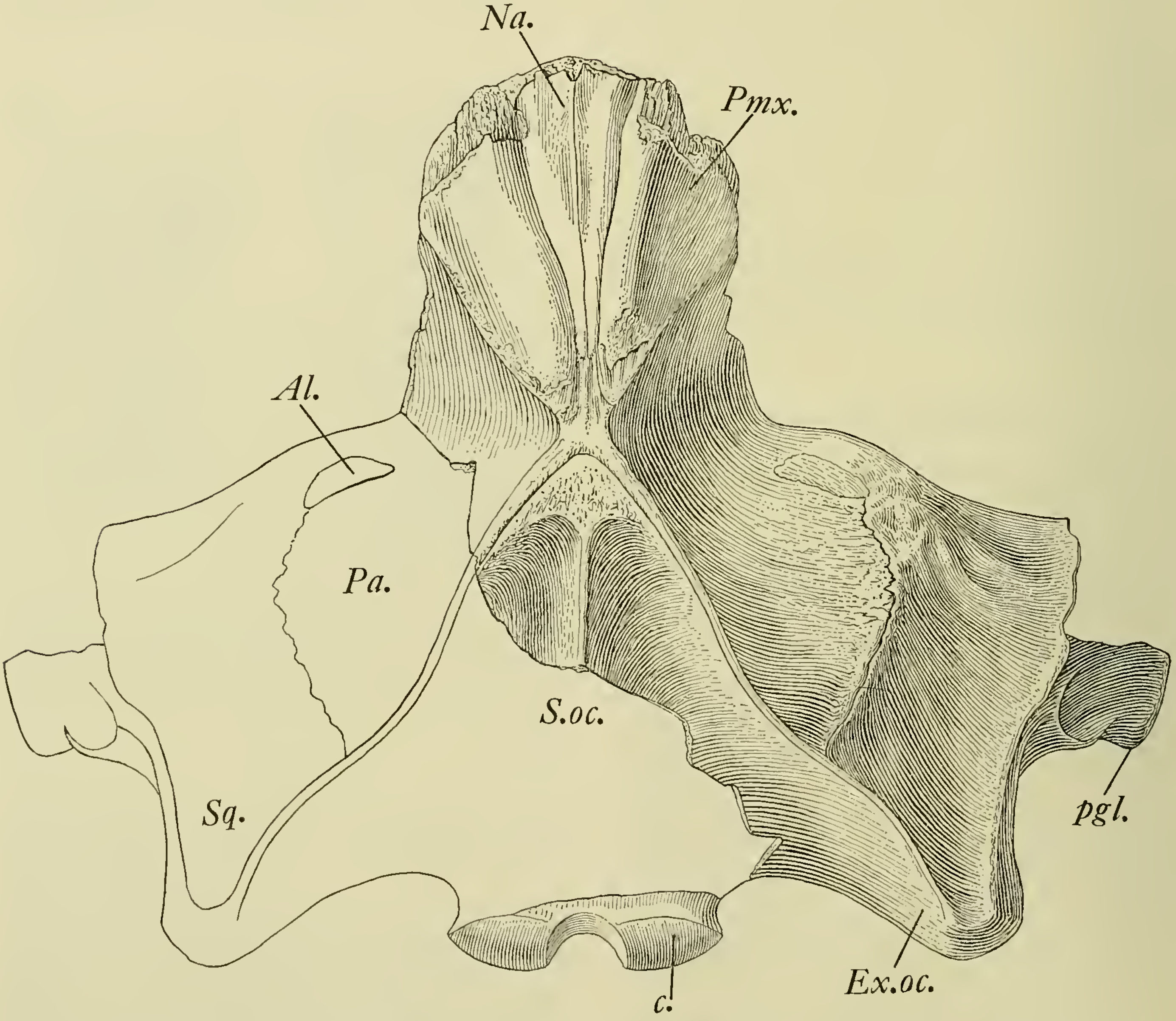

FIGURE 51.—Dorsal view of skull, USNM 8518, of *Metopocetus durinasus* Cope. Abbrs.: Al., alisphenoid; c., occipital condyle; Ex.oc., exoccipital; Na., nasal; Pa., parietal; pgl., postglenoid process; Pmx., premaxillary; S.oc., supraoccipital; Sq., squamosal.

On a *Mesocetus* skull (No. 5069) in the Zoological Museum at Amsterdam, The Netherlands, dredged up at a depth of 20 meters at Herenthals, Belgium, the nasals, strongly attenuated posteriorly but not co-ossified, are wedged in between but do not extend backward beyond the ascending hinder ends of the premaxillaries; these hinder portions of the premaxillaries are broken off at or just beyond the anterior ends of the nasals; and the ascending posterior end of each maxillary overlies the supraorbital process of the frontal alongside the hinder end of the premaxillary but does not extend as far backward. On the type skull of *M. durinasus* (fig. 51; USNM 8518) the supraorbital process of the frontal on each side, however, is broken off behind the posterior end of the maxillary and anterior to the hinder end of the ascending process of the premaxillary. A similar condition exists on the type skull of *Mesocetus longirostris* (MHNB 39; Van Beneden, 1886, pl. 34, fig. 1).

The two nasal bones of *M. durinasus* are fused longitudinally along the median line of contact, strongly attenuated posteriorly, wedged in externally between the posterior ascending ends of the premaxillaries, and are nearly complete anteriorly except for a narrow strip broken off dorsally. The posterior ascending portion of each premaxillary on each of these three fossil mysticete skulls is broader than normally on Miocene skulls and the backward thrust is restricted by the elevated temporal crest or ridge.

The skull of *Metopocetus durinasus* is of moderate size like those of Belgian fossil mysticetes assigned to the genera "*Heterocetus*," *Mesocetus*, "*Idiocetus*," and *Isocetus*. The cranium is larger than those of "*Heterocetus*" *brevifrons* and "*H.*" *sprangii*, and *Mesocetus latifrons;* smaller than *Mesocetus pinguis* and somewhat smaller than either *Mesocetus longirostris* (Van Beneden, 1886, pl. 34, fig. 1) or "*Idiocetus*" *laxatus* (Van Beneden, 1886, pls. 57–58).

The apical portion of the supraoccipital shield is attenuated on the skulls of *Metopocetus durinasus* (fig. 51) and *M. vandelli* (Kellogg, 1940, pl. 1), more abruptly so than on *Cetotherium rathkii* (Brandt, 1873, pl. 1, fig. 1), but all three types are quite unlike the more rounded and somewhat broader apical portion of the supraoccipital shield of *Mesocetus longirostris* (Van Beneden, 1886, pl. 34, fig. 1). The nasal bones on the skull of *Cetotherium rathkii* are not extended forward beyond the level of the preorbital angles of the supraorbital processes of the frontals; these bones are, however, noticeably extended forward beyond these angles on the skull of *Metopocetus vandelli* and possibly also on the skull of *M. durinasus.*

At the time when the type skull was described by Cope and later studied by True (1907) at the Woman's College (subsequently named Goucher College), Baltimore, Maryland, the left exoccipital, the left squamosal, and the right zygomatic process had been broken off from the strongly ossified cranium. Both occipital condyles and the adjoining basicranium, as far forward as the nasal choanae, were, however, attached to the cranium; these bones are now missing. Prominent knoblike lateral descending protuberances were present on each side of the now lost basioccipital.

The extent of the overriding of the cranial bones in the interorbital region by the median rostral bones suggests that the remodeling of the skull had advanced farther in *Metopocetus durinasus* than in *Mesocetus longirostris.*

Measurements (in mm.) of skull of USNM 8518 are as follows:

Transverse diameter of skull across outer surfaces of zygomatic processes, estimated	590±
Transverse diameter of skull between outer margins of exoccipitals, estimated	406±
Transverse distance between outer surfaces of occipital condyles	150
Vertical diameter of occipital condyle	95
Transverse diameter of foramen magnum	65
Greatest length of right nasal bone	155
Combined width of nasal bones, anteriorly	60
Distance from anterior end of nasal to articular surface of occipital condyle	450
Anteroposterior diameter of zygomatic process ventrally	115

In the above table, measurements of the occipital condyles, foramen magnum, zygomatic process, and the distance from occipital condyle to anterior end of nasal are those of either Cope or True, which were taken prior to subsequent breakage and loss of portions of the type cranium.

Periotic

The lateral protuberances on the basioccipital are much less strongly developed and the posterior process of the periotic of *M. durinasus* is quite differently shaped from that of "*Idiocetus*" *laxatus* (Van Beneden, 1886, pl. 54, figs. 3–4) which has a slender, elongated posterior process and a very short anterior process. The posterior process of *M. durinasus*, which is lodged between the postglenoid process of the squamosal and the exoccipital, has an unusually deep lengthwise groove for the facial nerve, which imparts a U-shaped outline to the distal end of this process, and in this respect exhibits a rather close resemblance to that of *Mesocetus longirostris* (Van Beneden, 1886, pl. 36, figs. 4–6). This Belgian left periotic (MNHB 1539) is characterized by the wide interoexternal groove for the facial nerve, which increases in width distally and imparts a spatulate appearance to the posterior process when viewed from the ventral side. From a posterior view, however, the posterior process is somewhat compressed anteroposteriorly and strongly attenuated toward the distal end. The length of this process is at least 95 mm. in contrast to 75 mm. for that of *M. durinasus.*

In addition to the resemblances observed in the posterior process, the right periotic of *Metopocetus durinasus* appears to approach *Mesocetus longirostris* in other characters as well. The *pars cochlearis* (pl. 48, fig. 3) of this Calvert cetothere is distinctly compressed in a dorsoventral direction and its ventral surface although convex is much less inflated than the same portion of the periotic of *Parietobalaena palmeri* (Kellogg, 1924, pl. 5, figs. 1–4). In this structural modification the periotic of *M. durinasus* seems to agree more closely with the periotic of *Mesocetus longirostris* than with those of other Belgian species.

The anterior process of *M. durinasus* is strongly compressed from side to side; the *pars labyrinthica* is rounded and nodular. From a ventral or tympanic view, the *fenestra ovalis* is concealed by the overhanging external face of the *pars cochlearis.* The shallow concavity for the reception of the head of the malleus is relatively large and is located between the fused base of the anterior pedicle of the bulla on the anterior process and the epitympanic opening of the Fallopian aqueduct.

Below the inward projecting wide but thin continuous rim of the circular internal acoustic meatus and the orifice of the Fallopian aqueduct, the cerebral face of the *pars labyrinthica* (pl. 48, fig. 4) is deeply depressed or excavated. This overhanging rim projects inward as much as 12 mm. beyond the very small orifice of the vestibular aqueduct and almost at a right angle to the cerebral face of the *pars labyrinthica.* The orifice of the cochlear aqueduct is actually slightly larger than the orifice of the vestibular aqueduct which opens into an unusually short slitlike depression.

The *fenestra rotunda* is almost as large as the internal acoustic meatus. A broad but short concave surface commencing above the posterior rim of the stapedial fossa and above the projecting shelf behind the *fenestra rotunda* extends across the posterior face of the *pars cochlearis* to the inner cerebral surface of the periotic. Van Beneden did not illustrate the internal cerebral face of the periotic of *Mesocetus longirostris.*

Measurements (in mm.) of periotic of *M. durinasus* (USNM 8518) and *M. longirostris* (Van Beneden, 1886, pl. 36; fig. 4–5, MNHB 1539) are as follows:

	USNM 8518, Type, Right	*MNHB 1539, Left*
Tip of anterior process to tip of posterior process	135	145
Epitympanic orifice of Fallopian aqueduct to tip of anterior process	51	48.3
Fenestra rotunda to tip of anterior process	59	61.8
Fenestra rotunda to tip of posterior process	89	103.3
Tympanic face of *pars cochlearis* to dorsal face of *pars labyrinthica*	44	46.5
External face of *pars labyrinthica* to cerebral face of *pars cochlearis* below internal acoustic meatus	32	36.5
Greatest length ventral face of *pars cochlearis*	41	—

Auditory Ossicles

Malleus.—The anteroposteriorly compressed slender stalk like anterior process is broken off above its point of ankylosis with the body of the right malleus. The two facets on the head of the malleus (USNM 8518; pl. 48, fig. 5) that articulate with the incus have the same shape and a similar position as the corresponding facets of *Balaenoptera borealis.* The nearly vertical hemicircular facet is above and separated by a groove from the somewhat horizontal smaller facet. At the internal end of the *processus muscularis* the manubrium is a short blunt nosed tubercle to which the ligamentary process of the tympanic membrane presumably was attached. The small, deep, circular pit on the anterior face near the internal end of the head of the malleus is situated in the usual area of attachment of the tensor tympani tendon. The head of this right malleus measures 15.5 mm. in length and 10.5 mm. in width. This malleus is not only larger than USNM 15575, but the internal end of the head is blunted and not attenuated.

Incus.—Two distinct facets on the body of the incus (USNM 8518) articulate with corresponding surfaces on the malleus, the largest of which (pl. 48, fig. 1) is shallowly concave, subcrescentic in outline and occupies the base of the body; it is separated from the smaller and more deeply concave facet on the internal side by a sharp-edged crest. The body of this right incus is rather bulbous in contrast to the short, bent outward *crus longum,* which has on the external face of its apex an ovoidal facet for articulation with the head of the stapes. The short *crus breve* is conical; its attenuated apical end rests in the minute *fossa incudis.* From the apex of the *crus longum* to the base of the body, the incus measures 9.5 mm., and the greatest diameter of the base is 6.3 mm.

Stapes.—The right stapes (USNM 8518; pl. 48, fig. 2) of this Calvert cetothere resembles rather closely the same inner ear bone of *Balaenoptera acutorostrata* (Doran, 1878, pl. 62, fig. 31). The intercrural aperture is small and connects the ovoidal concavities of the opposite sides. The footplate is closely fitted to the circumference of the *fenestra ovalis* and apparently permitted none or very limited side to side movement when in position. Nevertheless, only two of the 27 Calvert periotics examined retained the stapes in its normal position; it had been dislodged from the *fenestra ovalis* and lost on 24. A small scar on the posterointernal angle, which presumably marks the area of attachment of the tendon of the stapedial muscle, is less protuberant than in *B. acutorostrata*. The facet on the head of the stapes serves as the contact with the corresponding facet on the *crus longum* of the incus. The greatest length of this right stapes is 7.3 mm., and the greatest diameter of its footplate is 5 mm.

Vertebra

ATLAS.—"From the same locality and collection as the type skull" Case (1904, pl. 18, figs. 2a, 2b) figures a slightly eroded atlas (USNM 8518) whose dimensions correspond fairly closely to the greatest distance between the outside margins of the occipital condyles (150 mm.). The greatest distance between the outside margins of the anterior articlar facets of this atlas is 166 mm., and the dorsoventral diameter of the right articular facet is 107 mm. The dimensions of this atlas are similar to those of *Mesocetus longirostris* (Van Beneden, 1886, p. 47), except that it appears to be thinner, though this may possibly be the result of erosion on the posterior articular facets.

During the 70 years that have elapsed since the description of this type specimen, no other specimen that even remotely resembles this type of cranial architecture has either been added to the national collections or has been recognized among the many portions of skulls submitted for identification by local collectors. The construction of the skull and the peculiarities of the periotic, however, suggest a rather close affinity if not identity with the genus *Mesocetus*.

SIPHONOCETUS Cope

Siphonocetus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 140.

Type Species: *Balaena prisca* Leidy.

Diagnosis: Alveolar groove and dental [mandibular] canal distinct; alveolar groove roofed over and perforate. During the sequential developmental history of the mysticete mandible, failure of teeth to develop, according to Cope (1895a, p. 139), "would be accompanied by the loss of the interalveolar walls or septa, leaving the dental [alveolar] groove continuous and separate from the dental [mandibular] canal."

By having the alveolar "groove roofed over and distinct from the dental canal" this genus according to Cope represents a transitional stage following the loss of teeth and elimination of the intervening osseous septa between alveoli which would leave a continuous open groove separate from the dental (mandibular) canal. The genus *Siphonocetus* thus reputably had the dental (alveolar) groove "roofed over by the ossification of the gum and distinct from the dental [mandibular] canal." Gingival passages and foramina were present.

Winge (1909, p. 25; True, 1912, pp. 5–6) was certain "that Cope's interpretation of the canals in the lower jaw is incorrect," and pointed out that the furrow on the dorsal face of the mandible in which the fetal rudimentary teeth are lodged is closed, as in the adult finback, by growth of bony tissue. Furthermore, the mandibular canal through which the mandibular branch of the trigeminal nerve and associated blood vessels extend forward, is here described as being divided into an upper and lower passage or aqueduct in contrast to its usual undivided condition. From the upper aqueduct (the alveolar groove of Cope) branch channels on each side lead to the internal nutrient or gingival foramina and the external mental foramina.

Several Calvert cetothere mandibles had been broken transversely prior to excavation. Critical examination of these cross sections revealed that the position of the internal longitudinal mandibular canal as well as the distribution of the aqueducts leading to the external mental and the internal nutrient foramina correspond to the general arrangement in the Recent balaenopterine mandible. Ten interior dental arteries (branches of the mandibular artery) and their accompanying veins as well as multiple nerves were observed by Walmsley (1938, p. 143, fig. 35) in the mandibular canal of an adult finback (*Balaenoptera physalus*) cut transversely at about half way of its length.

SIPHONOCETUS PRISCUS Leidy

Balaena prisca Leidy, 1852, Proc. Acad. Nat. Sci. Philadelphia, vol. 5, no. 12, p. 308. (Preoccupied by *Balaena prisca* Nilsson, 1847, Skandinavisk Fauna, Lund, ed. 1, vol. 1 (Daggdjuren), p. 643. Fossil Fenhval. Type locality, sand near Ystad, Sweden, in 1722. Skull, atlas, dorsal vertebra and scapula.)

Balaenoptera prisca Cope, 1868b, Proc. Acad. Nat. Sci. Philadelphia, vol. 19, no. 4, pp. 144, 147.

Eschrichtius priscus Cope, 1869, Proc. Acad. Nat. Sci. Philadelphia, vol. 21, no. 11, p. 11.

Cetotherium priscum Cope, 1890, American Nat., vol. 24, no. 283, p. 616. (Not, *Cetotherium priscum* Brandt, 1842, Bull. Acad. Imp. Sci. St. Petersburg cl. phys.-math., vol. 1, nos. 10–12, p. 148.)

Siphonocetus priscus Cope, 1895a, Proc. American Philos. Soc. Philadelphia, vol. 34, no. 147, pp. 140, 141, 151, pl. 6, fig. 3.

Type Specimen: ANSP 12915. Fragment near middle of left mandible, presented by Robert H. Nash.

Type Locality: Westmoreland County, Virginia, Miocene.

Diagnosis: On October 21, 1851, two vertebrae and a piece of a mandible of a fossil cetacean [=*Balaena prisca* Leidy] as well as two vertebrae and two teeth of a saurian [=*Crocodilus antiquus* Leidy] from Westmoreland County, Virginia, were listed among the recent accessions to the Academy of Natural Sciences of Philadelphia as having been presented by Robert H. Nash (Proc. Acad. Nat. Sci. Philadelphia, vol. 5, 1851, p. 298). The fragment of the left mandible and a rather large caudal vertebra, which obviously did not belong to such a small setothere, formed

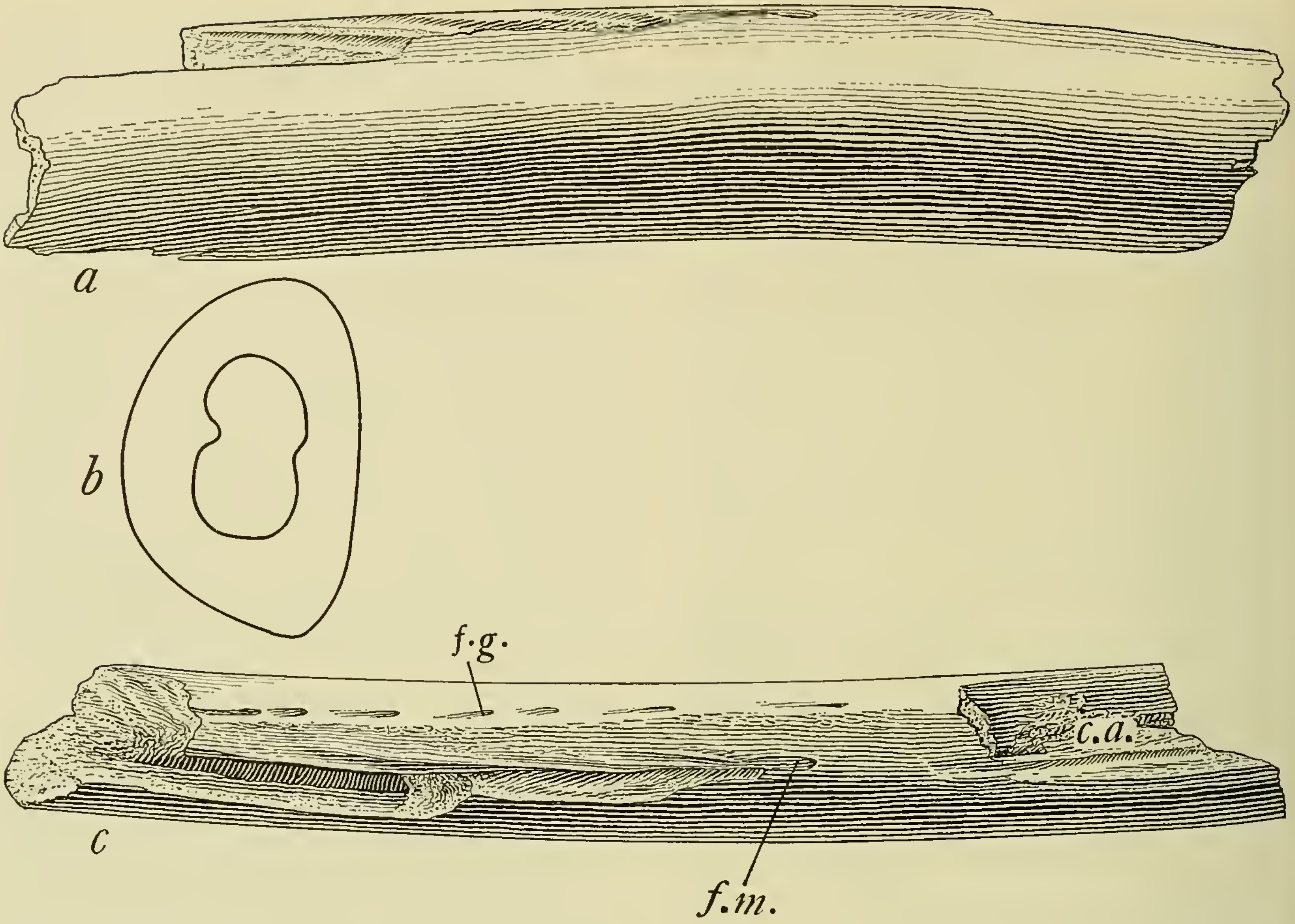

Figure 52.—Left mandible (type), ANSP 12915, of *Siphonocetus priscus* (Leidy): *a*, external view; *b*, cross section; *c*, dorsal view. Abbrs.: c.a., alveolar or mandibular canal; f.g., alveolar or gingival foramen; f.m., mental foramen.

the basis for Leidy's *Balaena prisca.* Leidy apparently did not originally publish precise measurements of the mandibular fragment (fig. 52) as will be noted from the appended measurements, but merely states that its length was 14 inches, vertical diameter 3 inches, and transverse diameter 2 inches. Subsequently, Leidy (1869, p. 442) published the following measurements of this mandibular fragment: Depth posteriorly, 34 lines [=71.9 mm.], anteriorly, 34 lines [=71.9 mm.]; thickness posteriorly, 24 lines [=50.8 mm.], anteriorly, 22 lines [=46.5 mm.]. Confirmatory measurements of the type mandible (ANSP 12915) are as follows: Maximum length, 375 mm.; vertical diameter at level of anterior mental foramen, 72 mm.; maximum transverse diameter at same point, 45.5; maximum vertical diameter 175 mm. behind anteriormost mental foramen, 72.5 mm.; maximum transverse diameter at same point, 50 mm. Six small internal nutrient (gingival) foramina in an interval of 190 mm.; five external mental foramina in an interval of 170 mm.

Cope (1869, p. 10), the same year, however, characterized the type mandible as follows: "upper edge broad, with outer series of foramina, and meeting inner edge at a right angle, which is the highest line, and with inner series of foramina just below it; most convex externally; large."

A label in the handwriting of Cope, now attached to this type mandible fragment, reads as follows: "*Siphonocetus priscus, Balaena prisca* Leidy. Neocene. City Point, Va. Rich'd Eppes, M.D." It is quite likely that this label was written in 1895. In that year Cope (1895a, p. 151) wrote that "Dr. Eppes discovered in the year 1854 the specimen which became the type of the *S. priscus* of Leidy." Cope obviously was mistaken both as to the date of collection and the collector, and also the locality, and some way confused the two mandibles that Leidy described at the meeting of the Academy of Natural Sciences of Philadelphia held on November 11, 1851. At that time, Leidy described *Balaena prisca* and *Balaena palaeatlantica.* The type of *Balaena palaeatlantica* was collected in 1851 by Dr. Richard Eppes on the south bank of the James River near City Point, Prince George County, Virginia, and presented by him to Professor W. E. Horner.

Cope (1895a, p. 140) made *Balaena prisca* the genotype of his new genus *Siphonocetus* which, with some other species, he established in part on theoretical grounds to meet with his interpretation of the relationships of the dental (mandibular) canal and the alveolar groove in different mandibles of fossil mysticetes. Cope (1895a, p. 139) considered that in the course of evolutionary development, after the lower teeth were lost, the alveolar septa were absorbed, leaving a continuous alveolar groove separated from the dental (mandibular) canal. He believed that in some instances this alveolar groove remained distinct from the dental canal and was roofed over by bone, while in others it united with the dental canal, and that this composite "gingivodental" canal was completely or partially roofed over by bone in some forms, but left open in others.

Those fossil mysticetes that have mandibles in which the alveolar groove and dental canal remained distinct or separate, but with the dorsal alveolar groove roofed over and perforated, Cope called *Siphonocetus.* Those in which the alveolar groove and dental canal were united into one gingivodental canal which was partially roofed over and with gingival passages and foramina on one side, he called *Tretulias,* while those which had the composite gingivodental canal open and no gingival passages, he called *Ulias.* Cope characterized the genus *Cetotherium* Brandt as having the alveolar groove and the dental canal combined and the resulting single gingivodental canal completely roofed over and perforated.

In summary the generic criteria proposed by Cope for the characterization of the genus *Siphonocetus*, which were based largely on theoretical considerations, have not been confirmed by examination of a number of Calvert mandibles of comparable dimensions and shape and are now regarded as erroneous and invalid. The asserted division of the mandibular canal into an upper and lower passageway by the intervening bone does not distinguish the type mandible of *Balaena prisca*, the type species of *Siphonocetus*, from that of *Cetotherium rathkii*, the type species of that genus. Furthermore, *Balaena prisca* Leidy, 1852, is antedated by *Balaena prisca* Nilsson, 1847. Leidy's type mandibular fragment has not been proven distinguishable from mandibles of other Calvert cetotheres and is, therefore, unidentifiable. In the absence of a recognizable osteological basis, the generic name *Siphonocetus* will not be employed in this review.

Caudal Vertebra

The caudal vertebra, which Leidy originally described as found associated with the mandibular fragment, and which he regarded as belonging to the same species, appears to be far too large as compared with the dimensions of the mandible to be referable to the same mysticete. As it is without the neural spine, and has never been illustrated, this caudal hardly merits further consideration. Leidy's measurements (1869, p. 442) of this caudal vertebra were as follows: Length of centrum, inferiorly, 67 lines [=141.77 mm.], superiorly, 67 lines [=141.77 mm.]; length of centrum, laterally, 77 lines [=163 mm.], in the axis, 82 lines [=173.5 mm.]; breadth of anterior articular end, 77 lines [=163 mm.]; depth of anterior articular end, 74 lines [=156.6 mm.]; breadth of posterior articular end, 78 lines [=165 mm.]; depth of posterior articular end, 74 lines [=156.6 mm.]; breadth of neural arch, 42 lines [=88.9 mm.]; and breadth of transverse process, 48 lines [=101.5 mm.].

Leidy's description (1869, p. 442) of this vertebra is as follows:

> "The caudal vertebra, from the anterior part of the series, is slightly longer than the breadth, and its articular extremities are near circular and convex. The posterior abutments of the chevrons extend nearly half the length of the body. The transverse processes projected from near the middle of the latter about an inch and three-fourths back of the edge of the anterior articulation. The spinal canal is narrow, not more than seven lines in width."

This very enticing theory, however, seems to be altogether erroneous. In all the mandibles examined the dental canal extends through the middle of the mandibular ramus as in other mammals, but gives off a complex series of branches to the dorsal portion of the ramus on both sides, the branches running obliquely forward and upward, and those of the inner side being generally much smaller than the outer ones. This arrangement may be likened to a trailing plant whose main stem or root (viz: *Cynodon*, Bermuda grass) runs horizontally a little below the surface of the ground, and sends out branches which extend upward and forward, and penetrate the surface at intervals. When studying broken fragments of mandibles one might readily be deceived into believing that the two superimposed passages or aqueducts which are visible at the end of a fragment are the openings of two separate canals (dorsal and ventral) running in a parallel line inside the mandible. In reality, however, the dorsal one is the broken end of a branch which united with the true dental canal at a point farther back. Looking carefully into such a fragment when the foramina are all free of matrix, one can see the various smaller branches extending out from the dental canal on both sides, and when a fragment of a mandible is broken off vertically their upward course can be traced with certainty. Examination of the broken ends of ten mandibles from the Calvert formation of comparable dimensions, as well as three that are split lengthwise confirms this explanation. It is true that in Recent right whales (Balaenidae) generally a groove or channel more or less deep will be observed on the dorsal surface of the mandible, but this is not to be confounded with the dental (mandibular) canal which is situated lengthwise as usual within the mandible.

Winge (1909, pp. 25–26) voiced his dissent from Cope's interpretation of the canals, but he seems inclined to accept the statement that the dental canal may be divided into an upper and lower passageway or aqueduct by a bony partition. He calls attention to the fact that Brandt's illustration (1873, pl. 1, fig. 9) of the type mandible of *Cetotherium rathkii* exhibits what appears to be this peculiarity, and remarks that the establishment of the new genus *Siphonocetus* was, therefore, unnecessary. If this division of the dental canal actually occurs, which seems improbable, this would not suffice to distinguish *Siphonocetus* from *Cetotherium*, and unless other characters can be found the genus has no validity. The mandibles that have been assigned by Cope to *Siphonocetus*, *S. pusillus*, *S. expansus*, and *S. priscus*, do not differ from one another in other acceptable diagnostic structural details. Hence the validity of the smaller species assigned to *Siphonocetus* by Cope, which were thought to be distinguishable among themselves on the basis of mandibular fragments chiefly by the number and arrangement of the gingival foramina on the inside of the upper margin of the mandibular ramus, has not as yet been confirmed by the acquisition of more complete mandibles. Although no detailed studies of the extent of individual variation in this respect have been made, it is questionable how far this character is reliable as a criterion of species. At present, however, about the only means of distinguishing the mandibles is size, since the greater or less convexity of the sides, though it may be of importance, is very difficult to appraise, as it varies considerably along the ramus from the anterior to the posterior end. The internal gingival foramina are in a single row and quite close to the dorsal margin of the mandible, and the external mental foramina rather more distant from that margin.

TRETULIAS Cope

Tretulias Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 143.

Type Species: *Tretulias buccatus* Cope.

Diagnosis: This genus was characterized by Cope as follows: "Dental canal obliterated, and dental groove without osseous roof. Gingival canals and foramina present at one side of the alveolar groove." *Tretulias*, like *Ulias*, was considered by Cope (1895a, p. 139) to have the dental (alveolar) groove fused with the dental (mandibular) canal, though the former retained the gingival passages and foramina.

TRETULIAS BUCCATUS Cope

Tretulias buccatus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 143.

Type Specimen: Cope based this genus and species on two fragments of mandibles, one "in fairly good preservation," and the other shorter and considerably worn. The last mentioned shorter specimen has not since been located. The longer specimen is part of a strongly weathered left mandible, length, 595 mm.; mandibular canal exposed on its entire length by erosion or disintegration of dorsal border of ramus; nine recognizable unusually broad (2–4 mm.) exposed gingival canals originating from mandibular canal and located on dorsointernal border of outwardly bowed ramus are directed forward. No. 9345, Division of Vertebrate Paleontology, United States National Museum (deposited by Maryland Geological Survey). Collector not known.

Type Locality: No definite locality recorded.

Diagnosis: According to Cope's interpretation, the mandibular canal has been obliterated and an open alveolar or gingivodental groove was not covered by a bony roof. Gingival foramina and their anteriorly directed horizontal grooves are present on the internal border of the ramus along the alveolar groove. Cope thought it possible that either the roof of the gingival groove failed to develop external to the gingival foramina or the roof was developed only above the gingival foramina, leaving the remainder of the gingival groove open. The external series of canals mentioned by Cope are not now recognizable on the type mandible.

Winge (1909, p. 27; True, 1912, pp. 6–7) has observed that Cope's interpretation cannot be correct and that his alveolar groove is unquestionably the mandibular canal. Breakage or erosion of the dorsal border of this type mandibular fragment has exposed the mandibular canal on its entire length. This canal is at least 23 mm. wide near the posterior broken off end and not more than 7 mm. at the anterior end of this fragment. The narrowing of this canal anteriorly and its greater width posteriorly indicate that this type fragment represents a section immediately anterior to the middle of the length of the complete mandible. Preservation of the gingival foramina and grooves may be attributed to uneven wear of the dorsal border of the ramus and this erosion was less effective in reducing the internal than the external wall of the mandibular canal. A longitudinal fissure or crack developed above the ventrointernal margin of this mandible was regarded as the Meckelian fissure by Cope and as an artificial crack by Winge (1909, pp. 28–29; True, 1912, pp. 7–8).

The ventral surface of this type mandibular fragment has also been eroded and, consequently, the vertical diameter of the ramus in this region when complete is uncertain.

The maximum transverse diameter at the posterior end is 75 mm. and 43 mm. near the anterior end. It seems obvious, however, that this section was part of a more robust or physically mature mandible than the type of *Ulias moratus.* The general conditions responsible for the weathered condition of this type specimen seem to have been similar to those for *U. moratus.* Whatever deterioration ensued during subsequent storage in the collections of the Maryland Geological Survey at The Johns Hopkins University, Baltimore, Maryland, was certainly of a minor nature. Both Winge and True regarded the validity of Cope's generic diagnosis as doubtful.

The type of *Tretulias buccatus* is a portion of a left mandible anterior to the middle of its length which is not distinguishable either in dimensions or in conformation from mandibles of comparable size of at least two Calvert cetotheres. Since this eroded type specimen lacks recognizable differential features, it is not identifiable and should be eliminated from the Calvert faunal list.

ULIAS Cope

Ulias Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 141.

Type Species: *Ulias moratus* Cope.

Diagnosis: This genus was characterized by Cope as follows: "Mandible with the gingivodental canal open throughout most if its length, closed only near its apex. Gingival foramina represented by a few orifices on the alveolar border near the distal extremity."

The mandible of *Ulias* was thus considered by Cope (1895a, p. 139) to represent a further degeneration from the condition attributed to *Siphonocetus* whereby the dental (alveolar) groove and the dental (mandibular) canal became united although the dental groove remained open. As a result of erosion, the few supposedly "gingival" foramina on the dorsal border near the distal end were misinterpreted inasmuch as they are unquestionably grooves or channels leading to external mental foramina in locations corresponding to those on the mandibles of USNM 23494.

ULIAS MORATUS Cope

Ulias moratus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 141.

Type Specimen: USNM 10595. Right mandible, length along external curvature, 1645 mm.; dorsal border of the ramus is broken or worn off, exposing for a considerable portion of its length the wide open bottom of the mandibular canal; a section 230 mm. in length anterior to the level of the coronoid process is filled in by a hard cemented sandy marl matrix. Apparently the piece from the distal third of this ramus which was mislaid when Cope established the species, was subsequently located and attached correctly to the adjacent portions of the mandible. The measurements of the type mandible published by Cope (1895a, p. 143) should be disregarded. The type mandible has been illustrated by Case (1904, pl. 24, fig. 1a, 1b). Deposited by the Maryland Geological Survey in Division of Vertebrate Paleontology, United States National Museum; Collector not known.

Type Locality: No definite locality recorded.

Diagnosis: Cope (1895a, pp. 141–142) believed that this genus at maturity retained characters which are present in fetal right whales (Balaenidae) and asserted that the type mandible was characterized by these features: Gingivodental canal open throughout most of its length, closed near apex. Gingival foramina represented by a few orifices on the alveolar border near the distal extremity. Alveolar groove is continuous with the dental canal, and is permanently open. Long series of mental foramina characteristic of the true whales absent; terminal mental foramen at distal end of ramus retained.

True (1912, p. 5) correctly stated that no internal gingival canals were visible. At least three of the anteriormost external mental foramina and the grooves leading forward therefrom were not completely obliterated by erosion.

Examination of the type mandible alongside other Calvert cetothere mandibles clearly demonstrates that most of the mental foramina and their anteriorly directed external grooves, as well as the internal nutrient or gingival foramina, when the mandible was complete, were located on the missing dorsal border above the level of the preserved ventral portion.

Winge (1909, pp. 26–27; True, 1912, p. 6) commented that "Cope's interpretation is certainly not correct," and correctly concluded that the asserted lack of mental foramina raised reasonable doubts as regards the undamaged condition of the type mandible.

This weathered type mandible (Case, 1904, pl. 24, figs. 1a, 1b) presumably was submerged under water for some time; it agrees in general preservation with other portions of cetothere mandibles recovered from exposures along the lower portion of the Patuxent River, which have the mandibular canal filled with an indurated sandy matrix.

Neither Winge nor True were afforded an opportunity to actually handle this type mandible which, at the time their articles were published, apparently, was not readily accessible in the stored collections of the Maryland Geological Survey at The Johns Hopkins University, Baltimore, Maryland.

Additional measurements (in mm.) are as follows: Transverse diameter of ramus 100 mm. behind anterior end, 38; 300 mm. behind, 48; 400 mm. behind, 53; 700 mm. behind, 55; 900 mm. behind, 56; and 1200 mm. behind, 57.

Cope (1896, p. 141) suggested that the mandible on which the genus *Ulias* was founded might belong to either the genus *Metopocetus* or *Cephalotropis*, although there was no direct evidence to support this assumption. The length (1645 mm.) of the type mandible of *Ulias moratus* is almost the same as that of *Mesocetus pinguis* (1642 mm.). If Cope's view of the internal structure of the mandible of *Ulias* should be proven correct, which does not seem likely, no comparisons would be necessary, as this type mandible was supposed to have a deep dorsal conjoined dental (mandibular) canal and alveolar groove, entirely open above, while the mandible of *Mesocetus* is roofed over above the mandibular canal as in other cetotheres. Cope's interpretation of the *Ulias* mandible is unquestionably erroneous, as already mentioned, but at present the allocation of this type mandible to any contemporary species involves a certain amount of uncertainty. If roofed over, as it was undoubtedly in life, its vertical diameter at the distal end would be approximately the same as the mandible of *Mesocetus longirostris* (90 mm.), but much less than the same measurement of the type mandible of *M. pinguis* (123 mm.); otherwise, it is not feasible to make any precise comparisons. It seems certain, nevertheless, that *Ulias* represents some form of cetothere rather than a right whale allied to *Balaena*, in view of the transversely flattened anterior extremity and the presence there of a lower internal ledge. The shape of the entrance to the mandibular canal and the convexity of the outer wall of the mandible in this region are not materially different from mandibles of other Calvert mysticetes.

Both Winge and True regarded the validity of Cope's generic diagnosis as doubtful. The missing dorsal border above the mandibular canal on the entire length of the ramus most certainly contributed to this misleading generic diagnosis. The loss of the coronoid process and more especially the articular surface of the condyle and the ventral angle, in addition to the destroyed dorsal border of the ramus, render direct comparisons with other mandibles of comparable size useless. Nevertheless, in length and general form the type right mandible of *Ulias moratus* does not appear to have exhibited, when complete, appreciable differences from a Calvert formation right mandible (USNM 16760; length, 1650 mm.). This fossil mysticete mandible is not identifiable and hence *Ulias moratus* should be removed from the Calvert faunal list.

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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.

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

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

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

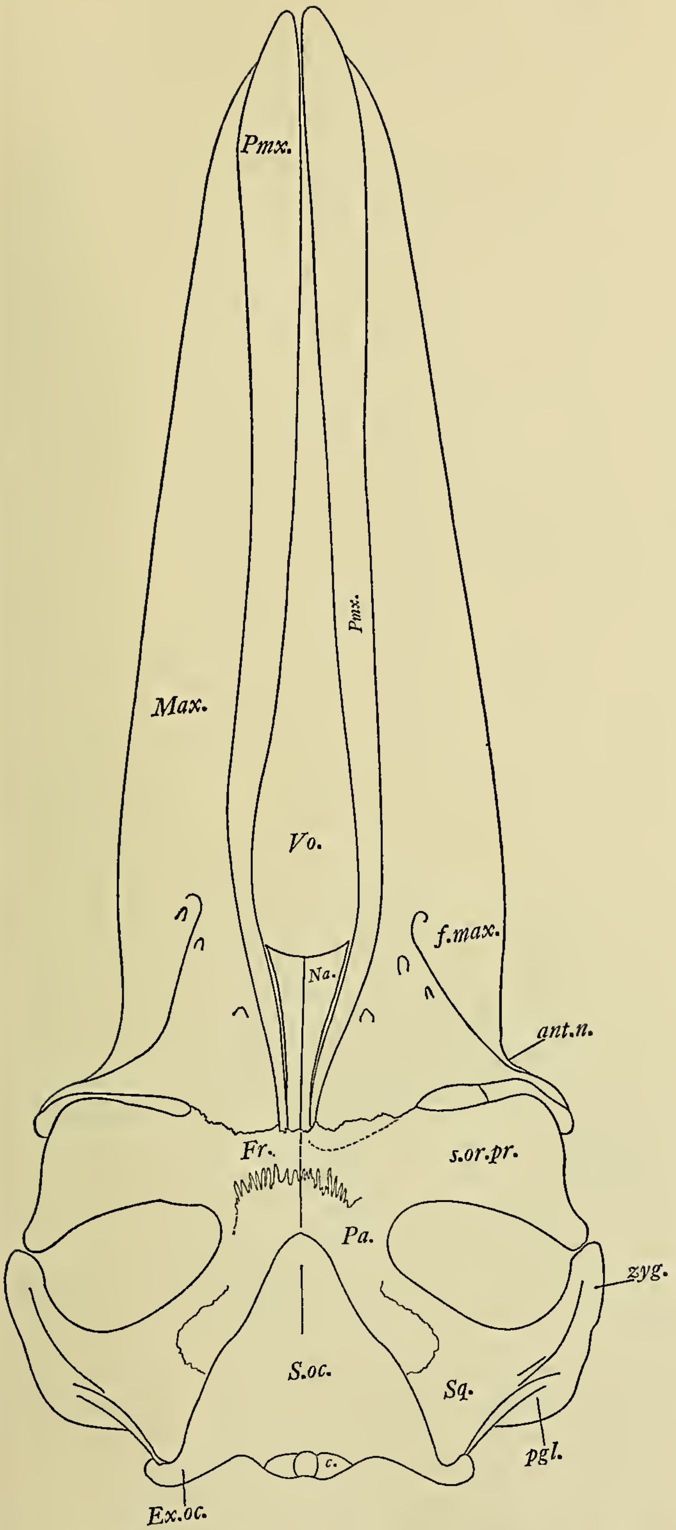

FIGURE 53.—Dorsal view of skull, USNM 16783, of *Diorocetus hiatus*, with left side of cranium restored. Abbrs.: ant.n., antorbital notch; Bo., basioccipital; c., occipital condyle; Ex.oc., exoccipital; f.m., foramen magnum; f.max., maxillary foramen or incisure; f.ov., foramen ovale; Fr., frontal; h.pt., 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.

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

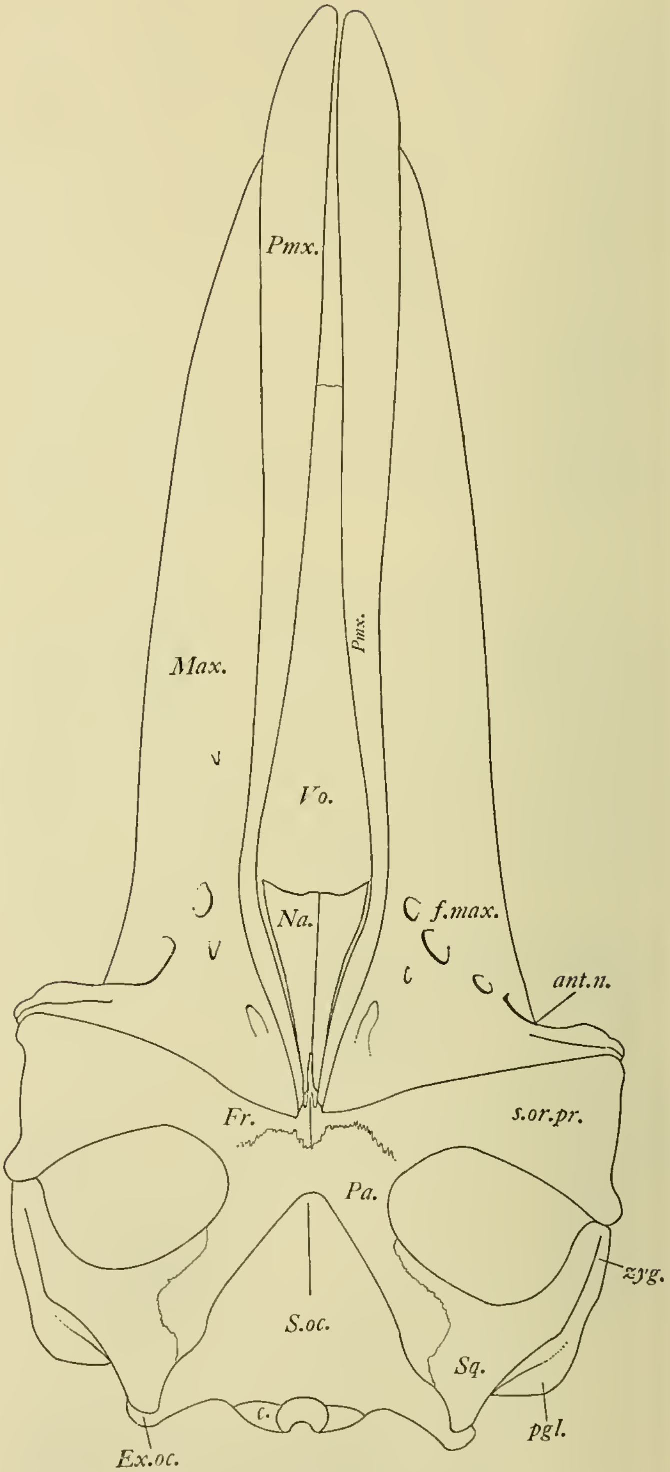

Figure 54.—Dorsal view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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.

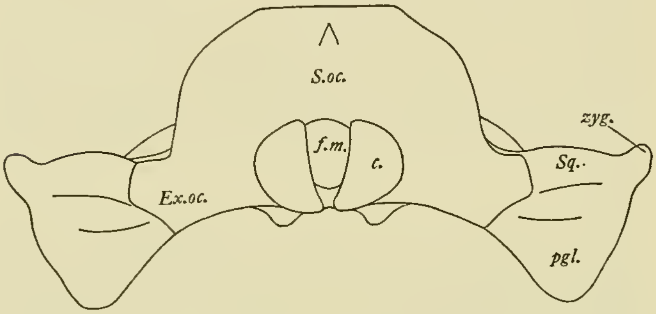

Figure 55.—Posterior view of skull, USNM 16783, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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 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.

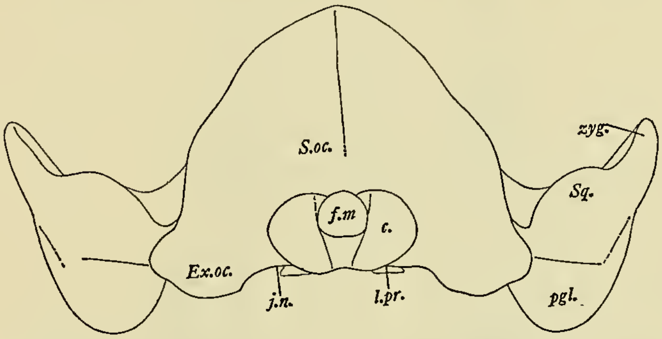

Figure 56.—Posterior view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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

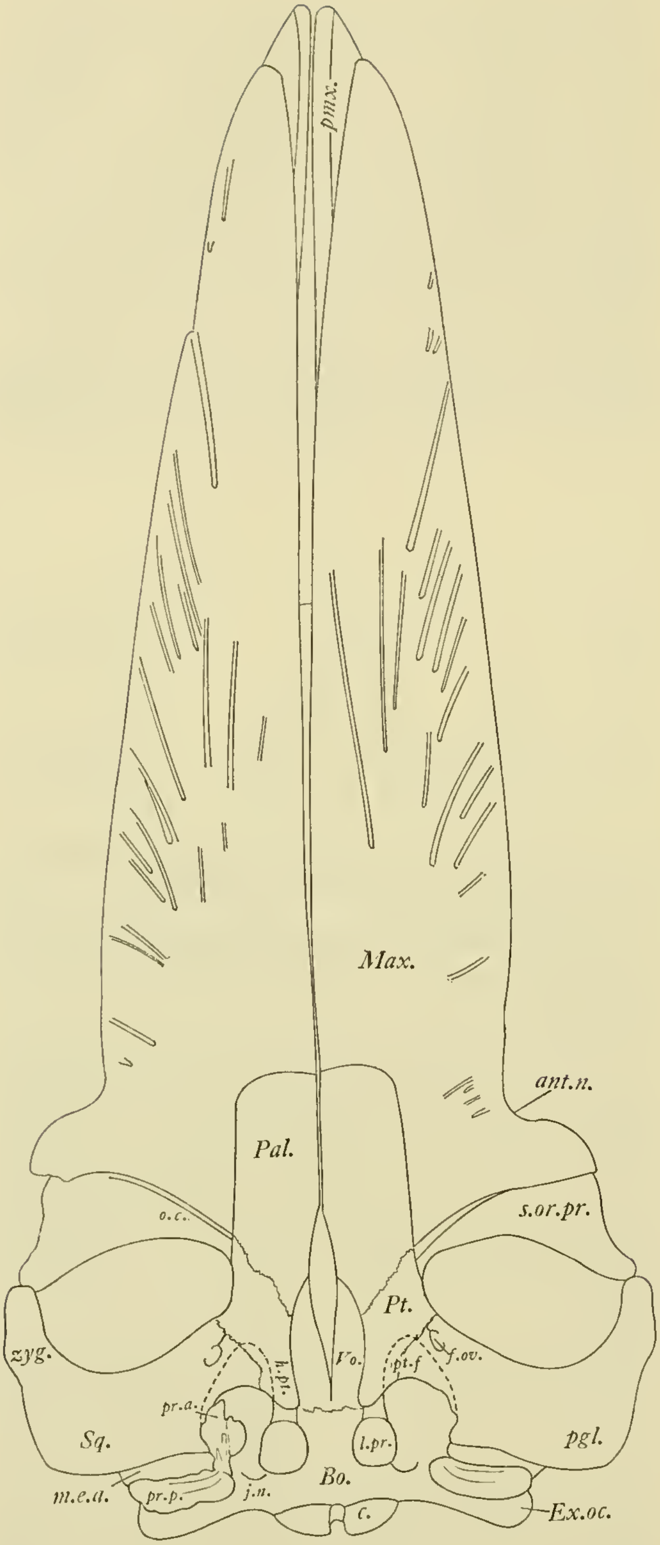

Figure 57.—Ventral view of skull, USNM 16783, of *Diorocetus hiatus*, with left side of cranium and hamular processes of pterygoid restored. For abbreviations, see figure 53.

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

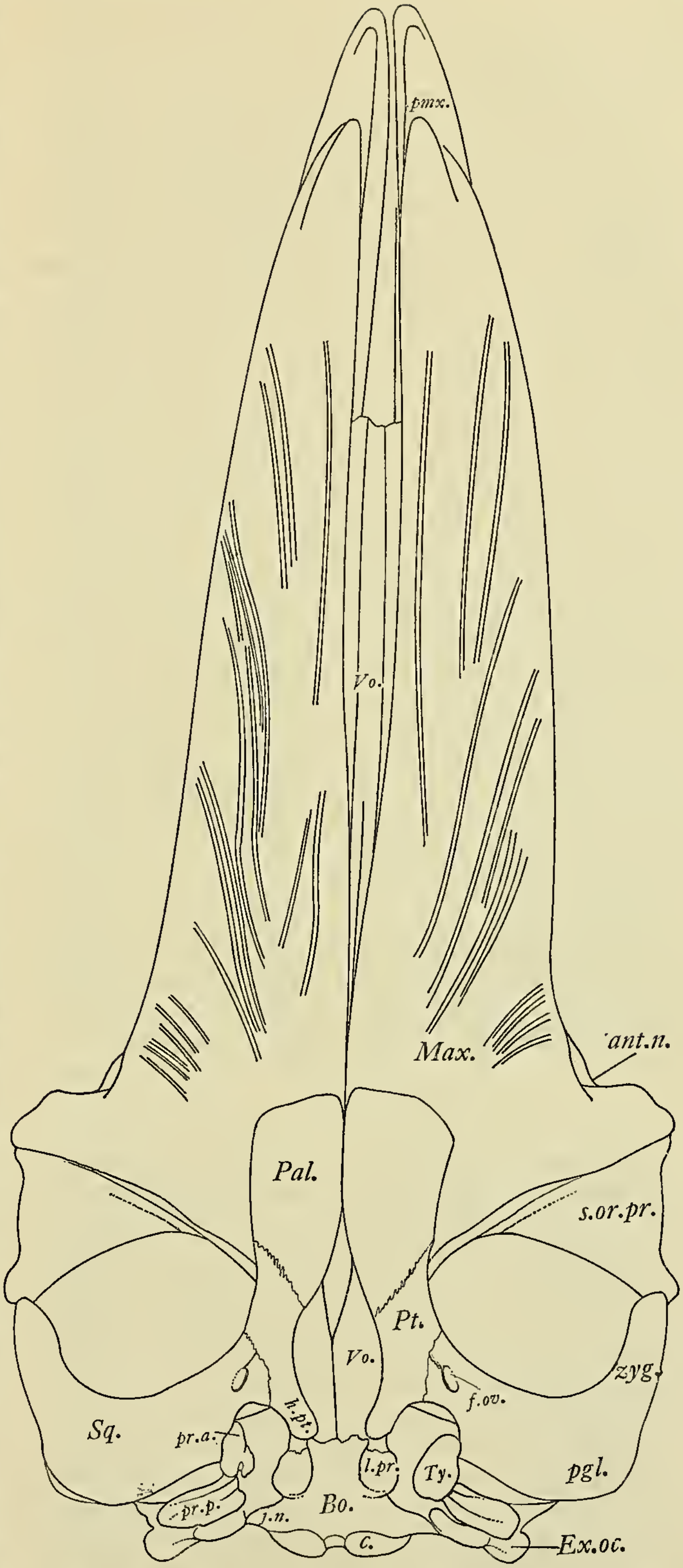

Figure 58.—Ventral view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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.

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.)

	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

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

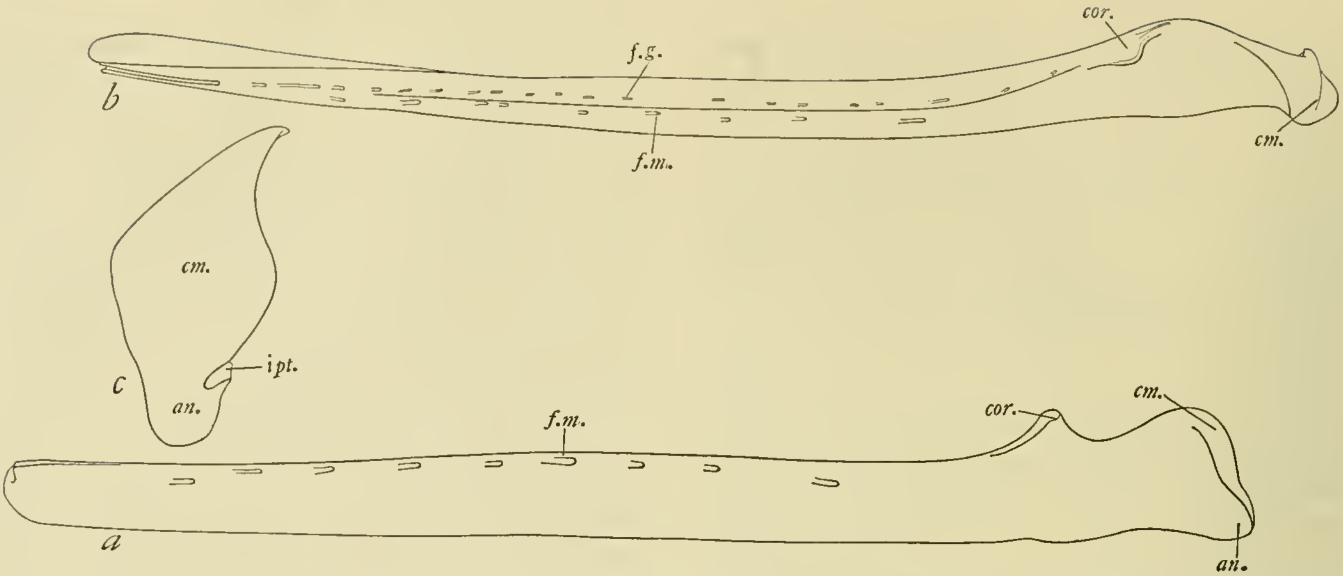

Figure 59.—Views of left mandible, USNM 23494, of *Diorocetus hiatus: a*, external view; *b*, dorsal view; *c*, condyle. Abbrs.: an., angle; cm., condyle of mandible; cor., coronoid process; f.g., gingival or alveolar foramen; f.m., mental foramen; ipt., groove for attachment of internal pterygoid muscle.

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.

	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

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 estimated length (270 mm.; 10½ 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.

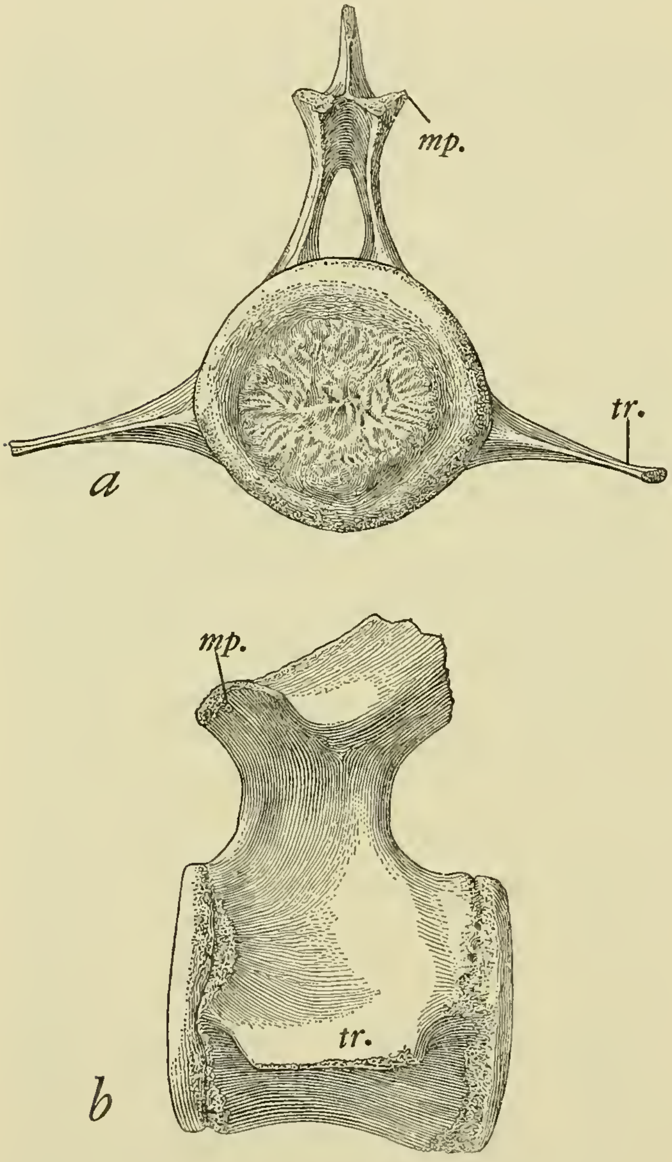

Figure 60.—Views of second caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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

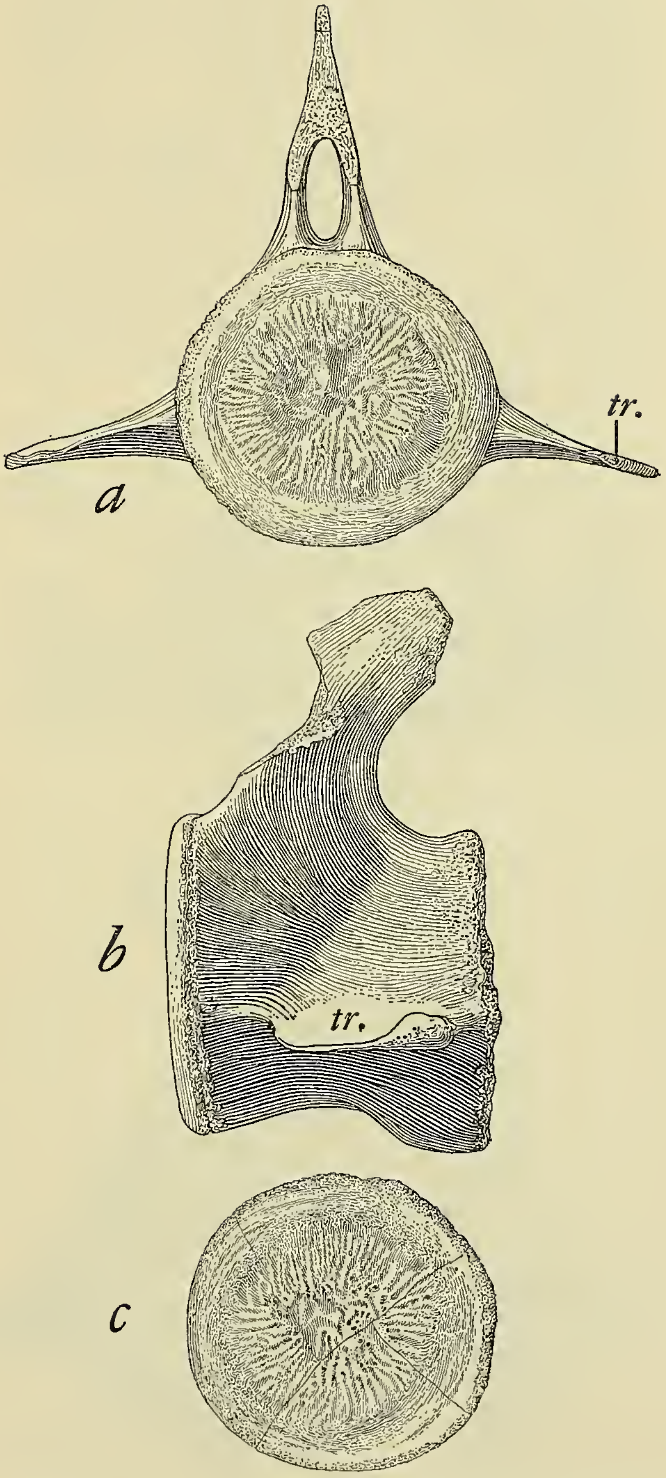

FIGURE 61.—Views of third caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view; *c*, posterior epiphysis. Abbrs.: tr., transverse process.

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

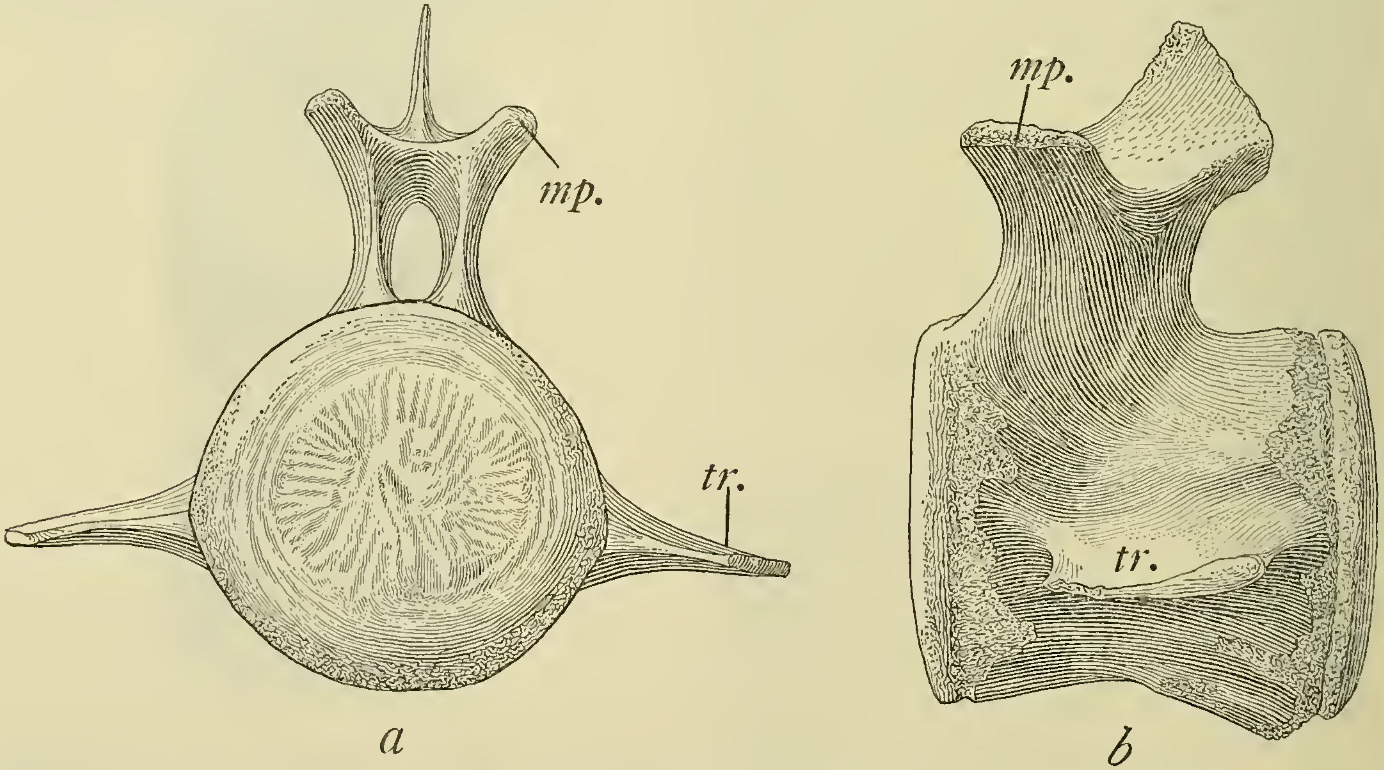

FIGURE 62.—Views of fourth caudal, USNM 16567, of *Diorocetus hiatus*: *a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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

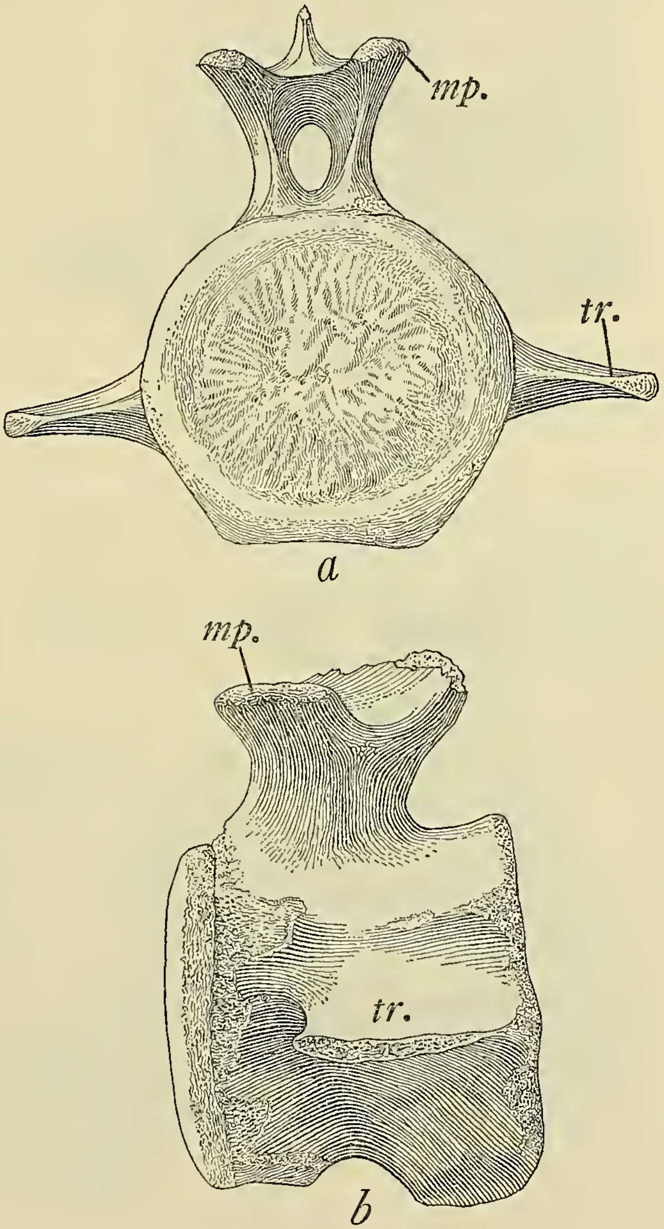

FIGURE 63.—Views of fifth caudal, USNM 16567, of *Diorocetus hiatus: a,* anterior view; *b,* lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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.

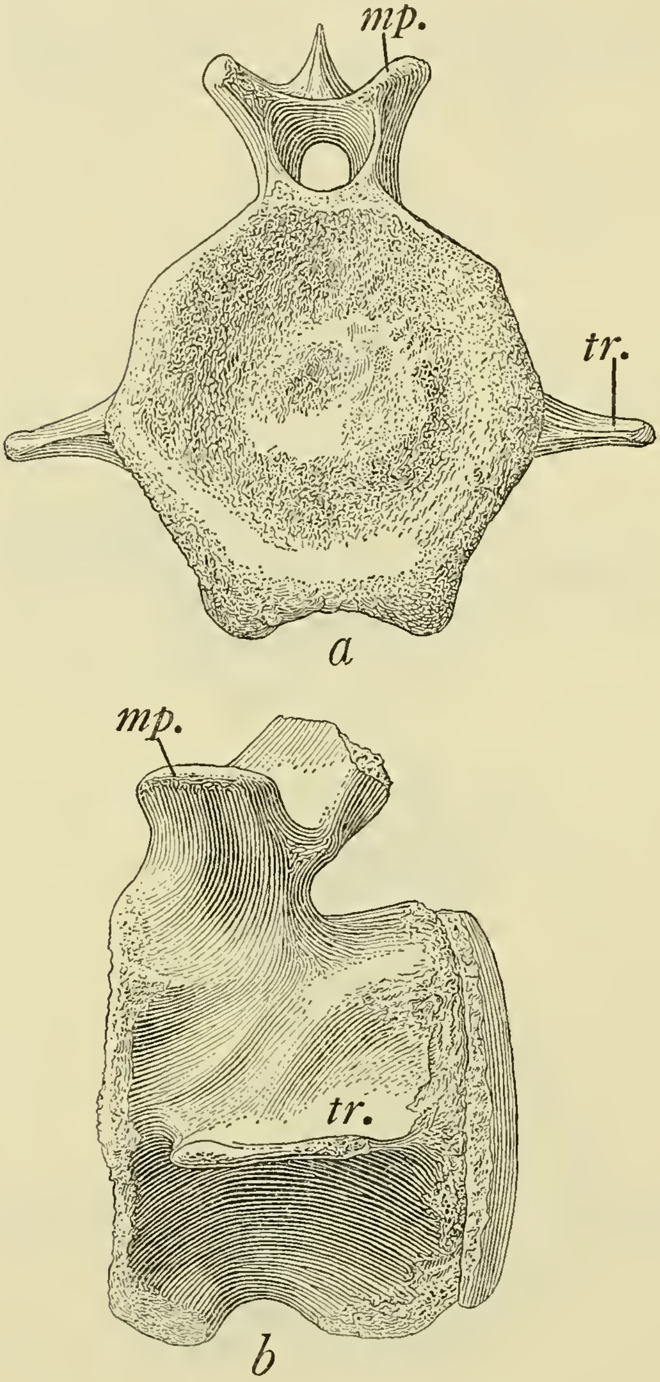

Figure 64.—Views of sixth caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.; mp., metapophysis; tr., transverse process.

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

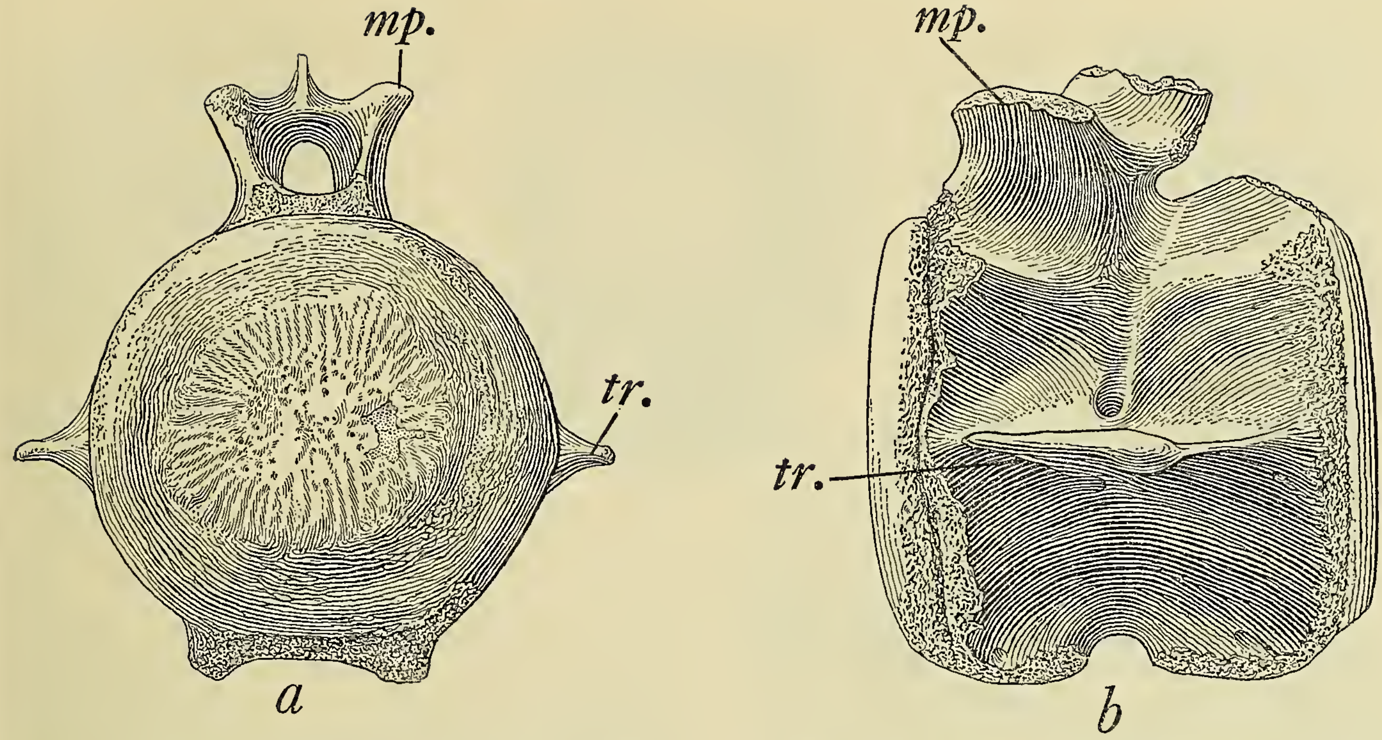

Figure 65.—Views of seventh caudal, USNM 16567, of *Diorocetus hiatus: a,* anterior view; *b,* lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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.

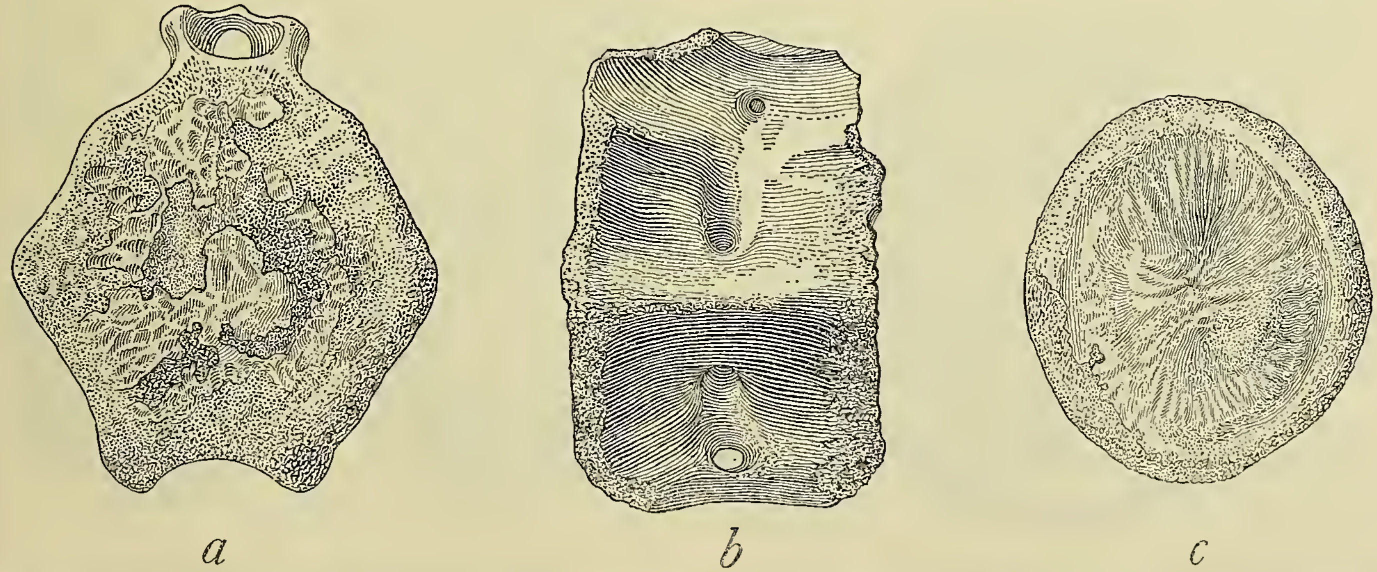

Figure 66.—Views of eighth caudal, USNM 16567, of *Diorocetus hiatus: a,* anterior view; *b,* lateral view, reversed; *c,* posterior epiphysis.

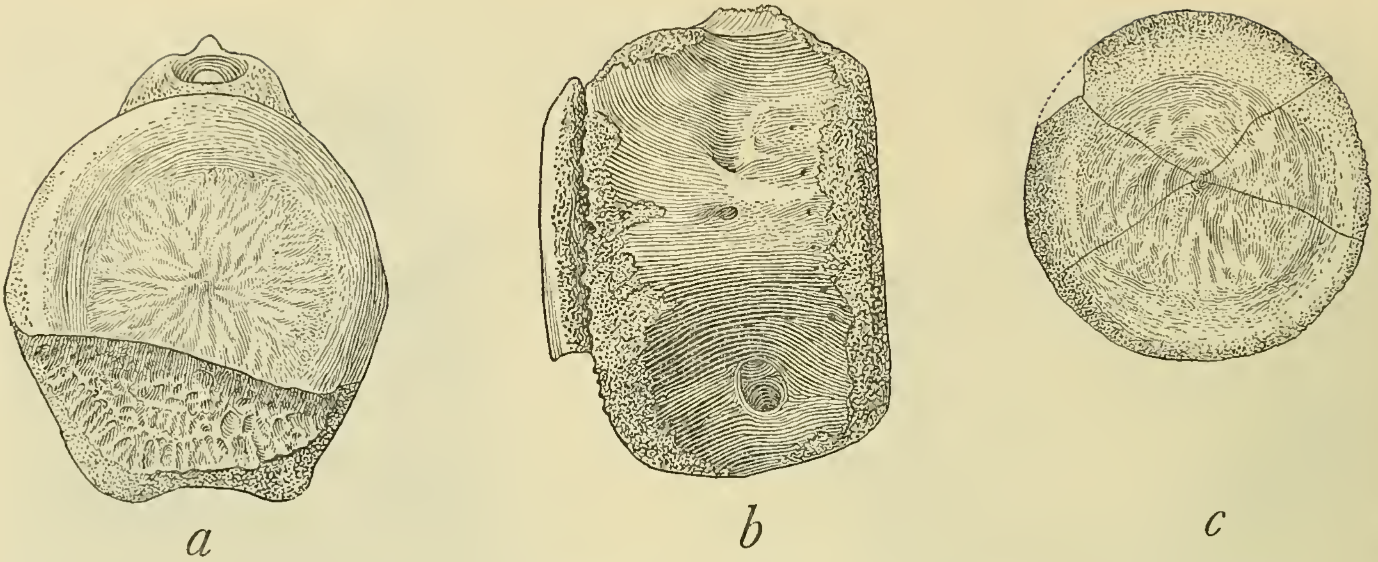

FIGURE 67.—Views of ninth caudal, USNM 16567, of *Diorocetus hiatus:* *a*, anterior view; *b*, lateral view; *c*, posterior epiphysis.

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.*

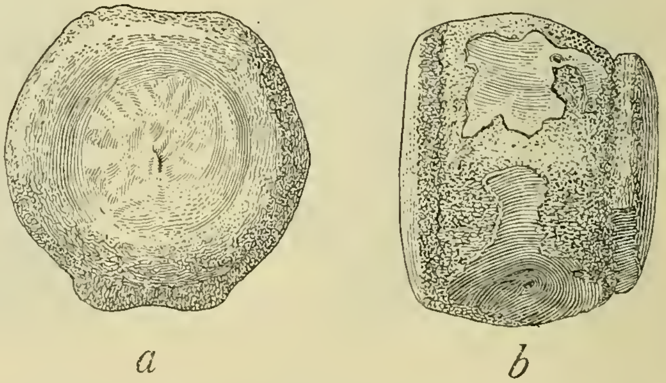

FIGURE 69.—Views of eleventh caudal, USNM 16567, of *Diorocetus hiatus:* *a*, anterior view; *b*, lateral view.

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.

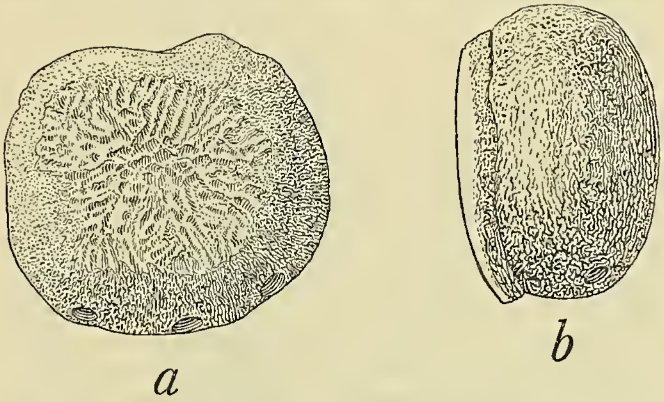

Figure 70.—Views of twelfth caudal, USNM 16567, of *Diorocetus hiatus: a,* posterior view; *b,* lateral view.

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.

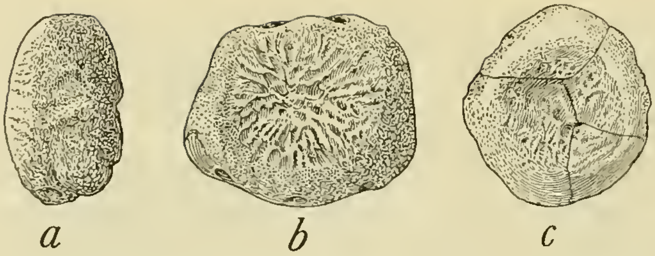

FIGURE 71.—Views of thirteenth caudal, USNM 16567, of *Diorocetus hiatus: a*, lateral view; *b*, posterior view; *c*, posterior epiphysis.

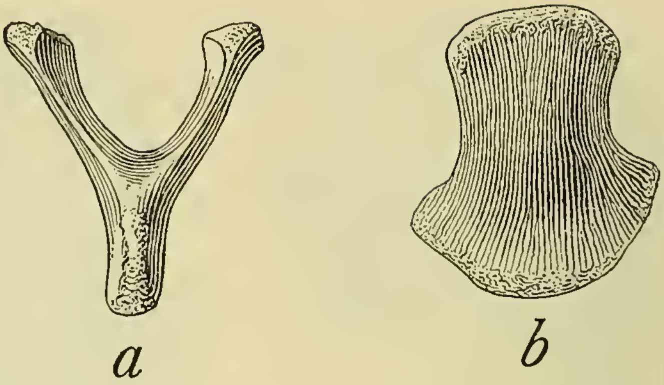

FIGURE 72.—Views of anterior chevron, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view.

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 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.

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

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 dorsoplantar 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 foreflipper 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.

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7. A Sharp-nosed Cetothere From the Miocene Calvert

Inadequacy of recovered skeletal remains of many described fossil mysticetes hampers comparable evaluation of attributed generic criteria. Continued uncertainty regarding the significance of observable differences in the telescoping or the slippage forward or backward of the cranial and rostral bones of the mysticete skull may persist until a larger number of representative types of mysticetes from successive geological faunas are recorded. It must be acknowledged that some skepticism is warranted regarding the validity of mysticete generic diagnoses based in whole or in part on such criteria as the conformation of the articular condyle of the mandible, the position of internal gingival (nutrient) and external mental foramina, the dimensions of the mandibles, unless comparable growth stages can be established, or the size of the tympanic bulla.

Notwithstanding such considerations it seems desirable to allocate a recognizably different specimen to a genus currently accepted as valid. The specimen hereinafter described is considered to be a smaller but geologically more recent member of the genus *Aglaocetus*. Lydekker in 1894 seems to have been the first to direct attention to the occurrence of the skull and associated vertebrae of a whalebone whale in a bed of mixed sand and clay belonging to the Patagonian (lower Miocene) marine formation at "el cerro del Castillo," opposite Trelew, province of Chubut, Argentina. A second skull from the same locality and a third skull (Kellogg, 1934), excavated on a small hill southwest of Pico Salamanca in the same province, have further elucidated the relations of the bones of the skull of this Patagonian *Aglaocetus moreni*.

AGLAOCETUS Kellogg

Aglaocetus Kellogg, 1934, Contrib. Palaeont., Carnegie Inst. Washington, publ. 447, p. 65. January 10, 1934.

Type species: *Cetotherium moreni* Lydekker.

AGLAOCETUS PATULUS, new species

Type specimen: USNM 23690. Skull (essentially complete, except for both lachrymals and jugals, and pterygoids in region of the pterygoid fossae), both tympanic bullae, left periotic, atlas, two cervical vertebrae, two dorsals, eight lumbars, and rib fragments. Collectors, Robert E. Weems, Frank C. Whitmore, Jr., and Albert C. Myrick, Jr.; April 6, 1966.

Horizon and Locality: About 3.5 feet above base of bluff in blue marly clay of zone 14, approximately 3.7 miles below mouth of Pope's Creek in Stratford Bluffs, about 1200 feet beyond swamp below (east of) "Big Meadows," Westmoreland Co., Va., Calvert formation, middle Miocene.

Referred Specimen: Two as follows: (1) USNM 13472; posterior portion of basicranium, apex of supraoccipital shield, right and left supraorbital processes of frontals, interorbital region of frontals, portions of maxillary and premaxillary, vomer, right and left periotics, right tympanic bulla, coll. Raymond M. Gilmore, C. Lewis Gazin and Remington Kellogg, August 9–10, 1933; in zone 14, Kenwood Beach cliff, about 428 yards south of road end at Governor Run, Calvert Co., Md., Calvert formation, middle Miocene. (2) USNM 23049; right squamosal incomplete, right periotic, ten lumbars, nine caudals, five chevrons, right scapula fragments, two metatarsals, two phalanges, rib fragments, coll. Wallace L. Ashby, jr., Frank C. Whitmore, jr., John E. Ott, Leroy Glenn, jr., and Remington Kellogg, July 15, 1963; base of zone 14, about 18 feet above beach level, 180 feet south of north end of first cliff south of mouth of Parker Creek, Calvert County, Md., Calvert formation, middle Miocene.

Diagnosis: Resembling *Aglaocetus moreni* (Kellogg, 1934, p. 66) in having the posteroexternal angle of the maxillary enlarged, its broad ventral plate underlapping the supraorbital process of the frontal. Resembling *A. moreni* and

"*Idiocetus*" *laxatus* (Van Beneden, 1886, pl. 54) in the limited interdigitation of rostral and cranial elements as well as in the shape of the triangular occipital shield. Differing from the Patagonian lower Miocene species in the following features: rostrum wider, less attenuated and lateral profile more convex; ascending process of maxillary shorter, less extended backward; apex of triangular occipital shield carried farther forward to level of center of orbit; zygomatic process of squamosal more robust, directed more forward and less obliquely outward. Presence of large foramen near anterior end of nasal may have no especial significance. From the Belgian upper Miocene (Anversian) genus, this mysticete differs in having the interdigitation of median rostral elements with cranium on interorbital region less accentuated; apex of triangular occipital shield carried forward to level of center of orbit; shorter intertemporal constriction; and zygomatic process of squamosal more robust.

The following combination of characters serve also to characterize this mysticete: slender nasals located for most part anterior to preorbital angles of the supraorbital processes; limited backward overriding of median interorbital region carrying rostral elements (ascending processes of maxillaries and premaxillaries and the nasals) barely beyond the level of preorbital angles of supraorbital processes of frontals; rostrum broad at base, each maxillary having an enlarged posteroexternal angle and a broad ventral plate underlapping the supraorbital process of the frontal; a short intertemporal constriction formed by opposite parietals; exposure of frontals in interorbital region reduced to a narrow strip; lateral protuberance of basioccipital large, elongated; anteroposteriorly compressed extremity of postglenoid process thin. Dome of *pars cochlearis* of periotic neither enlarged nor prolonged ventrally; posterior process narrow, with deep longitudinal groove for facial nerve; labyrinthic region bulbous. Neural canal of posterior cervical vertebrae unusually low and wide; pedicles of neural arch short and much wider transversely than anteroposteriorly; neural spine short and thin; atlas lacks hyapophysial process.

Skull

DORSAL VIEW.—Interlocking of the rostral and cranial portions of the skull (pls. 58–59) is effected in part by the splitting of the posterior extremity of each maxillary into a dorsal ascending process and a ventral plate. Behind the nasal fossa the relatively narrow internal ascending process of the maxillary is held in position in the rather deep sutural grooves on the upper surface of the interorbital portion of the corresponding frontal. Most of the dorsal surface of the relatively wide supraorbital process of the frontal is bare and not overridden by the hinder end of the maxillary.

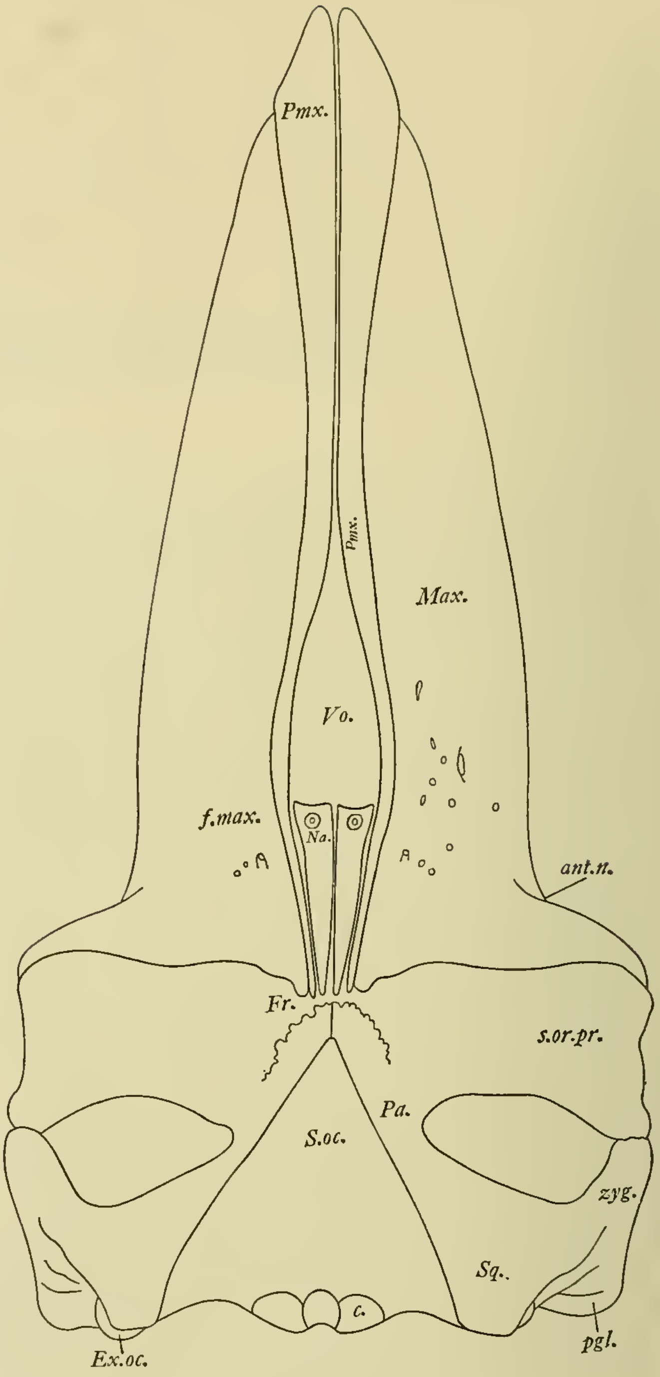

FIGURE 74.—Dorsal view of skull, USNM 23690, of *Aglaocetus patulus*. Abbrs.: ant.n., antorbital notch; Bo., basioccipital; c., occipital condyle; Ex. oc., exoccipital; f.m., foramen magnum; f.max., maxillary foramen or incisure; f.ov., foramen ovale; Fr., frontal; h.pt., hamular process of pterygoid; 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

The broad ventral plate of the maxillary is extended backward beneath the anterior border of the ventral surface of the supraorbital process of the frontal almost to the optic channel.

At the base of the rostrum (fig. 74) the maxillaries are quite broad, attributable in part to the posteroexternal enlargement. In this respect this portion of the skull approximates the similarly widened posterior end of the maxillary of the lower Miocene Patagonian *Aglaocetus moreni* (Kellogg, 1934, fig. 2). The angle formed by the thin outer edge with this posteroexternal enlargement constitutes the antorbital notch of the maxillary, From the level of the longitudinal premaxillary maxillary contact the dorsal surface of each maxillary slopes downward to its outer margin. Along its internal border each maxillary is overlain by the corresponding premaxillary. At least the internal face of the hinder half of each maxillary abuts against the outer surface of the troughlike vomer. On this skull the backward overslippage above the narrow interorbital portion of the frontals by the median portion of the rostrum has carried the hinder ends of the ascending processes of the premaxillaries and maxillaries as well as the nasals behind the level of the preorbital angle of the supraorbital process of the frontal but not to the center of the orbit, the dorsal ascending process of each maxillary being short and rather narrow.

Behind the level of the anterior ends of the nasals, three or four foramina are present in each maxillary external to the premaxillary maxillary contact. At least twelve foramina are present in the right maxillary. The largest of these foramina on the right side is 50 mm. behind the anterior end of the nasal. There are four small foramina in an interval of 50 to 75 mm. in front of the right nasal. About 65 mm. internal to the outer margin and 110 mm. anterior to the antorbital notch two small foramina are present. These foramina are not located in the area corresponding to the oblique incisure on the skull of USNM 16783.

In front of the nasal fossa, each premaxillary is noticeably flattened and projects forward beyond the maxillary, Each premaxillary attains its greatest width (77 mm.) at the level of the anterior ends of the maxillaries. The dorsointernal edges of the opposite premaxillaries parallel one another from the extremity of the rostrum to the anterior end of the nasal fossa. Prior to the distortion resulting from crushing, each premaxillary rested in the groove on the dorsointernal edge of the corresponding maxillary along the dorsal nasal fossa. Each narrowed premaxillary is bent downward and is also curved outward and then inward to conform to the curvature of this fossa. The rather narrow ascending process of each premaxillary is lodged in two or three sutural grooves on the dorsal interorbital surface of the frontal. The troughlike vomer forms the floor of the elongated nasal fossa.

The relatively long (235 mm.) nasal bones taper from their anterior to their posterior ends and are wedged in between the ascending processes of the opposite premaxillaries. Their posterior ends are lodged in sutural grooves on the interorbital surface of the frontal and anteriorly they overhang the nasal fossa. For most of their length the nasals are projected forward above the nasal passages beyond the level of the preorbital angle of the supraorbital process of the frontal. They do not extend backward beyond the level of the posterior ends of the ascending processes of the premaxillaries and maxillaries. The anteroexternal angle projects forward beyond the anterointernal angle of the right nasal, forming a concavely curved anterior edge. A hole or foramen is present behind the anterior edge of each nasal (fig. 74), possibly the result of fortuitous damage.

The frontals are narrowly exposed in the median interorbital region and are excluded from the vertex by the parietals. Between the hinder ends of the median rostral elements and the intertemporal constriction contributed by the parietals, the frontals are exposed for about 10 mm. Each supraorbital process of the frontal slopes gradually from the median interorbital region to its orbital rim. No curved transverse temporal crest seems to have been present, although such a crest, if developed, may have been obliterated by crushing. A rounded preorbital angle, a thick postorbital projection, and a thin arched orbital rim characterize the supraorbital process of the frontal. The rostral wall of the cranium is contributed largely by the frontals. Posteriorly, the frontal is overspread by the thin anterior border of the corresponding parietal. The lachrymals and the jugals were not preserved with this skull.

The parietals, which meet medially to constitute the short (50 mm.) intertemporal ridge, are each overridden above and behind by the external border of the large triangular supraoccipital shield. Anteriorly, the thin anterior border of the parietal overspreads the frontal and the base of its supraorbital process and extends forward almost to the level of the posterior margin of the ascending process of the corresponding maxillary. The nearly vertical parietal constitutes a major portion of the lateral wall of the braincase.

The posterolateral portion of the cranium is constituted by the large thick squamosal. From its anterior sutural contact with the pterygoid, the squamosal curves backward, outward and forward to the extremity of its zygomatic process around the temporal fossa. The zygomatic process is stout and is directed obliquely forward. Erosion of the dorsal surface of both zygomatic processes prevents

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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.

determination of the existence of a lengthwise continuation of the lambdoid crest.

A strong forward thrust of the supraoccipital shield has carried its acutely pointed apex to the level of the center of the orbit. At the level of the foramen magnum the transverse diameter (360 mm.) of the supraoccipital exceeds the greatest distance (305 mm.) from the dorsal rim of the foramen magnum to the apex. Most of this dorsally attenuated shield is depressed medially below the level of its lateral margins.

The exoccipitals are, with the exception of their outer ends, concealed from a dorsal view by the posterior overhang of the lambdoid crest. The large flattened occipital condyles do not project backward beyond the level of the extremities of the exoccipitals.

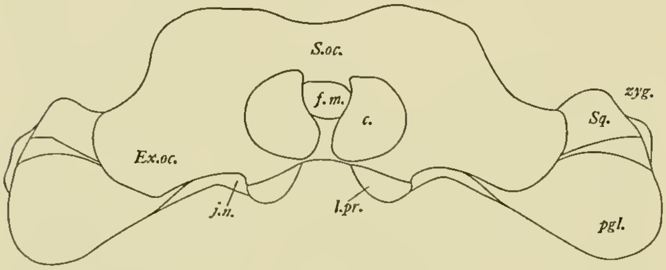

Figure 75.—Posterior view of skull, USNM 23690, of *Aglaocetus patulus*. For abbreviations, see figure 74.

Posterior view.—The dorsally attenuated triangular occipital shield (fig. 75), which constitutes essentially the entire posterior wall of the braincase, consists of the medially depressed supraoccipital and on each side of the foramen magnum the exoccipital. On each side the lambdoid crest on the posterior edge of the squamosal above the exoccipital curves upward and then forward along the external edge of the supraoccipital to its acutely pointed apex. No median vertical ridge is developed on this bone above the foramen magnum. Each exoccipital comprises a lateral wing of the posterior triangular shield.

From a posterior view it is seen that the foramen magnum is relatively large and ovoidal in outline. The large occipital condyles are less convex from side to side than from end to end. They are separated ventrally by a deep wide notch.

On each side of the median basicranial depression is the large downward projected lateral protuberance of the basioccipital. The external face of this protuberance constitutes the inner limit of the large notch or incisure for the jugular leash. External to the exoccipital the distally rounded postglenoid process extends downward 98 mm. below the level of the ventral edge of the occipital condyle and 70 to 82 mm. below the level of the ventral edge of the adjacent exoccipital. Except in the details just noted and in certain differences in the profiles of individual bones, the relations of the component parts of the hinder end of the cranium are similar to USNM 23494.

Lateral view.—The apex of the supraoccipital shield, the highest point of the dorsal profile, rises very little above the lateral margins of this shield, but more abruptly above the short intertemporal ridge. The slope from the median interorbital region to the extremity of the rostrum is very gradual. The greatest depth of the rostrum is at the anterior end of the palatines. The outer edge of the maxillary is thin throughout its length anterior to the antorbital notch.

The arched orbital rim of the supraorbital process of the frontal is dorsoventrally compressed, the preorbital angle is somewhat thinner than the underlying ventral plate of the maxillary and the postorbital angle is noticeably thickened dorsoventrally. The downward slope of the supraorbital process of the frontal from the median intertemporal region to the orbital rim is gradual.

The dorsoventral diameter of the basal portion of the postglenoid process (80 mm.) is almost twice the same measurement of the anterior end of the zygomatic process (44 mm.). Viewed from the side the posterior surface of the postglenoid process slopes obliquely downward and backward.

The nearly vertical parietal is concavely curved from end to end and contributes a major portion of the lateral wall of the braincase, meeting its opposite dorsally to form a short intertemporal ridge and overspreading the base of the frontal. The small alisphenoid is visible in the lateral wall of the braincase behind the base of the supraorbital process of the frontal above the pterygoid and below the parietal. The occipital condyles are not visible when the skull is viewed from the side.

Ventral view.—Except for the immediate region of the pterygoid fossa and portions of the ventral surface of the maxillaries, this skull (USNM 23690; pl. 59) is exceptionally complete. The major portion of the ventral surface of the rostrum is contributed by the maxillaries, which prior to deformation as the result of being shoved over the centra of dorsal vertebrae, met longitudinally along the midline of the rostrum, concealing the keel of the vomer. The presence of an unusually large posteroexternal angle on each maxillary has accentuated the narrowing of the rostrum. Flattening of the ventral surface of the maxillary is most obvious external to the median downward convex curvature, which conforms to the shape of the vomer against which it abuts. Along the anterior border, the supraorbital process of the frontal is underlapped by the thin posterior end of the corresponding maxillary. The ventral surface of each maxillary (fig. 76) is engraved by a series of grooves which, unfortunately as a result of poor preservation of the original surface in certain areas, cannot be traced in their entirety. The grooves near the posterior end of each maxillary opposite and in front of the palatine are quite short and are directed obliquely outward and backward. These grooves serve as channels for the nutrient vascular vessels and nerves that supply the palate and attached baleen of the living mysticetes. Except for a relatively few short ones more anteriorly along the outer border, the majority of the anterior grooves run lengthwise or nearly so. The right maxillary terminates 1370 mm. anterior to the posterior margin of the vomer and the right premaxillary extends 95 mm. beyond the maxillary. The distance from the anterior end of the right maxillary to the anterior edge of the optic channel at the base of the right supraorbital process is 1230 mm. The inner edges of the opposite maxillaries commence to diverge slightly on the ventral surface of the rostrum 115 mm. behind the anterior end of the right maxillary.

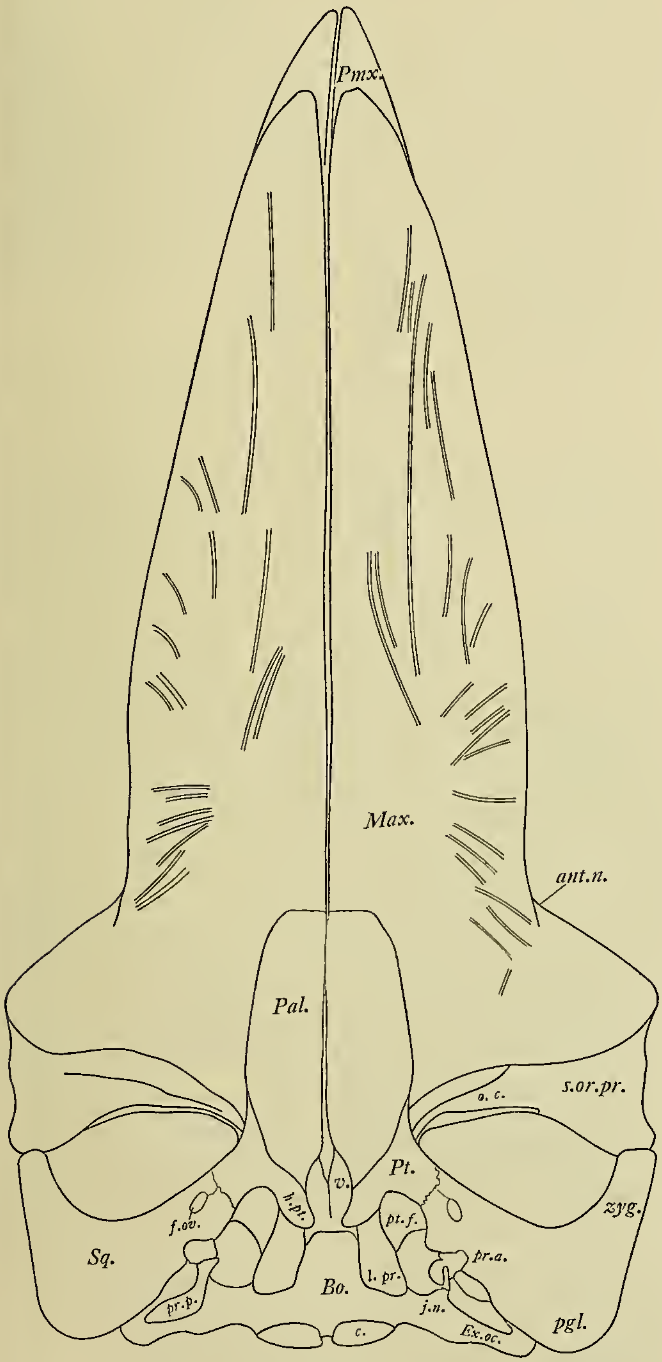

Figure 76.—Ventral view of skull, USNM 23690, of *Aglaocetus patulus*. For abbreviations, see figure 74.

At a point 130 mm. in advance of the posterior end of its horizontal plate the ventral keel of the vomer develops a narrow flattened surface, which is extended backward at the same horizontal level for 75 mm., and then, as a continuing thin vertical partition between the choanae, diminishes in vertical diameter until it disappears about at the posterior end of the vomer. The horizontal plate of the posterior end of the vomer conceals the basisphenoid from a ventral view and laterally is in contact with the corresponding edge of the vaginal process of the pterygoid.

Although the posterior border of each palatine is broken off and the precise termination of the anterior end uncertain on account of sloughing off of the thin borders of this bone, the anteroposterior diameter of each palatine was at least 300 mm. Each palatine anteriorly and externally overspreads the ventral surface of the corresponding maxillary. Posteriorly each palatine is suturally united with the pterygoid which contributes the missing internally projecting hamular process. The lachrymal and jugal bones were not attached to this skull and presumably were disassociated prior to burial by sediments.

The distally expanded supraorbital processes of the frontals are extended outward to the level of the large posteroexternal angles of the maxillaries. The deep 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 process.

On the internal two thirds of its length this optic channel resembles a partly closed tube, being bordered posteriorly by a thin osseous wall up to 35 mm. in vertical diameter, which terminates about 100 mm. from the external orbital rim. This deep posterior wall of the optic channel, the proximal portion of which is certainly complete on both supraorbital processes, seems to be contributed by the frontal, since no sutural contact with either the alisphenoid or parietal could be detected. The anterior wall of this optic channel (vertical diameter near its origin as much as 30 mm.) is contributed by the dorsoventral thickening of the supraorbital process. In width on the left process, this channel increases from a minimum of 20 mm. near its origin to a maximum of 50 mm. at the point where the posterior wall vanishes on the rim. The relationship of the orbitosphenoid cannot be determined since its normal position within this partly closed optic channel is hidden from view.

The central exposure of the basioccipital between its large lateral descending protuberances (left, transverse diameter, 55 mm.) is rectangular; its line of contact with the basisphenoid is overspread by the horizontal plate of the vomer. The flattened external surface of the lateral protuberance slopes obliquely upward. Anteriorly each lateral descending process or protuberance is overspread by the hinder end of the corresponding vaginal plate of the pterygoid, which is also in contact along its dorsointernal edge with the horizontally widened plate of the posterior end of the vomer. This portion of the pterygoid also contributes the inner outer wall of the corresponding internal choana. Only the broken off basal portion of the right hamular process is preserved on tnis skull. The attenuated anterior portion of the pterygoid is extended forward beyond the level of the internal end (origin) of the optic channel and is also suturally united along its internal edge with the palatine. The main portion of the pterygoid is suturally united in front with the hinder end of the palatine and behind with the bifurcated end of the squamosal which encloses the foramen ovale. The greatest anteroposterior diameter of the left foramen ovale is 26 mm. and the greatest transverse diameter 15 mm. The pterygoid comes in contact with the lower surface of the alisphenoid on the inner wall of the temporal fossa and is also narrowly in contact with the parietal.

The small pterygoid fossa 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 extent by the falciform process of the squamosal. The roof of this air-containing fossa and the floor also to some extent is formed by the pterygoid; it is continuous posteriorly with the tympanoperiotic recess. The extent to which the pterygoid contributes the floor of this fossa cannot be readily determined, since no remnants other than broken edges of this bone are present. The reconstruction of the pterygoid in the region of the pterygoid fossa shown on figure 76 is therefore somewhat conjectural.

The squamosal and its falciform process externally, the pterygoid anteriorly, the lateral protuberance of the basioccipital internally, and the exoccipital posteriorly enclose the tympanoperiotic recess. A broad notch or incisure on the exoccipital between the lateral protuberance and the *pars cochlearis* of the periotic corresponds to the posterior lacerated foramen for the jugular leash.

On the ventral surface the contact between the squamosal and the exoccipital is concealed by the posterior process of the periotic which is securely lodged in a deep groove. Between the posterior process of the periotic and the base of the hinder face of the postglenoid process is the rather broad (15 mm.) and shallow groove for the external auditory meatus.

The elongated zygomatic process is directed more forward than outward and is in direct contact with the postorbital projection of the supraorbital process of the frontal. Each postglenoid process is deflected obliquely backward and has its thin anteroposteriorly compressed extremity extended 55 mm. below the level of the lateral protuberance of the basioccipital. The posterior face of each postglenoid process is deeply concave and the anterior face is convex. The glenoid articular surface is concavely curved from extremity of postglenoid process to tip of zygomatic process (length, left process, 273 mm.). External to the excavation for the pro-otic portion of the periotic and in front of the sharp edged posterior rim, a relatively shallow concavity is present on the ventral surface of the squamosal.

The outer ends of the exoccipitals project backward slightly (12 mm.) beyond the level of the posterior articular surfaces of the occipital condyles. Although no definite paroccipital processes are developed for the attachment of each stylohyal, a small cavity is present on the corresponding area on the left exoccipital. The occipital condyles are not protuberant and are separated by a deep narrow (15 mm.) groove.

Measurements (in mm.) of the skull, USNM 23690, are as follows:

Greatest length of skull, anterior end of right premaxillary to level of posteroexternal angle of right exoccipital	1635
Distance from anterior end of right premaxiliary to posterior articular face of right occipital condyle	1600
Distance from anterior end of right premaxillary to apex of supraoccipital shield	1253
Greatest length of right premaxillary	1167
Distance from apex of supraoccipital shield to posterior end of right nasal bone	68
Transverse diameter of skull across posteroexternal angles of supraorbital processes of frontals	775
Transverse diameter of skull across preorbital angles of supraorbital processes of frontals	770
Greatest anteroposterior diameter of extremity of left supraorbital process of frontal	205
Transverse diameter of skull across outer surfaces of zygomatic processes	760
Transverse diameter of skull between outer edges of exoccipitals	490
Transverse diameter between outer edges of occipital condyles	167
Greatest or obliquovertical diameter of right occipital condyle	85
Greatest transverse diameter of right occipital condyle	69

Greatest transverse diameter of foramen magnum	46
Distance from dorsal rim of foramen magnum to apex of supraoccipital shield	305
Distance between anterior end of right premaxillary and extremity of right postglenoid process	1615
Distance between anterior end of right premaxillary and edge of optic channel (groove) at origin	1230
Right nasal, length externally	235
Right nasal, length internally	230
Right nasal, width anteriorly	50
Right nasal, width at base	15
Greatest breadth of basioccipital across lateral protuberances, outside measurement	180±
Greatest length of left zygomatic process, extremity of postglenoid process to anterior end	273
Distance from posterior surface of right occipital condyle to posterior end of vomer	132
Distance from posterior surface of right occipital condyle to anterior edge of right palatine	520±
Posterior edge of vomer to anterior edge of right palatine	390±
Distance between opposite foramina ovale	292

Tympanic Bulla

The left tympanic bulla (USNM 23690) was crushed against the left periotic on the type skull. The right bulla (USNM 13472) was pushed partially into the tympanoperiotic recess on the referred skull.

The type bulla (pl. 60, figs. 3–5) differs from the referred bulla (USNM 13472) in having the posterior end pinched in medially and attenuated ventrally to form a broad V-shaped vertical depression, an acute projecting ventrointernal angle, a less abruptly backward bending extremity of the sigmoid process, and a broader vertical groove in front of the sigmoid process. On the ventral face of the type bulla a low crest, which is better developed near the ends than at the middle, extends obliquely from the posteroexternal to the anterointernal angle. No trace of his crest is visible on the referred bulla.

The posterior pedicle arises internally from the posterior end of the involucrum and externally, behind the low blunt conical apophysis, from the posterior end of the thin curved outer lip.

The involucrum is creased transversely near the middle of its length; the eustachian outlet of the tympanic cavity is moderately wide. Viewed from the external side, the ventral profile is nearly straight, and the anterior end is more obliquely truncated than the convexly curved posterior end.

Little if any correlation was noted between the dimensions of the bulla and the size of the skull among more than 40 bullae of Calvert cetotheres assembled for comparison. Tangible differential features that may serve to distinguish specifically the several species of Calvert cetotheres were not readily observable. The usefulness of minor or apparent inconsequential variations in the contour of the bulla for purposes of identification is certainly questionable in the present state of our understanding of the developmental history of these cetotheres.

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

	USNM 23690 Left	*USNM 13472 Right*
Greatest length of tympanic bulla	76	71.5
Greatest width of tympanic bulla	47	42.5
Greatest vertical diameter of external side, ventral face to tip of sigmoid process	60	57
Greatest length of tympanic cavity	53	51.5

Periotic

On the type skull (USNM 23690) the posterior processes of both periotics are firmly lodged in the groove between the exoccipital and the base of the postglenoid process of the squamosal. Except for the *pars cochlearis* of the right periotic, both periotics are otherwise complete. The left periotic, whose labyrinthic region apparently is deformed internally by exostosis, was detached from the type skull. Both periotics (pl. 51, figs. 1, 2) were detached for examination from the referred basicranium (USNM 13472).

The rather broad deep groove for the facial nerve (pl. 60, fig. 1) traverses the ventral face of the narrow posterior process from the external wall of the stapedial fossa to the extremity of this process. A short obtuse anterior process projects forward from the bulbous labyrinthic region which is markedly convex externally but flattened internally. This swollen anterior portion of the periotic is lodged as usual in a deep excavation in the squamosal external to and behind the pterygoid fossa.

The side to side compressed anterior pedicle of the tympanic bulla was attached to the ventral surface of the labyrinthic region 10 mm. in advance of the epitympanic aperture of the Fallopian aqueduct. The broken off basal portion of the posterior pedicle of the bulla remains ankylosed to the anterointernal angle of the ventral surface of the posterior process.

A broad, smooth concave fossa (vertical diameter, 11 mm.; length 27 mm.) extends from the posterorinternal angle of the posterior process inward across the posterior face of the *pars cochlearis* behind the stapedial fossa and above (dorsal to) the *foramen rotunda* and its projecting shelf to the cerebral face of the referred periotic (USNM 13472). This area is partially concealed by a bony exostotic outgrowth on the type periotic.

As viewed from the ventral aspect the *fenestra ovalis* is concealed by the oblique slope of the external face of the *pars cochlearis*. A deep narrow groove extends forward and inward from the *fenestra ovalis* between the *pars cochlearis* and the anterior process. The shallow cavity for reception of the head of the malleus is located in front of and external to the epitympanic aperture of the Fallopian aqueduct. The *fossa incudis*, which is situated external to the groove for the facial nerve, is unusually deep and is bounded internally by a thin elevated rim.

The dome of the *pars cochlearis* (pl. 60, fig. 2), although convex is not prolonged ventrally and is not enlarged. The cerebral face of the *pars cochlearis* is small. Above the circular internal acoustic meatus the cerebral face of the referred periotic is concavely depressed behind and above an ovoidal rugose depression. The cerebral aperture of the Fallopian aqueduct is quite large and in close proximity to the internal acoustic meatus. On the referred periotic the vestibular aqueduct opens into a large, deep, elongated depression behind and above the internal acoustic meatus. Below this depression is the aperture of the small cochlear aqueduct. The topography of this internal area on the type periotic, although obscured by exostosis, is identical with that of the referred periotic.

On another right periotic (USNM 23049) the usual groove for lodging an extension of the air sac system on the posterior face of the *pars labyrinthica* is completely shut off by an osseous wall from the posterior end of the stapedial fossa; this malformation resulted from the deep excavation of the internal end of the posterior process.

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

	USNM 23049 Right	*USNM 23690 Left*	*USNM 13472 Left*
Length of posterior process, distance from external wall of stapedial fossa to extremity	92	87	94
Greatest dorsoventral diameter of periotic from most inflated portion of tympanic face of *pars cochlearis* to most projecting point on cerebral side	55.5	56	53
Distance between epitympanic orifice of Fallopian aqueduct and extremity of anterior process	53	52	45
Distance from external end of posterior process to anterior end of anterior process (in a straight line)	143	147	143

Cervical Vertebrae

The atlas, the right half of the third cervical and a well-preserved fifth cervical were associated with the type skull (USNM 23690). Both epiphyses were detached from the third and fifth cervicals, an indication of physical immaturity.

Atlas: Large, moderately thickened anteroposteriorly (USNM 23690); neural arch with low, rugose, ridge-like neural crest; high (91 mm.) hourglass-shaped neural canal (pl. 61, fig. 1); reniform anterior facets for articulation with occipital condyles of skull deeply concave, slanting obliquely outward from internal to external margins and separated ventrally by shallow groove (minimum width, 22 mm.). On each side the neural arch is pierced, nearer the anterior than the posterior margin, by a vascular foramen which opens into a ventrally directed groove. Transverse processes short, slightly compressed anteroposteriorly and obtuse. Crescentic posterior articular surfaces (pl. 61, fig. 2) slightly constricted medially. No hyapophysial process is developed. An ill-defined upward slanting shallow depression for reception of odontoid process of axis; forward projecting median angle of neural arch of axis does not articulate with neural arch of atlas posteriorly.

Additional measurements (in mm.) of atlas are as follows: greatest distance between outer margins of anterior articular facets, 170; greatest distance between outer margins of posterior articular facets, 180; greatest vertical diameter of right anterior articular facet, 114; greatest vertical diameter of posterior articular facet, 104.

Third Cervical: The right side of this cervical (USNM 23690) shows that the centrum was broadly elliptical, the neural canal unusually wide, and the transverse curvature of the roof of the neural arch rather gradual. The pedicles of the neural arch are short, slender and anteroposteriorly compressed; they support the transversely widened prezygapophysial facets; the somewhat larger postzygapophysial facets (pl. 61, fig. 3) are located on the under surface of the arch and project backward beyond the level of the posterior face of the centrum. The slender upper transverse process (diapophysis) is short, attenuated and projects outward from the pedicle of the neural arch; the lower process (parapophysis) is elongated, dorsoventrally compressed beyond its base. Since the extremities of both the upper and the lower processes were broken off there is no certainty that they were united distally to enclose completely the large cervical extension of the thoracic *retia mirabilia*.

Fifth Cervical: The neural canal of this cervical (USNM 23690) is wider than that of the third cervical and the short pedicles of the neural arch are extended farther ventrally on the dorsoexternal face of the centrum. The thin roof of the neural arch (pl. 61, fig. 3) is narrow and from it arises a very short thin, neural spine. Slender attenuated diapophyses project outward from the pedicles of the neural arch. The ovoidal prezygapophysial facets are unusually small; the postzygapophysial facets on the ventral surface of the neural arch are large and elongate. The roof of the neural canal is less elevated (36 mm.) than on the third cervical (45 mm.) and its width (96 mm.) is greater. The dorsoventrally compressed parapophysis projects outward and slightly backward from the ventroexternal angle of the centrum and is abruptly widened between its base and acuminate extremity. The extremities of the upper and lower transverse processes are separated by a wide gap.

Measurements (in mm.) of cervical vertebrae, USNM 23690, are as follows:

	Atlas	*C.3*	*C.5*
Anteroposterior diameter of centrum	58	21[b]	23.5[b]
Transverse diameter of centrum anteriorly	195	—	107.5
Vertical diameter of centrum anteriorly	—	80+	93
Tip of neural spine to ventral face of centrum anteriorly	158	138+	149
Greatest vertical diameter of neural canal anteriorly	93	50	36
Greatest transverse diameter of neural canal anteriorly	49	—	96
Greatest distance between outer ends of parapophyses	237	—	234
Least anteroposterior length of pedicle of neural arch	51	—	11
Greatest transverse diameter of centrum posteriorly	185	—	105
Greatest vertical diameter of centrum posteriorly	114	—	92

[b] =Both epiphyses missing.

Dorsal Vertebrae

The vertebra identified as the ninth and eleventh dorsals were intermingled with lumbar vertebrae which were in close contact with the ventral surface of the skull.

Ninth Dorsal: On the ninth dorsal (USNM 23690; pl. 63, fig. 1), the broad transverse process (parapophysis), dorsoventrally thickened at the base, projects outward from the dorsoexternal surface of the centrum. The anteroposteriorly expanded (80 mm.) distal end of this process is thicker posteriorly (16 mm.) than anteriorly (9 mm.) and is roughened for attachment of the head of the ninth rib. The metapophyses, which project forward beyond the level of the anterior face of the centrum, rise at least 60 mm. above the floor of the neural canal and limit externally the elongated prezygapophysial facets. Backward projecting postzygapophysial facets are reduced. The neural spine (pl. 62, fig. 1) is strongly inclined backward, but rises at least 125 mm. above the roof of the neural canal. The pedicles of the neural arch are relatively thin (minimum width, 14 mm.; the transverse width, 47 mm., slightly exceeds the vertical diameter, 45 mm., of the neural canal). The profile of the anterior face of the centrum is definitely subcordate.

Eleventh Dorsal: Extremities of both transverse processes of this dorsal (USNM 23690) are broken off. At the base these processes project outward from the external face of the centrum at a lower level than on the ninth dorsal, but are likewise dorosoventrally thickened; the anterior edge is thin and the posterior edge thickened. The pedicles of the neural arch have increased in anteroposterior diameter (58 mm.). The thin metapophyses are larger and rise 68 mm. above the floor of the neural canal; they are also less widely separated. Neither pre- nor postzygapophysial facets are present. The rather broad (75 mm.) neural spine, which rises about 130 mm. above the roof of the neural canal, is strongly inclined backward and truncated distally. The anterior face of the centrum retains the subcordate profile.

Measurements (in mm.) of the ninth and eleventh dorsal vertebrae (USNM 23690) are, respectively, as follows: anteroposterior diameter of centrum, 102, 113; transverse diameter of centrum anteriorly, 115, 119; vertical diameter of centrum anteriorly, 90, 93; minimum anteroposterior length of pedicle of neural arch, 55, 58; transverse diameter of neural canal anteriorly, 47, 40; vertical diameter of neural canal anteriorly, 45, 45; distance between ends of transverse processes, 280±,—; tip of neural spine to ventral face of centrum posteriorly, 240±, 250; dorsal edge of metapophysis to ventral face of centrum anteriorly, 151, 163.

Lumbar Vertebrae

Arranged in serial sequence, the centra of the third to tenth lumbars increase very gradually in length, width, and height. No distinct longitudinal median ridge or keel is developed on the ventral surface of the centra of the six anterior lumbars (USNM 23690). Notwithstanding the damaged condition of the parapophyses of the anterior lumbars, the remnants show that these dorsoventrally compressed processes diminish in length, but increase in width behind the seventh lumbar. The vertical diameter of the neural canal exceeds the transverse on all eight lumbars. No functional pre- and postzygapophysial facets are present; the elongated thin lamina-like metapophyses project forward and more upward than outward. Backward slanting neural spines increase in anteroposterior width toward the hinder end of the lumbar series. The minimum anteroposterior length of the pedicle of the neural arch diminishes.

Third Lumbar: Increased elevation of the thin lamina like metapophyses, a greater vertical diameter of the neural canal, and a more circular profile of the anterior end of the centrum are the most obvious features distin-

USNM 23690–Lumbar Vertebrae	*L–3*	*L–4*	*L–5*	*L–6*	*L–7*	*L–8*	*L–9*	*L–10*
Anteroposterior diameter of centrum	109[p]	118	104[b]	115+[a]	126[a]	119[p]	128	129[p]
Transverse diameter of centrum anteriorly	118	120	123	121	125	121	121	125
Vertical diameter of centrum anteriorly	99	96	100	103	106	107	107	113
Minimum anteroposterior length of pedicle of neural arch	52	56	53	52	48	48	48	46
Transverse diameter of neural canal	35	36	35	32	30	30	29	31
Vertical diameter of neural canal, anteriorly	52	51	50	46	44	43	42	41
Tip of neural spine to ventral face of centrum posteriorly	243±	265±	282±	285±	300±	320±	305±	328±
Dorsal edge of metapophysis to ventral face of centrum anteriorly	175	167±	180	175+	200	195	188	195

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

guishing the third lumbar (USNM 23690) from the eleventh dorsal. No material alteration of the oblique backward slant of the neural spine is observable. A more noticeable dorsoventral compression of the basal portion of the parapophysis characterizes this lumbar and those that follow in the series.

Fourth Lumbar: This lumbar (USNM 23690) also lacks the distal end of the backward slanting neural spine whose anteroposterior width has increased. No change in the width of the parapophysis at the base is observable.

Fifth Lumbar: This lumbar (USNM 23690) lacks both epiphyses; the right parapophysis is broken off at the base as well as the distal ends of the neural spine and the left parapophysis. As compared with the preceding lumbar, the width and height of the neural canal have diminished slightly. The thin lamina-like metapophyses, which rise 80 mm. above the floor of the neural canal, project forward beyond the level of the anterior face of the centrum, and their dorsal edges are separated anteriorly by an interval of 35 mm. The left parapophysis is directed outward and slightly forward.

Sixth Lumbar: Behind the fifth lumbar the height and width of the neural canal gradually diminishes to the end of this series, and so does the minimum anteroposterior width of the pedicles of the neural arch. The thin metapophyses of the sixth lumbar (USNM 23690) project forward to but not beyond the level of the anterior face of the centrum. At both ends of the centrum the transverse diameter exceeds the vertical diameter. The right parapophysis is broken off at the base, the distal end of the left process is incomplete, the distal end of the left process is incomplete, and the anterior epiphysis is missing.

Seventh Lumbar: This lumbar (USNM 23690) lacks the anterior epiphysis, the distal end of the left parapophysis and all of the right except the basal portion, and the extremity of the neural spine. As compared to the preceding lumbar, the thin metapophyses are less widely separated, but rise higher (90 mm.) above the floor of the neural canal. A distinct median longitudinal keel is developed on the ventral surface of the centrum.

Eighth Lumbar: Measurements of the centrum (USNM 23690) are not materially different from the seventh lumbar. The extremities of both parapophyses are incomplete, the distal end of the neural spine (pl. 62, fig. 2) is broken off, and the posterior epiphysis is missing. The left parapophysis (pl. 63, fig. 5), which is the most complete, projects outward and obliquely forward; its distal end seems to have been expanded. The backward slanting neural spine is wider anteroposteriorly (85 mm.) than on the anterior lumbars.

Ninth Lumbar: This lumbar (USNM 23690) lacks the distal end of the neural spine and the extremities of both parapophyses are damaged. These subspatulate parapophyses were expanded distally and projected less downward than outward from the lateral surface of the centrum, their extremities not extending beyond the level of the anterior face of the centrum. The median longitudinal keel is very indistinctly developed on the centrum.

Tenth Lumbar: This vertebra (USNM 23690; pl. 62, fig. 3) lacks the distal end of the neural spine and the posterior epiphysis. The nearly complete left parapophysis (pl. 63, fig. 3) is dorsoventrally compressed, slightly constricted near its base, expanded on its distal half and its posterior edge curved forward to the anteroexternal angle which extends forward beyond the level of the anterior face of the centrum. A distinct median longitudinal keel is present on the ventral surface of the centrum. The profile of the anterior end of the centrum (pl. 63, fig. 6) is circular. The thin metapophyses do not extend forward beyond the level of the anterior face of the centrum.

Measurements (in mm.) of lumbar vertebrae, USNM 23690, are as indicated above.

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8. Supplement to Description of PARIETOBALAENA PALMERI

As many as eight species representing four genera of Recent mysticetes, are or were periodically or seasonally present off the Atlantic and Pacific coasts of North America according to recorded historical accounts. Adults of the little piked whale (*Balaenoptera acutorostrata*), the smallest of these Recent mysticetes, range from 22 to 33 feet in length. The blue whale (*Balaenoptera musculus*), the largest, measures from 75 to 85 feet off North American coasts, and as long as 100 feet in Antarctic waters. The others attain, according to species, lengths from 40 to 75 feet.

Skeletal remains representing six and possibly seven fossil mysticetes have been recovered from the Calvert Miocene deposits of Maryland and Virginia. The length of the smallest of these Calvert cetotheres, *Parietobalaena palmeri*, did not exceed 14 or 15 feet, and the largest, "*Eschrichtius*" *cephalus*, 31 feet by Cope's estimate. In addition to the seven free cervicals, so far as is known, not more than twelve dorsals were present in the vertebral column; twelve appears to be the maximum number of lumbar vertebrae and fourteen the number of caudals. A total of forty five comprised the vertebral column.

Skeletons of adult Recent mysticetes are not only larger, with one exception, but are also comprised of more vertebrae than the Calvert Miocene cetotheres. This increase in the number of vertebrae occurs notably in the caudal series. The vertebral formula is often as follows:

Balaenoptera musculus:
C. 7; D. 15; L. 14; ca. 28 =total 64
B. physalus:
C. 7; D. 15; L. 15; ca. 25 =total 62
B. borealis:
C. 7; D. 13–14; L. 13–15; ca. 20–23 =total 55–57
B. acutorostrata:
C. 7; D. 11; L. 12–13; ca. 17–20 =total 49
Eschrichtius glaucus:
C. 7; D. 14; L. 12; ca. 23 =total 56
Megaptera novaeangliae:
C. 7; D. 14; L. 10–11; ca. 19–22 =total 51–54
Eubalaena glacialis:
C. 7; D. 14; L. 10–13; ca. 23–26 =total 55–57

The capitulum of each of the seven or eight anterior pairs of ribs of physically mature individuals of these Calvert cetotheres has a definite articular contact with a well-defined facet on the posterolateral surface of the preceding vertebra. Rib articulation with the centrum of these anterior dorsal vertebrae has persisted in only one of the living whalebone whales, the gray whale (*Eschrichtius glaucus*). A distinct neck between the tuberculum and capitulum is present on five or six pairs of the anterior ribs. The corresponding ribs are unusually robust. This whale has been observed rolling in kelp beds along the shore and apparently it is not inconvenienced by occasional stranding in the shallow muddy lagoons of Baja California.

The reduction in the number of ribs having a capitular articulation with the centrum of anterior dorsals is another characteristic of Recent balaenopterid whales. Although three and occasionally four pairs of anterior ribs have a well-defined neck separating the tuberculum and capitulum, no distinct facet is developed on the centrum for an articular function.

This reduced capitular articulation by the ribs in the anterior thoracic region appears to be another one of the astonishing simplifications of bodily structure resulting from a long lost requirement for protective support for a thorax adapted to an exclusively buoyant existence. Were these large whales not buoyed up by water, their great weight would collapse the thorax and lungs, causing suffocation and death.

When cast ashore by incoming tide, a stranded living whale continues breathing with difficulty until death ensues; the crushing weight of the anterior portion of the body on the chest cavity must be lifted by exerting abnormal muscular effort each time air is drawn into the lungs. A cardiovascular overload results. Intrathoracic pressure resulting after muscular relaxation impedes the venous return to the heart in the chest cavity.

On the cetothere skull the supraorbital process of the frontal slopes gradually downward and outward to the orbital rim from the level of the dorsal surface of the interorbital region. On the balaenopterine skull the supraorbital process of the frontal is abruptly depressed at the base to a level below the dorsal surface of the interorbital region. This abrupt depression of an originally sloping supraorbital process makes its appearance geologically without any transitional or intermediate stage, or at least none has been described. The mechanical basis or necessity for this alteration is not readily apparent.

That the Miocene cetotheres were plankton feeders is certainly indicated by the grooves on the ventral rostral surface of the maxillaries which on skulls of Recent whalebone whales serve as channels for the vascular vessels and nerves supplying the lateral rows of baleen.

Among Recent mysticetes two general tendencies in the remodeling of skull architecture are noted. One end result is largely limited to the forward movement or thrust of the posterior cranial elements (Balaenidae), carrying the apex of the supraoccipital shield forward beyond the orbit and the associated very slight or limited backward movement of the rostral elements, the nasal bones being located entirely in front of the supraorbital processes of the frontals.

In the other type of remodeling (Balaenopteridae), the median rostral elements (ascending processes of maxillaries and premaxillaries and the nasals) in a backward movement override the frontals to or usually beyond the level of the preorbital angle of the supraorbital process of the frontal.

Among the Miocene antecedents of the Recent mysticetes are several types of interdigitation, including skulls on which the nasals are either almost entirely or only partially located anterior to the preorbital angle of the supraorbital process of the frontal, as well as either limited or extensive backward overriding by the median rostral elements.

PARIETOBALAENA Kellogg

Parietobalaena Kellogg, 1924, Proc. U.S. Nat. Mus., vol. 63, publ. 2483, p. 1. February 5, 1924.

Type species: *Parietobalaena palmeri* Kellogg.

Diagnosis: Parietals meet medially to form a ridge between the apex of the supraoccipital shield and the frontals; maxillary, premaxillary, and nasal sutural contact grooves extended backward on frontals beyond level of preorbital angle of supraorbital process; rostrum tapering toward extremity; transverse temporal crest developed on supraorbital process of frontal on mature skulls; nasals located for most part anterior to level of preorbital angle of supraorbital processes; zygomatic process of squamosal slender, attenuated anteriorly and extended forward to or almost to elongated postorbital projection of supraorbital process of frontal; postglenoid process directed more downward than backward, flattened on its posterior face and rounded distally; occipital condyles small; exoccipitals directed obliquely downward and backward, with lateral end projecting backward beyond level of articular surface of condyle on adult skulls; *pars cochlearis* of periotic with strongly convex dome or apex extended ventrally; a short narrow fossa of variable depth behind rim of fossa for stapedial muscle and above *fenestra rotunda* and its projecting shelf extends across posterior face of *pars labyrinthica* to its cerebral face. Tympanic bulla and periotic resemble in some details those of "*Idiocetus*" *laxatus* Van Beneden (1886, pl. 54, figs. 3–4). A deep groove for attachment of internal pterygoid muscle present below articular surface of condyle and above angle on internal surface of posterior end of mandible.

PARIETOBALAENA PALMERI Kellogg

Parietobalaena palmeri Kellogg, 1924, Proc. U.S. Nat. Mus., vol. 63, publ. 2483, p. 2.

Type specimen: USNM 10668. A cranium of a fairly young individual in a fair state of preservation; the nasals, jugals, and lachrymals, as well as the rostrum and its component parts, the maxillaries, premaxillaries, and vomer, are missing. Both periotics are attached to the cranium; incomplete left tympanic bulla is detached. Collector, William Palmer; August 14, 1913.

Type locality: From face of cliff near center of zone 11 and about 3 feet above beach level, approximately 1 mile north of Dares Wharf, Calvert Co., Md., Calvert formation, middle Miocene.

Referred specimens: Twenty, as follows: (1) USNM 7424: posterior end left mandible, length 395 mm., coll. William Palmer and A. C. Weed, May 31, 1912, in zone 11 at base of cliff about 150 yards north of old pier at Dare's wharf, Calvert Co., Md., Calvert formation, middle Miocene. (2) USNM 10677: skull, right and left mandibles, right tympanic bulla, right periotic, 18 ribs and fragments, coll. William Palmer and Norman H. Boss, September 1908, in zone 10 at base of cliff about ⅝ mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (3) USNM 10909: basicranium, portions of rostrum, periotics, coll. David B. Mackie, Aug. 10, 1908, in zone 10, about 2 miles south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (4) USNM 11535: cranium and portions of maxillaries, premaxillaries and vomer, both tympanic bullae, both periotics, right mandible, humerus, 6 cervicals, 1 dorsal, 1 caudal, 2 phalanges, and 10 ribs and fragments, coll. Norman H. Boss and Remington Kellogg, May 23, 1926, in zone 11, about a mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (5) USNM 12697: right and left mandibles, atlas, 1 cervical, 5 dorsals, 5 lumbars, 3 caudals, 5 epiphyses, radius and ribs, coll. William Palmer and Norman H. Boss, Dec. 6, 1913, in zone 10, about ½ mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (6) USNM 13874: hinder portion of basicranium, right and left tympanic bulla, right and left periotic, and atlas, coll. R. Lee Collins, Mar. 24, 1936, in zone 11, about 8 feet above base of cliff, one mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (7) USNM 13903: left mandible, lacking condyle, coll. Wm. F. Foshag and Charles W. Gilmore, July 12, 1936, in zone 12, about 600 feet south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (8) USNM 15576: left tympanic bulla, with malleus attached, coll. S. F. Blake, Mar. 27, 1938, in zone 16, about 3 feet above base of cliff at Calvert Beach, Calvert Co., Md., Choptank formation, middle Miocene. (9) USNM 16119: skull and portion of rostrum, right and left tympanic bulla; right and left periotic, 1 rib, coll. Wm. F. Foshag and Remington Kellogg, July 15, 1939, in zone 12, 9/10 mile north of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (10) USNM 16568: right and left tympanic bullae, right and left periotics, portions of skull, right and left mandible, axis, 3 cervicals, 2 lumbars, coll. Wm. F. Foshag and Remington Kellogg, Aug. 5, 1940, in zone 12, 625 yards south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (11) USNM 16570: skull, right mandible, right periotic, 1 dorsal, 1 caudal, fragments scapula, coll. Charles W. Gilmore, Wm. F. Foshag, H. S. Bryant, and Remington Kellogg, June 7, 1940, in zone 12, 695 yards south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (12) USNM 16667: axis, 1 dorsal, 2 lumbars, 11 caudals, coll. Wm. F. Foshag and Remington Kellogg, July 17, 1941, in zone 10, about 1 mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (13) USNM 16838: Cranium, right and left tympanic bulla, right and left periotic, portions of rostrum, coll. R. Lee Collins, June 10, 1937, in zone 10, one and ½ miles south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (14) USNM 20376: right and left tympanic bulla, right and left periotic, squamosals, coll. W. Gardner Lynn, Nov. 4, 1933, about 1 mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (15) USNM 23015: right tympanic bulla, right periotic, right squamosal, coll. A. C. Murray and John George, in zone 12, 700 yards south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (16) USNM 23022: skull, both tympanic bullae, both periotics, coll. James R. Switzer, March 1958, in zone 13, 700 yards north of road end at Governor Run, Calvert Co., Md., Calvert formation, middle Miocene. (17) USNM 23055: right and left tympanic bulla, left periotic, portions of skull, right mandible, axis, 1 cervical, 5 dorsals, 1 caudal, portions of ribs, coll. Howard Hruschka, Nov. 17, 1963, in zone 13, 500 yards north of road end at Governor Run, Calvert formation, middle Miocene. (18) USNM 23203: posterior end right mandible, portions of skull, atlas, axis, 5 cervicals, 12 dorsals, 10 lumbars, 9 caudals, 2 chevrons, coll. Robert E. Weems, July 4, 1964, about 3.6 miles below mouth of Pope's Creek, Stratford Bluffs, Westmoreland Co., Va., Calvert formation, middle Miocene. (19) USNM 23448: 4 dorsal vertebrae, portions of ribs, coll. Albert C. Myrick, Jr., Feb. 13, 1965, in zone 14, 350 yards north of road end at Governor Run, Calvert Co., Md., Calvert formation, middle Miocene. (20) USNM 23725: skull, coll. Albert C. Myrick, Jr. and Charles F. Buddenhagen, June 1, 1966, in zone 10, Holland Cliffs, on Patuxent River, about ¾ mile north of Deep Landing, Calvert Co., Md., Calvert formation, middle Miocene.

Skull

The major portion of the left side of the restored skull (USNM 10677), now exhibited in the vertebrate paleontology hall of the United States National Museum, was destroyed prior to excavation. The length of this skull (pl. 65, fig. 3) is 1115 mm. Another skull (USNM 23022) possesses a fairly complete braincase, both zygomatic processes and the premaxillaries, but lacks the supraorbital processes as well as the external borders of both maxillaries. This skull (pl. 64, fig. 2) measures 1200 mm. in length. Another skull (USNM 16570; pl. 64, fig. 3) measuring 1250 mm. in length lacks the right zygomatic process and adjacent portion of the cranium, the major portions of both supraorbital processes, and most of the left side of the rostrum. The largest skull (USNM 11619; pls. 66 and 67) has a fairly well-preserved braincase and both zygomatic processes, but lacks most of the supraorbital processes and retains only portions of the rostral elements.

Dorsal view.—The skulls of this cetothere represent a less advanced stage in the modification of skull architecture by either forward or backward overriding of adjacent bones. On the skulls of young or adolescent individuals of this species the posterior ends of the median rostral elements extend backward to or slightly beyond the level of the preorbital angles of the supraorbital processes. With approach or attainment of physical maturity

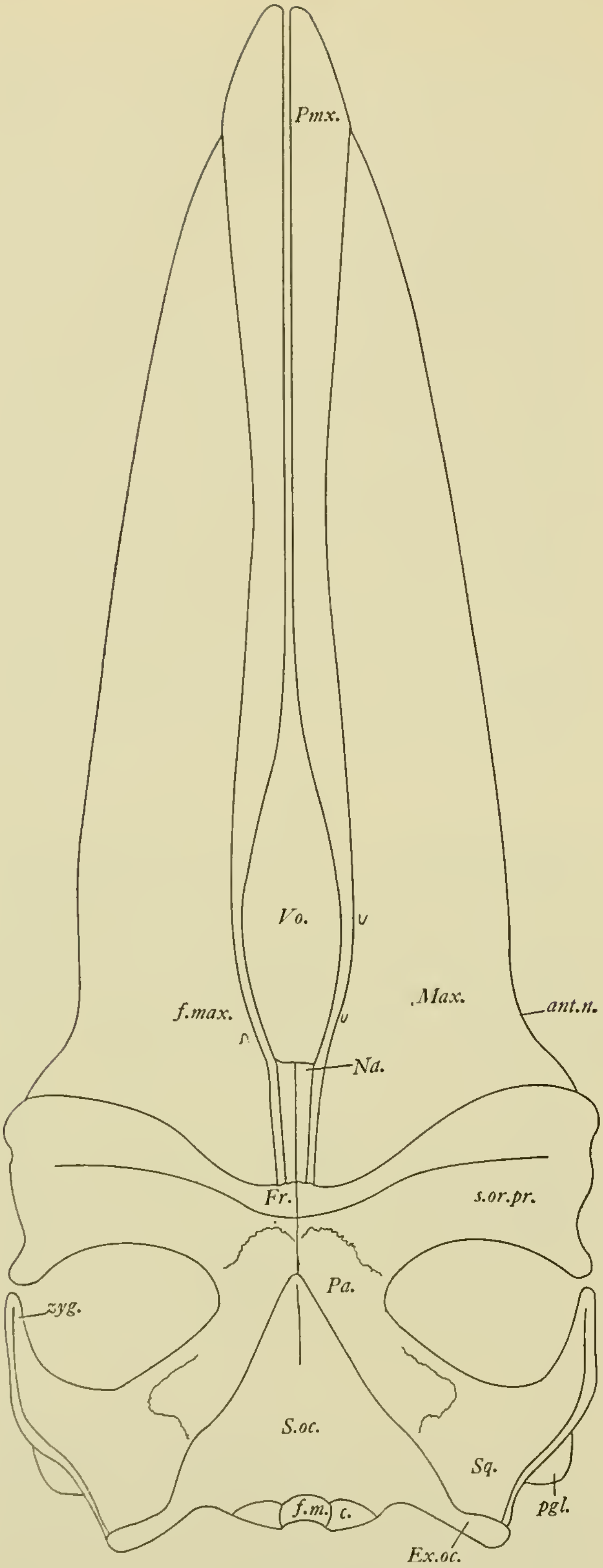

FIGURE 77.—Dorsal view of skull, USNM 16119, of *Parietobalaena palmeri* Kellogg. Reconstruction based on four skulls. For abbreviations, see figure 79.

these median rostral elements (fig. 77) are extended backward nearly to the level of the center of the orbit.

In front of the nasal fossa (USNM 23022; length, 260± mm.) in the narrow mesorostral trough, the premaxillaries are in contact to their anterior ends. In front of the anterior end of the vomer (USNM 23022; length, 785 mm.), which terminates 310 mm. behind the extremity of the right premaxillary of this skull the opposite maxillaries do not meet on the midline to contribute the bottom of the mesorostral trough. The internal surface of each premaxillary, however, is concavely curved downward to form the dorsal portion of the lateral wall of the mesorostral trough.

Each premaxillary (USNM 16570) attains its maximum width (45 mm.) at the level of the anterior ends of the corresponding maxillary. The posterior ascending portion of each premaxillary rests in a narrow groove on the dorsointernal border of the adjacent maxillary and is lodged at the hinder end in the narrow grooves on the dorsal surface of the frontal. Dorsally, each relatively thin premaxillary is narrowed alongside the nasals. On each side the premaxillary follows the curvature of the nasal fossa and then progressively increases in depth and width. On the anterior three fourths (600± mm.) of the length of the rostrum (800± mm.) the dorsal surfaces of the premaxillaries are noticeably flattened. Poorly preserved nasal bones are present on two skulls (USNM 10677, 16119); they are detached and lost from all other skulls of this species in the collection. On the above-mentioned skulls, the grooves for sutural contact on the frontals and the interval between the posterior ends of the opposite premaxillaries also indicate their width.

This skull is also characterized by a narrow tapered rostrum, equivalent to two-thirds of the length of the skull (occipital condyle to end of premaxillary); slender zygomatic process; narrow postglenoid process; moderate forward thrust of the supraoccipital shield, the dorsal half being narrowed toward the acuminate apex; a sharp-edged intertemporal ridge formed by parietals at contact on midline; and wide temporal fossa.

The apex of the supraoccipital shield (fig. 77) projects forward to or beyond the level of the anterior ends of the zygomatic processes and these slender processes are directed obliquely outward and forward.

Each maxillary is abruptly widened at the base by the posteroexternal basal angle that projects laterally beyond the preorbital angle of the supraorbital process on Recent mysticete skulls. The lachrymal, which normally is lodged on the posterior face of this angle was not preserved. The thin lateral edge of each maxillary is slightly curved toward its anterior end. Except for its posterointernal extremity, each maxillary does not override the superaorbital process of the frontal dorsally, but does along the anterior border ventrally. Two to four small nutrient foramina are located near the contact with the premaxillary on the posterior half of each maxillary. Jugal bones were not associated with any of these skulls.

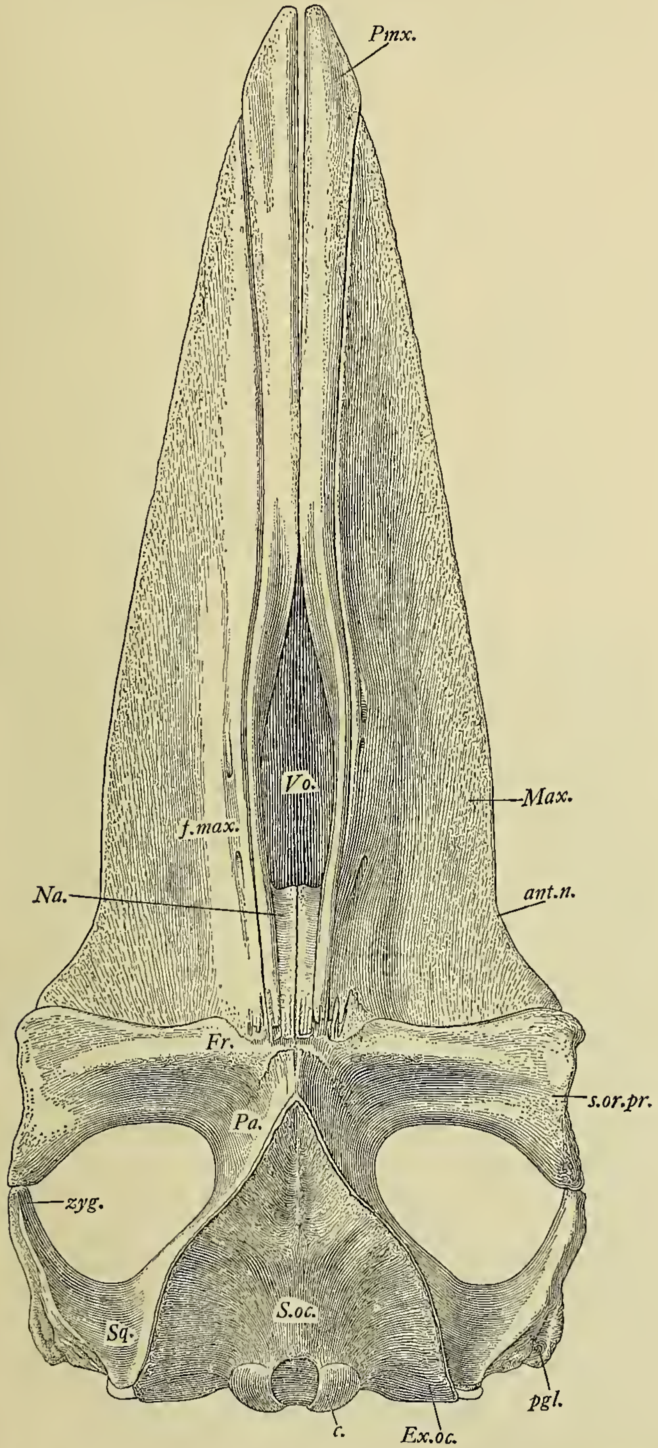

Figure 78.—Dorsal view of skull, USNM 10677, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

Between the intertemporal region contributed by the parietals and the posterior ends of the rostral bones, the frontal bones (USNM 10677; fig. 78) are exposed for an interval of less than 15 mm. Each frontal slopes gradually downward from the midline behind the nasals to the orbital rim of the supraorbital process of the frontal. The transverse ridge or crest is low and indistinctly developed on the supraorbital processes of all the skulls. Whether or not the rounded preorbital angle of the supraorbital process projected outward beyond the lateral extensions of the postero-external end of the maxillary cannot be determined since this region is missing on all the skulls. The stout postorbital projection of the supraorbital process is extended backward to the anterior end of the zygomatic process.

The opposite parietals meet on the midline of the cranium to constitute a sharp-edged ridge; they are also overlapped above and behind by the lateral borders of the supraoccipital shield. The thin anterior border of each parietal overlaps the interorbital basal portion of the corresponding frontal.

On each side the posteroventral portion of the braincase is constituted by the squamosal. Behind its contact with the pterygoid, the squamosal follows the curvature of the

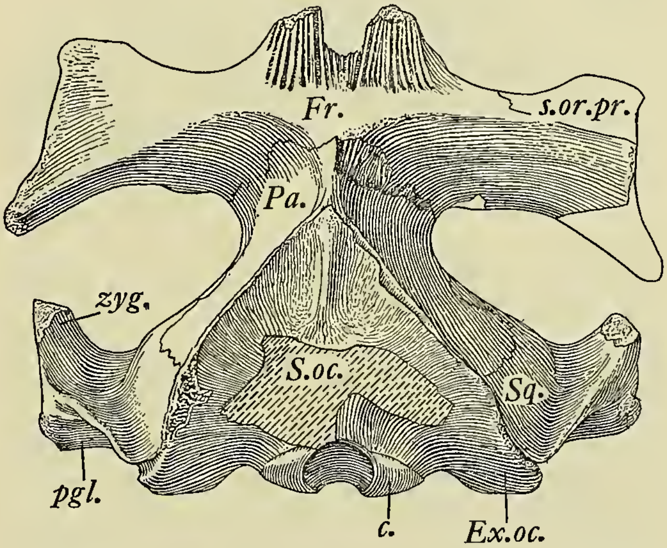

Figure 79.—Dorsal view of skull (type), USNM 10668, of *Parietobalaena palmeri* Kellogg. Abbrs.: ant. n., antorbital notch; Bo., basioccipital; Bs., basisphenoid; c., occipital condyle; Ex.oc., exoccipital; f.m., foramen magnum; f.max., maxillary foramen or incisure; f.ov., foramen ovale; Fr., frontal; h.pt., hamular process of pterygoid; j.n., jugular notch or incisure; l. pr., lateral or descending protuberance of basiocipital; 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; pr.s.p., presphenoid; 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.

temporal fossa to the extremity of its zygomatic process. This slender zygomatic process is directed obliquely outward and forward to or almost to the end of the postorbital projection of the supraorbital process. The lambdoidal crest is continued forward on the dorsal edge of the zygomatic process.

Except at their extremities the exoccipitals on skulls of the immature individuals (fig. 79) are largely concealed from a dorsal view; the occipital condyles project backward beyond the level of the ends of the exoccipitals. On skulls of older individuals (fig. 77) the exoccipitals project backward beyond the level of the articular surfaces of the occipital condyles. The transverse diameter (250 mm.) of the triangular occipital shield on the largest skull (USNM 16119) at the level of the dorsal rim of the foramen magnum exceeds the greatest distance (195 mm.) from the dorsal rim of this foramen to the apex of this shield. On another skull (USNM 23022) these measurements are, respectively, 220 and 190 mm. The transverse diameter of this supraoccipital shield is progressively reduced above the middle of its height to the apex.

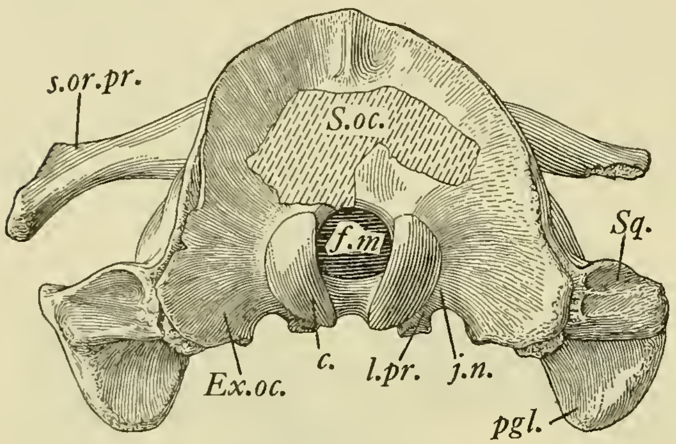

Figure 80.—Posterior view of skull (type), USNM 10668, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

Posterior view.—The ratio of height to the width of the braincase diminishes with growth and the exoccipitals become extended farther laterally. Depression of the top of the braincase increases with age.

The broad supraoccipital constitutes the major portion of the triangular shield which curves upward and forward. On the cranium (USNM 10668; fig. 80) of the young whale this shield from a posterior view appears more rounded than it is actually. The lambodidal crest (fig. 81) constituted by the lateral margins of the supraoccipital and exoccipital and the abutting edges of the parietals and squamosals, increases in prominence toward the apex of the shield; laterally it continues forward along the dorsal edge of the zygomatic process.

The occipital condyles are semi-elliptical in outline, broadest above the middle of their height, and their articular surfaces are convex in both vertical and transverse directions. The occipital condyles are less protuberant on the adult skull than on that of the young. Each postglenoid process is prolonged ventrally, flattened on its posterior face, and rounded distally.

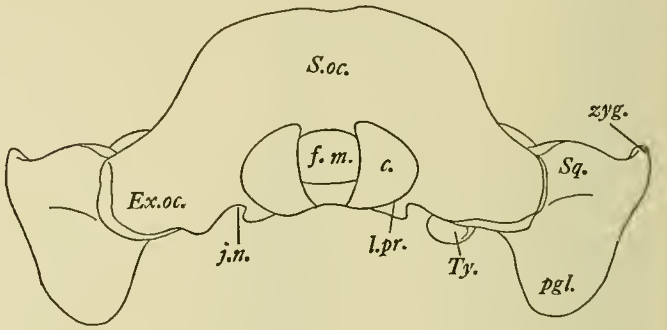

Figure 81.—Posterior view of skull, USNM 16119, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

Lateral view.—The highest point in the dorsal profile (USNM 10677; pl. 64, fig. 3) is behind the apex of the supraoccipital shield. In front of the apex, the intertemporal ridge slopes to the flattened median interorbital region; between this median region and the extremity of the rostrum the slope of the dorsal profile is very gradual. The greatest dorsoventral diameter of the rostrum is at the hinder end of the nasal fossa. The convex side to side curvature of the dorsal surface of the rostrum is gradually diminished toward the extremity; the ventral surface of the rostrum is quite flat on the distal one third.

The orbital border of the supraorbital process of the frontal is dorsoventrally compressed and shallowly arched. Elongation of the postorbital projection has lengthened the orbit and shortened the interval between the ends of this projection and the attenuated slender zygomatic process. The postglenoid process extends more downward than backward, its glenoid surface being slightly convex.

From a lateral view 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, forming a sharp-edged ridge. On quite young skulls (USNM 16838), the ovoidal external end of the alisphenoid is located on the outer wall of the braincase between the pterygoid ventrally and the parietal. On more mature skulls (USNM 23022) the alisphenoid is more elongated and dorsoventrally compressed. In describing the relations of the bones in this region, Ridewood (1922, p. 262) comments that among mammals it is unusual for the squamosal to extend forward to meet the pterygoid, as it does on mysticete skulls, as is also the location of the foramen ovale in a cleft at the end of the squamosal behind the pterygoid.

The occipital condyles are not visible when the skull is viewed from the side.

Ventral view.—Description of the ventral aspect of the skull will of necessity be based on several specimens. The ventral surface of the cranium is best preserved on USNM 16119 (fig. 82); the relations of several individual bones are well defined on a young skull (USNM 10668), and the rostral bones are fairly complete on USNM 10677.

Of the several bones comprising the skull, the largest is the maxillary, which except for the thin proximal border is sufficiently complete on the right side of an immature skull (USNM 10677; pl. 65, fig. 4) to show the arrangement of the grooves for the nutrient vessels that supply the palate and the attached baleen. Most of these grooves are located on the flattened ventral surface external to the median downward curved internal border that is applied to the trough of the vomer. The longest of these grooves (fig. 83) are located chiefly on the anterior half of the rostrum and they are directed more forward than the shorter and more numerous oblique grooves. A few shorter curved grooves directed more transversely than those elsewhere on the palatal surface are present near the proximal end of the rostrum.

The vomer on the skull (pl. 65, fig. 4) is fortuitously exposed ventrally, by the separation of the maxillaries, for nearly its entire length on the rostrum. On all these skulls, a downward directed median vertical partition, mainly arising from the horizontal vaginal plate of the vomer and separating the choanae, diminishes in height behind the median divergence posteriorly of the opposite palatines. On the largest skull (USNM 16119), the flat ventral edge of this partition becomes visible 120 mm. in front of the posterior edge of the horizontal vaginal plate of the vomer and vanishes about 25 mm. anterior to this edge. This horizontal plate conceals, when present, the transverse ankylosis of the basioccipital and basisphenoid and also the sutural contact of the latter with the presphenoid (fig. 84). Laterally this horizontal plate is suturally in contact with the corresponding edge of the vaginal process of the pterygoid. The trough of the vomer is widest near the level of the anterior ends of the palatines.

Each elongated palatine meets its opposite on the midline, is applied to the ventral surface of the trough of the vomer, is in contact anteriorly and externally with the corresponding maxillary, and, posteriorly, is suturally united with the pterygoid. The posterior divergence of the posterointernal edge of the palatine commences on the vertical partition between the choanae about 120 mm. in front of the posterior edge of the vaginal plate of the vomer. The anteroposterior

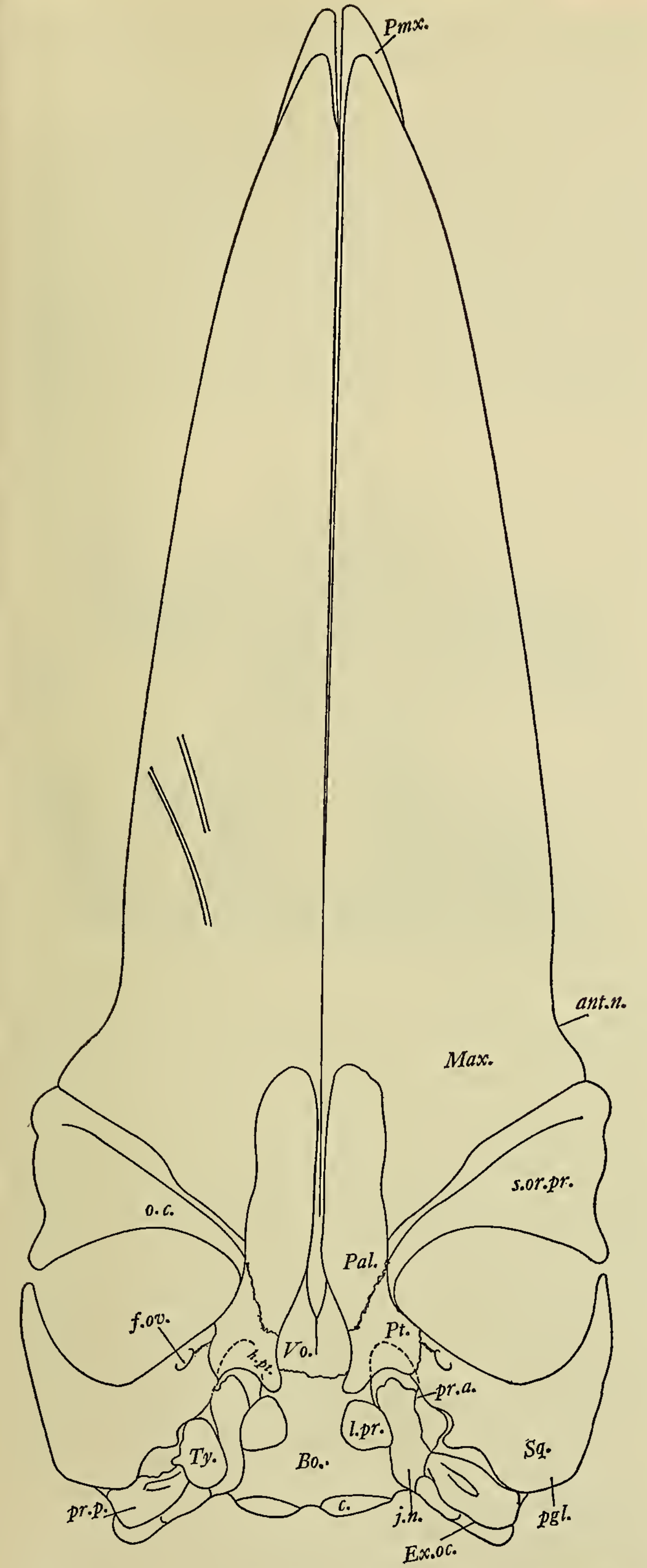

Figure 82.—Ventral view of skull, USNM 16119, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

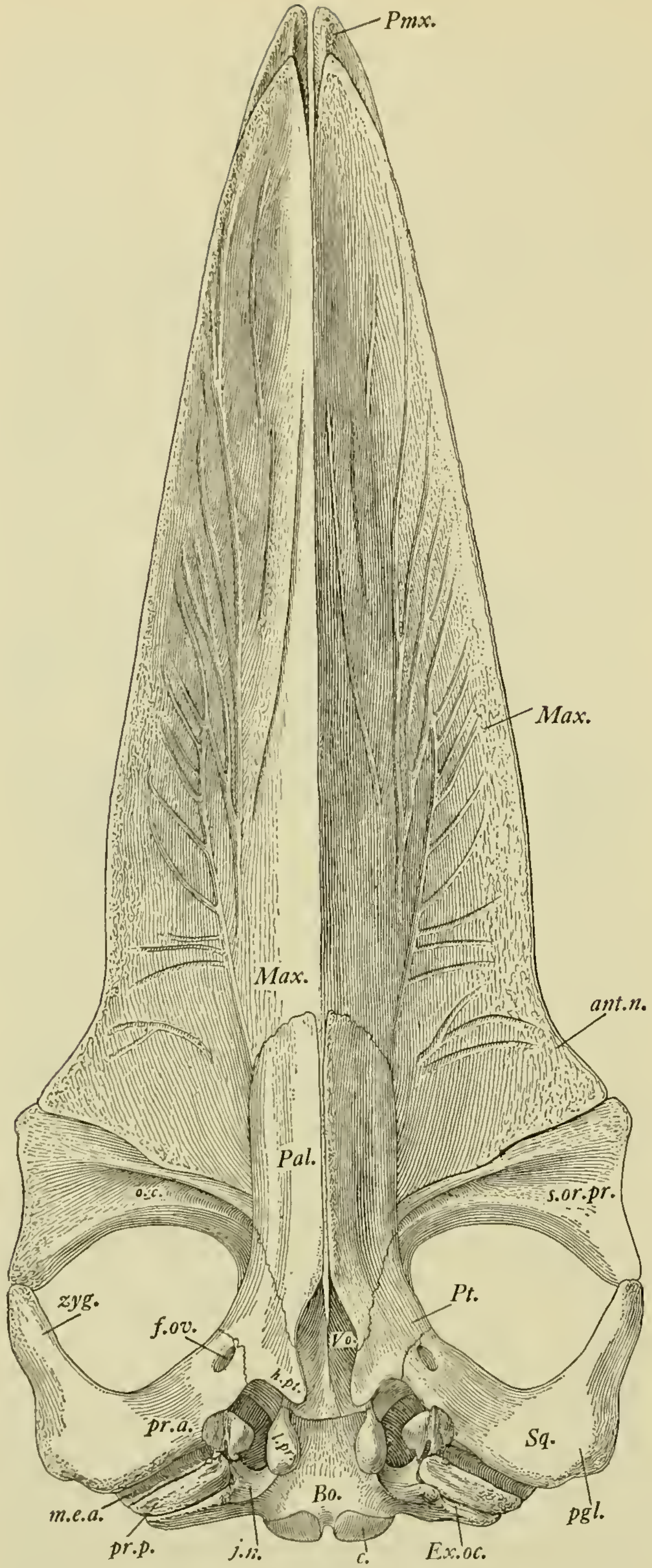

FIGURE 83.—Ventral view of skull, USNM 10677, of *Parietobalaena palmeri* Kellogg, restored. For abbreviations, see figure 79.

diameter of the palatine is equivalent to about 17 (USNM 16570) to 20 percent (USNM 10677; fig. 83) of the length of the skull.

The supraorbital processes of the frontals are incomplete on all skulls except the young specimen (USNM 10668). On one (USNM 10677), the outer portion of the right process is well preserved (pl. 65, fig. 4). The preorbital angle of this process is rounded and the postorbital is extended backward to the end of the zygomatic process. On the young skull (fig. 84; USNM 10668) the channel for the optic nerve curves outward on the ventral surface of the supraorbital process of the frontal in the usual manner and increasing in width becomes widest at the orbital rim. Near its origin this channel is located on the posterior surface of this process but twists downward to the ventral surface and then on its outward course is located behind the well-defined anterior wall.

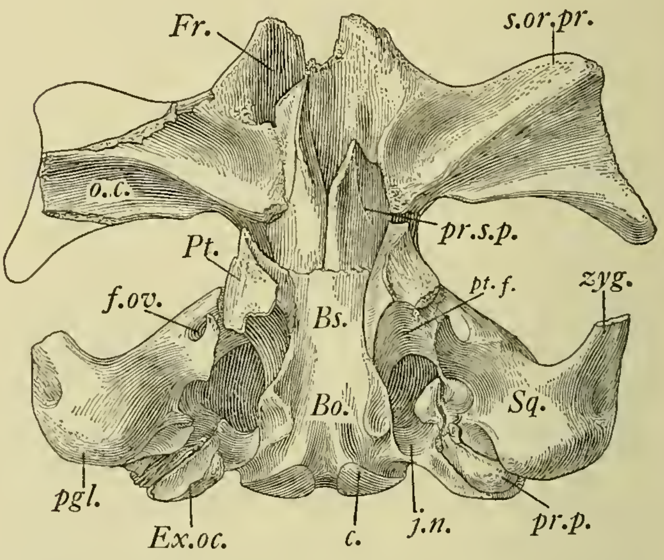

FIGURE 84.—Ventral view of skull (type), USNM 10668, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

The ventral surface of the relatively narrow basioccipital is shallowly concave. On each side of this bone the lateral descending protuberance, although variable in shape possibly attributable to age, is convex internally and overlapped anteriorly by the vaginal process of the pterygoid. The basioccipital is so intimately fused with the basisphenoid, even on the young skull (USNM 16838), that the sutural contact is obliterated. A narrow gap separates the alisphenoid and the presphenoid at least until physical maturity. Both the alisphenoid and the presphenoid are hidden from a ventral view by the overspreading ventral horizontal plate of the vomer.

The pterygoid is intercalated between the posterior end of the palatine and the bifurcated anterior end of the squamosal. This bifurcation of the squamosal encloses the foramen ovale.

The relatively small pterygoid fossa is constituted by the vaginal process of the pterygoid internally, anteroexternally by the ventrally curving thickened anterior and external borders of the pterygoid, and to a limited extent posteroexternally by the falciform process of the squamosal. The pterygoid contributes the osseous roof of this fossa. This pterygoid fossa is continuous posteriorly with the tympanoperiotic recess, which is bounded by the squamosal externally, by the pterygoid anteriorly, by the lateral protuberance of the basioccipital internally, and by the exoccipital posteriorly. A broad notch or incisure on the exoccipital at the posterior end of this recess constitutes the posterior lacerated foramen for the jugular leash.

On the ventral surface the contact between the exoccipital and the squamosal is concealed by the posterior process of the periotic, which is securely lodged in a transverse groove on the squamosal behind the postglenoid process of the squamosal. At the base of the postglenoid process and anterior to the posterior process of the periotic is the transverse groove or channel for the external auditory meatus. On the ventral edge of the exoccipital external to the jugular notch is a narrow depression which constitutes the paroccipital process or area for attachment of the stylohyoid.

The slender anteriorly attenuated zygomatic process is directed outward and forward. The postglenoid process is not enlarged or thickened and is deflected obliquely backward. The flattened posterior surface of the postglenoid process contrasts strongly with the convexity of its anterior surface and the internal concave area on the adjacent ventral surface of the squamosal.

The skull (MHNB 4018) identified by Abel (1938, p. 28, fig. 4) as *Isocetus depauwii* has 420 mm. zygomatic width. As compared to this Calvert cetothere, the Belgian skull is characterized by a strongly attenuated and much narrower rostrum throughout its length; the zygomatic process is also more robust. Furthermore, the Belgian skull is distinguished by a somehwat different profile of the temporal fossa when viewed from the ventral side, the zygomatic process being turned forward abruptly almost at a right angle from the anterior temporal surface of the squamosal. A deep crease at this point on the anterior border of the squamosal distinguishes skulls of recent *Balaenoptera*.

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

	USNM 16119	*USNM 10677*
Greatest length of skull, anterior end of right premaxillary to level of posteroexternal angle of right exoccipital	1280+	1100
Distance from anterior end of right premaxillary to posterior articular face of right occipital condyle	1260±	1105
Distance from anterior end of right premaxillary and extremity of right postglenoid process	1240±	—
Distance from anterior end of right premaxillary and apex of supraoccipital shield	1050±	885
Greatest length of right premaxillary	—	817
Distance from apex of supraoccipital shield to posterior end of right nasal bone	80	60
Transverse diameter of skull across preorbital angles of supraorbital processes	—	454±
Greatest anteroposterior diameter of extremity of right supraorbital process of frontal	150±	143
Transverse diameter of skull across outer surfaces of zygomatic processes	496	442±
Transverse diameter of skull between outer edges of exoccipitals	345	265±
Transverse distance between outer edges of occipital condyles	138	—
Greatest or obliquovertical diameter of right occipital condyle	75.5	69
Greatest transverse diameter of right occipital condyle	47	42
Greatest transverse diameter of foramen magnum	48	—
Distance from dorsal rim of foramen magnum to apex of supraoccipital shield	193	208
Distance from anterior end of right premaxillary to anterior end of right nasal bone	—	708
Greatest length of right nasal bone	—	120
Transverse diameter of anterior end of right nasal bone	—	18.5
Transverse diameter of posterior end of right nasal bone	—	14
Combined width of nasal bones, anteriorly	—	38.5
Greatest transverse distance between outer margins of premaxillaries at level of anterior ends of maxillaries	—	88.5
Greatest breadth of basioccipital across lateral protuberances, outside measurement	125	—
Greatest length of left zygomatic process, extremity of postglenoid process to anterior end	214	—
Greatest anteroposterior diameter of left palatine	225	—
Greatest transverse diameter of left palatine	60+	—
Distance from posterior surface of right occipital condyle to posterior end of vomer	120	—
Distance from posterior surface of left occipital condyle to anterior edge of left palatine	390	—
Posterior edge of vomer to anterior edge of left palatine	273	—

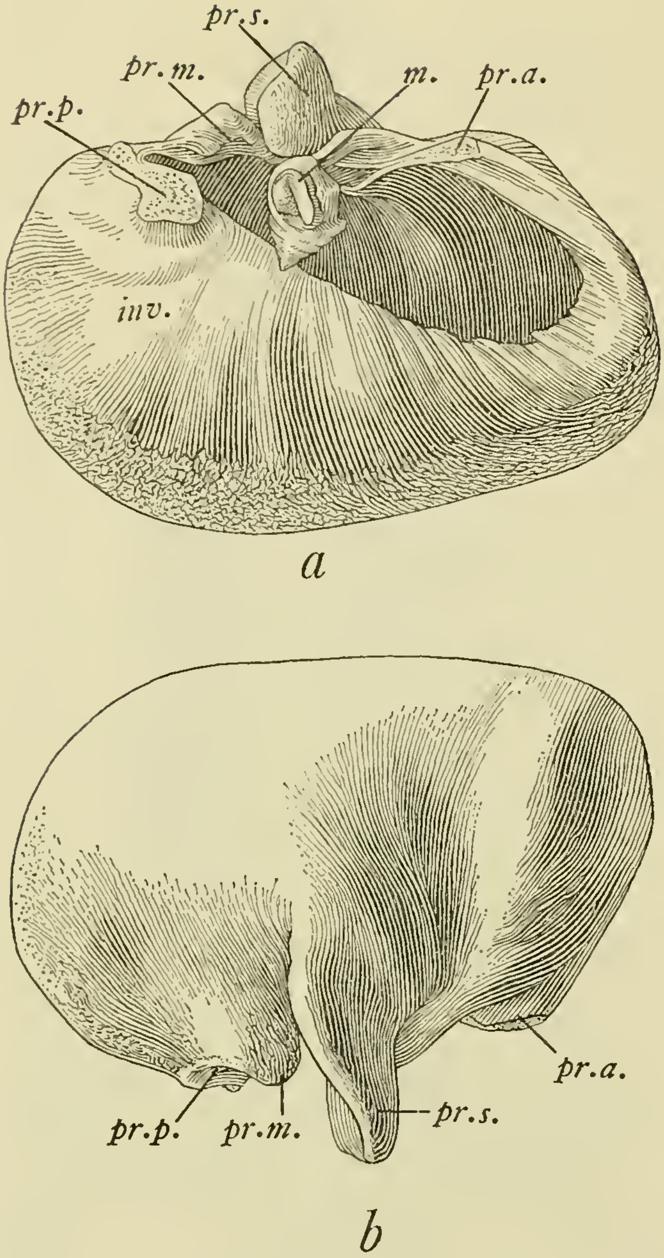

Figure 85.—Views of left tympanic bulla and malleus, USNM 15576, of *Parietobalaena palmeri* Kellogg: *a*, dorsal view; *b*, external view. Abbrs.: a.c., orifice of cochlear aqueduct; a.i.c.F., internal aperture of aquaeductus Fallopii; a.p., anterior pedicle of bulla; a.v., orifice of vestibular aqueduct; c.f., channel for facial nerve; f.a.s., fossa for extension of air sac system; f.c.m., fossa for head of malleus; fe.o., fenestra ovalis; fe.r., fenestra rotunda; inv., involucrum; m., malleus; m.a.i., internal acoustic meatus; p.c., pars cochlearis; p.p., posterior pedicle of bulla; pr.a., anterior process (pro-otic); pr.m., processus medius or conical apophysis; pr.p., posterior process (opisthotic); pr.s., sigmoid process; t.s.f., tractus spiralis foraminosus.

Tympanic Bulla

An undamaged tympanic bulla attached to the right periotic (USNM 13874), which was associated in the Calvert zone 11 with the hinder part of the basicranium and a left tympanic bulla with complete attached malleus (USNM 15576) found isolated from other skeletal elements in the Choptank zone 16 are the best preserved of twelve bullae referred to this species. The left tympanic bulla, which was associated with the type cranium (USNM 10668) of *Parietobalaena palmeri* in the Calvert zone 11 lacks a portion of the thin outer lip, the anterior pedicle, the sigmoid process, and the normally attached malleus. This bulla (greatest length, 57 mm.) is slightly smaller than either the above mentioned right bulla (USNM 13874; greatest length, 60.5 mm.) or another right bulla (USNM 10677; greatest length, 59 mm.) detached from a skull (length, 1107 mm.) excavated in Calvert zone 10.

The posterior pedicle (fig. 86a), located transversely on the tympanic bulla, is much thicker where it is ankylosed to the periotic than the thin longitudinal attachment of the anterior pedicle. This posterior pedicle may or may not be separated by a cleft from the low, blunt posterior conical apophysis (fig. 86a); in either condition it arises internally from the posterior end of the thickened involucrum and externally at the posterior end of the outer lip.

Viewed from the ventral aspect the posterior end of the bulla is obliquely truncated in an internoexternal direction, the transverse diameter of the anterior end is less than the posterior end, and a low faintly defined ridge extends obliquely from the posteroexternal angle to the anterointernal angle.

The thin overarching outer lip, whose anterior pedicle is ankylosed to the anterior process of the periotic, does not by its curvature abruptly reduce the width of the eustachian outlet of the tympanic cavity. The width of the involucrum (fig. 86a) is strongly diminished at its anterior end and transverse creases are indistinct except near the eustachian outlet.

Referring again to the outer lip, it would appear that some functional demand existed for twisting the rounded and thickened sigmoid process (fig. 85b) at right angles to the longitudinal axis of the bulla as well as for the presence of a deep groove between it and the posterior conical apophysis. The slender stalk-like anterior process of the malleus (fig. 85a) was attached in the normal position along the posterior border of the sigmoid process.

Viewed from the external aspect (fig. 86b) the depth of the rounded posterior profile exceeds that of the less convex anterior end.

Accumulation of a representative series of tympanic bullae during the past forty years from the Calvert formation, some isolated and others associated with crania, has shown that their lengths do not provide a reliable basis for identification. Lengths of the bullae of this species range from 52 to 63 mm. Other minor differences may be attributed to age factors.

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

	USNM 10668 Left	*USNM 16119 Right*	*USNM 10677 Right*	*USNM 13874 Right*	*USNM 15576 Left*
Greatest length of bulla	57	59.5	59	60.5	62.5
Greatest width of bulla	—	34.5	36	35	33
Greatest vertical diameter on external side, ventral face to tip of sigmoid process	—	43	43.5	45	49
Greatest length of tympanic cavity	44	42	44	41.5	46

Periotic

Likeness of cetothere periotics without some degree of relationship seems unlikely. The degree of affinity may be assessed by noting the extent of resemblance of auditory structures that appear to be less susceptible of modification during growth. For example the shape of the *pars cochlearis* of this species exhibits very little change in the growth stages from new born to adult. The most obvious alteration occurs in the shape and dimensions of the posterior process (fig. 84), which is firmly wedged in a deep groove between the exoccipital and the postglenoid portion of the squamosal. Nine periotics either attached to or associated with skulls or crania were selected to illustrate the range of individual variation. A similar type of *pars cochlearis* is found in the Belgian Anversian "*Idiocetus*" *laxatus* (Van Beneden, 1886, pl. 54, figs. 3, 4).

On the posterior face of the *pars cochlearis* above (dorsal to) the *foramen rotunda* and its projecting shelf and behind the stapedial fossa is a short, narrow fossa (vertical diameter, 4 to 8 mm.) of variable depth that extends from the internal end of the posterior process to the inner (cerebral) face of the periotic (fig. 87b). It is separated from the fossa for the stapedial muscle by the thin crestlike posterior ridge bounding the latter. This fossa extends upward and inward from the fossa for the stapedial muscle.

The *pars cochlearis* is relatively small, compressed slightly from side to side (fig. 88a), somewhat triangular in profile when viewed from the internal (cerebral) side; the dome or apex of the *pars cochlearis* (fig. 88b) is conspicuously extended ventrally. No discernible alteration in the size of the *pars cochlearis* during growth was noted among these periotics. The cerebral face of the labyrinthic region dorsal to the internal acoustic meatus is variable in appearance, smooth (flat or concave) or porous and rugose (USNM 16119).

On the internal face, the internal acoustic meatus is small, usually somewhat circular in outline at level of the cerebral rim, but occasionally ovoidal; this rim is 9 to 14 mm. above (dorsal to) the dome of the *pars cochlearis*. The vestibular aqueduct (fig. 87b) opens into an elongated or broad ovoidal depression of variable depth on the cerebral face. The cerebral aperture of the Fallopian aqueduct is either adjacent to the rim of the internal acoustic meatus (USNM 13874), at the anterodorsal angle of the *pars cochlearis* (USNM 10909; pl. 48, fig. 6), or small and within the cerebral rim of the internal acoustic meatus (USNM 20376).

The shape of the posterior process (opisthotic) appears to be quite variable, and this variation may not be entirely

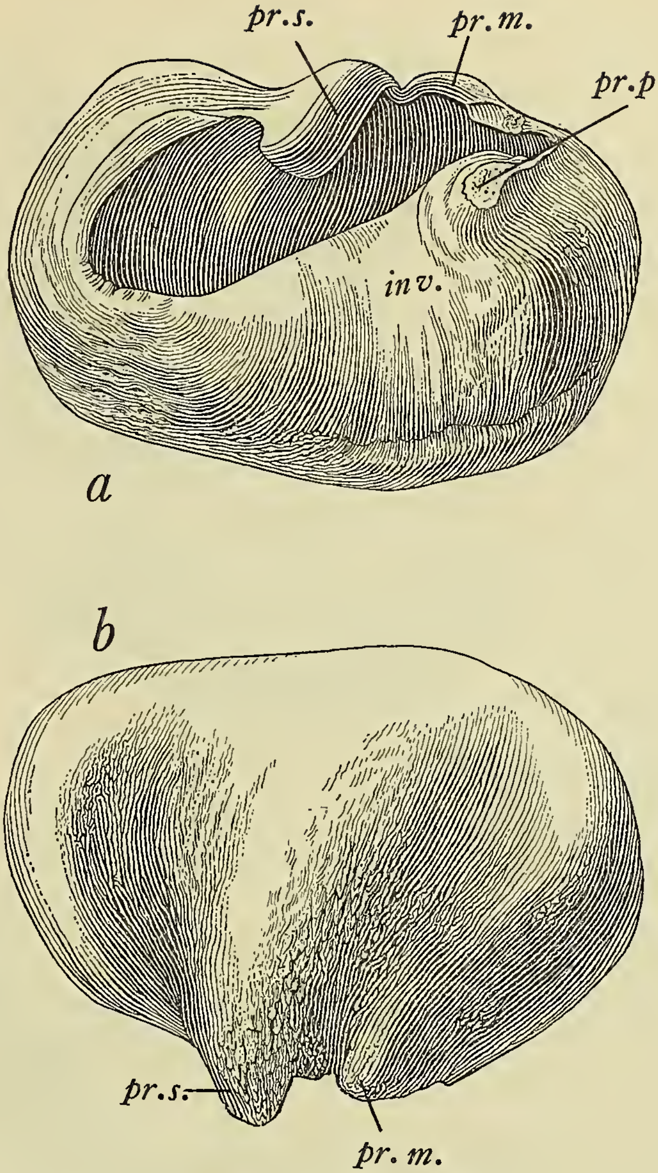

FIGURE 86.—Views of right tympanic bulla, USNM 10677, of *Parietobalaena palmeri* Kellogg: *a*, dorsal view; *b*, external view. For abbreviations, see figure 85.

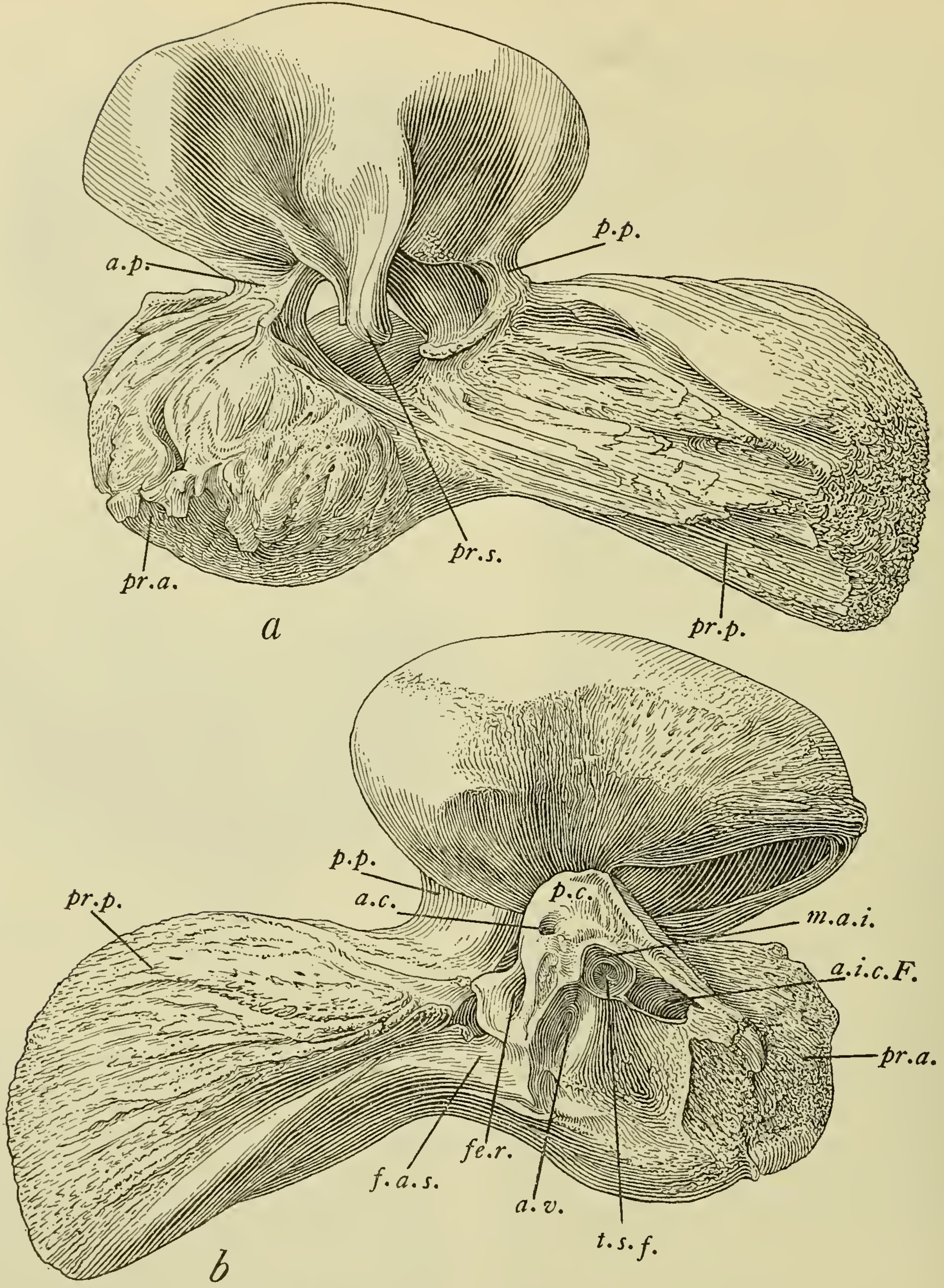

FIGURE 87.—Views of right tympanic bulla and periotic, USNM 13874, of *Parietobalaena palmeri* Kellogg: *a*, external view; *b*, internal view. For abbreviations, see figure 85.

attributable to age. On most skulls the posterior process (fig. 88b) is relatively short and abruptly expanded beyond the base; on others it is either gradually enlarged toward the extremity or slender and elongated (pl. 48, fig. 6). The posterior pedicle of the tympanic bulla (fig. 87a) before it was dislodged or broken off while in storage was ankylosed with the anterointernal angle of the posterior process. Behind this pedicle, the groove for the facial nerve extends outward toward the extremity of the ventral face of this process. The series of crania now available indicate that the lengthening of the posterior process continues to physical maturity. Enlargement of the posterior process seemingly cannot be attributed to old age. One physically immature individual (USNM 23203) has the posterior process (length, 90 mm.) unusually expanded toward its distal extremity (greatest diameter, 77 mm.). Epiphyses are ankylosed to the centra of only 3 of the 36 vertebrae associated with this specimen. Continued growth of the anterior process appears somewhat limited.

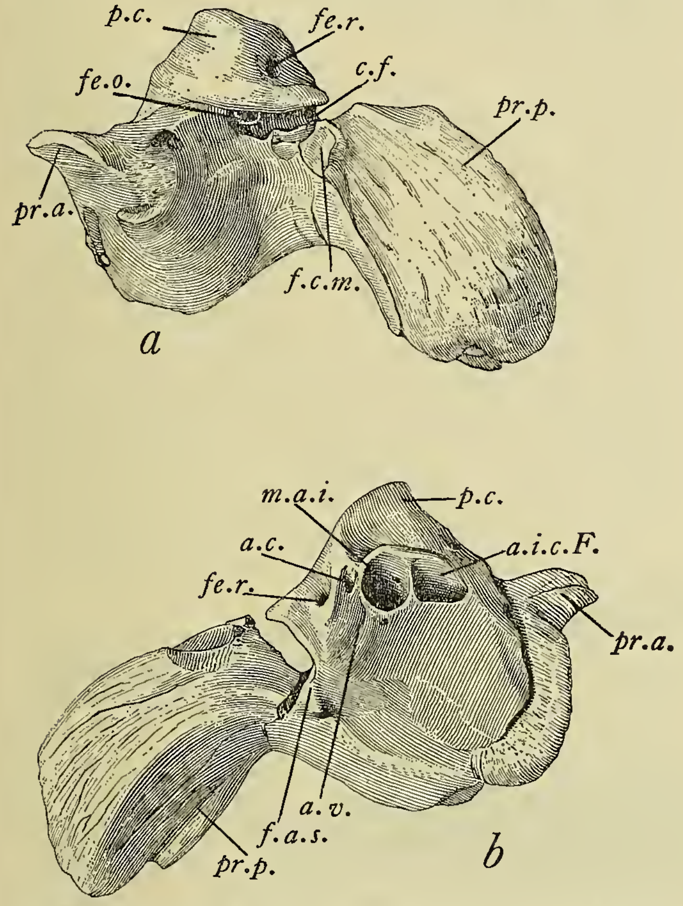

Figure 88.—Views of right periotic (type), USNM 10668, of *Parietobalaena palmeri* Kellogg: *a*, ventral view; *b*, internal view. For abbreviations, see figure 85.

The anterior process (pro-otic) is very short, dorsoventrally compressed distally; the labyrinthic region is enlarged, bulbous, and sculptured (fig. 87a). The relatively short anterior process and the adjoining labyrinthic region are securely lodged in an excavation on the cerebral face of the squamosal. The thin anterior pedicle (fig. 87a) of the tympanic bulla is fused with the epitympanic face of the anterior process in front of the fossa for reception of the head of the malleus. This shallow concavity for the head of the malleus is located either anterior to or alongside (USNM 23055) the epitympanic orifice of the Fallopian aqueduct. Overhang of the obliquely inclined external face of the *pars cochlearis* conceals the *fenestra ovalis* from a ventral view.

On some periotics (USNM 22995) an anteroposterior crease divides the external and internal portions of the tympanic or ventral face of the *pars cochlearis*, the outer portion being normally smooth and convex. On other periotics the internal or cerebral portion of this ventral surface is irregularly excavated or depressed (USNM 13874). On most periotics the smooth convex ventral surface of the tympanic face of the *pars cochlearis* does not extend inward as far as the rim of the internal acoustic meatus.

The small fossa for the stapedial muscle is slightly rugose and extends downward on the internal face of the base of the posterior process and on the external face of the *pars cochlearis*. On some periotics (USNM 22995) the functioning of the muscle attached in this fossa would appear to have been considerably restricted by the extent of the projecting ledge above the *fenestra rotunda*.

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

	USNM 10668 Right	*USNM 13874 Right*	*USNM 22995 Right*	*USNM 16119 Right*	*MHNB*[1] *29 Right*
Length of posterior process, distance from external wall of stapedial fossa to extremity	48	66	83	87	122
Greatest dorsoventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* to most projecting point on dorsal face	43	43	53	52	53.6
Distance between epitympanic orifice of Fallopian aqueduct and extremity of anterior process	30	33	44	41	57.2
Distance from external end of posterior process to anterior end of anterior process (in straight line)	82	97	118	132	166

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[1] "*Idiocetus*" *laxatus* Van Beneden, No. 29, Musée royal d'Histoire naturelle de Belgique, Bruxelles.

Auditory Ossicles

Rather rare preservation of the auditory ossicles of Calvert mysticetes seems attributable in part to the fragile nature of the anterior and posterior pedicles that attach the tympanic bulla to the periotic. Tidal action, which periodically washed skulls cast on the beach, probably resulted in breakage except when favorable conditions lead to rapid burial, in sediments. In a relatively few instances skulls have been excavated that have the tympanic bulla crushed against the periotics in approximate normal position. In other instances, the tympanic bullae are found dislodged and shoved into the tympanoperiotic recess of the cranium or occasionally somewhere near the skull. The outer lip of the detached bulla is often fractured and it usually lacks both the anterior and posterior pedicles. Quite frequently the labyrinthic region of the periotic is broken off at the point of connection with its posterior process (opisthotic). All of these hazards of preservation have limited the possible recovery of the auditory ossicles.

Of the 34 Calvert tympanic bullae in the collection only one (USNM 15576) retained the malleus attached to the outer lip. A detached malleus was found in the matrix contained in the epitympanic cavity of one periotic (USNM 23015).

The slender stalklike processus anterior (Ridewood, 1922, pp. 241, 247) of the malleus is ankylosed at the base with the outer lip of the bulla (fig. 85a) along the anterior border of the sigmoid process (USNM 15576). The two facets on the head of the malleus that articulate with the incus have the same shape and relationship as the corresponding facets of *Balaenoptera borealis*.

The nearly vertical dorsal hemicircular facet meets the smaller horizontal facet at a right angle, and both facets are situated above the internal dorsal face of the prominent tubercle. At the internal end of the tubercle (*processus muscularis*) the short manubrium is more acuminate and less nipple-like and not as noticeably bent backward at its distal extremity as the corresponding process of *B. borealis*, although the scar for attachment of the ligamentary process of the tympanic membrane is likewise located ventrally at the distal end. A similar attachment has been reported for *Balaenoptera musculus* by Lillie (1910, p. 779). On each of the two small circular nodules on the anterior face of the head of the malleus there is a scar. To the scar on the nodule located anteriorly on the rounded tubercle of the head of the malleus the tensor tympani tendon was attached (Doran, 1878, p. 454). The scar on the adjacent nodule located anteriorly on the outer portion of the head of the malleus presumably served for attachment of a little ligament.

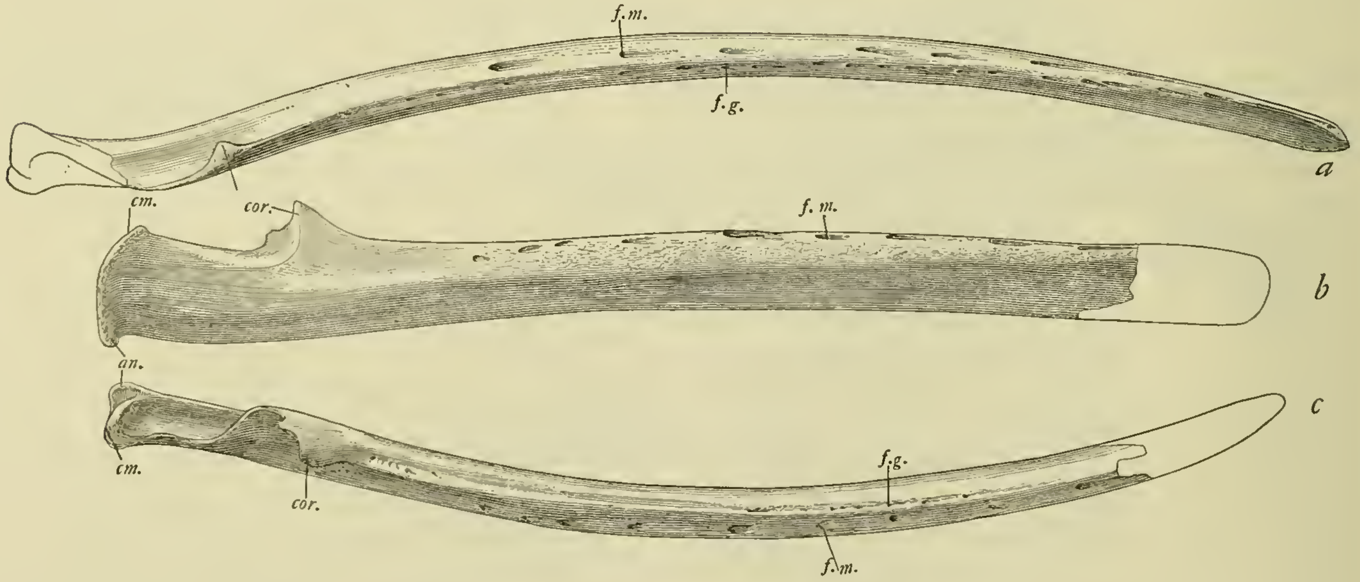

FIGURE 89.—Views of right and left mandibles, USNM 10677, of *Parietobalaena palmeri* Kellogg: *a*, dorsal view of left mandible; *b*, external view of right mandible; *c*, dorsal view of right mandible. Abbrs.: an., angle; cm., condyle of mandible; cor., coronoid process; f.g., gingival or alveolar foramen; f.m., mental foramen; ipt., groove for attachment of internal pterygoid muscle.

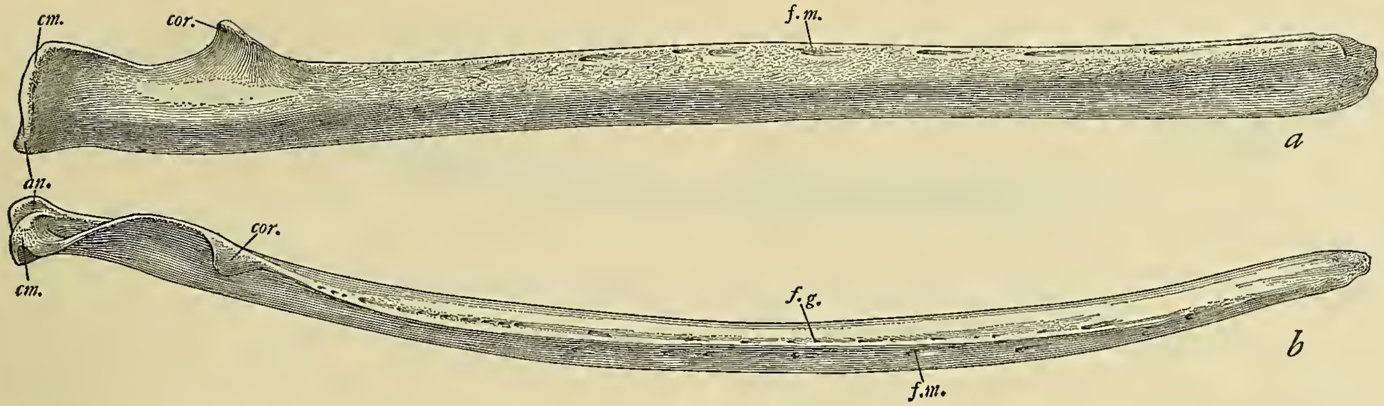

Figure 90.—Views of right mandible, USNM 11535, of *Parietobalaena palmeri* Kellogg; *a*, external view; *b*, dorsal view. For abbreviations, see figure 89.

These two small nodules are also located in the same relative position on the malleus of *B. borealis.* The head of the malleus measures 11 mm. in length and 7.2 mm. in width.

No incus was found associated with the ear bones of the Calvert cetotheres collected for the vertebrate paleontological collections. Quite probably this little ossicle may have been overlooked in some instances when the tympanic bulla or periotic have been freed from the enveloping matrix. On all periotics of this species examined the stapes had been dislodged and lost.

Mandibles

Both mandibles (fig. 89a–c were associated with one (USNM 10677) of the four more or less complete skulls (USNM 16570, 23022, 23725), but none were found near the type cranium (USNM 10668) that belonged to a rather young individual. A longer right mandible (USNM 11535), which was intermingled with a number of skeletal elements including a cranium, rostral bones, bullae, periotics, seven vertebrae, ribs, and a humerus, is essentially complete except for limited erosion of the articular face of the condyle. This individual was not physically mature, since the epiphyses were not ankylosed to the centra of the cervical vertebrae. Less complete mandibles provided supplementary information. One of the smallest (fig. 91 a, b) is a left mandible (USNM 12697; length 918 mm., anterior end missing) of a young whale about the same age as the type, whose greatest vertical diameter anteriorly is 58.5 mm.

When compared with the mandibles of the Belgian Anversian fossil mysticetes described by Van Beneden, the resemblances shown by the mandible of *Isocetus depauwii* to the Calvert mandible require more than a cursory assessment. The length in a straight line of the type left mandible of *I. depauwii* (MHNB 170; Van Beneden, 1886, pl. 70, fig. 1) is 1128 mm. and that of a Calvert right mandible (USNM 11535; fig. 90 a, b) is 1195 mm. The vertical diameter of the mandibular ramus of this Belgian species near the distal end is 84 mm., and the same measurements for this Calvert mandible is 73 mm. The Belgian mandible is thus slightly shorter but more robust than that of the Calvert cetothere.

The profile of the articular face of the condyle of the Calvert mandible compares favorably with that of *I. depauwii* (Van Beneden, 1886, pl. 70, fig. 8), which measures 55 mm. transversely. The greatest transverse diameter of the condyle of these small Calvert mandibles ranges from 55 mm. (USNM 11535) to 62 mm. (USNM 23203) and 80 mm. (USNM 23731). Increase in width certainly modifies the profile of the condyle (fig. 92a–c) and this fact leads clearly to the inference that unlimited reliance should not be placed on the condyle for defining mysticete genera, at least for related genera. More weight should be accorded to the sum or combination of less variable diagnostic characters.

During growth toward physical maturity, a widening of the mandibular condyle and its covering fibrous pad for the usual attachment to the glenoid articular area would accompany an increase in width of the postglenoid process. The maximum side to side expansion of the condyle may occur either above (USNM 23731) or below (USNM 7424) the middle of its vertical diameter. The articular surface

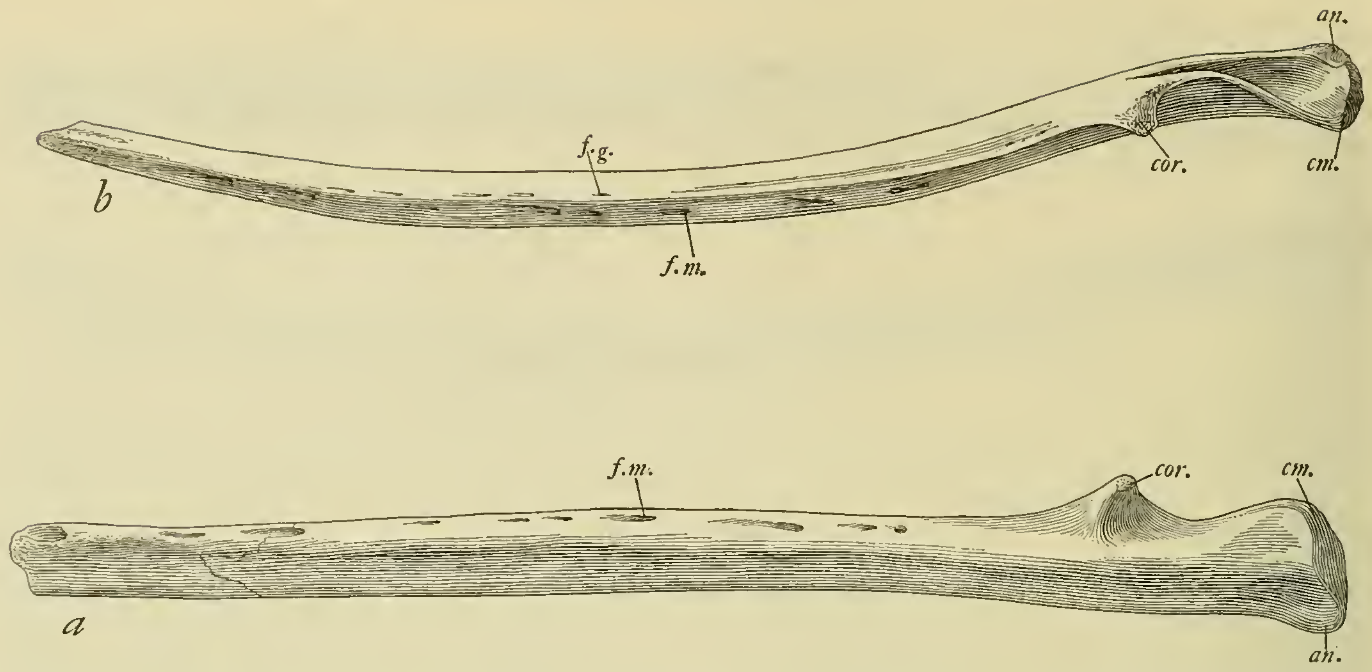

FIGURE 91.—Views of left mandible, USNM 12697, of *Parietobalaena palmeri* Kellogg, young individual: *a*, external view; *b*, dorsal view. For abbreviations, see figure 89.

of the condyle may be either somewhat flattened (USNM 23731) or convex (USNM 23203). On all the mandibles the condyle is bounded ventrally on the internal face of the ramus above the angle by the deep groove for the attachment of the internal pterygoid muscle. This groove is not extended across the posterior articular surface. With one exception the dorsal portion of the condyle is bent inward to conform with the curvature of the rim of the ramus behind the coronoid process; on this mandible (USNM 23203; fig. 92c) the rim is abnormally abruptly depressed some 20 mm. below the forward projecting dorsal edge of the condyle. On other mandibles, the forward curving external border of the condyle projects noticeably beyond the lateral surfaces of the adjacent portions of the ramus. Lengthening of the mandibular ramus is accompanied by an increase in the interval between the condyle and the coronoid process. On three of the mandibles, the posterior articular surface of the condyle is, respectively, 150 mm. (USNM 23203), 180 mm. (USNM 11535), and 200 mm. (USNM 7424) distant from the center of the apex of the coronoid process.

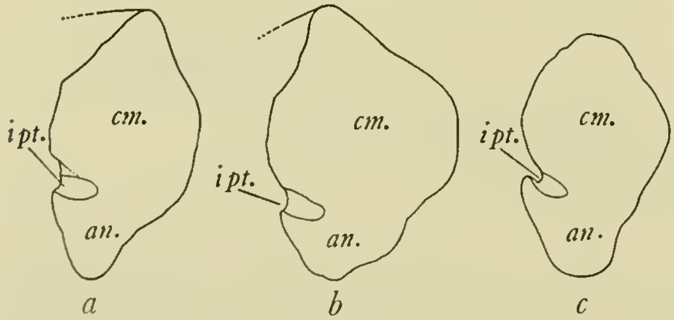

FIGURE 92.—Posterior views of condyles of mandibles of *Parietobalaena palmeri* Kellogg: *a*, right mandible (USNM 7424); *b*, right mandible (USNM 23731); *c*, right mandible (USNM 23203). For abbreviations, see figure 89.

The coronoid process (fig. 90b) is bent outward and less noticeably backward above and anterior to the entrance of the mandibular canal, terminating in an everted apex, convex internally and concave externally. For a distance of 650 mm. in front of the apex of the coronoid process a groove or rather a longitudinal ridge (fig. 90b) forms the dorsal edge of the horizontal ramus. The small internal nutritive foramina make their appearance posteriorly about 75 mm. anterior to the apex of the coronoid process and below its rising anterior rim; commencing at a level about 10 mm. below the dorsal edge of this rim they rise gradually to the dorsal surface anteriorly. At the anterior end of this ridge these small internal foramina and their anteriorly directed narrow grooves follow the dorsal surface to the extremity of the horizontal ramus, the terminal groove being more than 100 mm. in length. There are at least 20 of these small internal nutrient foramina on the right mandible (USNM 11535).

The most posterior mental foramen (fig. 90a) on the external surface of the right mandible (USNM 11535) is located 410 mm. anterior to the posterior articular face of the condyle. There are eight mental foramina on this mandible, each opening into an anteriorly directed groove of variable length (15 to 80 mm.). Eight mental foramina (fig. 89b) are present on both of the shorter mandibles (USNM 10677). A large terminal foramen (fig. 89a) is present below the dorsal edge at the end of the mandible. Spacing of the external mental foramina varies from 38 to 88 mm. on one mandible (USNM 11535), 60 to 117 mm. on another (USNM 13903), and 76 to 97 mm. on a third (USNM 10677). Similar variation in spacing is exhibited by the internal nutritive foramina.

Behind the distal one sixth (200 mm.) the lateral surfaces (fig. 93) of the mandibular ramus become progressively more convex dorsoventrally, the external more especially so than the internal surface. The convex curvature of the external surface ends abruptly where it meets at an acute angle (fig. 93e) the ventral limit of the internal surface. All mandibles referred to this species are bowed outward. Viewed from the side, the ventral profile of the mandible is almost straight. The symphysis was short. Above the ventral edge of the anterior one ninth of the horizontal ramus and below the short longitudinal crease, the lower border (dorsoventral depth, 20 mm.) of the internal face of the ramus is depressed.

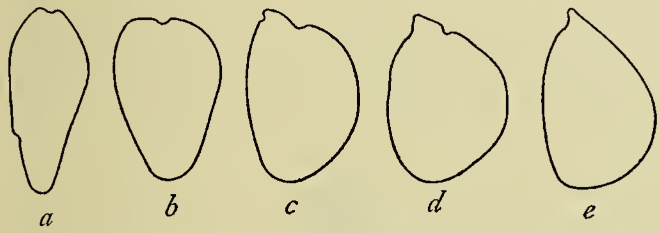

Figure 93.—Cross sections of right mandible, USNM 11535, of *Parietobalaena palmeri* Kellogg: *a*, 100 mm. behind anterior end; *b*, 300 mm. behind anterior end; *c*, 500 mm. behind anterior end; *d*, 700 mm. behind anterior end; *e*, 900 mm. behind anterior end.

The mandible being comprised internally to a varying extent of porous bone, depending in part on age and growth factors, and saturated in Recent mysticetes with oil, is susceptible to alteration and compression by the crushing effects of weight of overlying sediments. Allowance accordingly should be made for distortion in comparative measurements of the mandibles.

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

	USNM 11535 Right	*USNM 10903 Left*	*USNM 10677 Left*
Greatest length of mandible as preserved in a straight line	1195	1164	983
Greatest length of mandible as preserved along outside curvature	1230	1200+	1046
Distance from anterior end to level of center of apex of coronoid process along outside curvature	1035	1041	937±
Greatest vertical diameter 100 mm. behind anterior end of ramus	73	70.5	78.2
Greatest transverse diameter 100 mm. behind anterior end of ramus	30.5	29	32.5
Greatest vertical diameter 300 mm. behind anterior end of ramus	63.5	64.5	66
Greatest transverse diameter 300 mm. behind anterior end of ramus	42.5	37.5	44.2
Greatest vertical diameter 500 mm. behind anterior end of ramus	67	64.5	69
Greatest transverse diameter 500 mm. behind anterior end of ramus	48	43.7	46.2
Greatest vertical diameter 700 mm. behind anterior end of ramus	66.7	64.7	63.6
Greatest transverse diameter 700 mm. behind anterior end of ramus	52	45.5	49.5
Least vertical diameter of ramus between coronoid process and condyle	80	74	—
Greatest vertical diameter through coronoid process	116	98	128±
Greatest vertical diameter of hinder end of ramus including condyle	102	—	—
Greatest transverse diameter of condyle	55	—	—

Vertebrae

Thirty eight vertebrae (USNM 23203), including 7 cervicals, 12 dorsals, 10 lumbars, and 9 caudals of 1 skeleton, and 4 dorsals (USNM 23448) of another individual are referred to this species. The epiphyses of most of the vertebrae belonging to the first mentioned skeleton are detached, an indication of physical immaturity. The 4 dorsals, however, have all epiphyses firmly ankylosed and are obviously physically mature; their dimensions and structural features closely parallel those of the longer series. The measurements suggest that the 12 dorsals and the 10 lumbars are a consecutive series. Twelve dorsals and 11 or 12 lumbars were present in the vertebral column of the larger Calvert cetotheres.

The total length of the skeleton, including the skull (length, 1115 to 1250 mm.), from the extremity of the rostrum to and including the terminal caudal did not exceed 14 or 15 feet.

Cervical vertebrae.—None of the cervical vertebrae (USNM 23203) were ankylosed to either the one in front or the one behind. All have the epiphyses detached from the centrum. The atlas has a vestigal ridge-like neural spine, and short, thick, and blunt transverse processes. The hyapophysial process, if present on the narrow splintered ventral strip, was reduced to a thin backward projecting shelf.

The roof of the axis is concave ventrally and ornamented dorsally with 3 thin longitudinal ridges, widened and truncated posteriorly, and deeply excavated anteriorly. The axis has a small obtuse odontoid process; the transverse processes are broad at the base, tapered toward their extremity, turned downward and backward, and imperforate. An irregular depression at base posteriorly on each process marks the former location of the foramen transversarium. Upper and lower transverse processes of the third cervical are not united distally by an osseous isthmus to enclose the cervical extension of the thoracic retia mirabilia; the slender attenuated lower process is bent more backward than downward. Extremities of upper and lower transverse processes of the fourth cervical are broken off and missing; the lower process is dorsoventrally compressed near its base, directed downward and slightly backward. Upper transverse process of fifth cervical is anteroposteriorly compressed near the base, attenuated distally; the lower transverse process is slender, bent more backward than downward; extremities of these processes are broken off and missing. All processes of the sixth cervical are broken off near the base; slender lower transverse processes were present; the anteroposteriorly compressed upper transverse processes were rather broad at the base. The seventh cervical lacks lower transverse processes; the anteroposteriorly compressed upper transverse process is broad at the base.

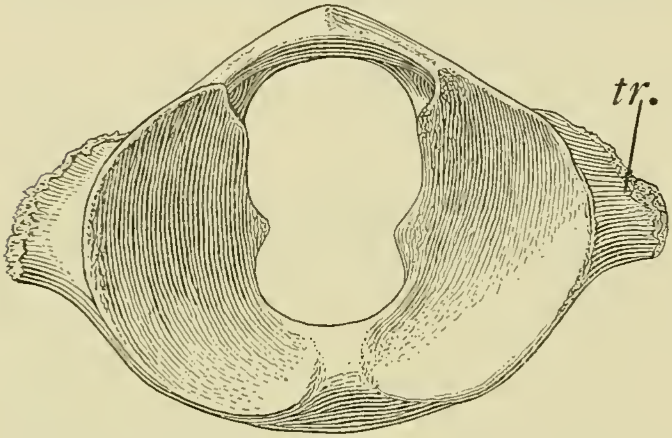

Figure 94.—Anterior view of atlas, USNM 11535, of *Parietobalaena palmeri* Kellogg. Abbr.: tr., transverse process.

Viewed from in front the profile of the centrum of the sixth and seventh cervicals is elliptical, the vertical diameter of the fifth (63 mm.) exceeds that of the preceding cervicals, and the fourth and third were widened transversely.

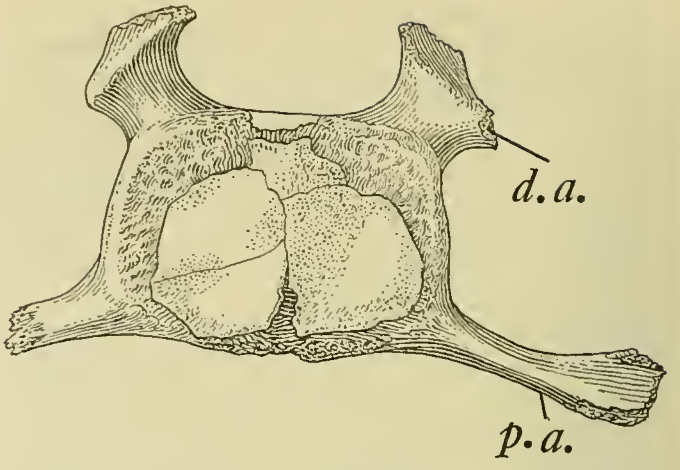

Figure 95.—Anterior view of third cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. Abbrs.: d.a., diapophysis; p.a., parapophysis.

The length of the 7 cervical vertebrae, including the cartilaginous intervertebral disks, is approximately 235 mm. (9¼ inches).

The distance (124 mm.) between the outer edges of the anterior articular facets of the atlas (fig. 94) of another physically immature specimen (USNM 11535) is less and

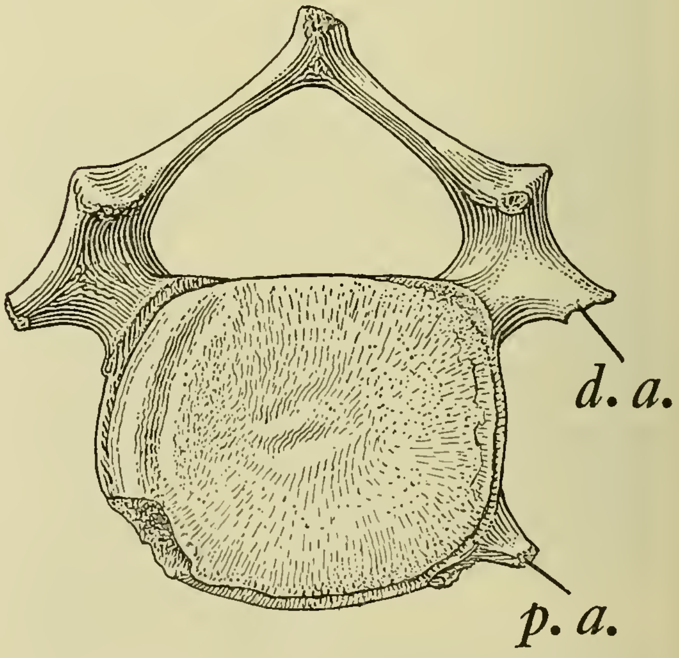

Figure 96.—Anterior view of fourth cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 95.

USNM 23203–Cervical Vertebrae	*Atlas*	*Axis*	*C.3*	*C.4*	*C.5*	*C.6*	*C.7*
Greatest vertical diameter of vtebra, tip of neural spine to ventral face of centrum	104	—	—	—	—	—	—
Greatest anteroposterior diameter of centrum	58	50 [p]	25 [a]	28 [a]	30 [a]	26 [b]	26 [b]
Greatest vertical diameter of centrum, anteriorly	—	—	65	59	64	62	56
Greatest vertical diameter or neural canal, anteriorly	64	—	—	—	—	—	—
Greatest transverse diameter of neural canal, anteriorly	44	47.5	—	—	—	—	—
Greatest distance between outer ends of parapophyses	150	192	—	—	—	—	—
Least anteroposterior diameter of right pedicle of neural arch	—	—	10	10.5	11	10.5	12
Greatest distance between outer magins of anterior articular facets	131	129	—	—	—	—	—
Vertical diameter of anterior articular surface	85	72	—	—	—	—	—
Greatest vertical diameter of centrum, posteriorly	45	54	65	60	62	58	57.5
Greatest transverse diameter of centrum, posteriorly	131	94	77	87	76	77	78

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

the centrum is much thinner (43 mm.) than USNM 23203. This atlas also lacks a neural spine and the shape of the transverse processes is similar. Four additional cervical vertebrae were associated with this specimen. The anterior profile of the centra of these cervicals is more rectangular and thus differs from the elliptical shape of USNM 23203. On the third cervical (fig. 95) the lower transverse process is directed outward, widened at the extremity and not bent backward; the basal portion of the combined pedicle of the neural arch and the diapophysis is narrow, noticeably less widened than on USNM 23203. The transverse processes of the fourth cervical (fig. 96) are slender and the upper process is not expanded dorsoventrally. Very slender upper and lower transverse processes are present on the fifth cervical (fig. 97); the neural spine on the complete neural arch is very short; and the centrum is quite thin (19 mm.). The centrum of the sixth cervical (fig. 98) is as thin as the fifth; the dorsovental diameter (18 mm.) of the combined basal portion of the pedicle of the neural arch and diapophysis is less than half the corresponding measurement (39 mm.) of USNM 23203. Growth and individual variability of the cervical vertebrae tend to minimize the accuracy of any identification of nonassociated specimens. Although the atlas is the most variable of the cervical vertebrae, the inclosure of the cervical extension of the thoracic retia mirabilia seems not to have resulted in any uniform modification of the upper and lower transverse processes.

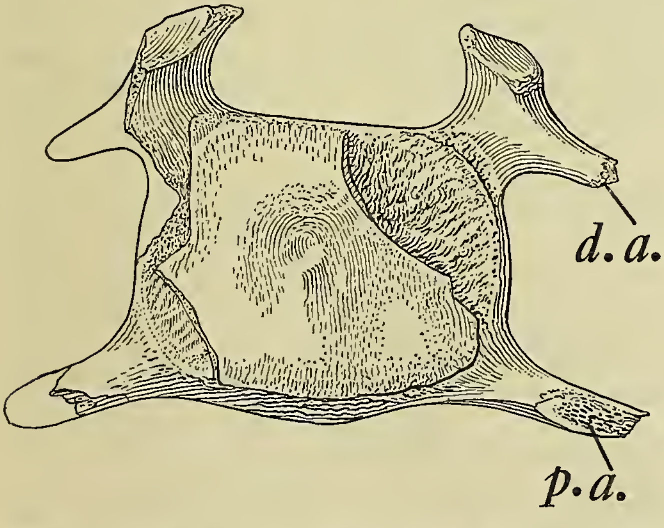

FIGURE 97.—Anterior view of fifth cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 95.

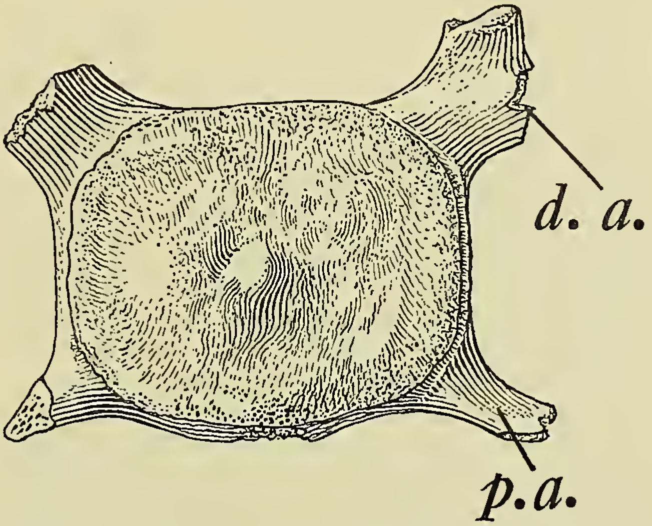

FIGURE 98.—Anterior view of sixth cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 95.

Measurements (in mm.) of cervical vertebrae, USNM 23203, are as indicated above.

DORSAL VERTEBRAE.—Both epiphyses are detached from the centra of the 12 consecutive dorsals (USNM 23203) All of the epiphyses are, however, firmly ankylosed to the

USNM-23208 Dorsal Vertebrae

	D.2	*D.3*	*D.4*	*D.5*	*D.6*	*D.7*	*D.8*	*D.9*	*D.10*	*D.11*	*D.12*
Anteroposterior diameter of centrum	33^{b}	43^{a}	50^{p}	47.5^{b}	53^{b}	64^{p}	62^{b}	79	78^{p}	76^{b}	85^{p}
Transverse diameter of centrum anteriorly	82	84	76	78	81	81	83	74	73	77	69
Vertical diameter of centrum anteriorly	53	52	54	54	54	63	59	62	59	63	63
Tip of neural spine to ventral face of cantrum posteriorly	—	160	—	—	—	—	—	173+	172+	—	—
Minimum anteroposterior length of pedicle of neural arch	16	19.5	20	27.5	34	42	50	46	51	52	50
Transverse diameter of neural canal anteriorly	47	43	43	45	40	43	42	31	29	31	28
Vertical diameter of neural canal anteriorly	—	31	—	—	—	—	—	28	30	30	27
Distance between ends of transverse processes	193	181	166	—	146.5	148	158+	170	208	230+	231+
Dorsal edge of metapophysis to ventral face of centrum anteriorly	—	68	66	—	77.5	—	—	—	100	106	111
Transverse diameter of centrum posteriorly	86.5^{df}	76^{df}	89^{df}	90^{df}	90^{df}	87^{df}	77	76	79	78	79
Vertical diameter of centrum posteriorly	54.5	53	53	54	56	59	59	59	62	65	64

^{a}=Anterior epiphysis missing. ^{b}=Both epiphysis missing. ^{p}=Posterior epiphysis missing. ^{df}=Posterior demifacet present.

centra of the 4 dorsals of another individual (USNM 23448). The anteroposterior diameters of the centra of the dorsals increase from the first to the twelfth and the transverse diameter of each exceeds the vertical diameter of the anterior end. From before backwards, the profiles of both ends of consecutive dorsal centra are modified from a dorsally flattened and transversely widened ellipse on the anterior dorsals to a more definite subcordate shape from the middle to the posterior end of this series.

On each side of the centrum of the first to seventh dorsals, inclusive, below the level of the floor of the neural canal and adjacent to or on the edge of the posterior epiphysis, there is an articular facet for the capitulum of the following rib. No vestige of this facet can be recognized on the eighth dorsal. The transverse diameter of the neural canal of the second dorsal (47 mm.) exceeds that of the twelfth (28 mm.); the vertical diameter of the neural canal is decreased less noticeably.

The pedicles of the neural arch are robust and wide on the anterior eight dorsals. The articular ends of the diapophyses progressively increase in width from the first to the eighth dorsal. On these eight anterior dorsals the diapophyses arise in part from the pedicle of the neural arch and in part from the dorsointernal portion of the centrum anteriorly. The parapophyses of the ninth to twelfth dorsals, inclusive, project outward from the lateral surface of the centrum and progressively increase in length. These processes are bent upward on the ninth, tenth, and eleventh dorsals. The neural spines are incomplete on all the dorsals; there is, however, a marked increase in the anteroposterior diameter of the neural spine at the base toward the hinder end of this series. The width of the interval between the opposite prezygapophysial facets decreases from the anterior to the posterior end of the dorsal series.

On the first six of the anterior dorsals, the articular facet on each metapophysis is flat; the demarcation of the outer edge of this facet by an anteroposterior crest becomes prominent on the seventh and presumably also on the eight, but certainly on the ninth this crestlike development has culminated in the inclination of each metapophysis to almost vertical. These side to side compressed metapophyses increase in size and rise higher above the floor of the neural canal from the eighth dorsal to the posteriormost lumbar.

The total length of the twelve dorsals, including the cartilaginous intervertebral disks, is about 760 mm. (30 inches).

Measurements (in mm.) of dorsal vertebrae, USNM 23203, are as indicated above.

Measurements (in mm.) of dorsal vertebrae, USNM 23448, are as follows:

	D.2	*D.5*	*D.6*	*D.7*
Anteroposterior diameter of centrum	36	51	56.4	61
Transverse diameter of centrum, anteriorly	82.5	82	84	84
Vertical diameter of centrum, anteriorly	54.5	54	58.5	59
Minimum anteroposterior length of pedicle of neural arch	13	25	33	41
Transverse diameter of neural canal, anteriorly	52	50	49	47
Vertical diameter of neural canal, anteriorly	27	29	22	20
Distance between ends of diapophyses	181	159	151	150
Dorsal edge of metapophysis to ventral face of centrum anteriorly	72	71	74	80

	D.2	*D.5*	*D.6*	*D.7*
Tip of neural spine to ventral face of centrum posteriorly	112	134	167	184
Transverse diameter of centrum posteriorly, including demifacets	86	93	95	95
Vertical diameter of centrum posteriorly	55	54	57	61
Distance between outer margins of prezygapophysial facets	81	68	65	54
Distance between outer margins of postzygapophysial facets	70	49	26	24

Lumbar vertebrae.—When excavated the epiphyses of the 6 anterior lumbars (USNM 23203) were detached; both epiphyses were attached to the centra of the seventh and eighth lumbars; and the anterior epiphysis was ankylosed to the centrum of the ninth and tenth lumbar. Four of the lumbars lack most of the neural arch, the neural spines of all the lumbars are either damaged, incomplete or missing; the first, second, fifth, and ninth lumbars possess an essentially complete left transverse process; and the metapophyses are preserved on the first and ninth lumbars, but are missing of the others.

A rather sharp-edged ventral median longitudinal keel is developed on the centra of the second to tenth lumbars, inclusive; no rudiment of this keel, however, is present on the first lumbar. In serial sequence, the centra increase in length from the first to the posteriormost lumbar, the transverse and vertical diameters of the neural canal diminish, and the transverse processes are shortened. The transverse processes of the first, second and fifth lumbars are slender, elongated and are directed slightly forward. As compared to the first and second lumbar, the left transverse process on the ninth lumbar is broader (minimum anteroposterior diameter, 45 mm.), shorter, and is directed more obliquely forward. The elongated thin lamina-like metapophyses project upward and forward beyond the level of the anterior face of the centrum and are inclined obliquely outward from ventral to dorsal edges. The neural spine of the ninth lumbar was more strongly inclined backward than that of the first lumbar. Assuming that at least 11 vertebrae comprised the lumbar series, the estimated length of this section of the vertebral column is 1125 mm. (44¼ inches).

Measurements (in mm.) of lumbar vertebrae, USNM 23203, are as indicated below.

Caudal vertebrae.—Of the 9 caudal vertebrae (USNM 23203), the first to the sixth, inclusive, are consecutive; the remaining three are regarded as the ninth, tenth, and twelfth. The epiphyses were associated with but not attached to the centra or the first and second caudals. Eleven caudals (USNM 16667) of another individual are consecutive from the fourth to the fourteenth, the terminal vertebra. The epiphyses of the fourth and fifth caudals of this series were not ankylosed to the centra, but are firmly attached on the others. Associated with these caudals were 1 dorsal and 2 lumbars that lack epiphyses; this individual was not only smaller but also less mature than USNM 23203.

The anteroposterior, as well as the transverse and vertical diameters of the anterior end of the centrum, diminish from the first to the terminal caudal; the reduction of these dimensions is rather abrupt behind the tenth caudal. These four or five terminal caudals are embedded in the caudal flukes of Recent mysticetes. The interval between the dorsal edges of the opposite metapophyses progressively diminishes from the first to the sixth caudal; these processes are strongly reduced, almost vestigial on the seventh and eighth caudal. On the five anterior caudals, these metapophyses are curved upward and outward.

The neural spines of the 3 anterior caudals, although relatively short, project above the metapophyses; they diminish rapidly in height behind the first caudal and on the fifth to the eighth, inclusive, are reduced to a low crest. The neural canal, which has a roof as far backward as the eighth or ninth caudal, decreases in transverse and vertical diameter.

USNM 23203–Lumbar Vertebrae	*L.1*	*L.2*	*L.3*	*L.4*	*L.5*	*L.6*	*L.7*	*L.8*	*L.9*	*L.10*
Anteroposterior diameter of centrum	83[p]	81[b]	91	95.5	99	102	103	108	97[p]	101
Transverse diameter of centrum anteriorly	72.5	71.5	68.5	65	73	74	76	79	75	85
Vertical diameter of centrum anteriorly	63	66.5	63	67.5	66	70	72	75	73	75
Minimum anteroposterior length of pedicle of neural arch	41	—	—	—	47	—	46	45	44	—
Transverse diameter of neural canal anteriorly	28	—	—	—	—	23	19	13.5	16	17±
Vertical diameter of neural canal anteriorly	30	—	—	—	35	—	28	24	19	—
Distance between ends of transverse processes	—	—	—	—	289	—	—	—	—	—
Dorsal edge of metapophysis to ventral face of centrum anteriorly	110	—	—	—	—	—	—	133	—	—
Transverse diameter of centrum posteriorly	79	74	71	74	75	75	77	78	80	86.5
Vertical diameter of centrum posteriorly	63	66	65	69	68.5	69	73	75	73	75

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

Measurements (in mm.) of caudal vertebrae, USNM 23203 and USNM 16667, are as follows:

USNM 23203–Caudal Vertebrae	*Ca.1*	*Ca.2*	*Ca.3*	*Ca.4*	*Ca.5*	*Ca.6*	*Ca.9*	*Ca.10*	*Ca.12*
Anteroposterior diameter of centrum	97[p]	108	108	106	103	85[p]	58[b]	56.4	35
Transverse diameter of centrum anteriorly	83	83.5	82	81	87	89	74.5	67.5	46
Vertical diameter of centrum anteriorly	81.5	81.5	86	97	97	86.5	78.5	73.5	41
Tip of neural spine to ventral face of centrum posteriorly	152+	154	130	123	110+	102	—	—	—
Minimum anteroposterior length of pedicle of neural arch	45	43	46	48	45	54	15.5	—	—
Transverse diameter of neural canal anteriorly	16	14	14	11	12	14	10	—	—
Vertical diameter of neural canal anteriorly	16	16	9	10	9	5	—	—	—
Distance between ends of transverse processes	—	125+	158+	—	123	104	—	—	—
Dorsal edge of metapophysis to ventral face of centrum anteriorly	127	136	132	131	126	111	—	—	—
Transverse diameter of centrum posteriorly	—	81	87	86	86	—	70	63	43
Vertical diameter of centrum posteriorly	—	88	105	100	86+	89	74	65.5	35

USNM 16667–Caudal Vertebrae	*Ca.4*	*Ca.5*	*Ca.6*	*Ca.7*	*Ca.8*	*Ca.9*	*Ca.10*	*Ca.11*	*Ca.12*	*Ca.13*	*Ca.14*
Anteroposterior diameter of centrum	93	77+[a]	86	83	78	68	51	34+[p]	29[p]	22[b]	19
Transverse diameter of centrum anteriorly	84	84	81	82	82	70	62	60	51	44	38
Vertical diameter of centrum anteriorly	83.5	84	85	79	79	74	64	50	42	35	32
Minimum anteroposterior length of pedicle of neural arch	41.5	42	43	47	51	—	—	—	—	—	—
Transverse diameter of neural canal anteriorly	20	17	13	12	11	7	—	—	—	—	—
Vertical diameter of neural canal anteriorly	18	17	7	8	8	—	—	—	—	—	—
Distance between ends of transverse processes	148+	127	110	94	—	—	—	—	—	—	—
Dorsal edge of metapophysis to ventral face of centrum anteriorly, including haemapophyses	112.5	107	105	102	91	79	—	—	—	—	—
Tip of neural spine to ventral face of centrum posteriorly, including haemapophyses	127.5	113	109	104	94	—	—	—	—	—	—
Transverse diameter of centrum posteriorly	85	80.5	84	82	73.5	65	55	50	46	—	—
Vertical diameter of centrum posteriorly	85	82	83.5	80	76	69	57	48	41	—	—

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

The sharply defined median longitudinal ventral ridge on the centrum of the posterior lumbar is replaced on the first caudal (USNM 23203) by an anterior and posterior low central protuberance, but no distinct tubercles. A pair of large posterior haemal tubercles (hyapophyses) are developed on the second and third caudals. An anterior pair and a posterior pair of haemal tubercles are, however, developed on the fourth and fifth caudals. On each side of the haemal groove on these two caudals between the anterior and posterior haemal tubercle is a notch through which the segmented blood vessels pass on their upward course on the lateral surface of the centrum in front of the anterobasal angle of the transverse process and thence obliquely to the posterior end of the neural canal.

Commencing with the sixth or seventh and present, as well on the eighth, the anterior and posterior haemal tubercles on each side of the haemal groove are joined by an osseous isthmus which is pierced by a foramen for passage of the segmental blood vessels. The short transverse process of these caudals is pierced centrally at the base by a foramen for these blood vessels, which reach the posterior end of the neural canal. The caudals behind the ninth, the hindermost one to which chevrons were attached and the last on which the roof of the neural canal persists, are pierced by vertical passages from the ventral face to the dorsal neural depression or groove. Three orifices on the ventral surface and two on the dorsal surface of the centrum provide the passage for branches of the caudal artery and vein between the haemal groove and the terminal portion of the neural canal.

The horizontally outward directed transverse process is longer and narrower on the first than on the third caudal which has the terminal portion widened; it is quite short on the fifth, sixth, and seventh caudal. This process is obliquely truncated distally on the seventh and is pierced at the base by the vascular foramen. The transverse and vertical diameter of the last five in the caudal series exceed the anteroposterior diameter of the centrum.

The length of the fourteen caudal vertebrae, including the cartilaginous intervertebral disks, is about 1085 mm. (42¾ inches).

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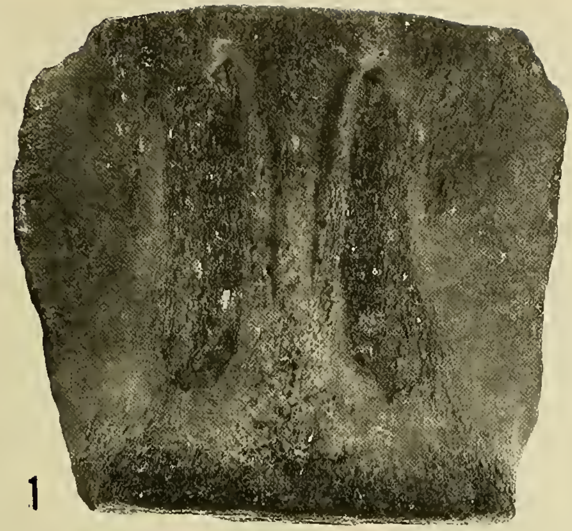
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2


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6

Lumbar and Caudal Vertebrae, ANSP 12769, Eschrichtius pusillus Cope (Type)

1, Dorsal view of lumbar; 2, lateral view of caudal; 3, dorsal view of dorsal vertebra.

Dorsal Vertebrae, ANSP 12769, Megaptera expansa Cope (type)

4, Anterior view of eighth dorsal; 5, anterior view of fifth dorsal; 6, anterior view of ninth dorsal.

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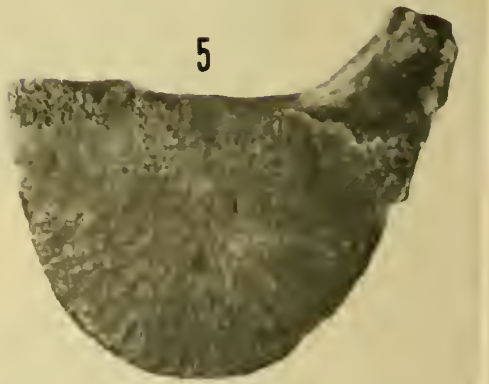

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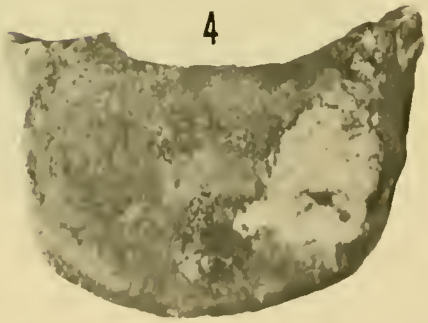


DORSAL VERTEBRAE AND CONDYLE OF MANDIBLE OF *MESOCETUS SIPHUNCULUS* COPE

1, first dorsal, posterior view (AMNH 22669); 2, condyle of right mandible (AMNH 22665); 3, anterior dorsal, posterior view (AMNH 22669); 4, anterior dorsal, posterior view (AMNH 22669); 5, middle dorsal, anterior view (AMNH 22669)

RIGHT PERIOTIC AND AUDITORY OSSICLES, USNM 8518, METOPOCETUS DURINASUS

1, Incus with scar on crus longum and small crus breve on left side; 2, stapes; 3, tympanic or ventral view of right periotic; 4, cerebral or internal view of right periotic; 5, articular facet on malleus.

LEFT PERIOTIC, USNM 10909, PARIETOBALAENA PALMERI

6, Cerebral or internal view; 7, tympanic or ventral view.

1

2

Skull, USNM 16783, Diorocetus hiatus

1, Dorsal view; 2, ventral view.

Skull, USNM 23494, of Diorocetus hiatus
1, Dorsal view; 2, ventral view.

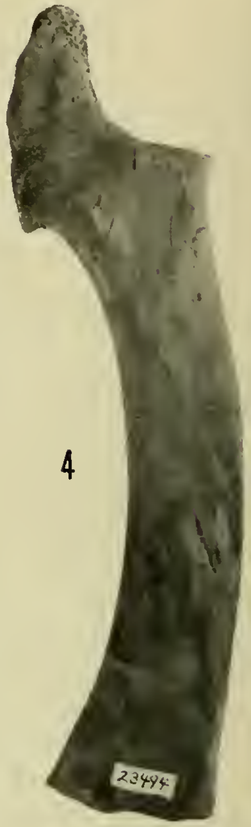
RIGHT PERIOTICS

Aglaocetus patulus (USNM 13472): 1, ventral or tympanic view; 2, internal or cerebral view.
Diorocetus hiatus (USNM 23494): 3, internal or cerebral view; 4, ventral or tympanic view.

Right Scapula and Right Tympanic Bulla, USNM 23494, *Diorocetus hiatus*

1, Internal view of right scapula. Right tympanic bulla: 2, dorsal view; 3, ventral view; 4, external view.

1



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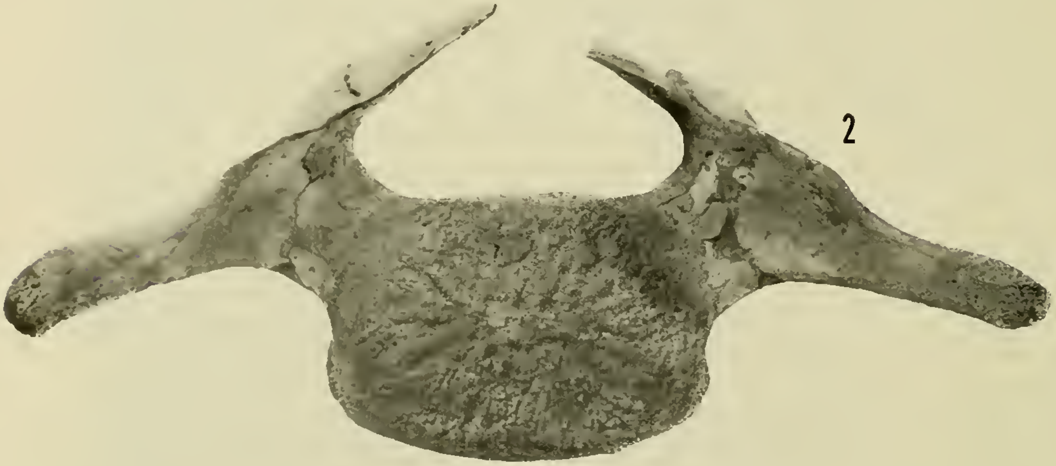

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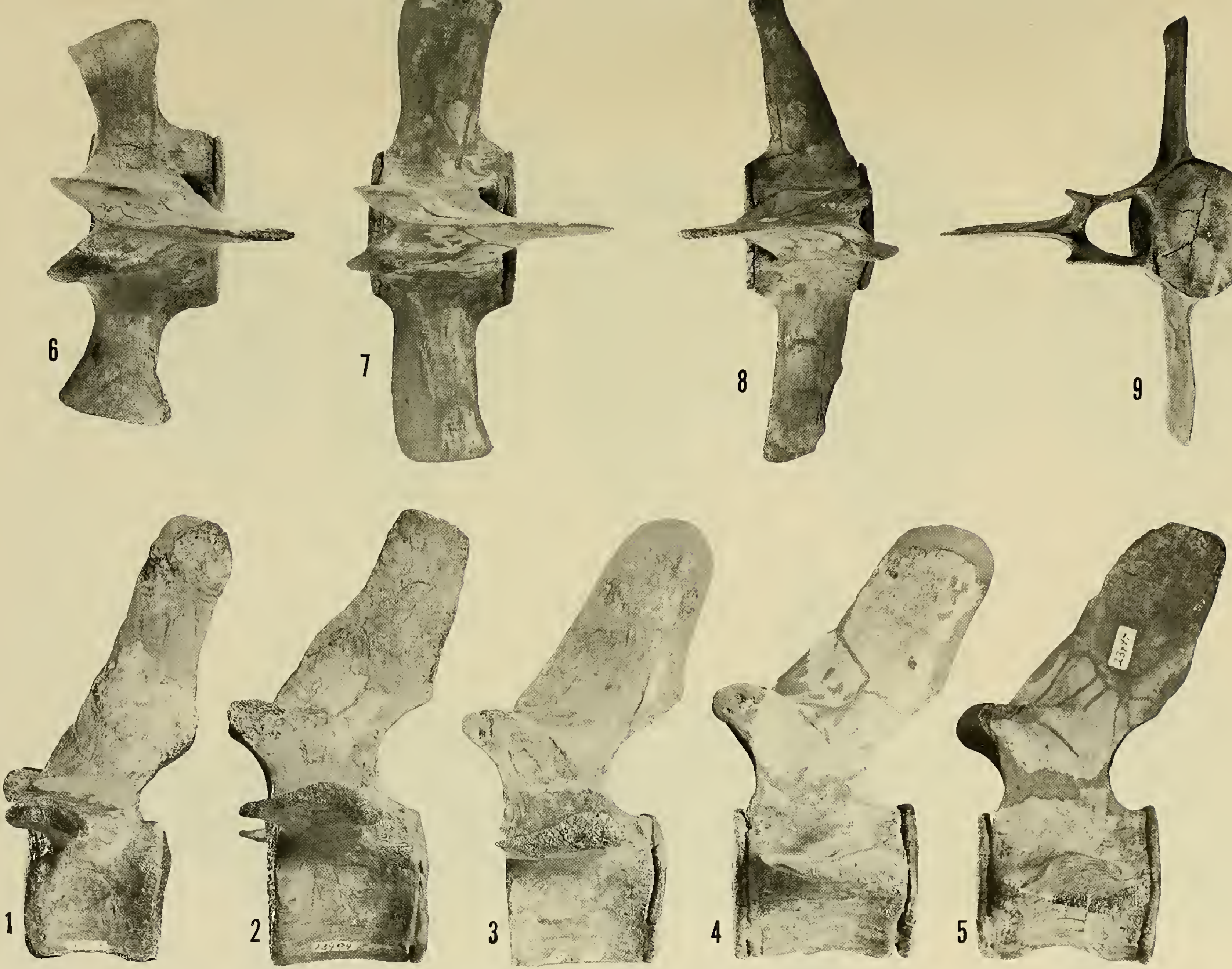
3

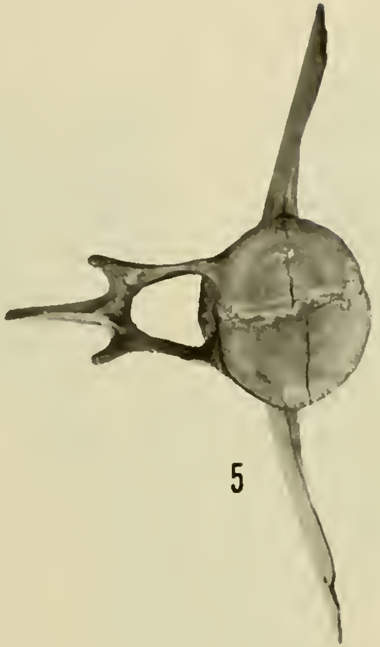
Cervical and Dorsal Vertebrae, and Ulna, Diorocetus hiatus

1, Anterior view of axis (USNM 16783); 2, anterior view of seventh cervical vertebra (USNM 23494); 3, anterior view of first dorsal (USNM 16783); 4, internal view of left ulna (USNM 23494).



Dorsal Vertebrae, USNM 23494, Diorocetus hiatus

Lateral views: 1, seventh dorsal; 2, ninth dorsal; 3, tenth dorsal; 4, eleventh dorsal; 5, twelfth dorsal.
Dorsal views: 6, ninth dorsal; 7, eleventh dorsal; 8, twelfth dorsal.
Anterior view: 9, eleventh dorsal.



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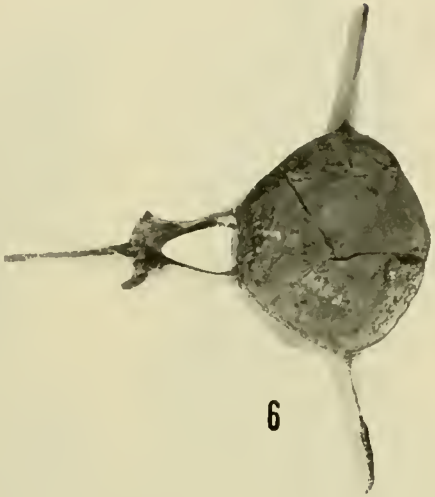

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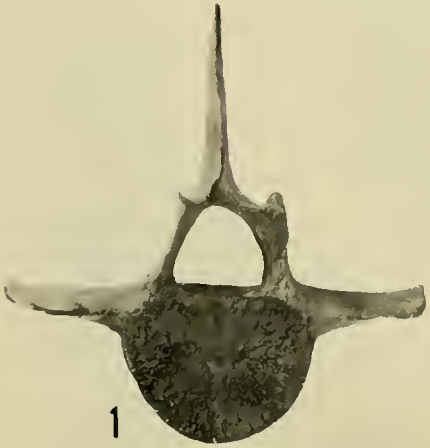

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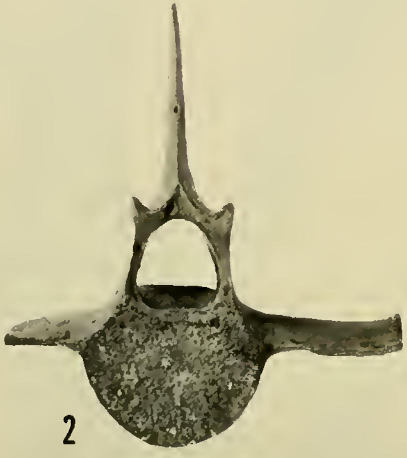

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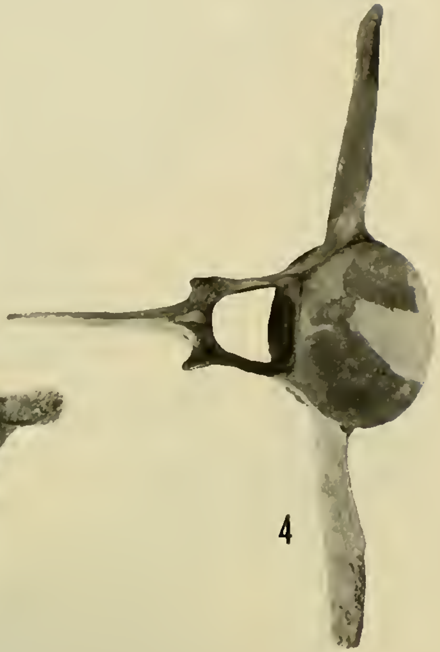
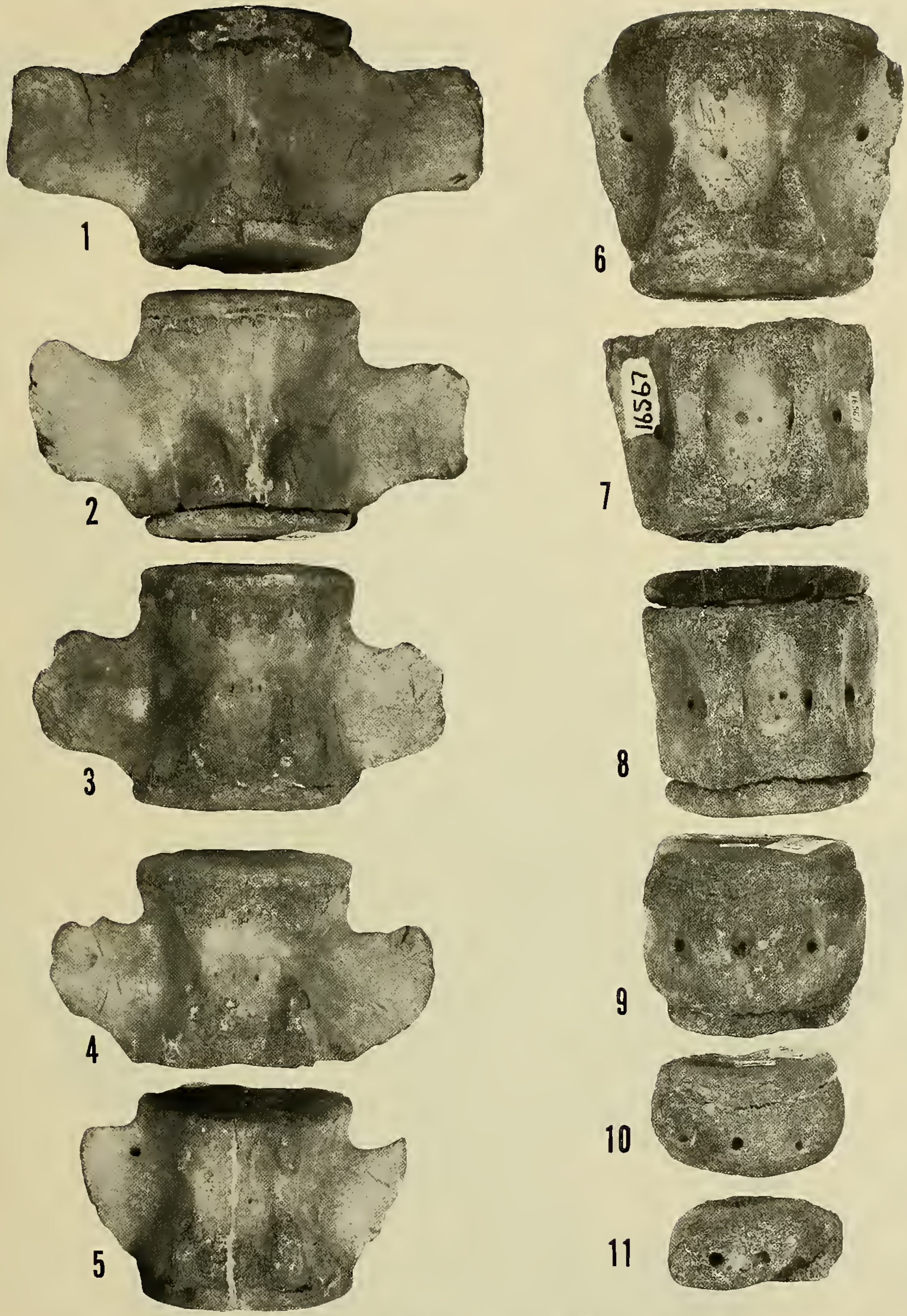


4

Dorsal and Lumbar Vertebrae, USNM 23494, Diorocetus hiatus

Anterior views: 1, ninth dorsal; 2, tenth dorsal; 3, seventh dorsal; 4, twelfth dorsal; 5, second lumbar; 6, eleventh lumbar. Dorsal views: 7, second lumbar; 8, ninth lumbar.



VENTRAL VIEWS OF CAUDAL VERTEBRAE, USNM 16567, DIOROCETUS HIATUS

1, Second caudal; 2, third caudal; 3, fourth caudal; 4, fifth caudal; 5, sixth caudal; 6, seventh caudal; 7, eighth caudal; 8, ninth caudal; 9, eleventh caudal; 10, twelfth caudal; 11, thirteenth caudal.

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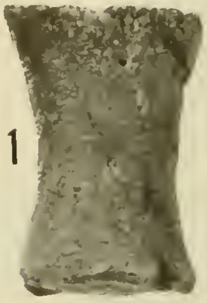

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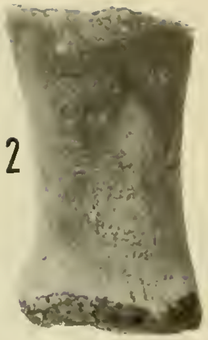

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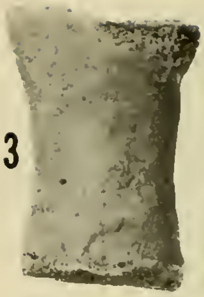

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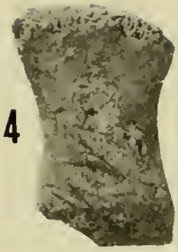

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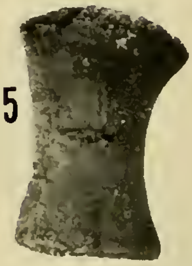

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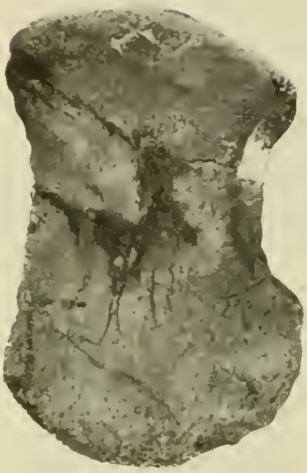

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Metapodials and Chevrons, USNM 23494, Diorocetus hiatus

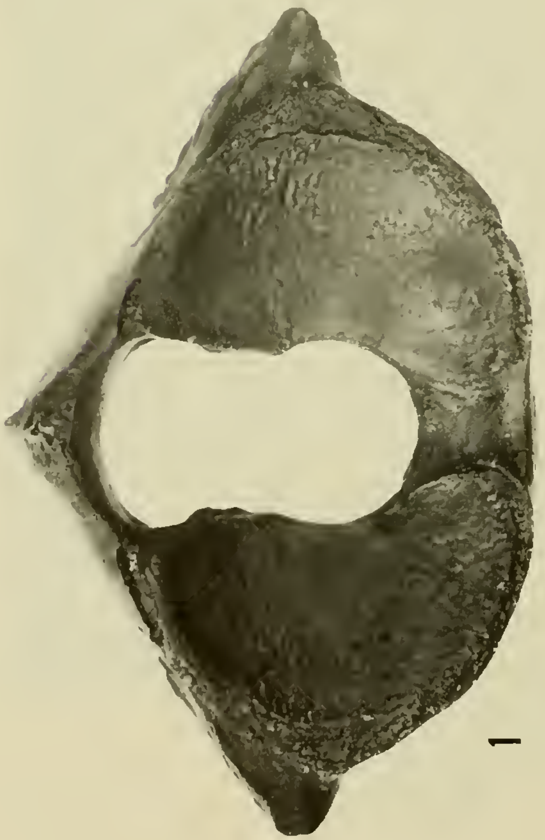
1, 2, 3, metapodials; 4, 5, phalages; 6, 7, lateral view of anterior chevron; 8, lateral view of first chevron; 9, 10, anterior view of anterior chevron; 11, anterior view of first chevron.

Dorsal View of Skull, USNM 23690, Aglaocetus patulus

Ventral View of Skull, USNM 23690, Aglaocetus patulus

Left Periotic and Left Tympanic Bulla, USNM 23690, Aglaocetus patulus

1, Tympanic or ventral view of left periotic; 2, cerebral or internal view of left periotic; 3, external view of left tympanic bulla; 4, ventral view of left tympanic bulla; 5, dorsal view of left tympanic bulla.



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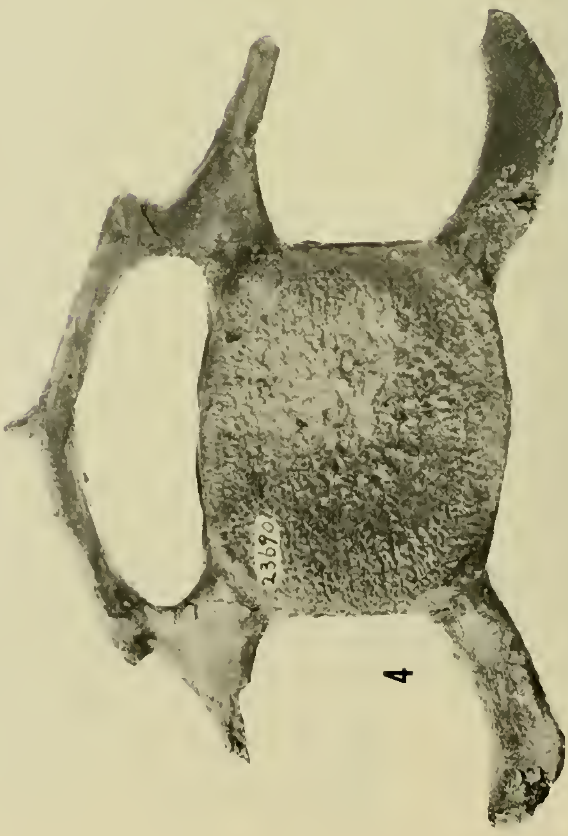


4

CERVICAL VERTEBRAE, USNM 23690, AGLAOCETUS PATULUS

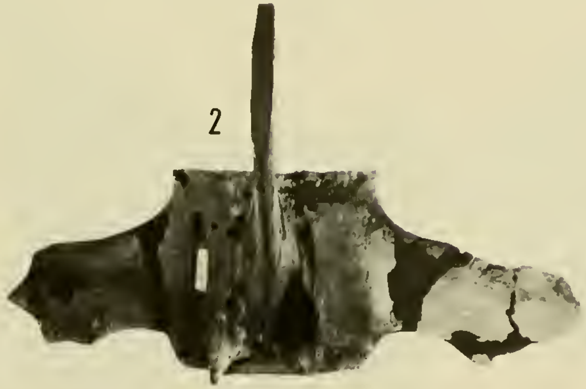
1, Anterior view of atlas; 2, posterior view of atlas; 3, posterior view of third cervical; 4, posterior view of fifth cervical.

Lateral Views of Dorsal and Lumbar Vertebrae, USNM 23690, Aglaocetus patulus

1, ninth dorsal; 2, eighth lumbar; 3, tenth lumbar.

1

2



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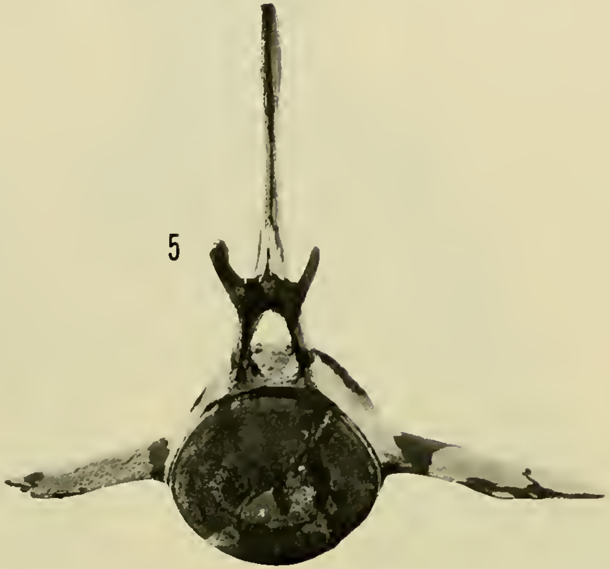

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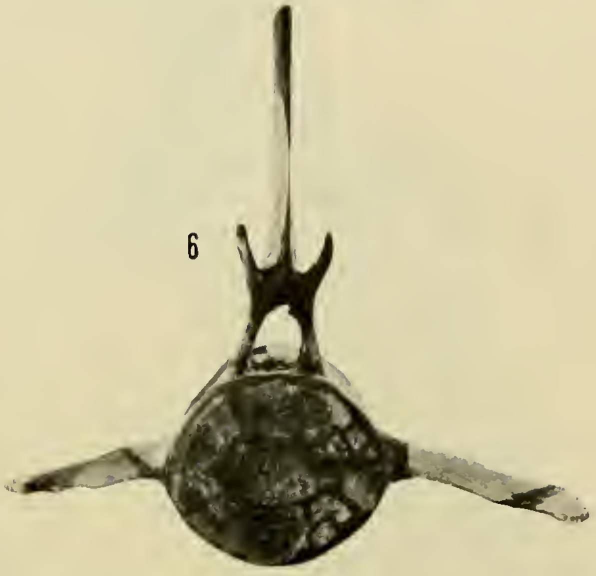


VIEWS OF DORSAL AND LUMBAR VERTEBRAE, USNM 23690, AGLAOCETUS PATULUS

Dorsal views: 1, ninth dorsal; 2, eighth lumbar; 3, tenth lumbar.
Anterior views: 4, ninth dorsal; 5, eighth lumbar; 6, tenth lumbar.

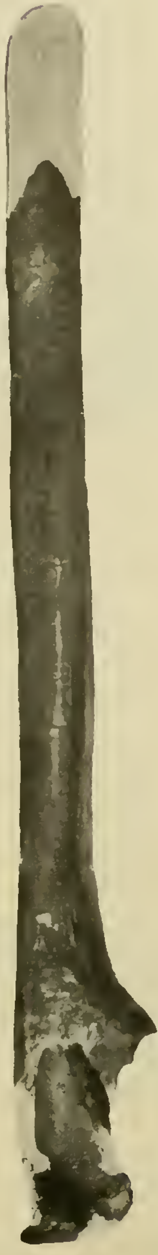
1

2

3

SKULLS OF PARIETOBALAENA PALMERI

1, Lateral view (USNM 10677); 2, dorsal view (USNM 23022); 3, dorsal view (USNM 16570).



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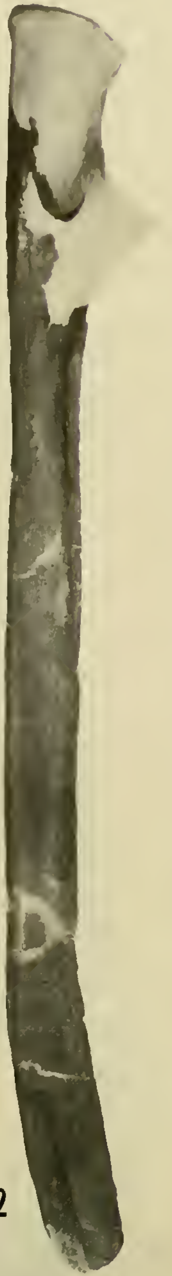

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SKULL AND MANDIBLES, USNM 10677, PARIETOBALAENA PALMERI, RESTORED

1. Internal view of right mandible; 2, internal view of left mandible; 3, dorsal view of skull; 4, ventral view of skull.

DORSAL VIEW OF SKULL, USNM 16119, *PARIETOBALAENA PALMERI*

VENTRAL VIEW OF SKULL, USNM 16119, PARIETOBALAENA PALMERI

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[Names of new genera and species in italics; page numbers of principal accounts in boldface.]

U.S. GOVERNMENT PRINTING OFFICE: 1968