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FOSSIL MARINE MAMMALS

From the Miocene Calvert Formation Of Maryland and Virginia

Parts 1 and 2

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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. Non-perforated 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 2⅛ 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

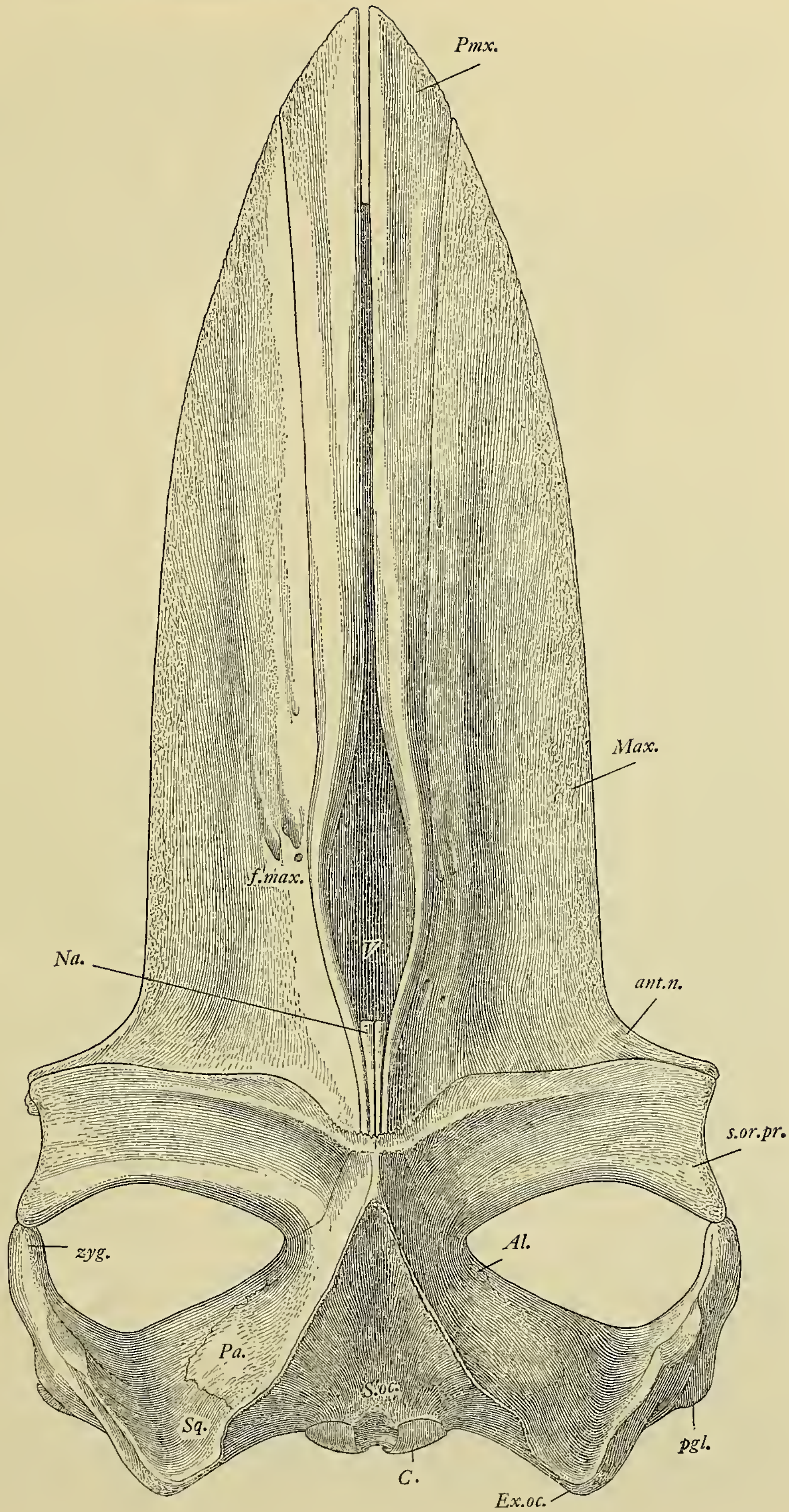

FIGURE 1.—Dorsal view of skull, USNM 11976, of *Pelocetus calvertensis*, with restored borders of rostrum and right supraorbital process. Abbrs.: Al., alisphenoid; ant.n., antorbital notch; Bo., basioccipital; C., occipital condyle; Ex.oc., exoccipital; f.max., maxillary foramen; f.ov., foramen ovale; 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.

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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.

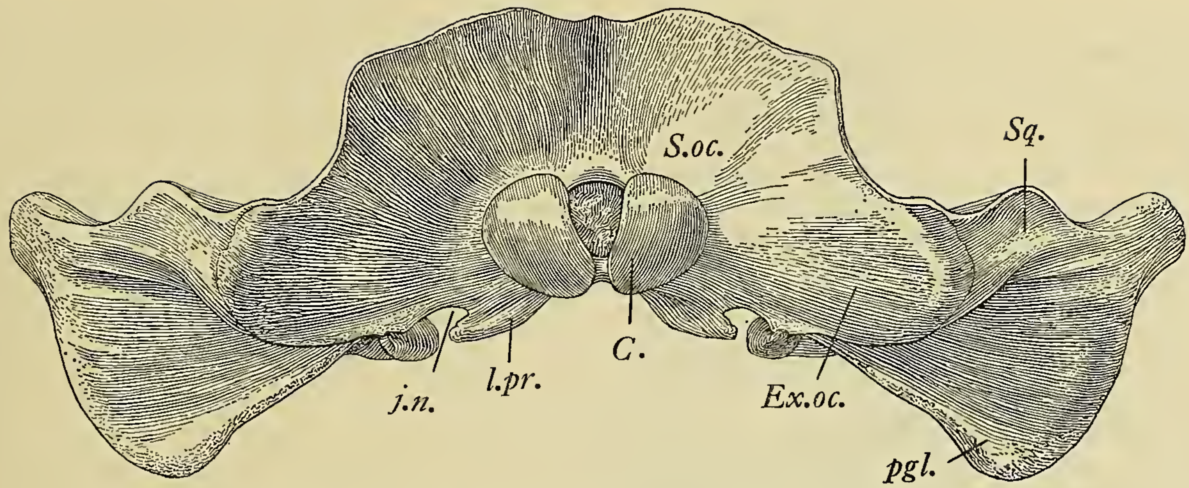


FIGURE 2.—Posterior view of skull, USNM 11976, of *Pelocetus calvertensis*. For abbreviations, see figure 1.

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.

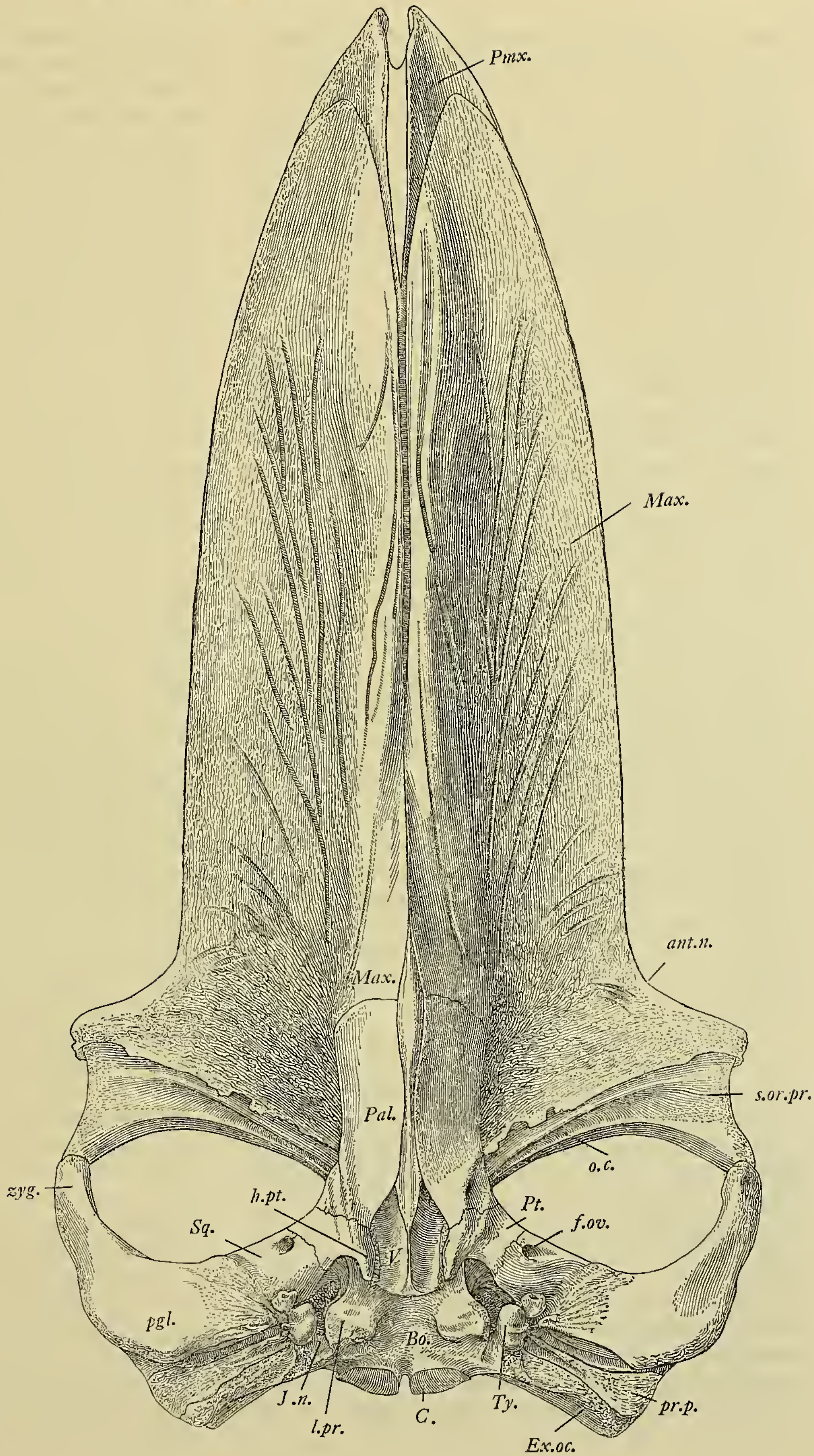
Commencing at a point 380 mm. in front of the anterior edge of the right palatine, the inner edges of the maxillaries are spread apart slightly, exposing the ventral keel of the vomer. At a point 480 mm. in front of the posterior edge of the horizontal vaginal plate, the vomer develops a wide, flattened 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.

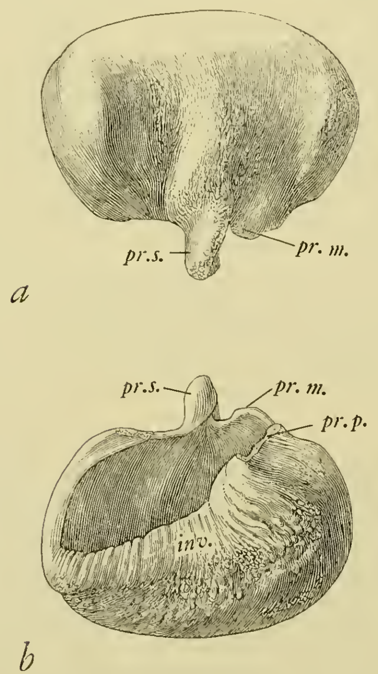


FIGURE 4.—Views of right tympanic bulla, USNM 11976, of *Pelocetus calvertensis: a*, external view; *b*, dorsal view. Abbrs.: inv., involucrum; pr.m., processus medius or conical apophysis; pr.p., base of pedicle of posterior process; pr.s., sigmoid process.

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.

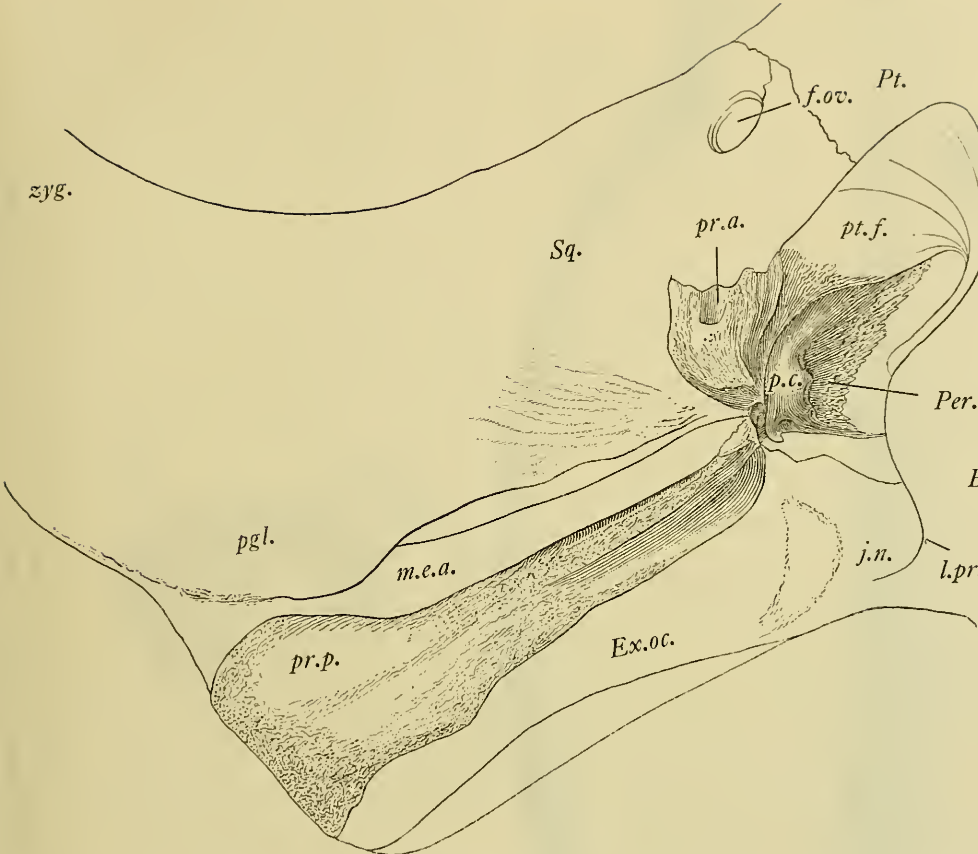


FIGURE 5.—Ventral view of right periotic, USNM 11976, of *Pelocetus calvertensis*. Abbrs.: Bo., basioccipital; Ex.oc., exoccipital; f.ov., foramen ovale; j.n., jugular notch or incisure; l.pr., lateral or descending process of basioccipital; m.c.a., channel for external auditory meatus; p.c., pars cochlearis; 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.

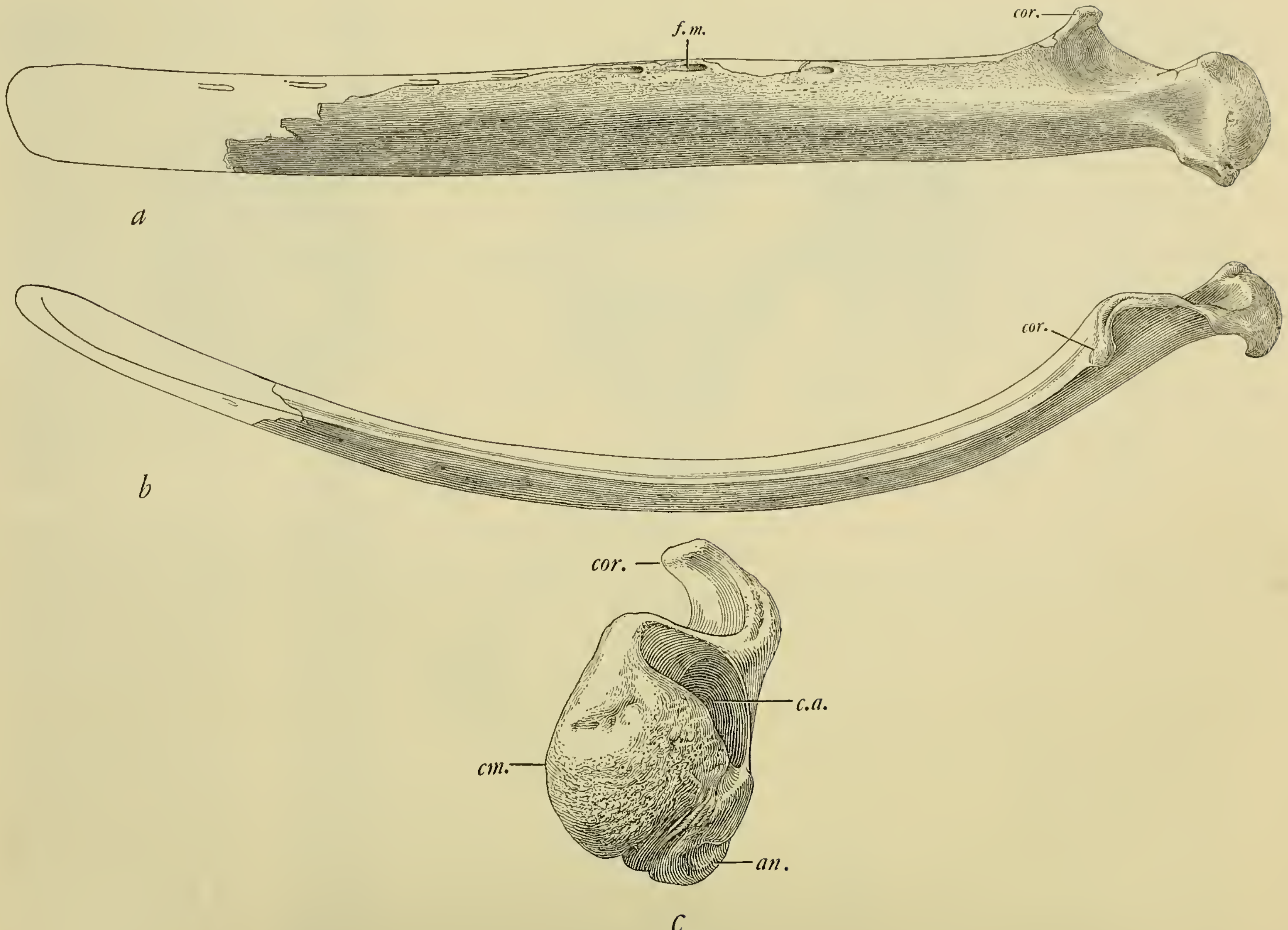


Figure 6.—Left mandible, USNM 11976, of *Pelocetus calvertensis:* *a*, external view; *b*, dorsal view; *c*, posterior view. Abbrs.: an., angle; c.a., alveolar or mandibular canal; cm., condyle of mandible; cor., coronoid process; f.m., mental foramen.

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-

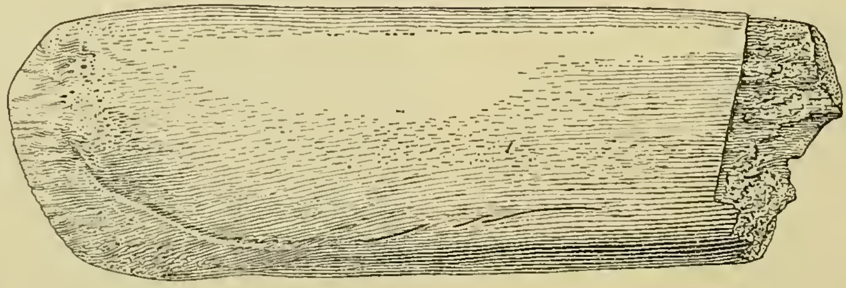


FIGURE 7.—Internal view of anterior end of right mandible, USNM 14693, of *Pelocetus calvertensis*.

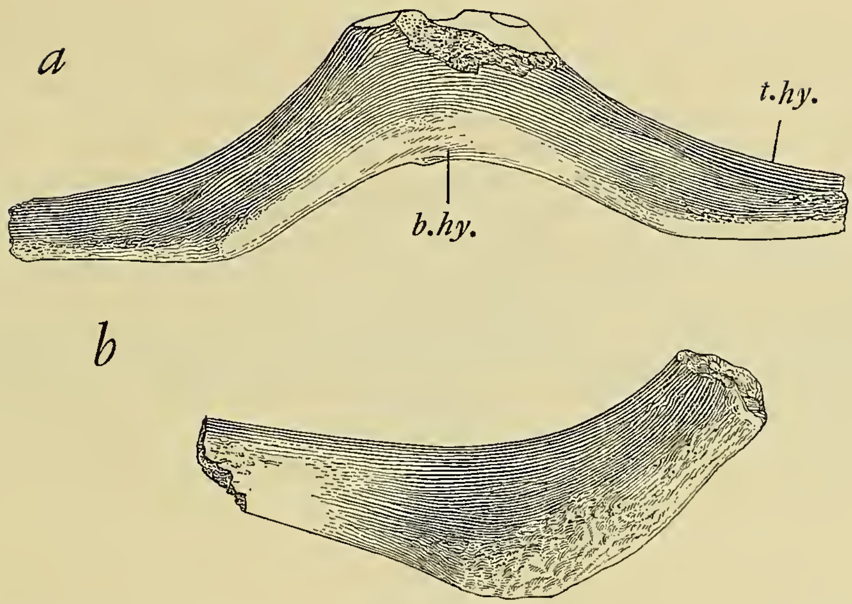


FIGURE 8.—Views of hyoid bones, USNM 11976, of *Pelocetus calvertensis: a*, dorsal view of basihyal and ankylosed thyrohyals; *b*, ventral view of right stylohyal. Abbrs.: b.hy., basihyal; t.hy., thyrohyals.

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

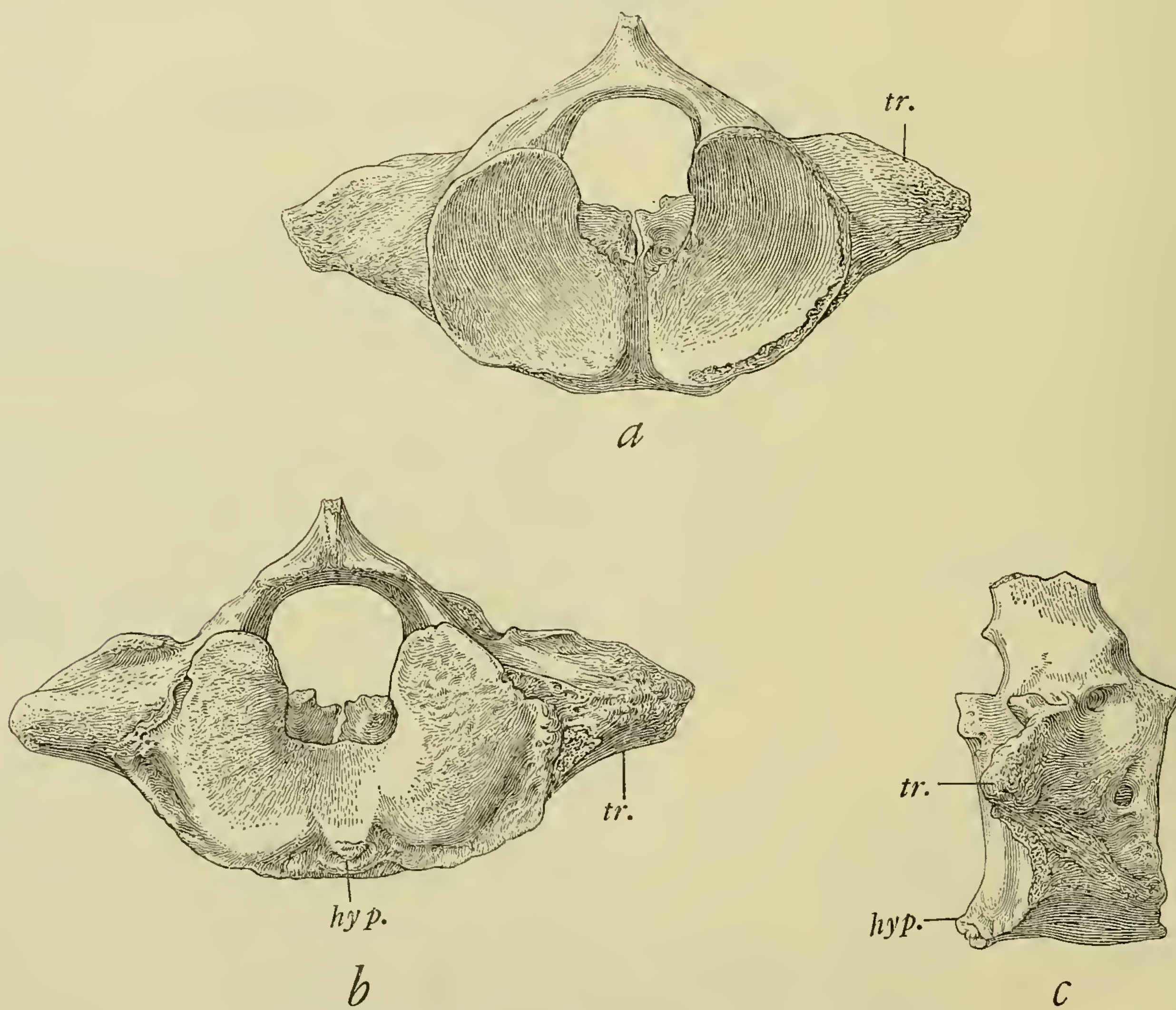


Figure 9.—Views of atlas, USNM 11976, of *Pelocetus calvertensis: a,* anterior view; *b,* posterior view; *c,* lateral view. Abbrs.: hyp., hyapophysial process; tr., transverse process.

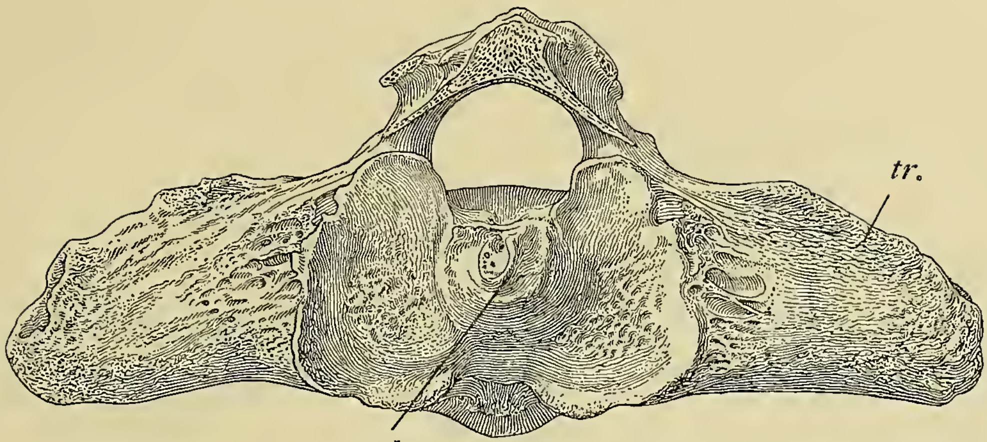


FIGURE 10.—Anterior view of axis, USNM 11976, of *Pelocetus calvertensis*. Abbrs.: od., odontoid process; tr., transverse process.

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.

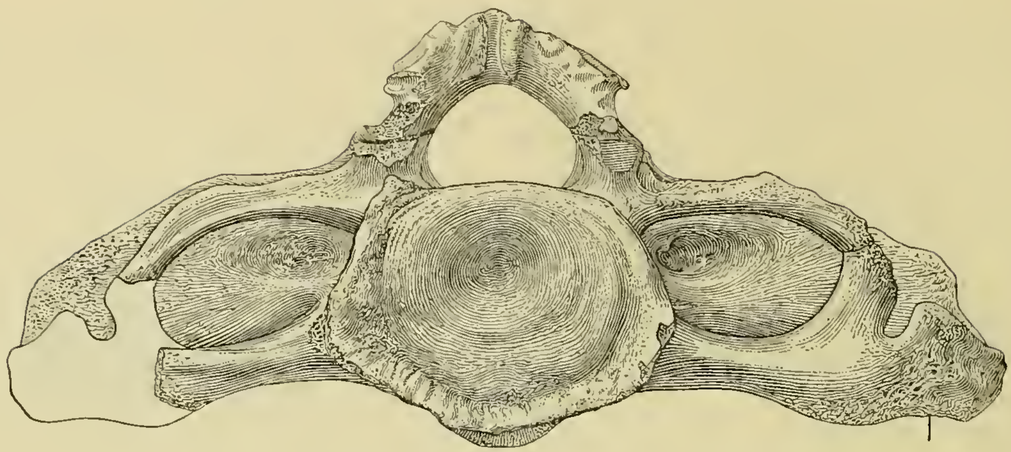


FIGURE 12.—Posterior view of third cervical and axis, USNM 11976, of *Pelocetus calvertensis*. Abbr.: tr., transverse process.

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 dorso-external surface of the centrum. A rugose and excavated

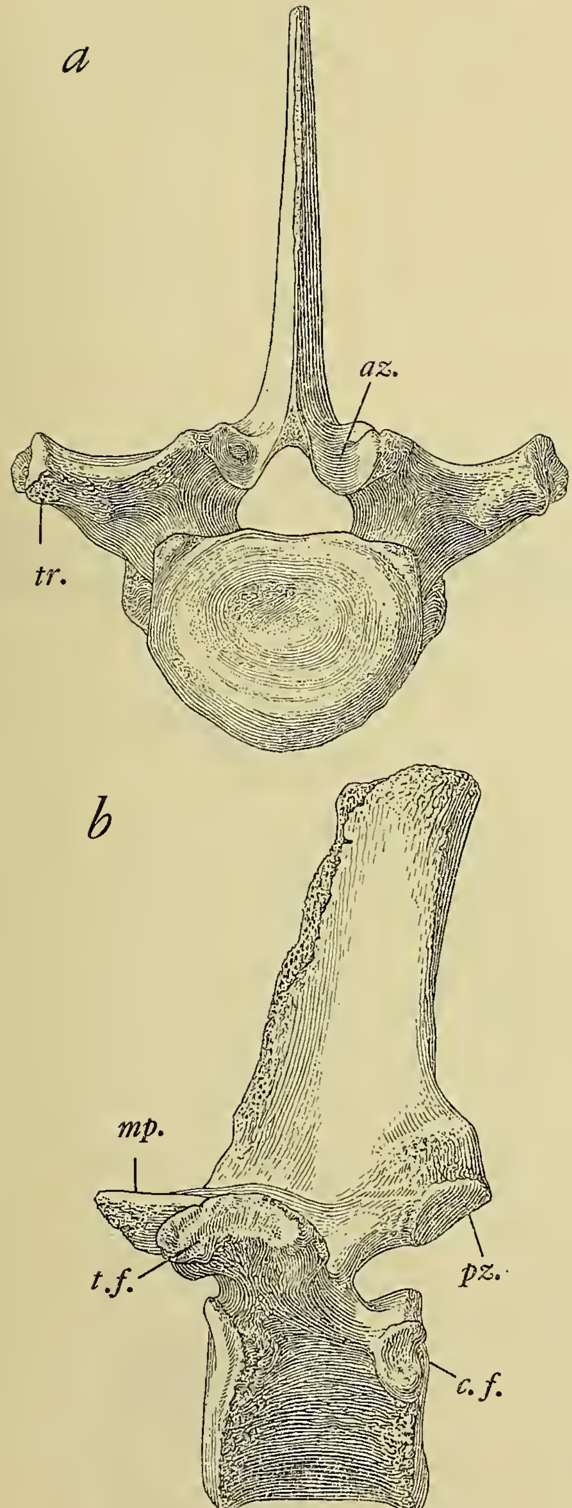


Figure 15.—Views of eighth dorsal, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: az., prezygapophysial facet; c.f., facet for capitulum; mp., metapophysis; pz., postzygapophysial facet; t.f., facet for tuberculum; tr., transverse process.

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.

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

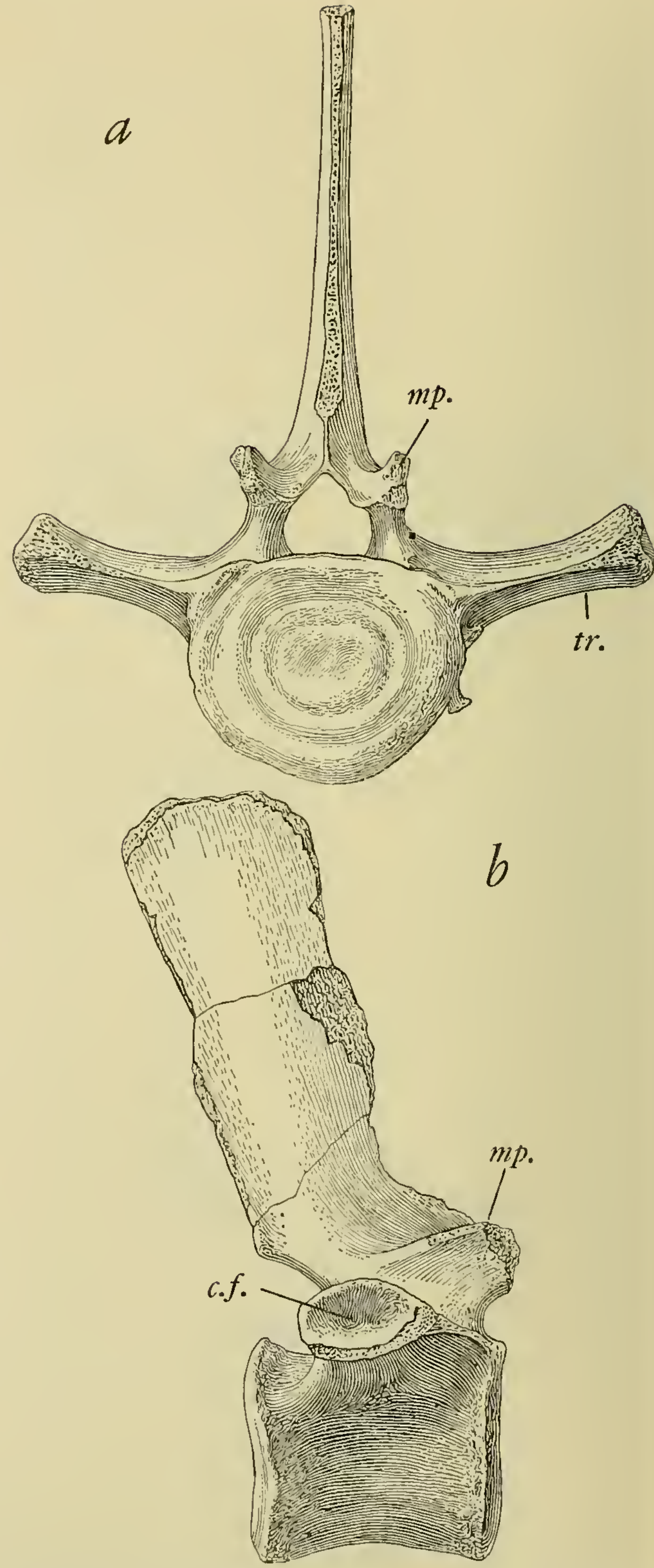


FIGURE 16.—Views of tenth dorsal, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: c.f., facet for capitulum; mp., metapophysis; tr., transverse process.

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

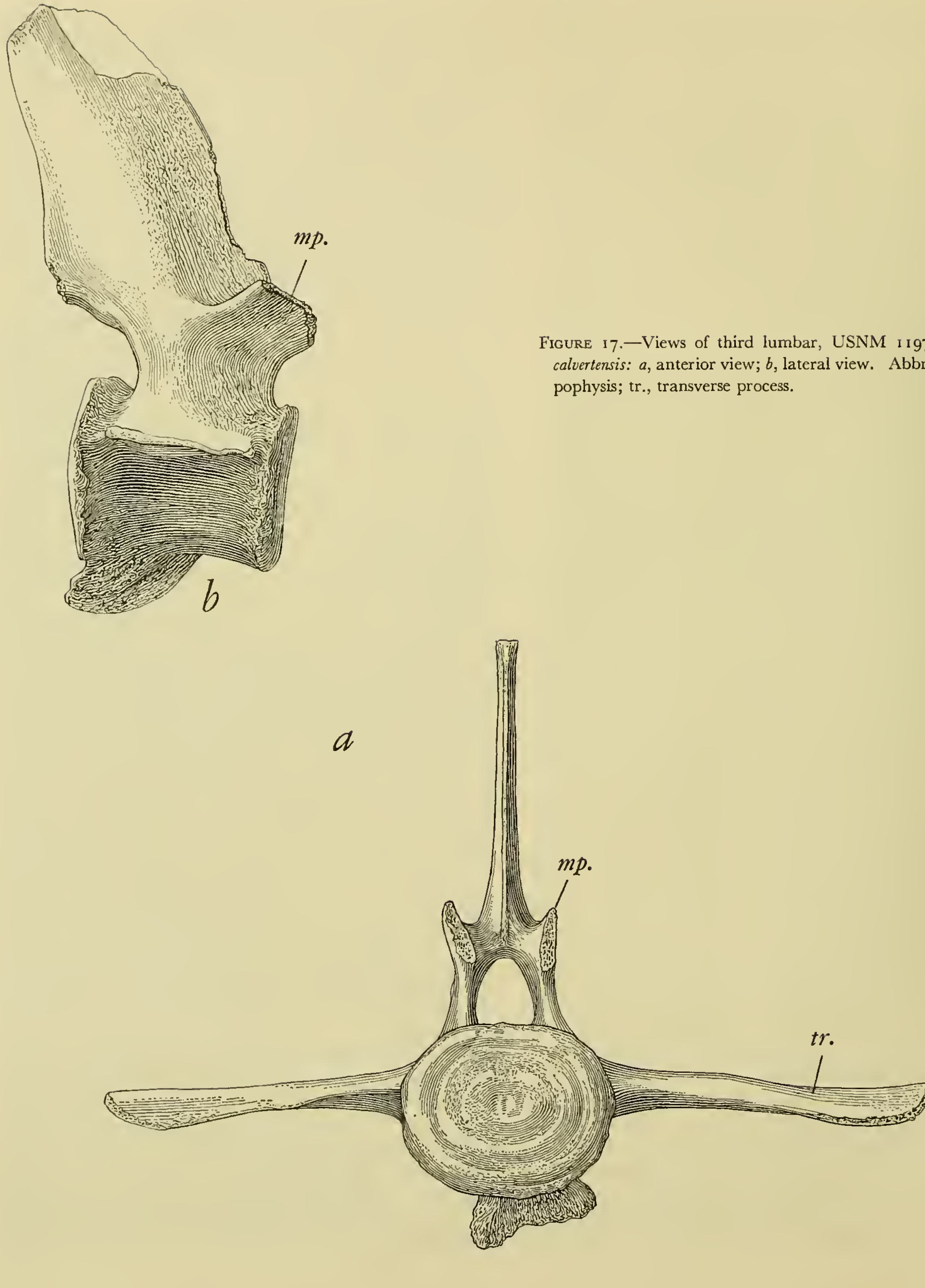


FIGURE 17.—Views of third lumbar, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

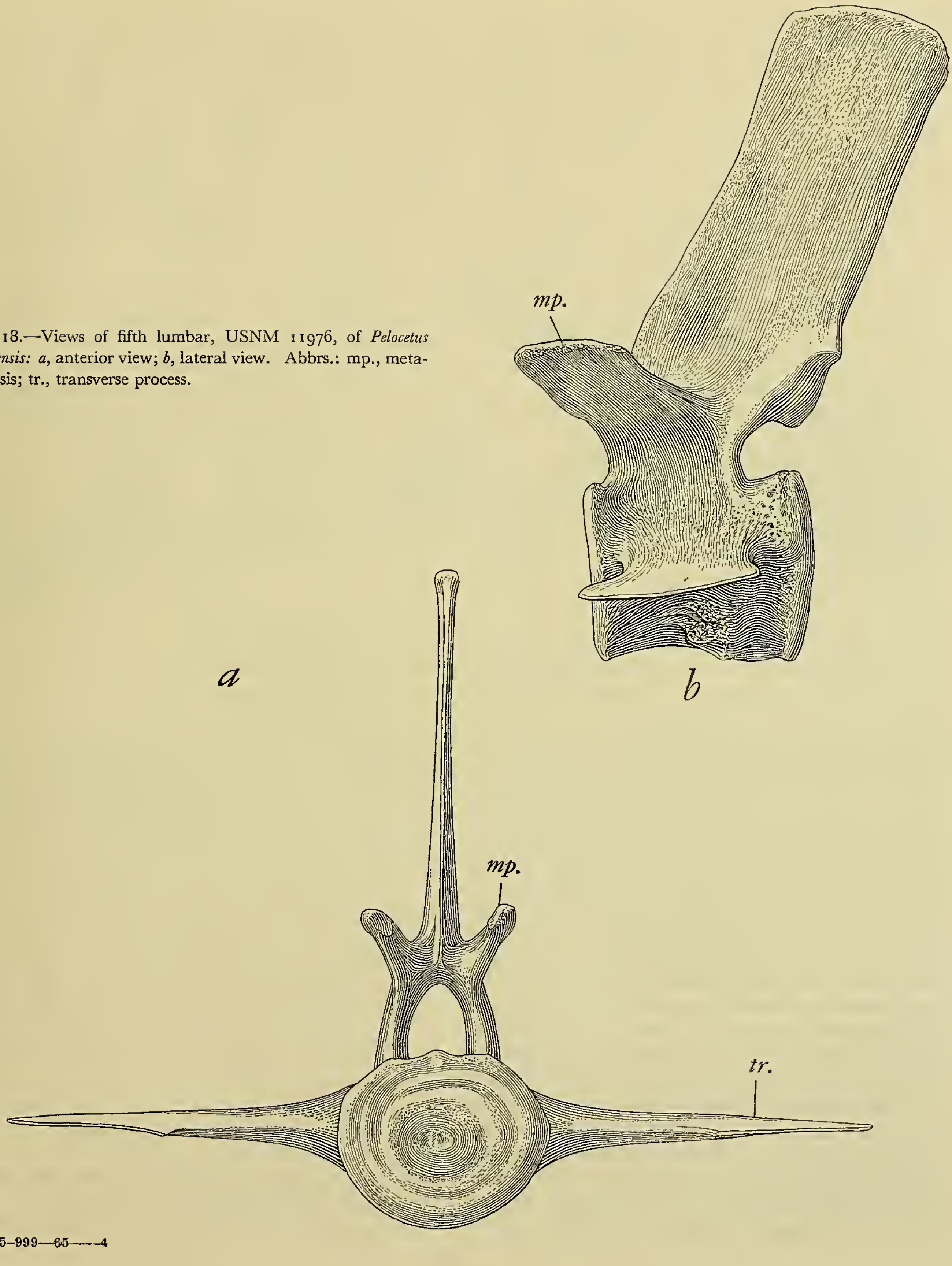


FIGURE 18.—Views of fifth lumbar, USNM 11976, of *Pelocetus calvertensis: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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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

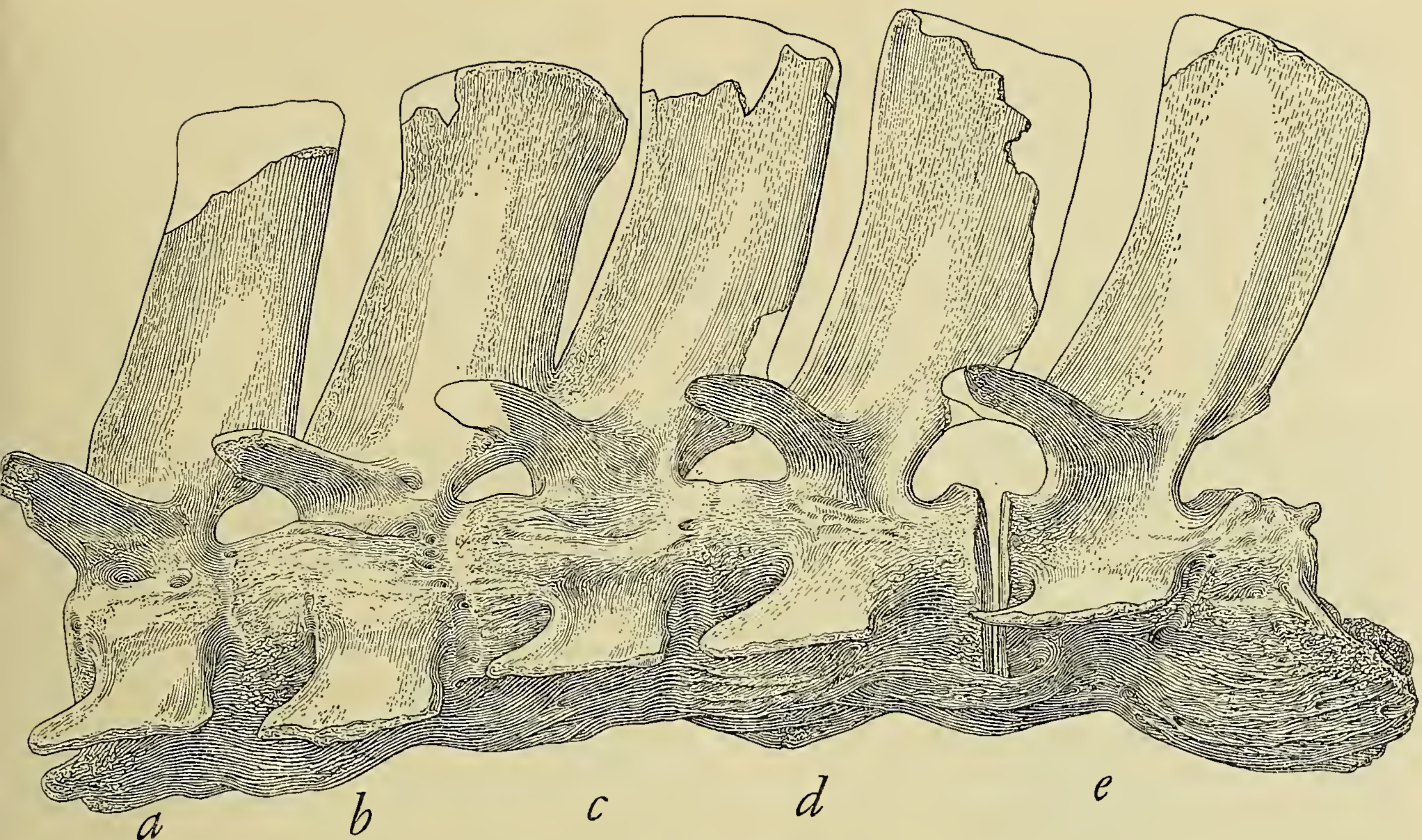

FIGURE 19.—Lateral views of ankylosed lumbar vertebrae, USNM 11976, of *Pelocetus calvertensis: a,* sixth lumbar; *b,* seventh lumbar; *c,* eighth lumbar; *d,* ninth lumbar; *e,* tenth lumbar.

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.

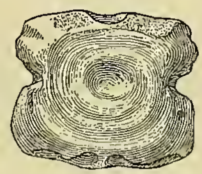

FIGURE 20.—Anterior view of posterior caudal, USNM 11976, of *Pelocetus calvertensis*.

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

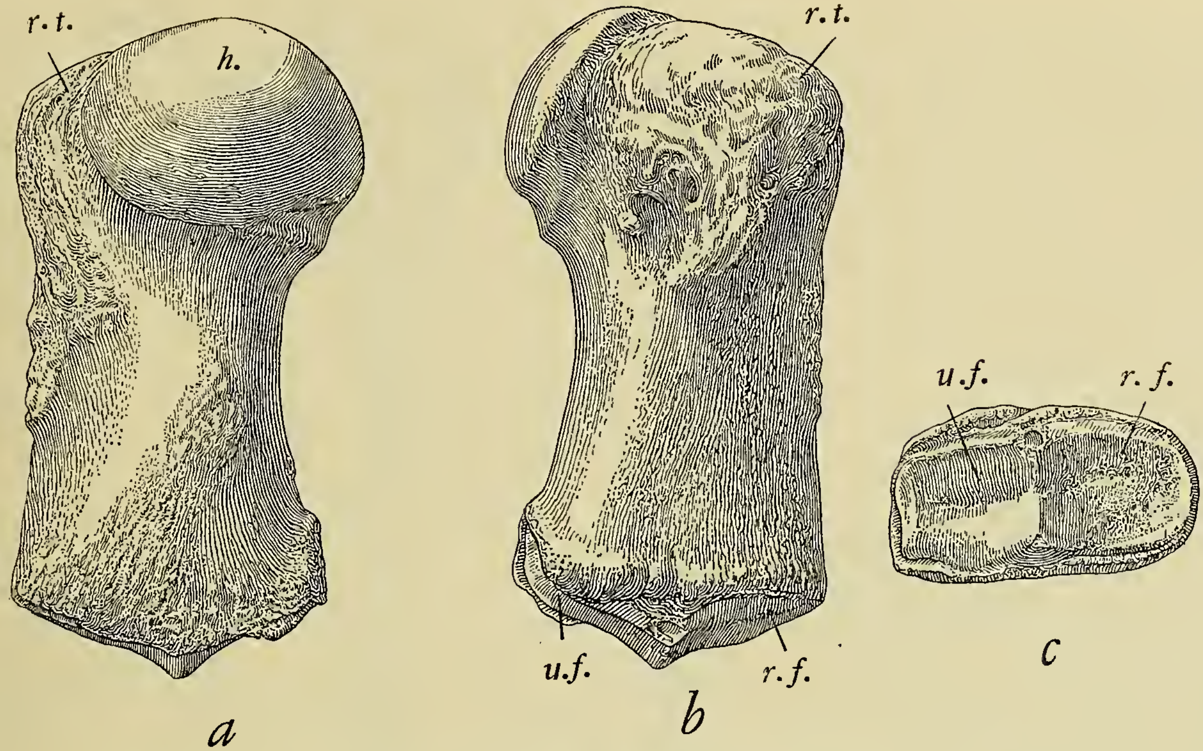

FIGURE 22.—View of left humerus, USNM 11976, of *Pelocetus calvertensis*: *a*, external view; *b*, internal view; *c*, view of distal end. Abbrs.: h., head; r.f., radial facet; r.t., radial tuberosity; u.f.; ulnar facet.

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,

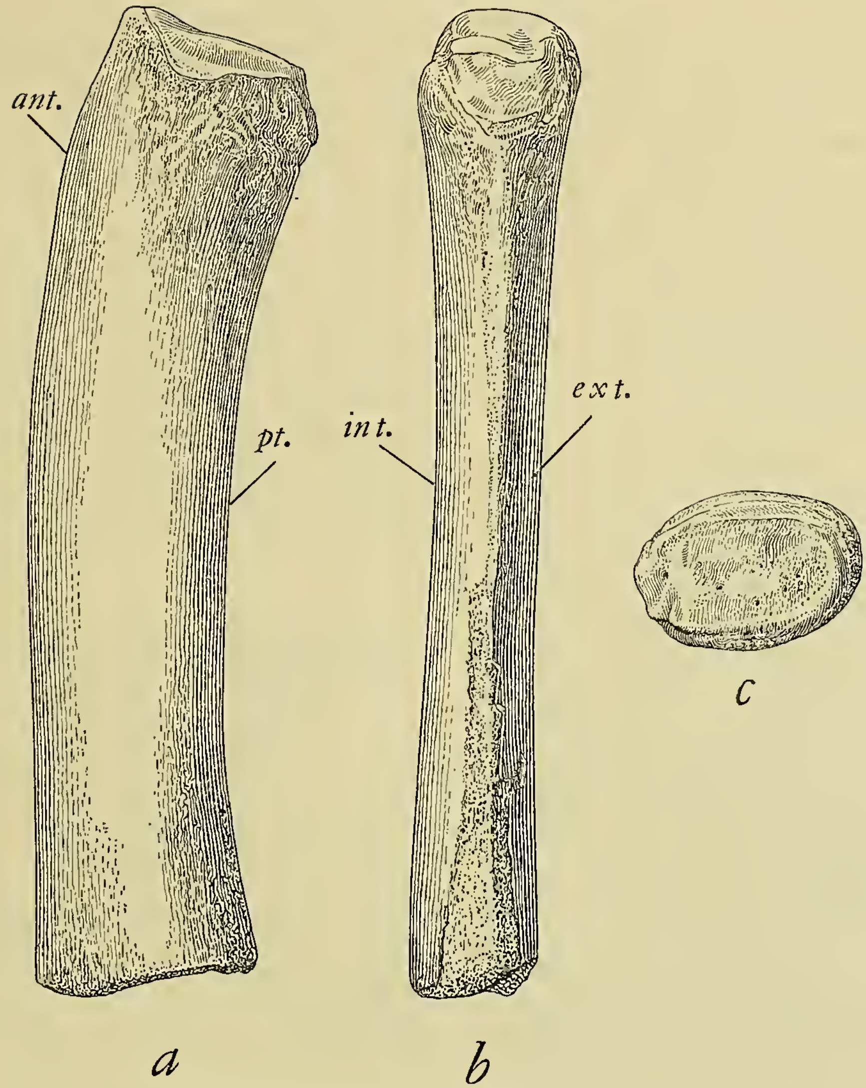

FIGURE 23.—Views of right radius, USNM 11976, of *Pelocetus calvertensis: a*, internal view; *b*, posterior view; *c*, view of distal end. Abbrs.: ant., anterior face; ext., external face; int., internal face; pt., posterior face.

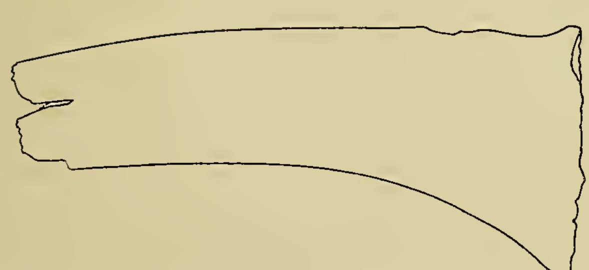

FIGURE 24.—External outline of right ulna, USNM 11976, of *Pelocetus calvertensis*.

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.

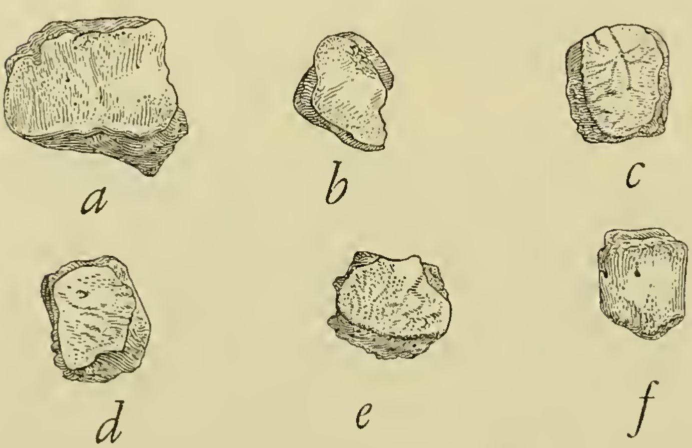

Figure 25.—View of carpal bones, USNM 11976, of *Pelocetus calvertensis: a*, radiale; *b*, pisiforme; *c*, intermedium; *d*, carpalia; *e*, ulnare; *f*, carpalia.

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.

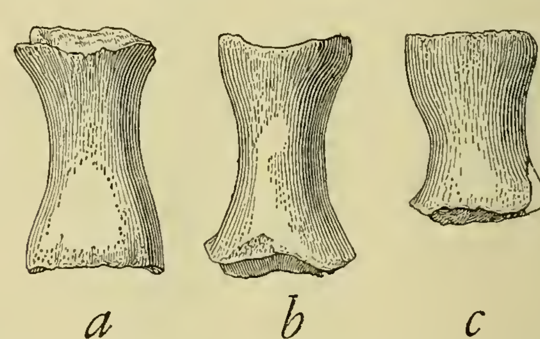

Figure 26.—Views of metacarpals, USNM 11976, of *Pelocetus calvertensis: a*, right metacarpal III; *b*, left metacarpal III; *c*, right metacarpal IV.

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

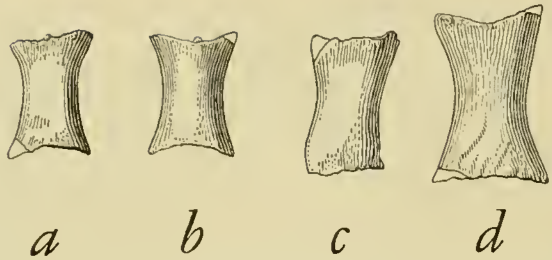

FIGURE 27.—Views of phalanges, USNM 11976, of *Pelocetus calvertensis: a* and *b*, small phalanges; *c*, medium size phalange; *d*, large phalange.

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.

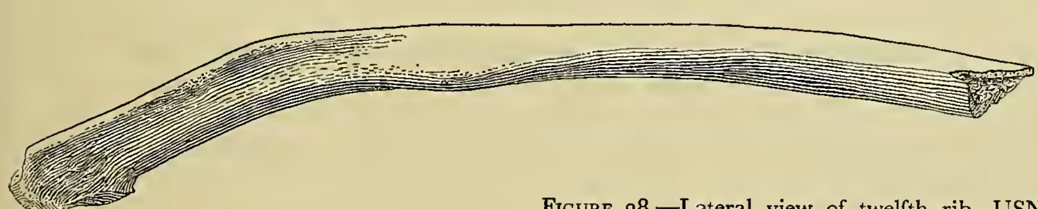

FIGURE 28.—Lateral view of twelfth rib, USNM 11976, of *Pelocetus calvertensis*.

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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; 1/4 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, 1/2 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, 3/4 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.

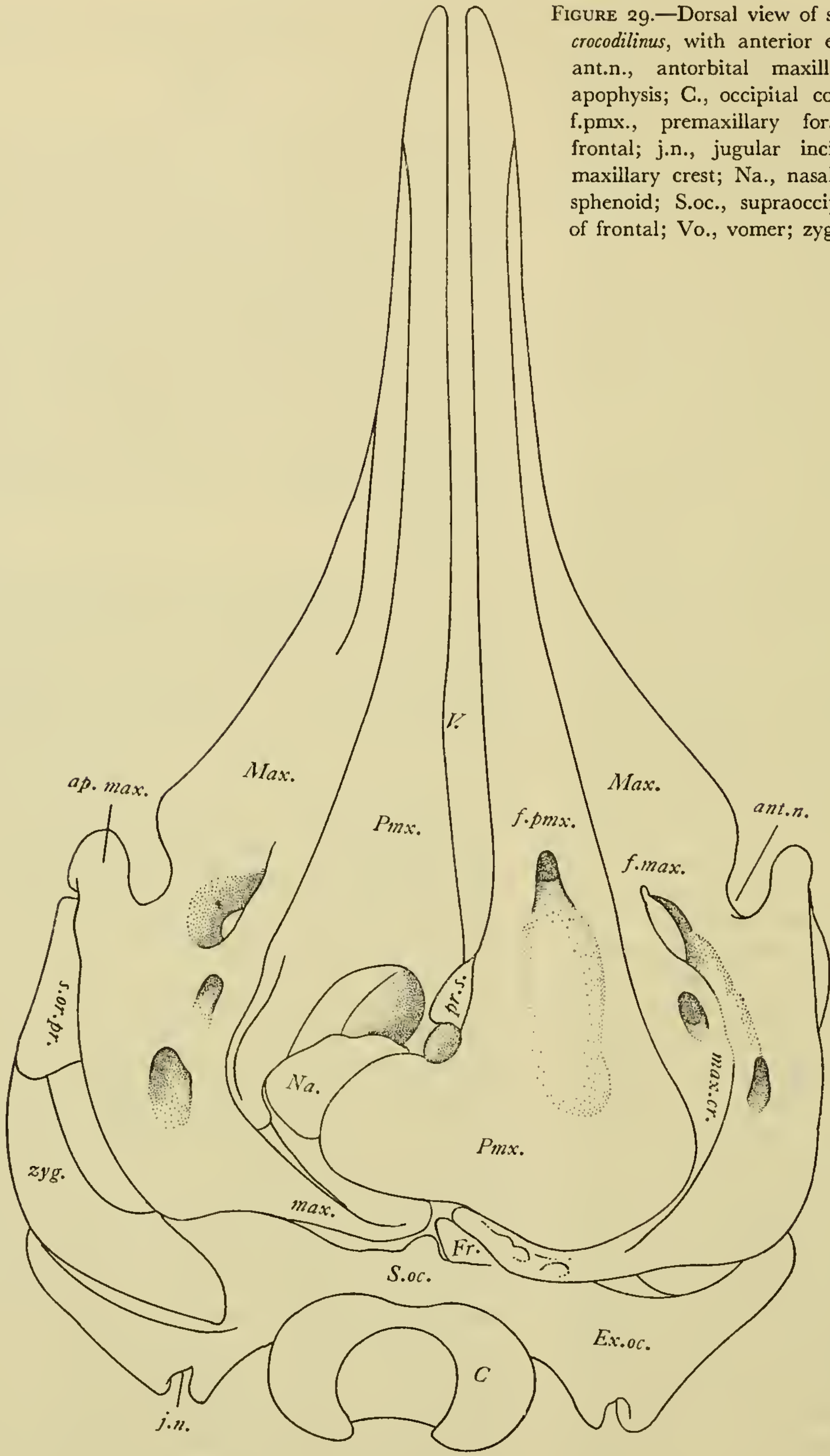

FIGURE 29.—Dorsal view of skull, USNM 22926, of *Orycterocetus crocodilinus*, with anterior end of rostrum restored. Abbrs.: ant.n., antorbital maxillary notch; ap.max., maxillary apophysis; C., occipital condyle; f.max., maxillary incisure; f.pmx., premaxillary foramen; Ex.oc., exoccipital; Fr., frontal; 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

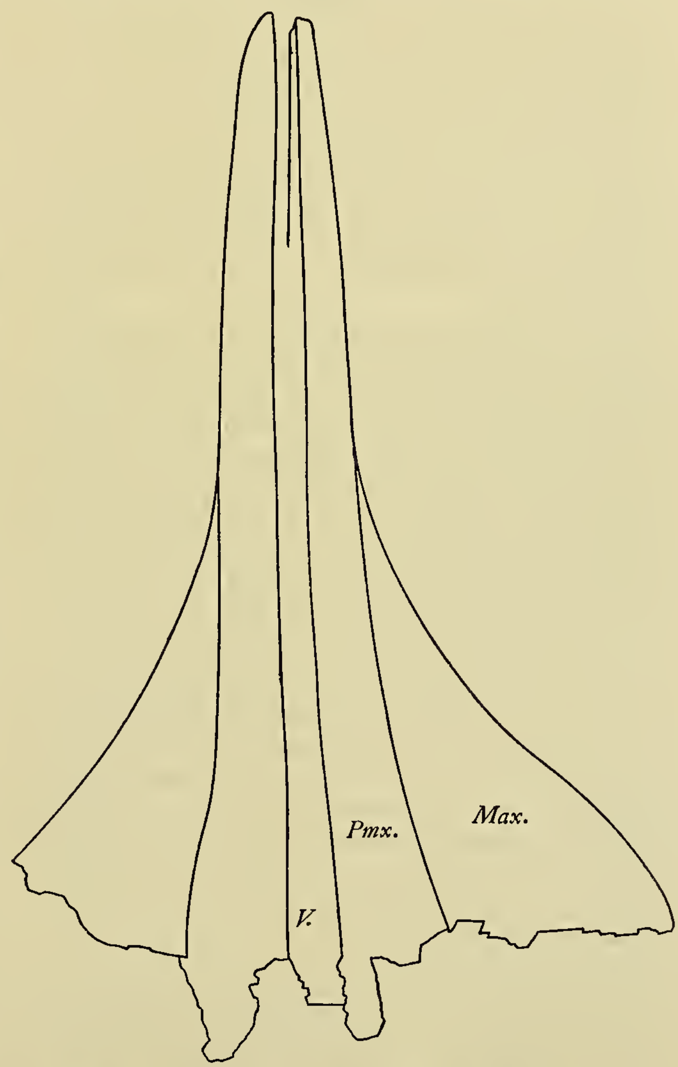

FIGURE 30.—Dorsal view of rostrum, USNM 22931, of *Orycterocetus crocodilinus*. Abbrs.: Max., maxillary; Pmx., premaxillary; Vo., vomer.

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,

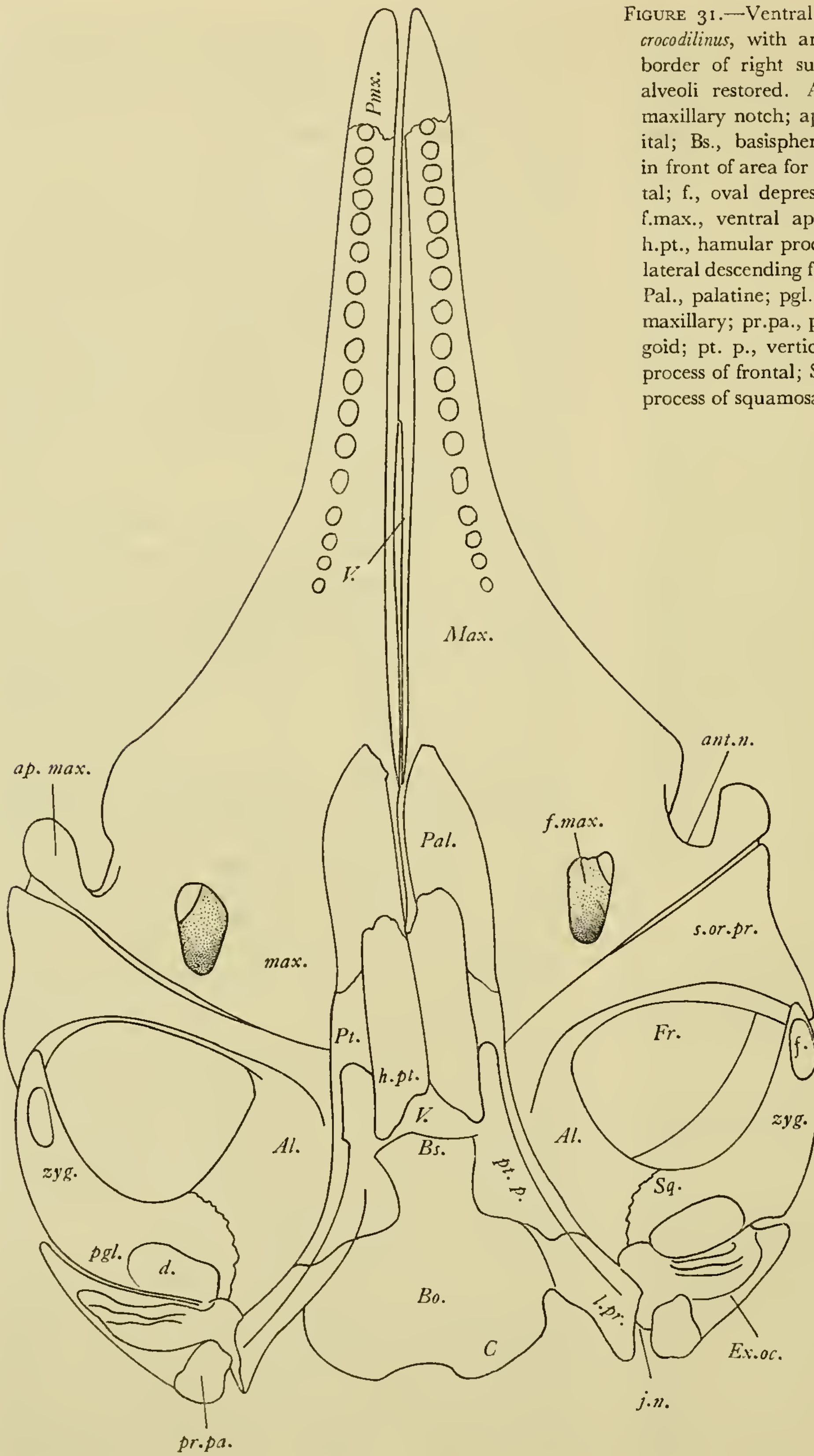

FIGURE 31.—Ventral view of skull, USNM 22926, of *Orycterocetus crocodilinus*, with anterior end of rostrum, incomplete orbital border of right supraorbital process, occipital condyles, and alveoli restored. Abbrs.: Al., alisphenoid; ant.n., antorbital maxillary notch; ap.max., maxillary apophysis; Bo., 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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Dorsal View of Skull, USNM 11976, Pelocetus calvertensis

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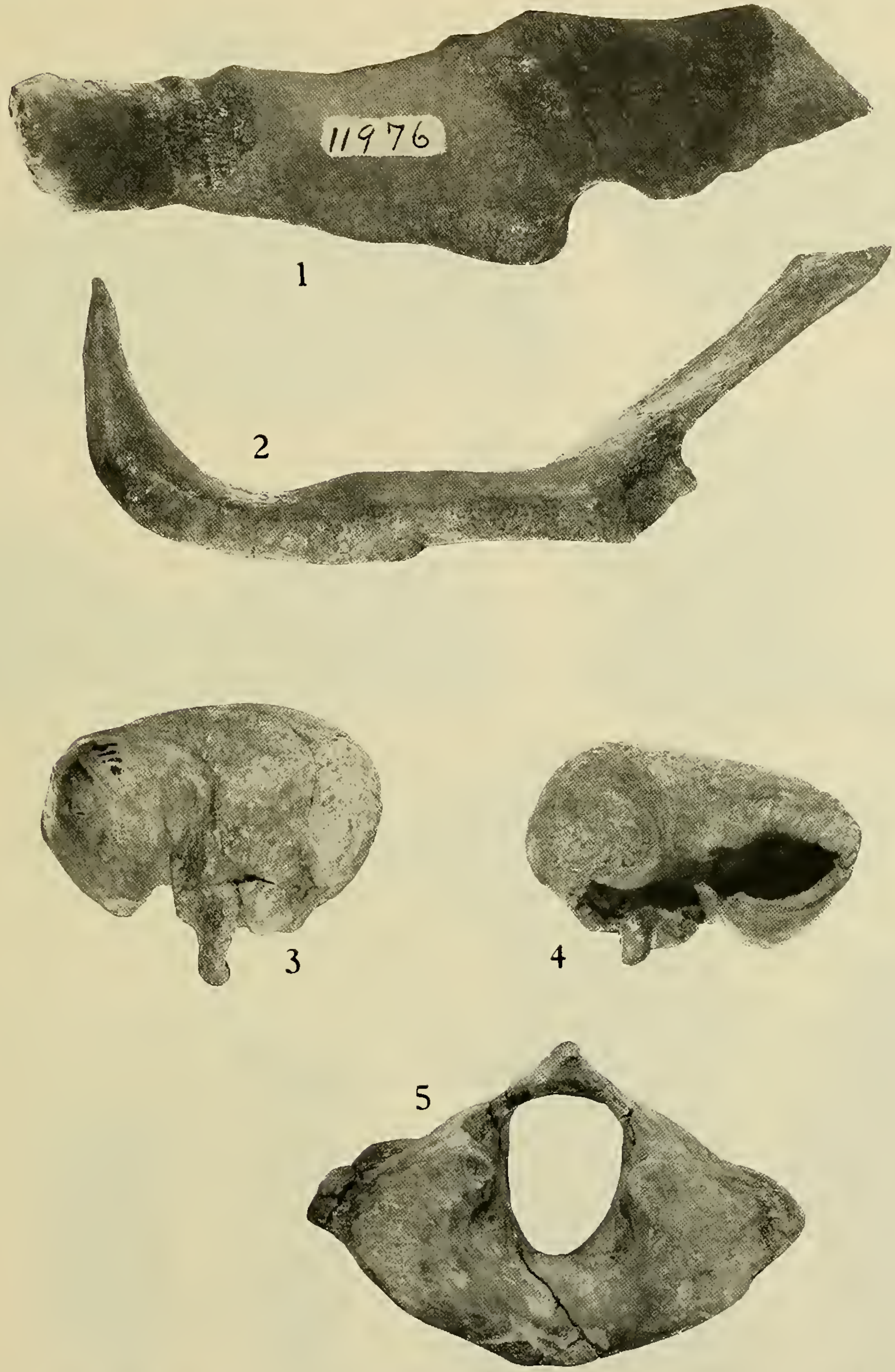
Ventral View of Skull, USNM 11976, Pelocetus calvertensis

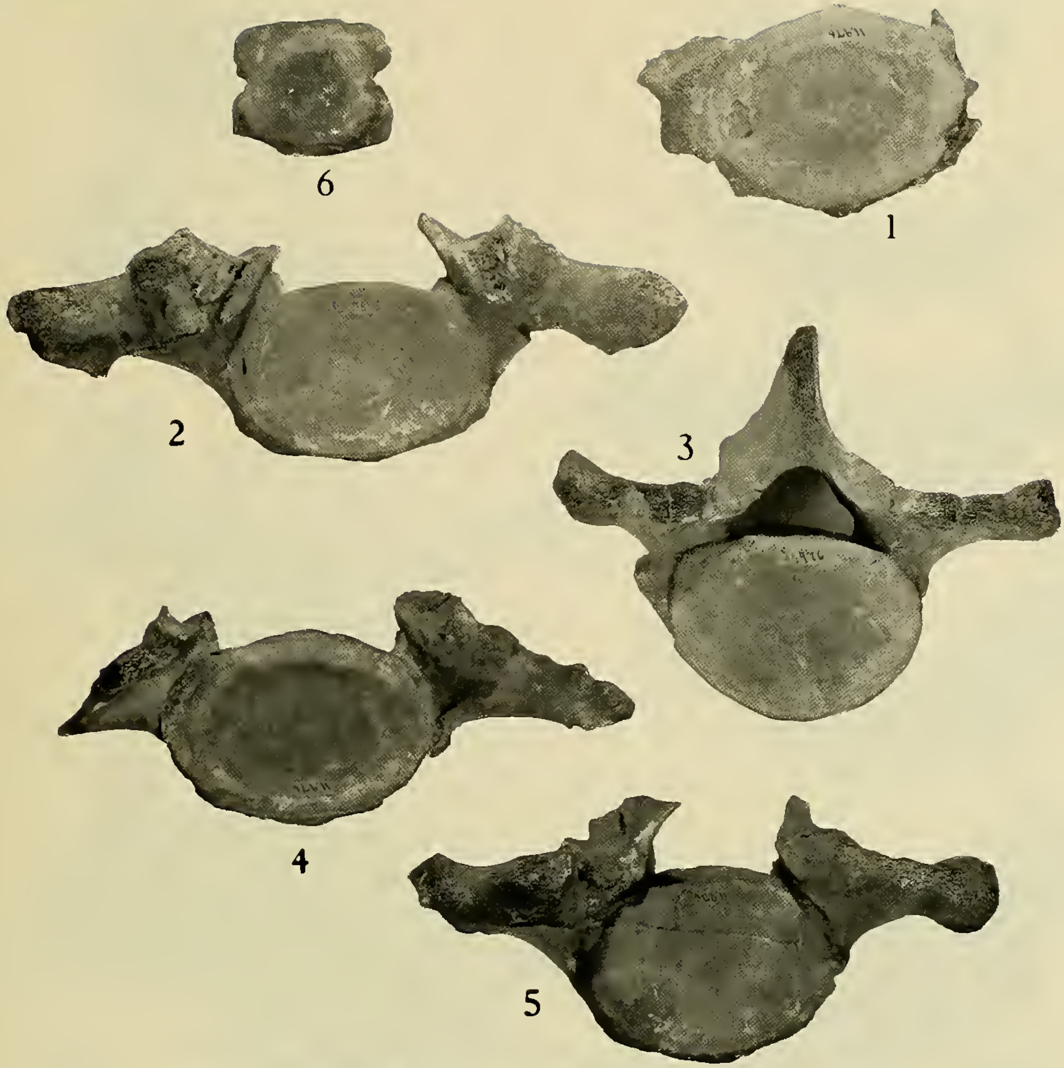


Left Jugal Bone and Right Tympanic Bulla, USNM 11976, *Pelocetus calvertensis*

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).

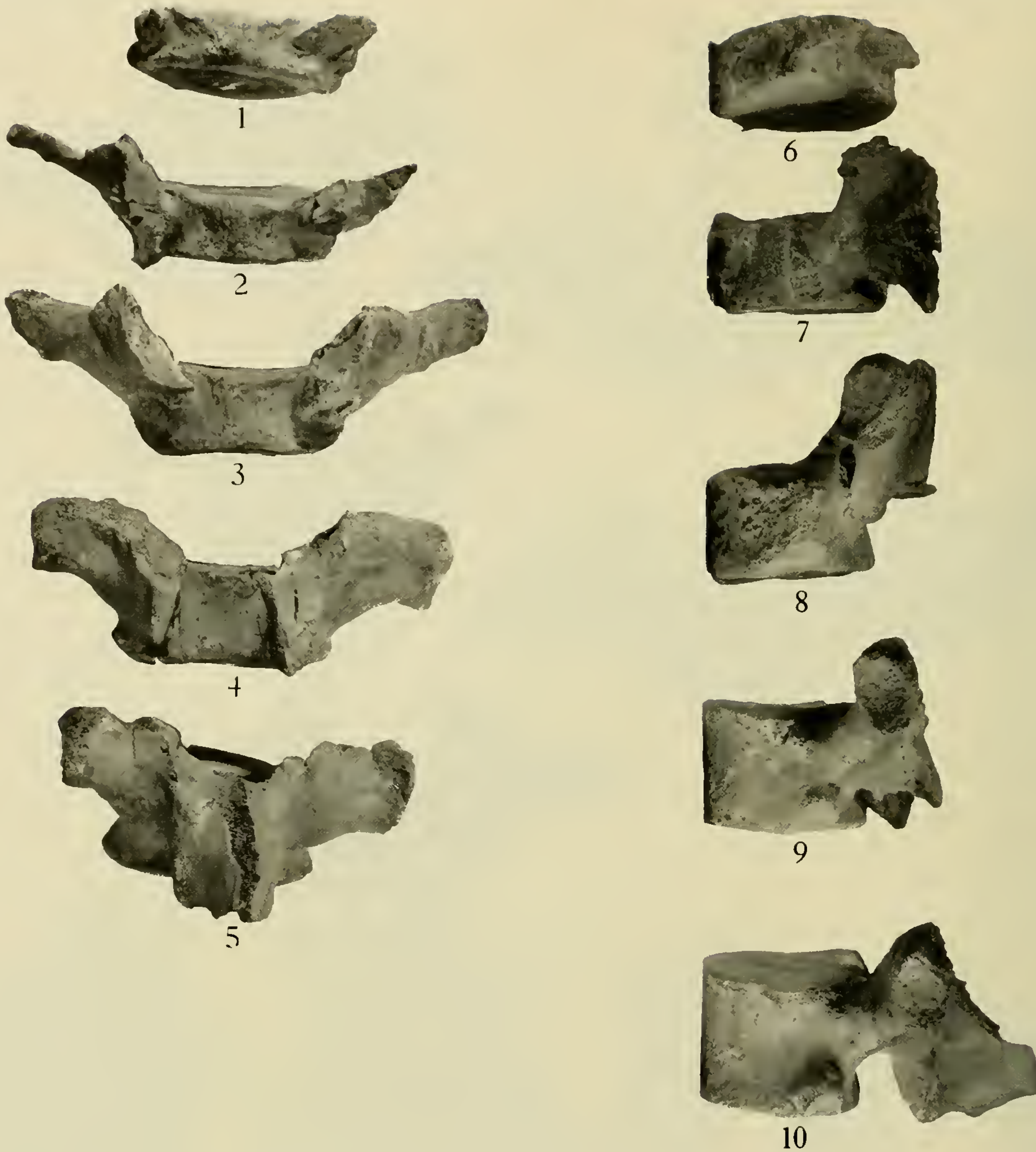
CERVICAL VERTEBRAE, USNM 11976, PELOCETUS CALVERTENSIS

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.



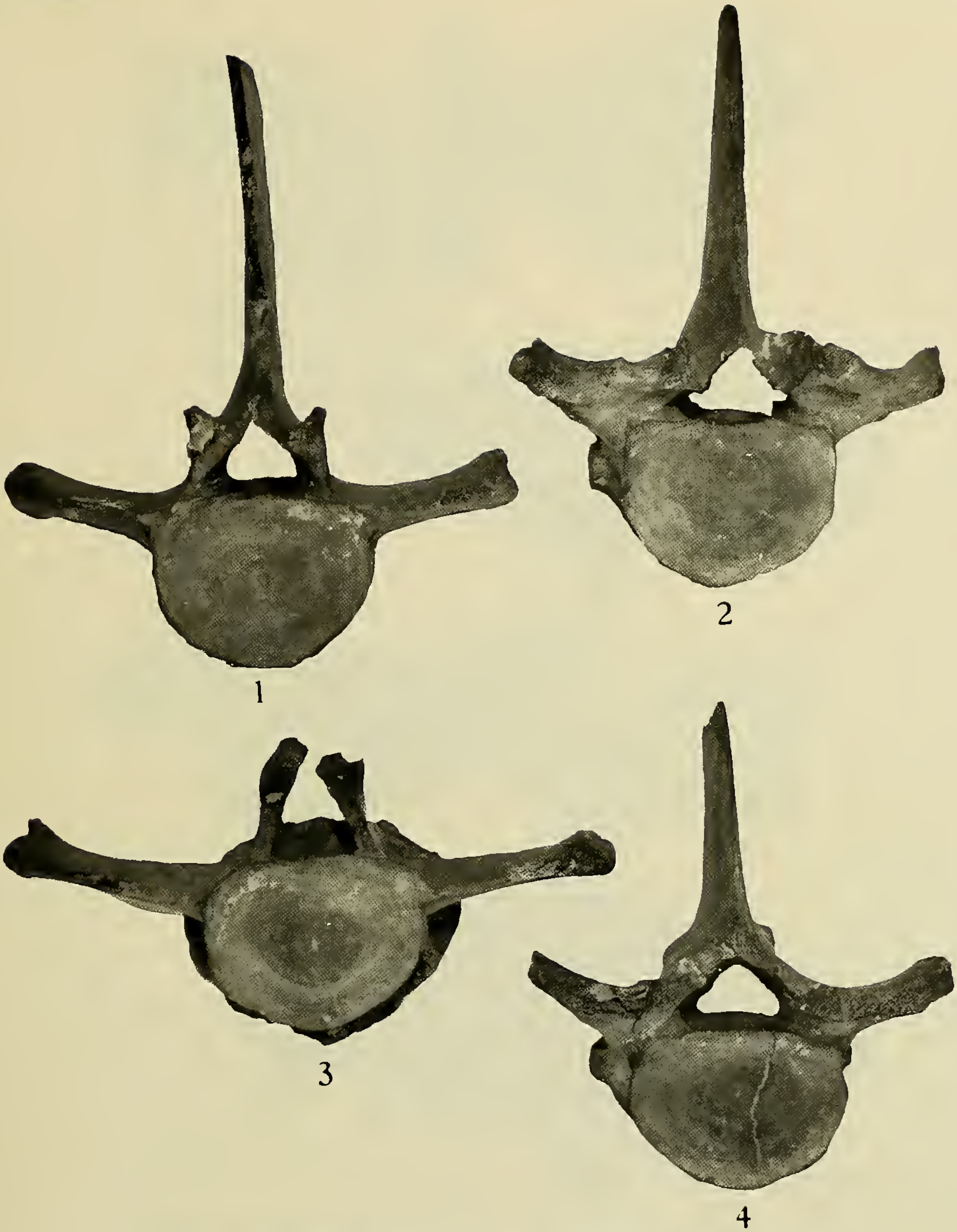
DORSAL VERTEBRAE, USNM 11976, PELOCETUS CALVERTENSIS

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.

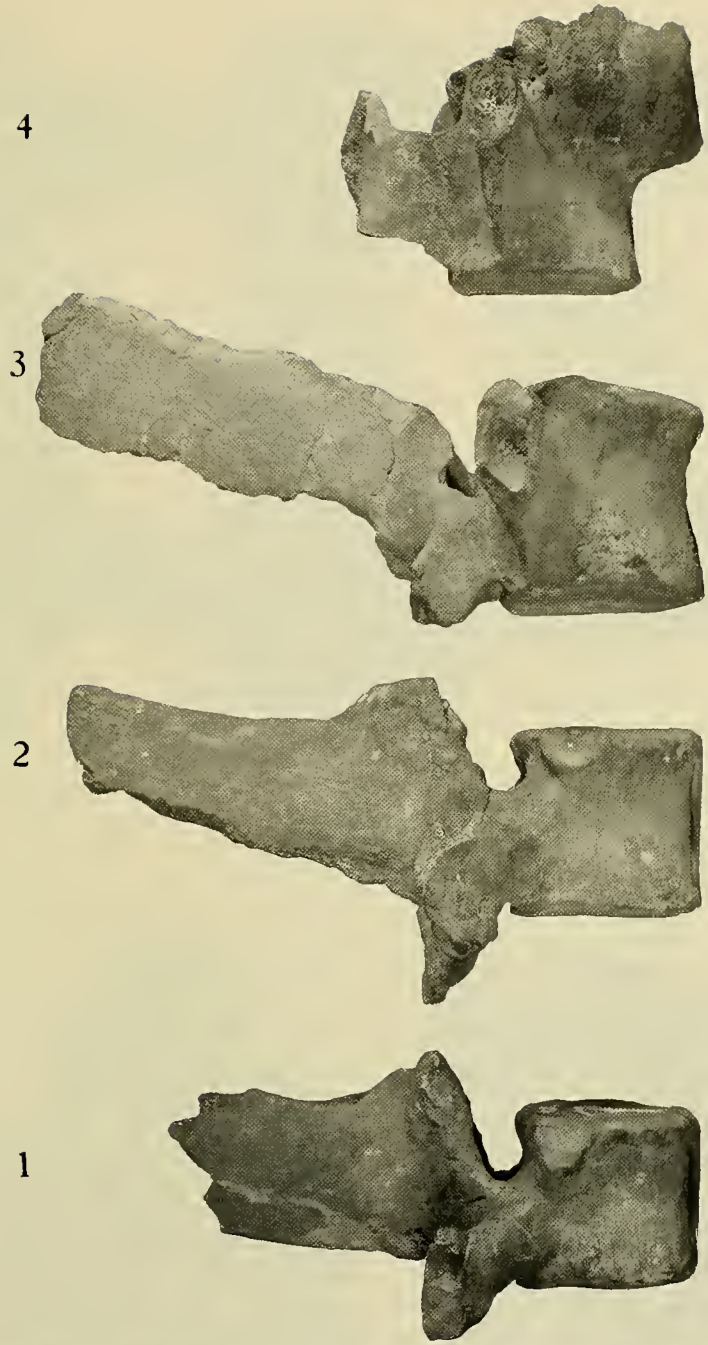


Dorsal Vertebrae, USNM 11976, Pelocetus calvertensis

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.

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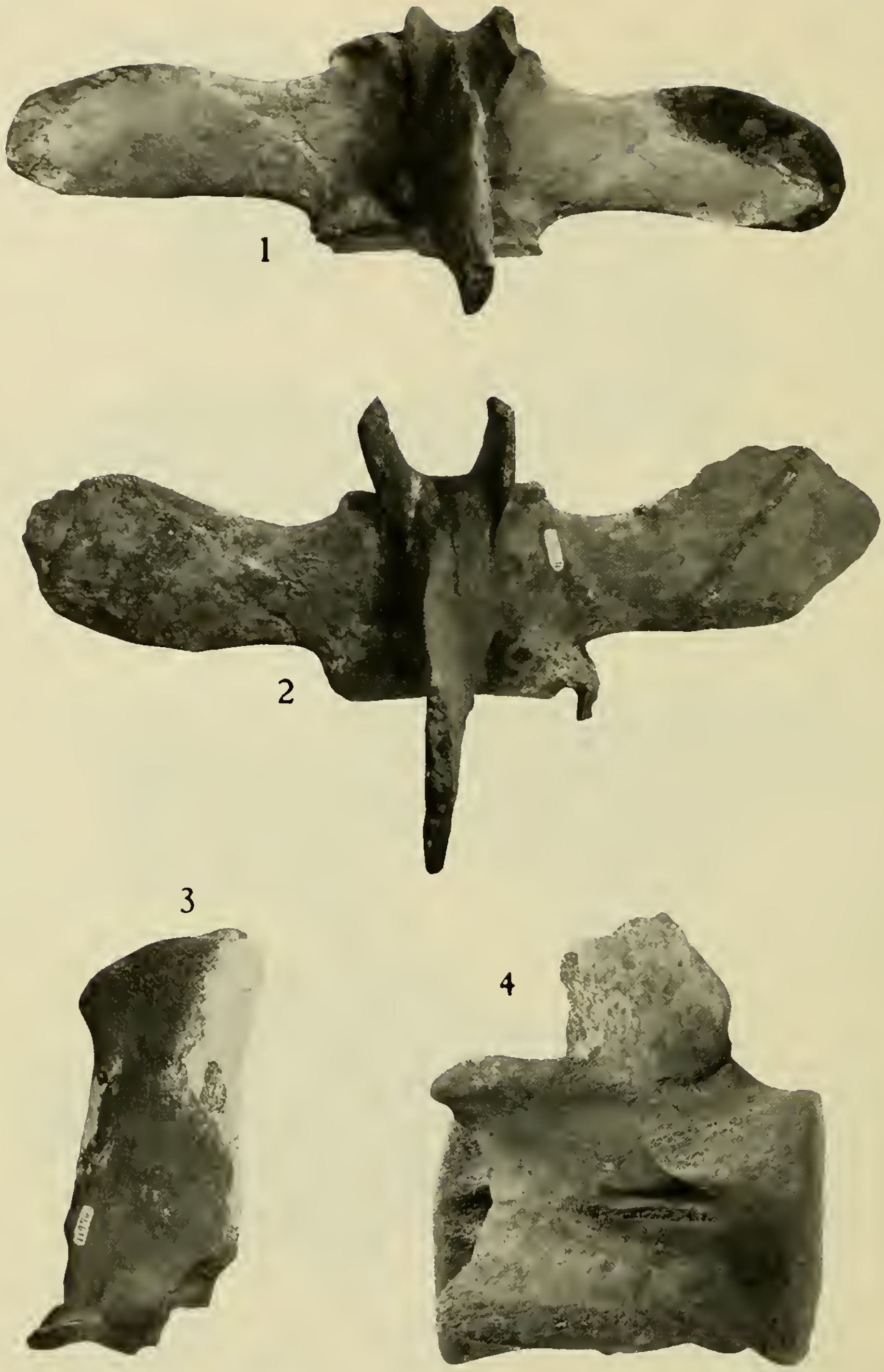
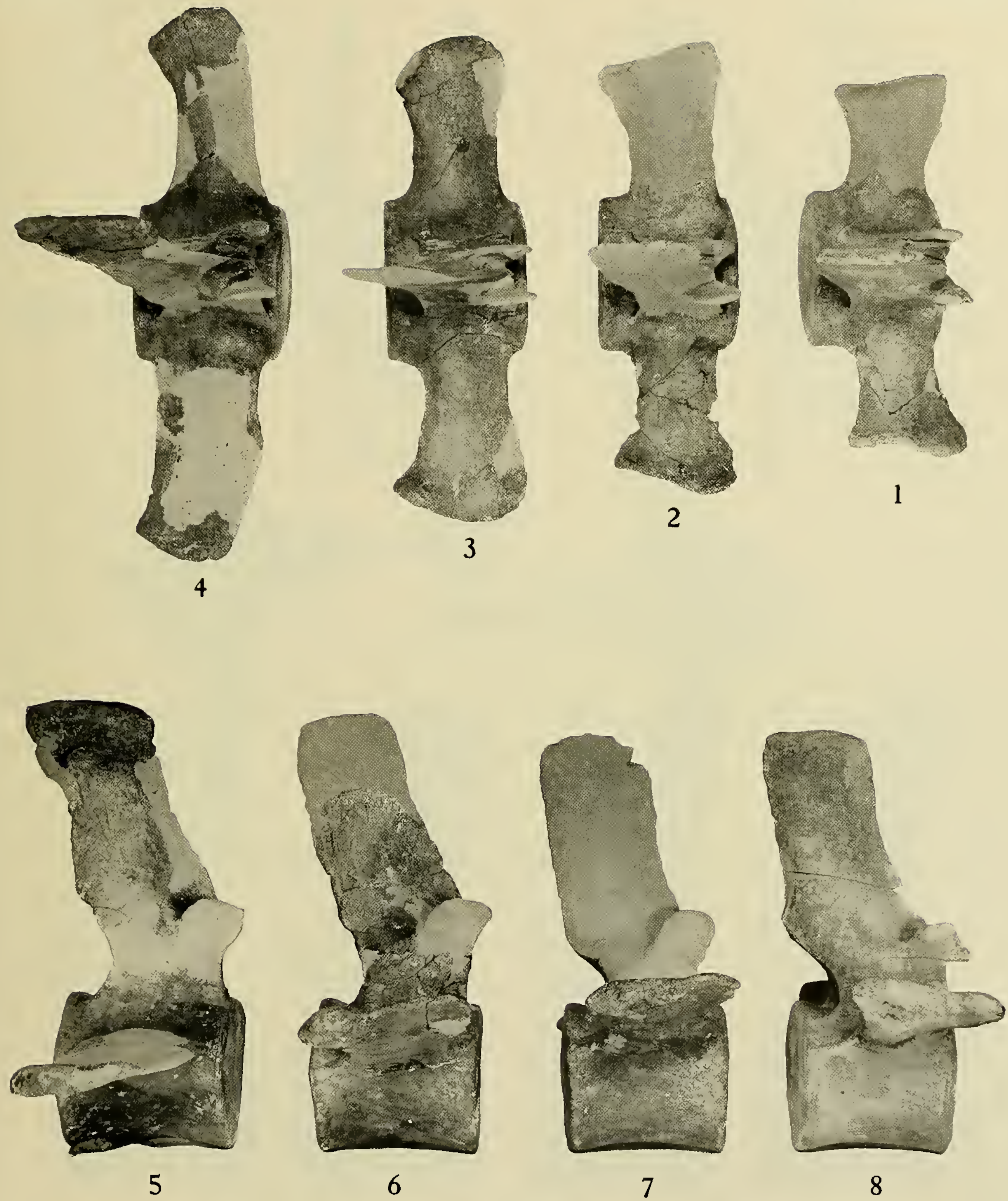


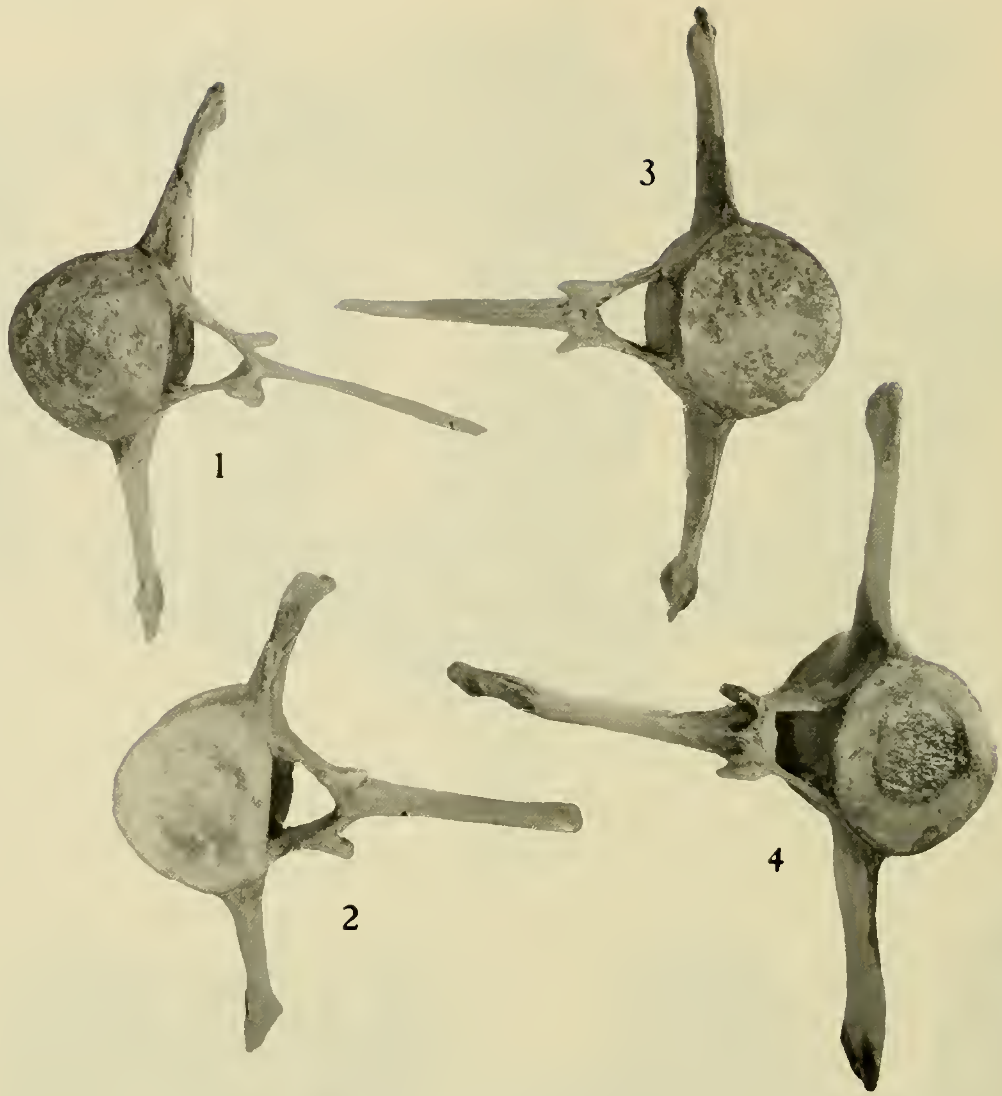
Lumbar Vertebrae, USNM 11976, *Pelocetus calvertensis*

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



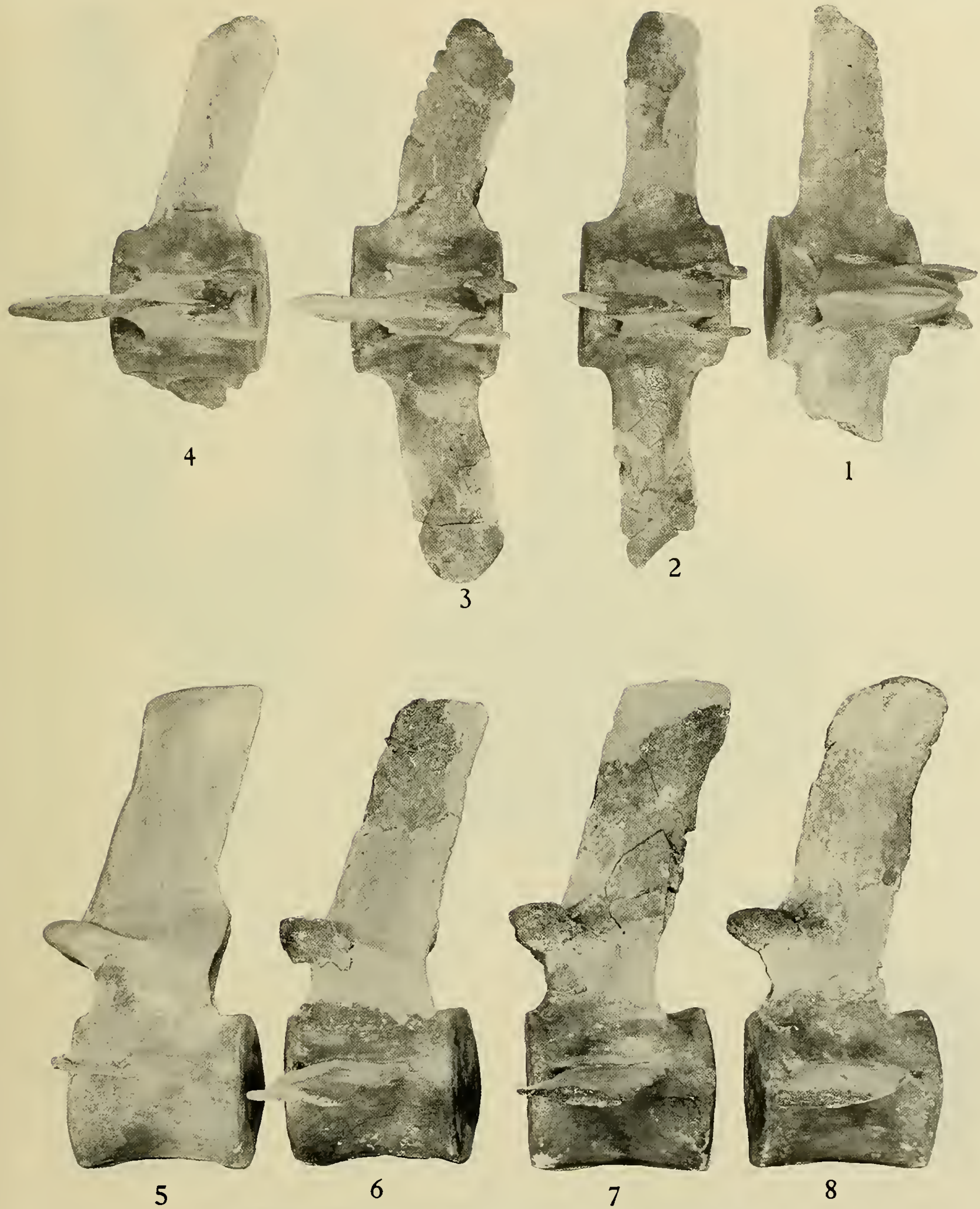
Dorsal Vertebrae, USNM 23058, Pelocetus calvertensis

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.

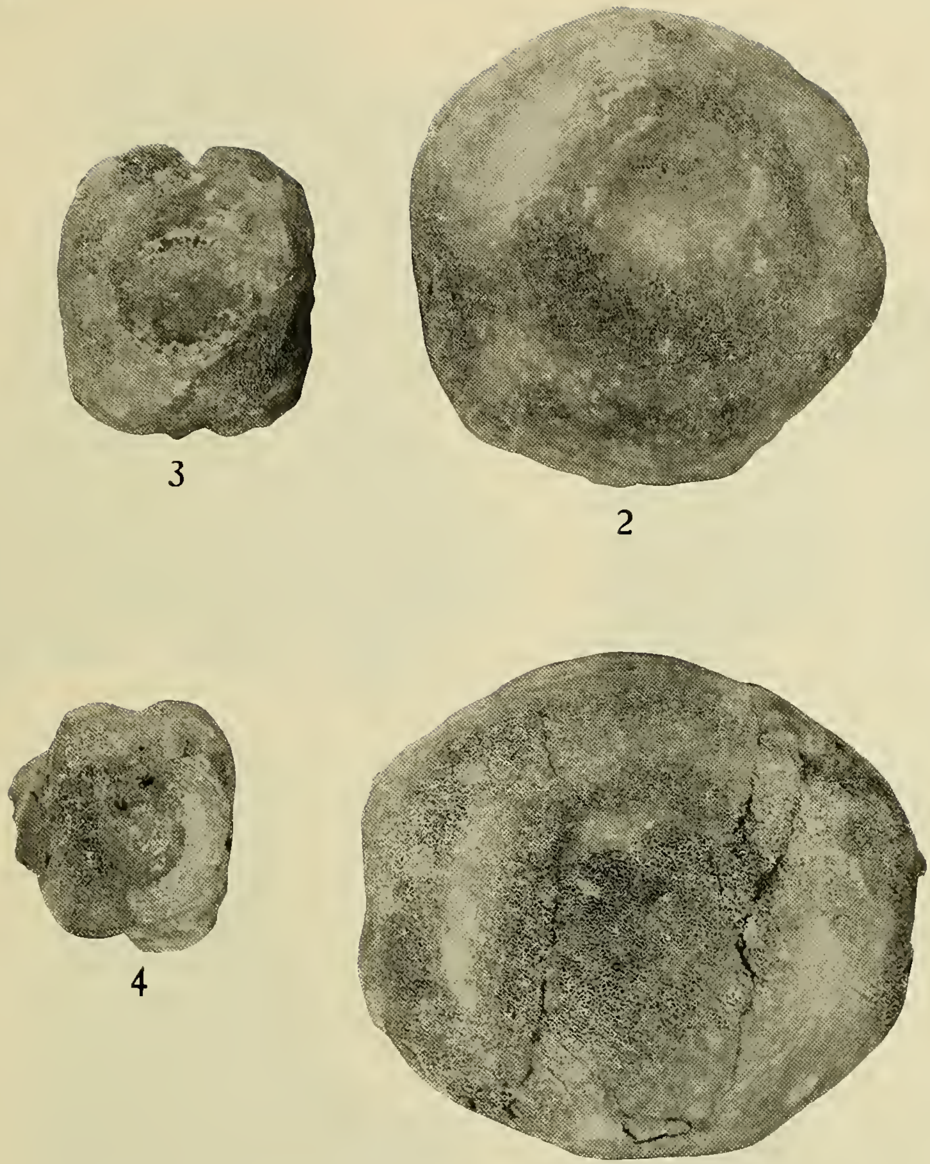


LUMBAR VERTEBRAE, USNM 23058, PELOCETUS CALVERTENSIS

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.

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).

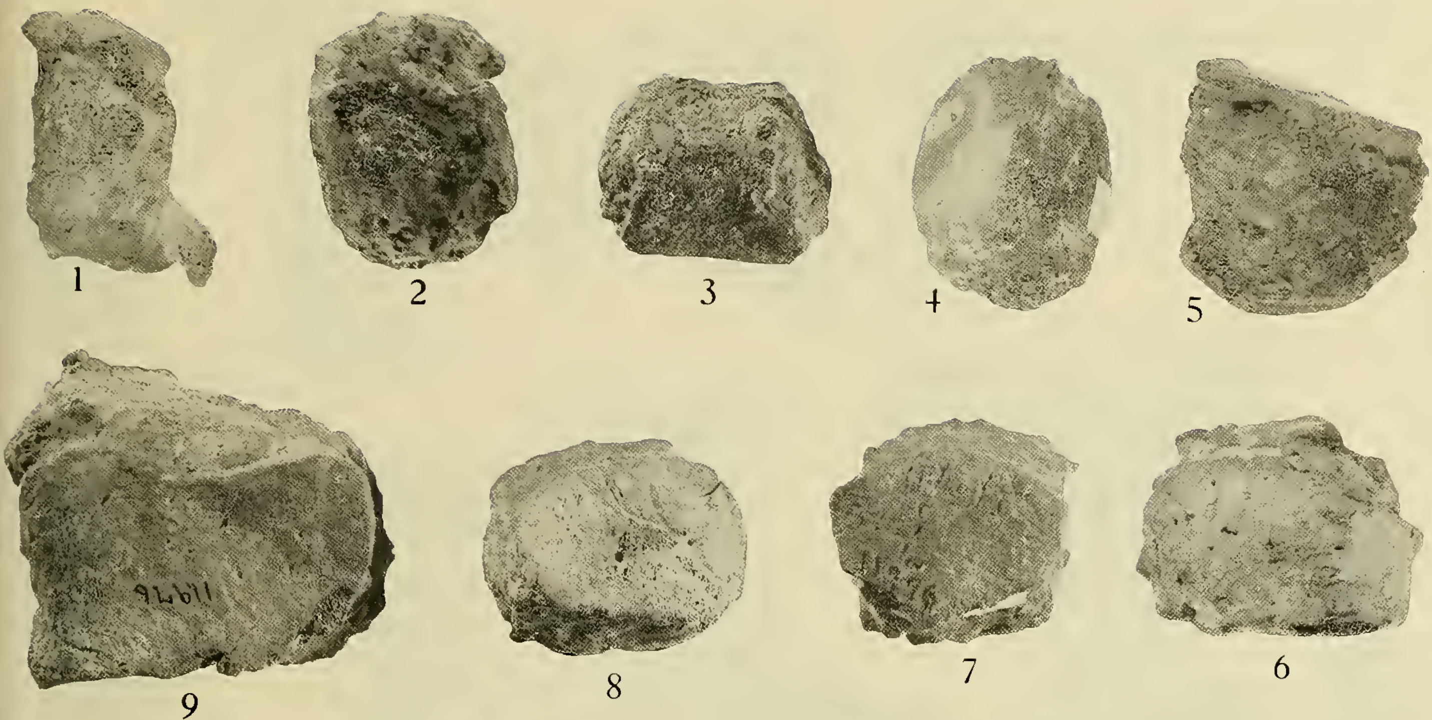


Terminal Vertebrae, USNM 23058, *Pelocetus calvertensis*

Anterior views.

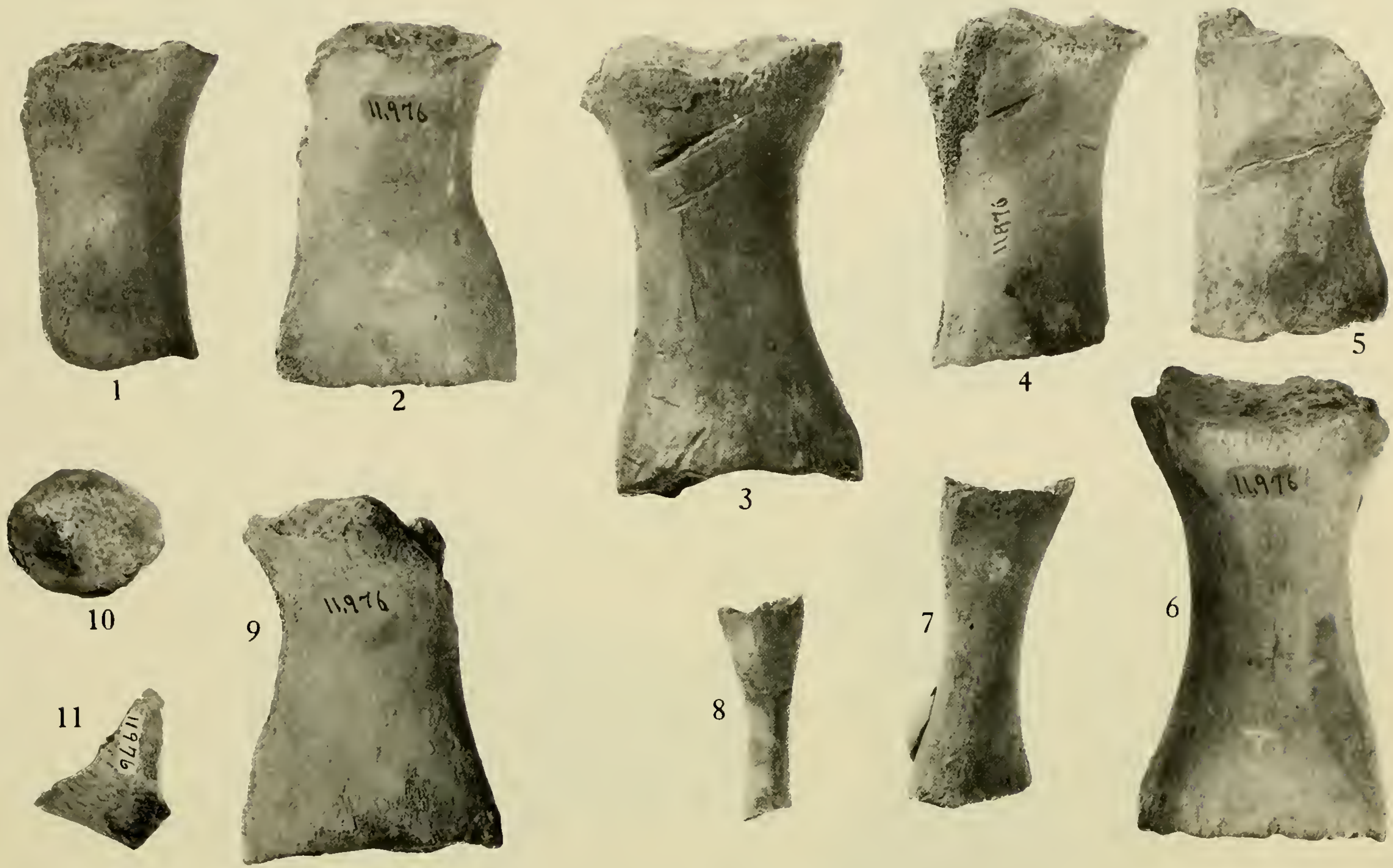
Right Ulna and Left Periotic, USNM 23059, Pelocetus calvertensis

1, External view of right ulna; 2, tympanic view of left periotic; 3, cerebral view of left periotic.



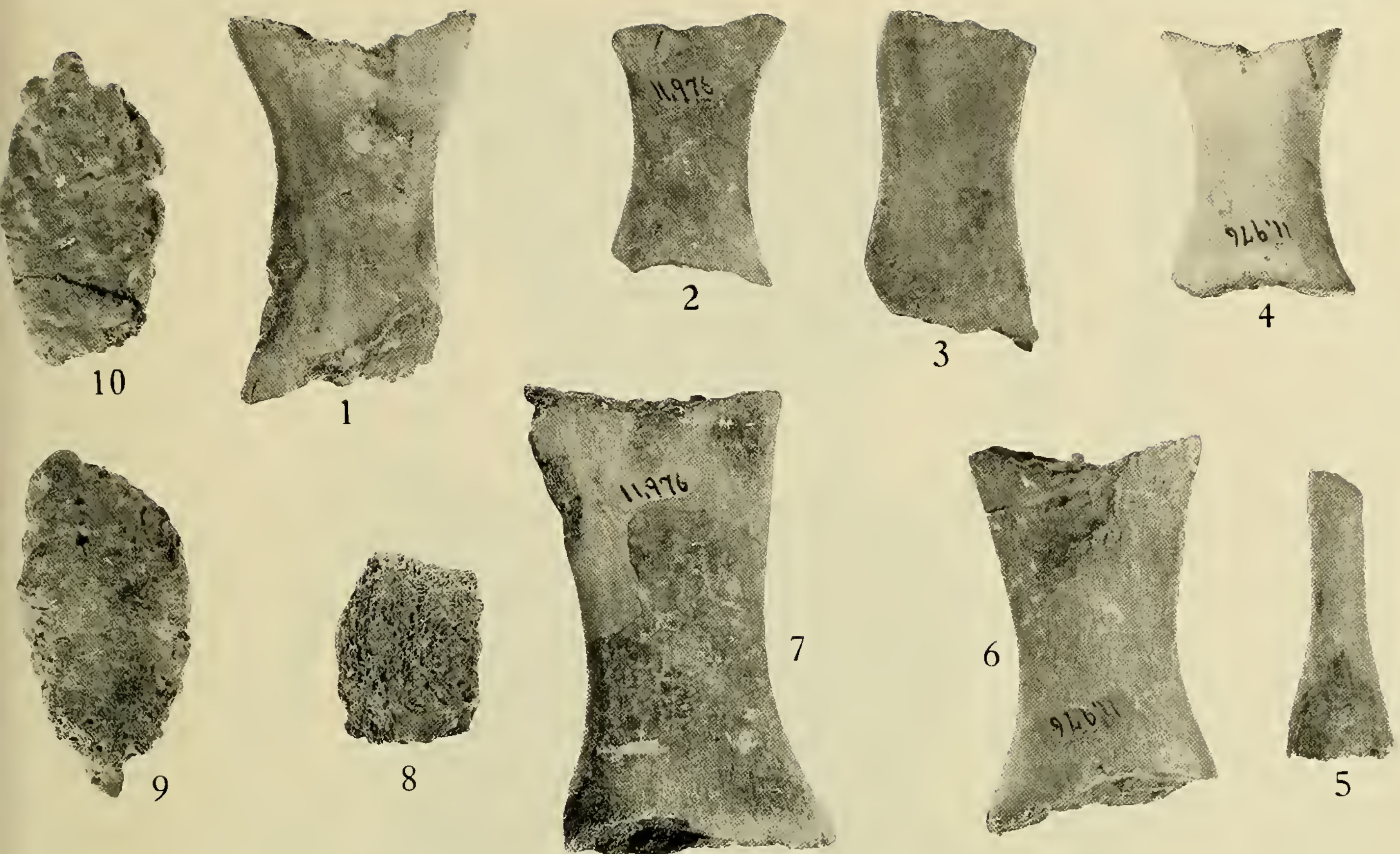
CARPAL BONES, USNM 11976, *PELOCETUS CALVERTENSIS*

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.

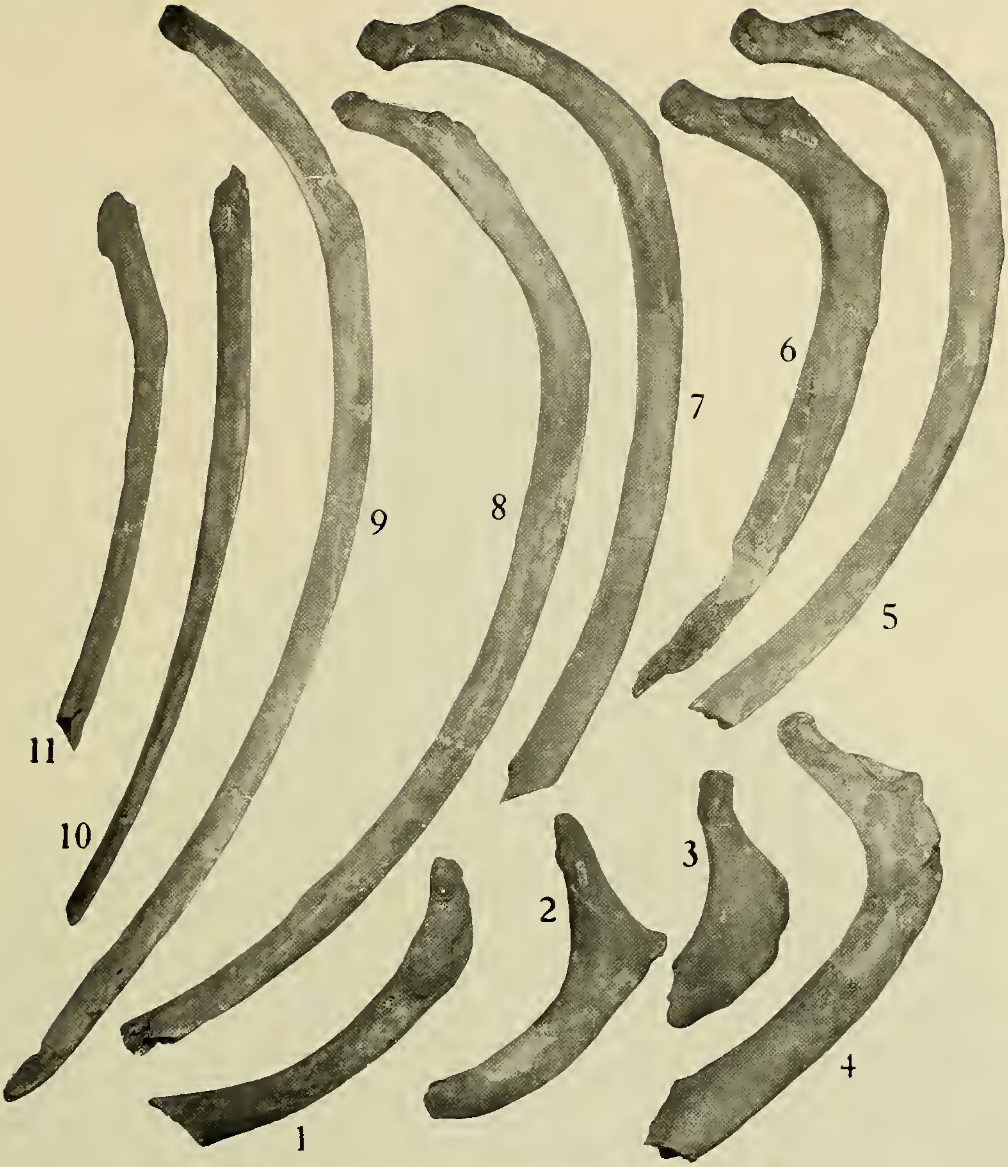


PHALANGES, USNM 11976, PELOCETUS CALVERTENSIS

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.

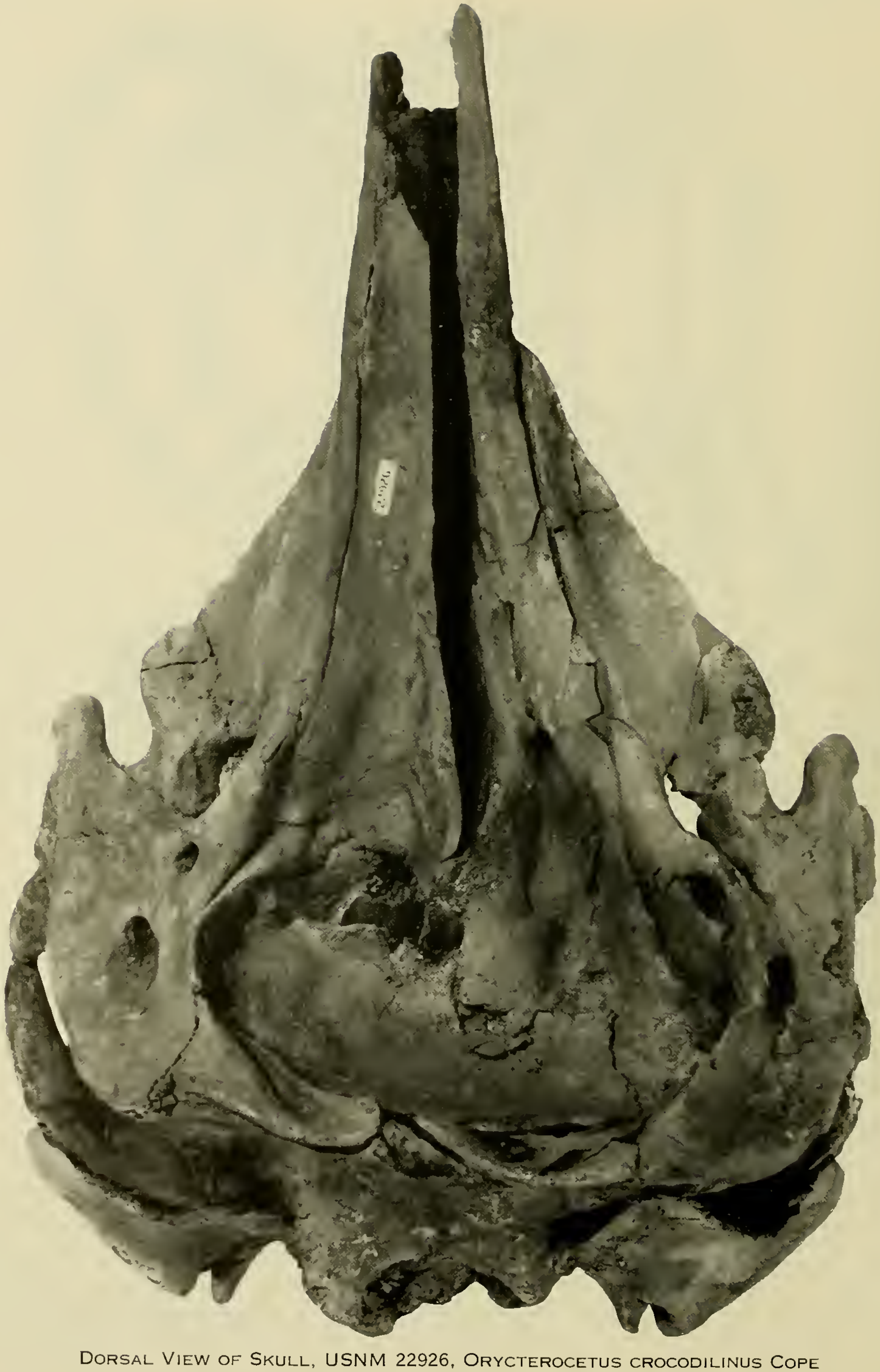
Bones, USNM 11976, Pelocetus calvertensis

Tentative identification as sternum.

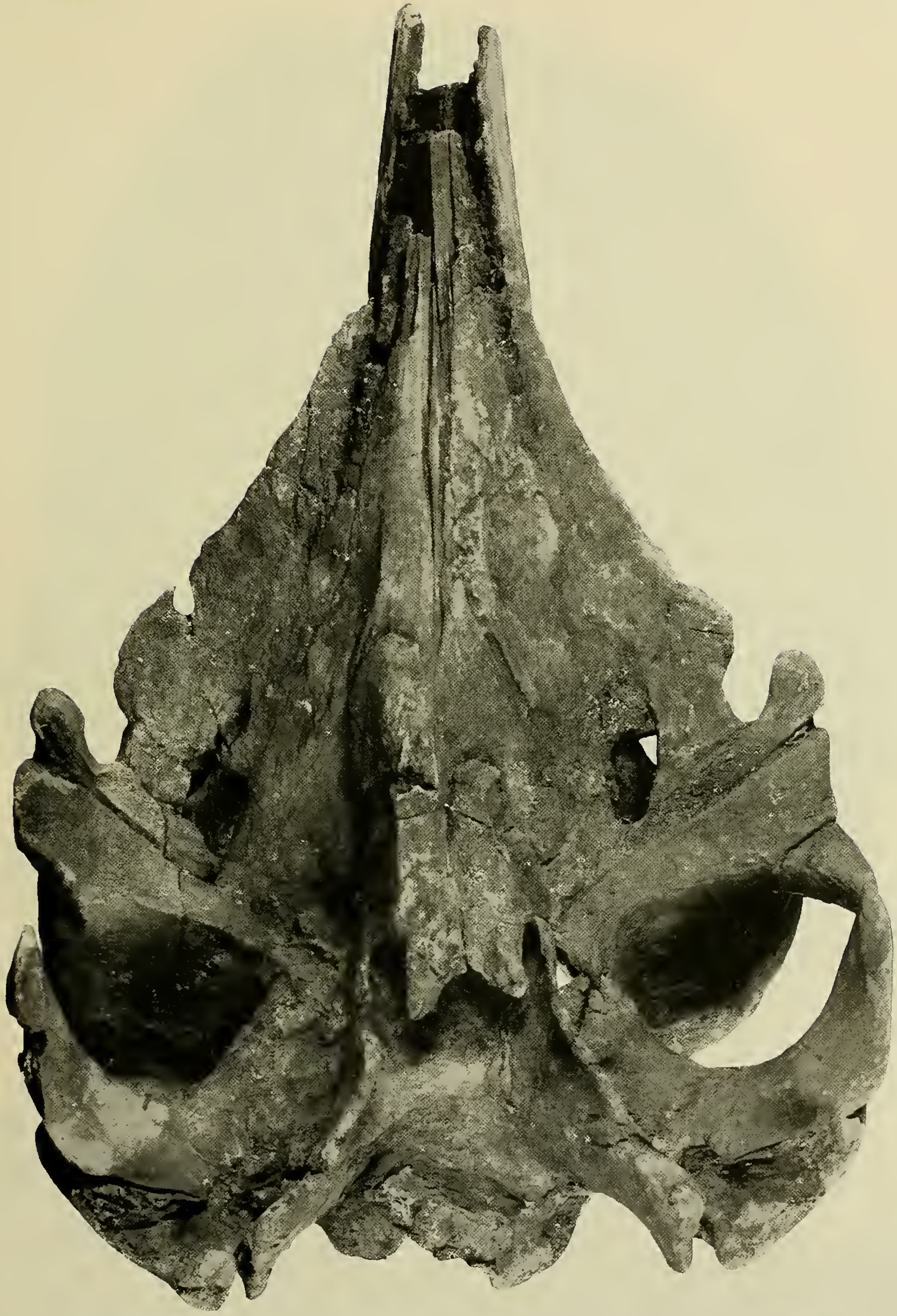


RIBS, USNM 11976, PELOCETUS CALVERTENSIS

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.



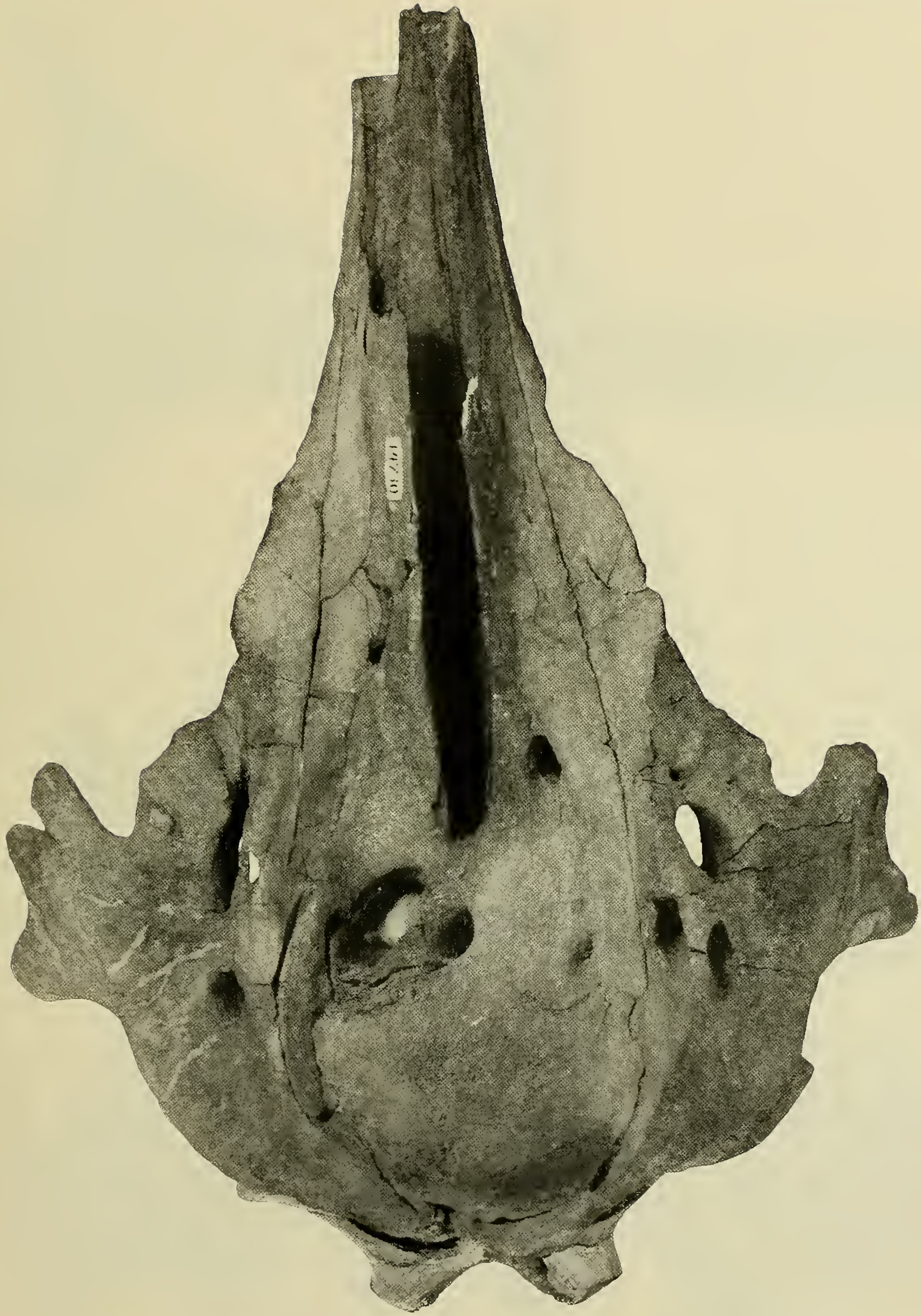
Dorsal View of Skull, USNM 22926, Orycterocetus crocodilinus Cope



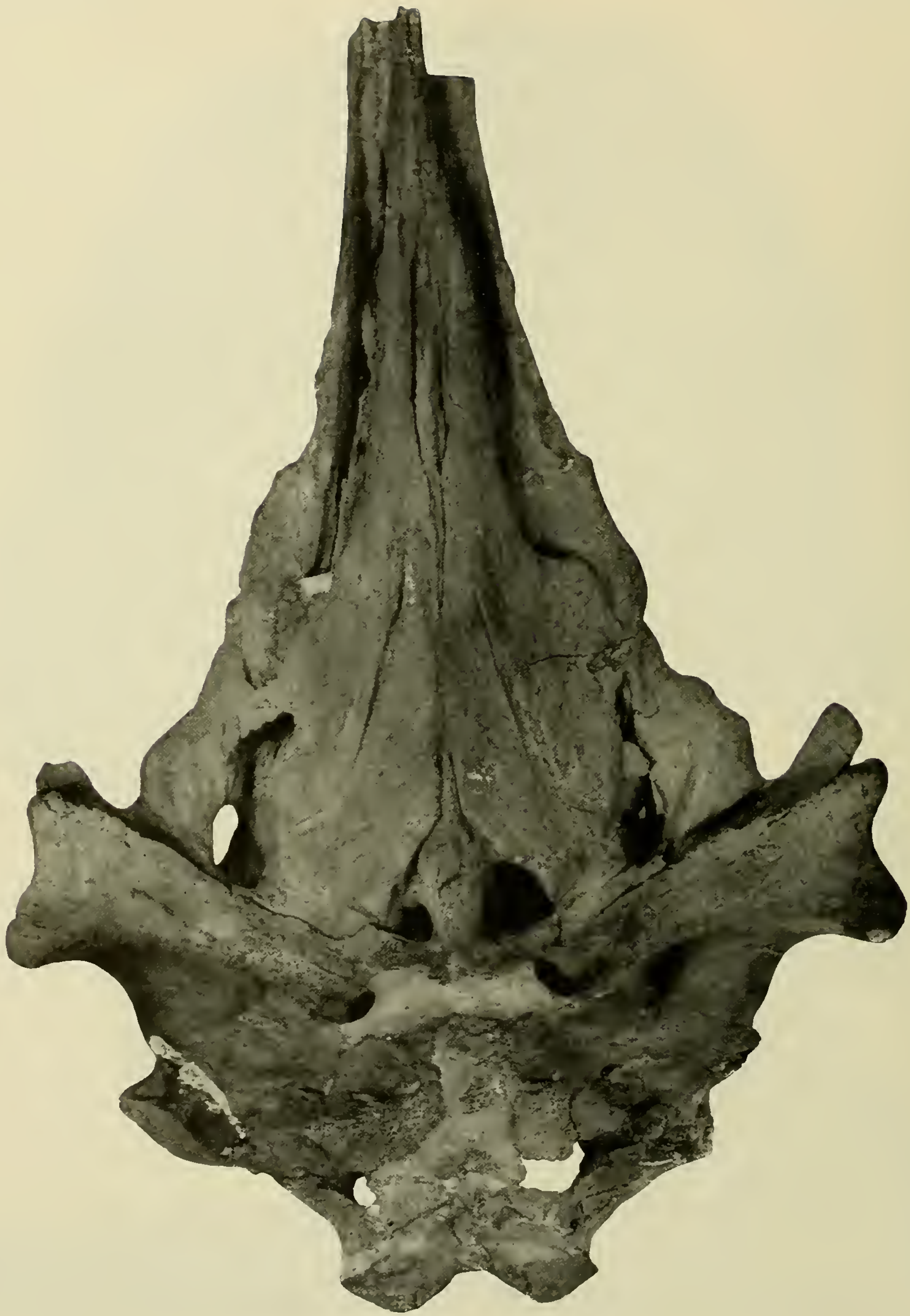
Ventral View of Skull, USNM 22926, Orycterocetus crocodilinus Cope

Skull, USNM 22926, *Orycterocetus crocodilinus* Cope

Top: Posterior view. Bottom: Lateral view.



Dorsal View of Skull, USNM 14730, Crycterocetus crocodilinus Cope

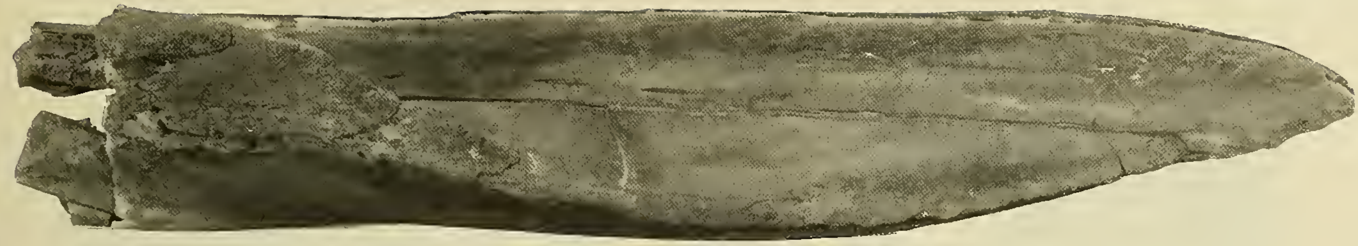


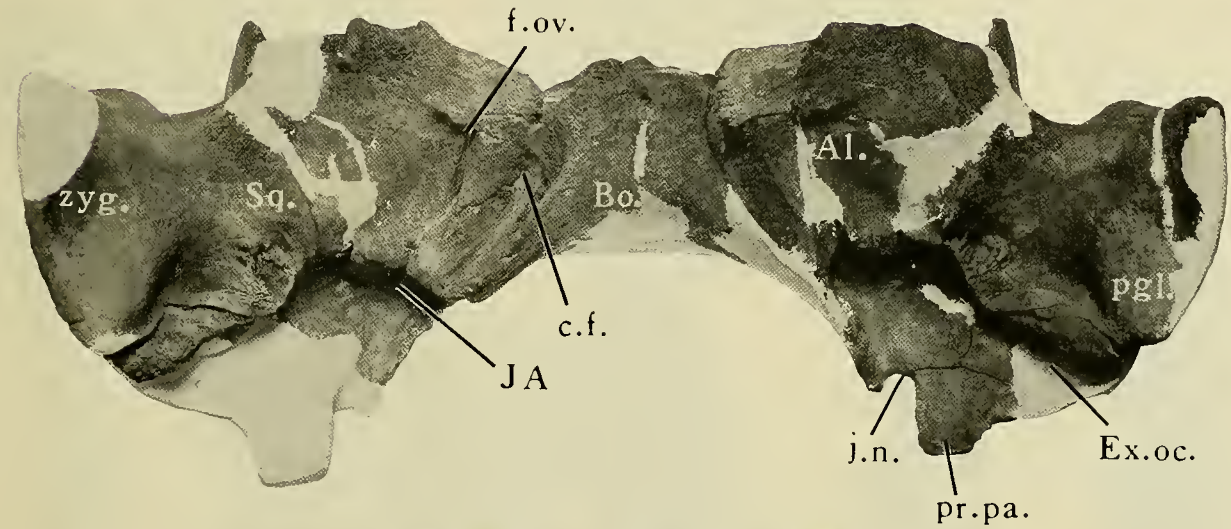
Ventral View of Skull, USNM 14730, Orycterocetus crocodilinus Cope

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).