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FOSSIL MARINE MAMMALS

From the Miocene Calvert Formation of Maryland and Virginia

Parts 5–8 (end of volume)

REMINGTON KELLOGG

Research Associate, Smithsonian Institution

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

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

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

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

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

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

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

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

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

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

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

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

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

ESCHRICHTIUS Gray

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

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

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

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

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

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

ESCHRICHTIUS CEPHALUS Cope

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

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

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

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

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

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

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

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

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

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

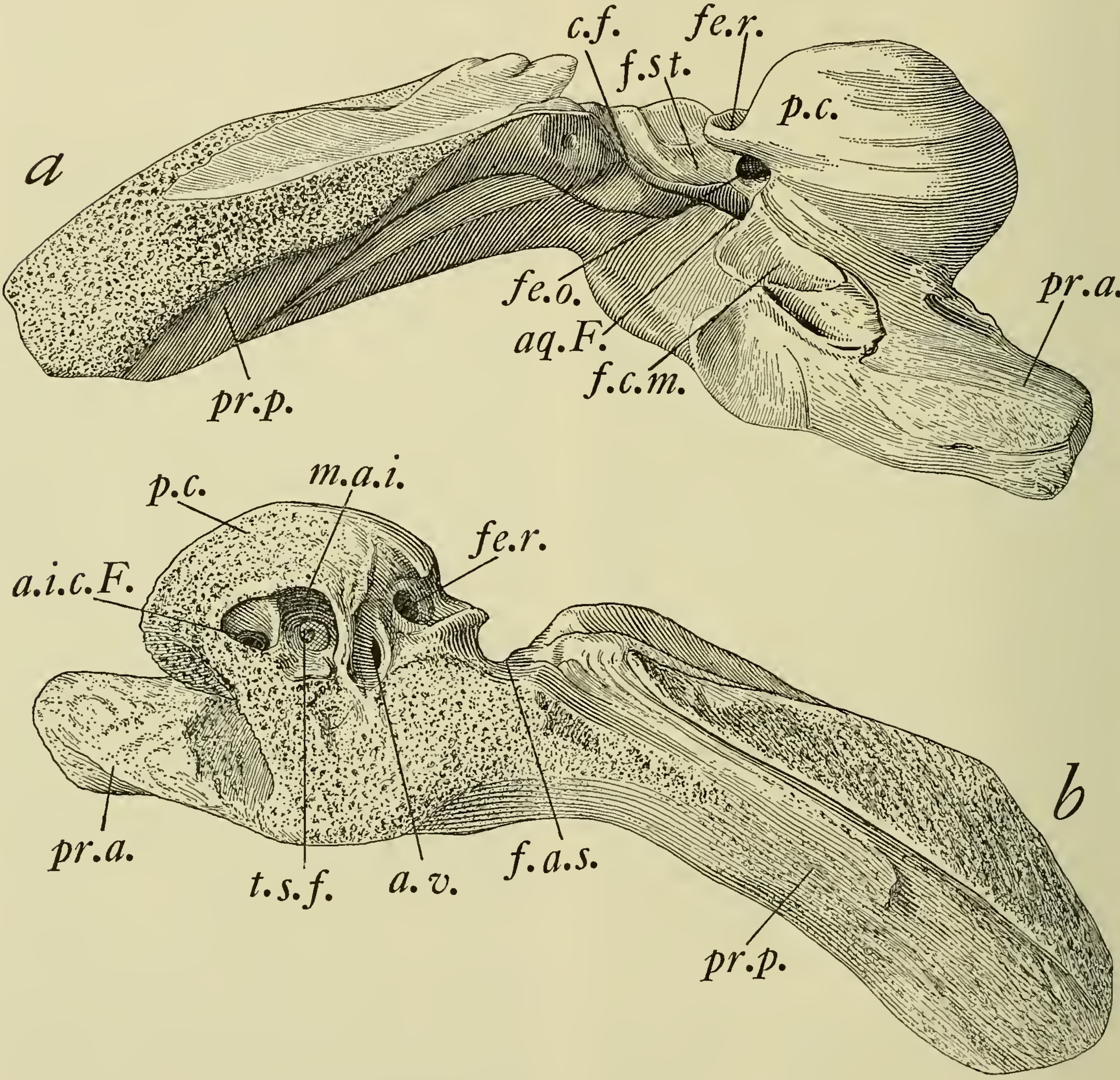

FIGURE 39.—Views of left periotic, AMNH 1750 of (?)*Balaenoptera sursiplana* Cope: *a*, ventral or tympanic view; *b*, internal or cerebral view. Abbrs.: a.i.c.F., internal aperture of aquaeductus Fallopii; aq.F., epitympanic orifice of aquaeductus Fallopii; a.v., aperture of aquaeductus vestibuli; c.f.,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

Skull

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

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

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

Tympanic Bulla

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

Periotic

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

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

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

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

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

Mandible

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

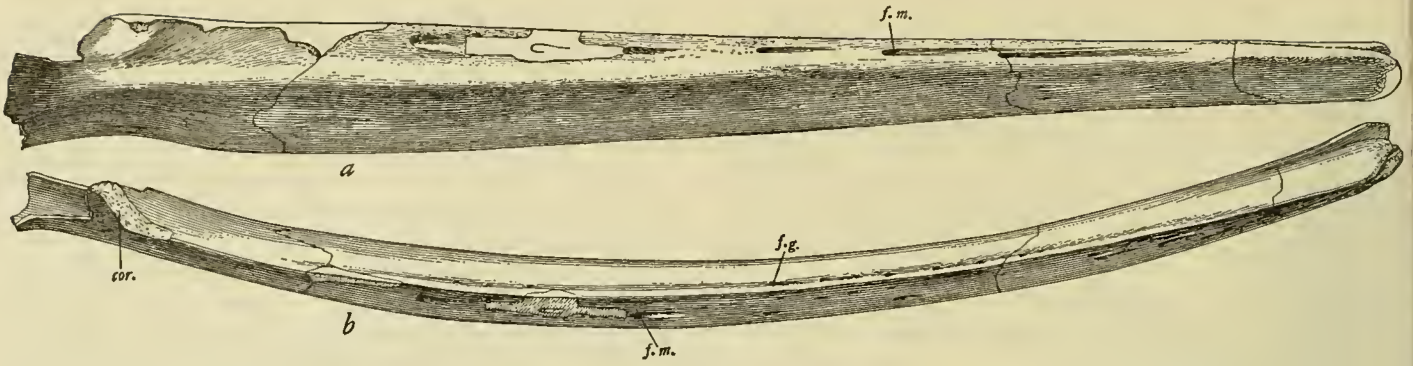

FIGURE 40.—Views of right mandible, ANSP 12691, of *Eschrichtius cephalus* Cope: *a*, external view; *b*, dorsal view. Abbrs.: cor., coronoid process; f.g., gingival or alveolar foramen; f.m., mental foramen.

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

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

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

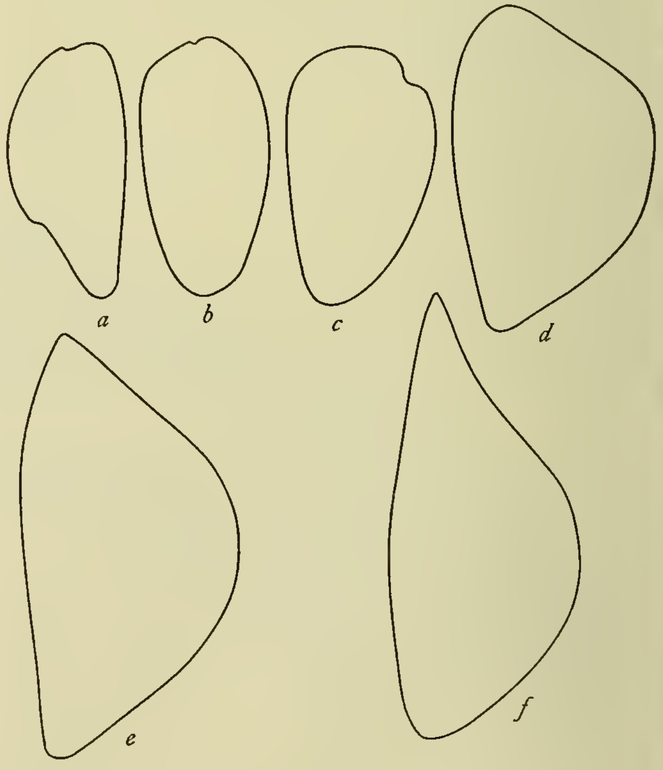

FIGURE 41.—Cross sections of right mandible, ANSP 12691, of *Eschrichtius cephalus* Cope; *a*, 100 mm. behind anterior end; *b*, 300 mm. behind anterior end; *c*, 500 mm. behind anterior end; *d*, 1000 mm. behind anterior end; *e*, 1500 mm. behind anterior end; *f*, 2000 mm. behind anterior end.

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

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

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

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

Vertebrae

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

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

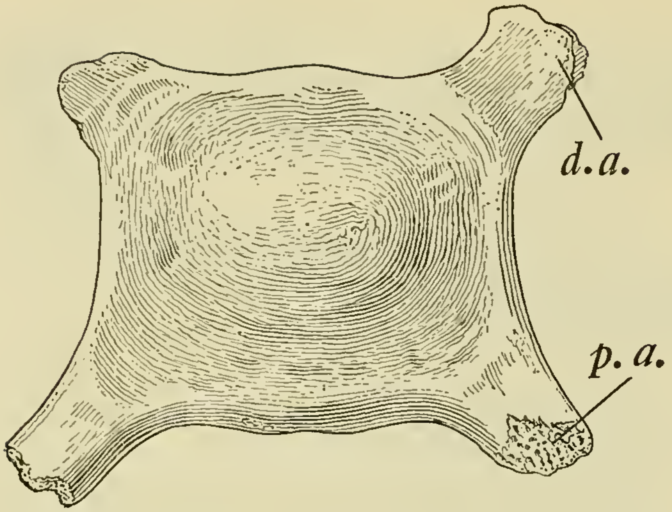

Figure 42.—Anterior view of fourth cervical, ANSP 12692, of *Eschrichtius cephalus* Cope. Abbrs.: d.a., diapophysis; p.a., parapophysis.

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

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

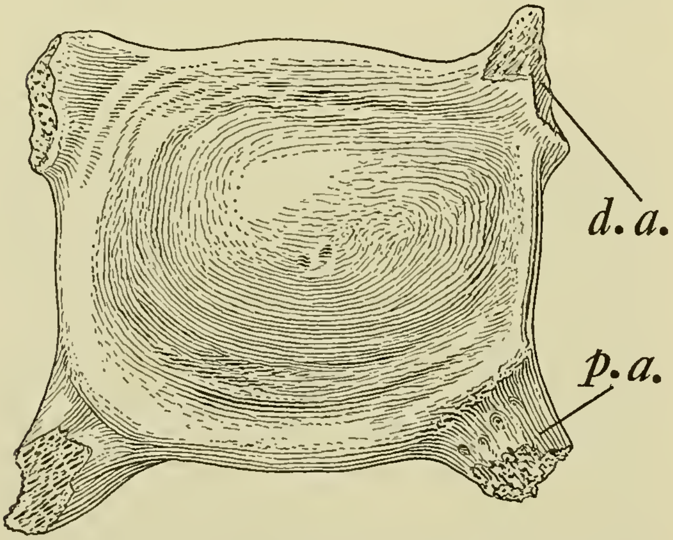

Figure 43.—Anterior view of fifth cervical, ANSP 12692, of *Eschrichtius cephalus* Cope. Abbrs.: d.a., diapophysis; p.a., parapophysis.

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

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

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

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

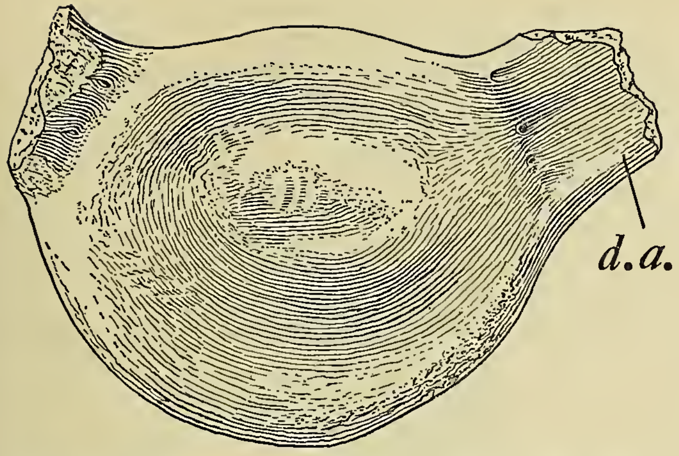

Figure 45.—Anterior view of seventh cervical, ANSP 12692, of *Eschrichtius cephalus* Cope. Abbrs.: d.a., diapophysis.

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

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

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

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

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

Forelimb

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

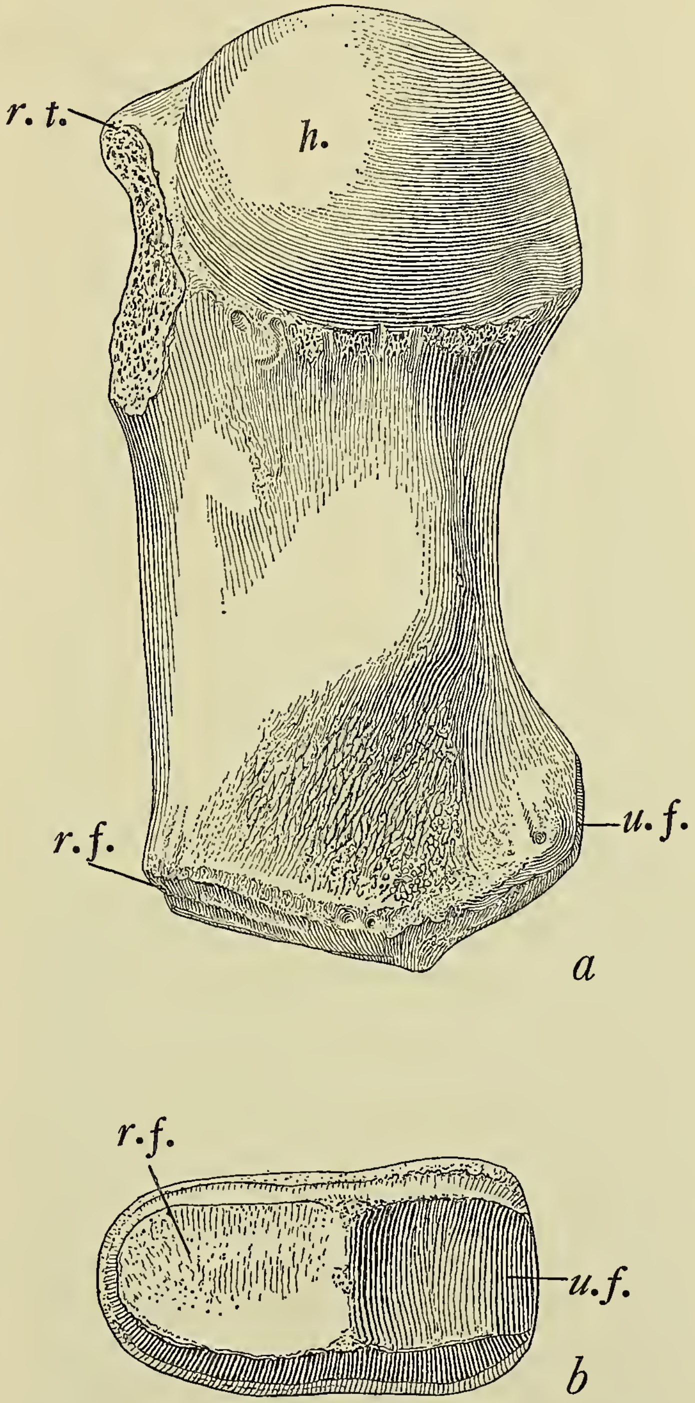

Figure 46.—Views of left humerus, ANSP 12691, of *Eschrichtius cephalus* Cope: *a*, external view; *b*, view of distal end. Abbrs.: h, head; r.f., radial facet; r.t., radial or greater tuberosity; u.f., ulnar facet.

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

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

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

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

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

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

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

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

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

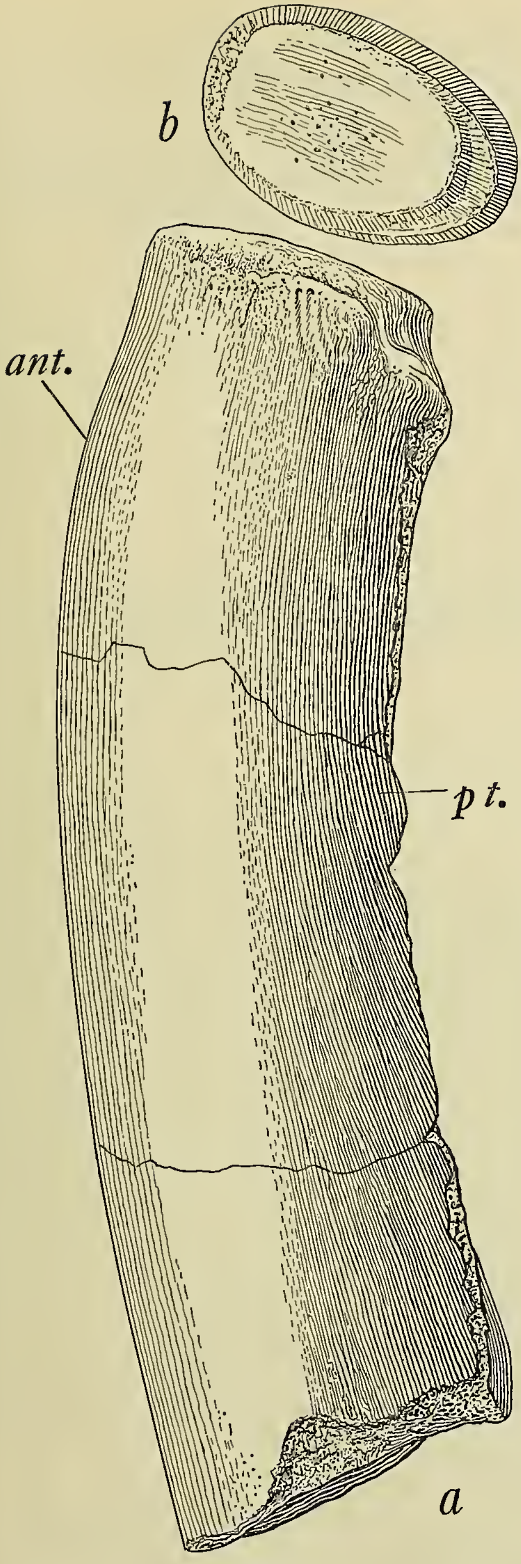

FIGURE 47.—Views of left radius, ANSP 12691, of *Eschrichtius cephalus* Cope: *a*, internal view; *b*, view of proximal end. Abbrs.: ant., anterior face; pt., posterior face.

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

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

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

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

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

ESCHRICHTIUS PUSILLUS Cope

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

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

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

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

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

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

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

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

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

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

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

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

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

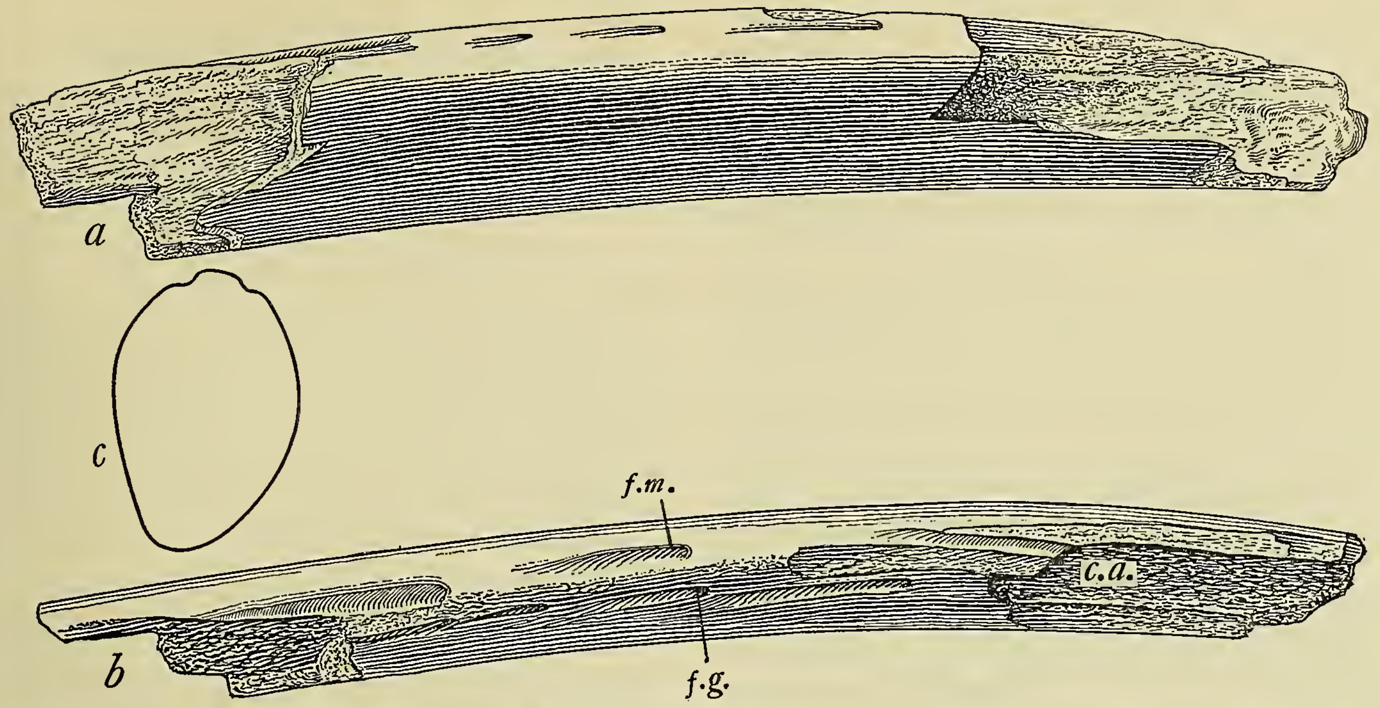

Figure 48.—Views of right mandible, ANSP 12912, labeled *Eschrichtius pusillus* Cope: *a*, external view; *b*, dorsal view; *c*, cross section 210 behind broken anterior end. Abbrs.: c.a., alveolar or mandibular canal; f.g., gingival or alveolar foramen; f.m., mental foramen.

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

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

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

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

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

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

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

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

MEGAPTERA Gray

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

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

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

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

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

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

MEGAPTERA EXPANSA Cope

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

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

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

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

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

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

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

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

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

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

Inasmuch as the fossil remains on which *M. expansa* was established consisted solely of vertebrae, the allocation of portions of mandibles from several sources in the absence of associated skeletal elements would appear to require more justification than advanced by Cope. Accumulated materials have since shown that some of the original type vertebrae of *M. expansa* (although part of an obviously mixed assortment) are questionably separable from those of *Eschrichtius pusillus*. The fact that the internal gingival foramina are described as being located on the dorsal flattened surface of the mandible would indicate that Cope, at that time, did not attach much significance to their being below the median dorsal ridge in other specimens. These internal foramina usually begin proximally on the internal side and gradually approach or rise to the dorsal margin, ending by crossing over the margin at the distal extremity of the mandibular ramus. One would expect, therefore, to find these foramina close to or on the margin in some pieces of the mandible and lower down on others. The Belgian species *Mesocetus pinguis* (Van Beneden, 1886, pl. 44, figs. 1, 2) shows this kind of an arrangement. If one takes into consideration the extent of erosion on this mandibular fragment, a more plausible interpretation of the location of these foramina becomes obvious. The wearing down of the median longitudinal ridge has flattened somewhat the dorsal surface of the ramus; the gingival foramina were, however, actually below this surface when the ramus was unworn.

Among the ten dorsal vertebrae mentioned by Cope (1868d, p. 193) as originally included among the numerous vertebrae in the Thomas collection from Charles County, Maryland, and from the Nomini Cliffs, Westmoreland County, Virginia, presented by Oliver N. Bryan, are two dorsals whose measurements were given in the type description of *Megaptera expansa*. One of these two dorsals, the ninth (pl. 46, fig. 6), agrees fairly closely in the dimensions and shape of the centrum to the corresponding dorsal vertebra of USNM 23494. The other, now regarded as the fifth dorsal (ANSP 12769; pl. 46, fig. 5), however, belongs in the dorsal series of another Calvert cetothere, since it has a wide dorsoventrally compressed subcordate anterior end on the centrum and is quite obviously different in profile. Another vertebra, the eighth dorsal (pl. 46, fig. 4), in this collection of ten, is smaller than its counterpart in the USNM 23494 skeleton. At least two different cetotheres are thus represented among the dorsals designated by Cope as type vertebrae. All of these vertebrae possess mere basal remnants of their processes and they do not exhibit other features on which a precise characterization may be based. The identification of the original type vertebrae of *M. expansa* is further complicated by the association under one catalog number (ANSP 12769) of 28 or more vertebrae, in part at least originally included among the many vertebrae on which Cope (1868d, p. 191) based *Eschrichtius pusillus*, a somewhat larger mysticete. No justification exists either on the basis of the supposed diagnostic characters listed by Cope or on the shape, characteristics and dimensions of any of the vertebrae then available to him for referring *Megaptera expansa* either to *Megaptera*, *Eschrichtius*, *Siphonocetus*, or *Cetotherium*. The species *Megaptera expansa* is, therefore, held to be indeterminable and to be ignored henceforth.

MESOCETUS Van Beneden

Mesocetus Van Beneden, 1880, Bull. Acad. roy. Sci., Lettres et Beaux-Arts Belgique, Bruxelles, ser. 2, vol. 50, no. 7, p. 22.

Type Species: *Mesocetus longirostris* Van Beneden. (Type fixed by Hay, Bull. no. 179 U.S. Geol. Surv., Dept. Interior, 1902, p. 600).

Diagnosis: Van Beneden's rather brief generic diagnosis of *Mesocetus* (1880, p. 22) is limited to the relations of bones that comprise the top of the cranium—the well-developed parietals and the long space between the [apex of] supraoccipital and the frontals. Subsequently from Croatia [Yugoslavia] under the generic name *Mesocetus*, Van Beneden did describe and illustrate as *M. agrami* a posterior end of a left mandible (1884, pl. 2, fig. 10) and also a basicranium with attached tympanic bulla and periotic. Comments in this memoir apparently led Cope (1895a, p. 153) to state that Van Beneden established *Mesocetus* for mysticetes that resemble odontocetes in having the transverse widening of the condyle situated at the middle of the relatively thin and laterally compressed posterior end of the mandible. The articular condyle is thus situated below the dorsal rim of the posterior portion of the ramus behind the coronoid process. Van Beneden observes that the condyle of *M. agrami* is flattened and widened with projecting lateral edges, but is not set off from the ramus like the head of a femur, and is adapted to articulate almost vertically with the glenoid surface of the squamosal. As a result of his own observations, Van Beneden (1884, p. 18) attached great importance to the condyle for the establishment of the generic sections among mysticetes.

MESOCETUS SIPHUNCULUS Cope

Mesocetus siphunculus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 153.

Type Specimen: AMNH 22665. Anterior portion of right mandible and its detached condyle; coronoid process and the portion of the ramus between coronoid process and condyle destroyed. Collector, E. D. Cope; April 1895.

Type Locality: Pamunkey River, probably near Hanover, Hanover County, Virginia. Associated with a turtle (*Syllomus crispatus* Cope), vertebrae of at least four Calvert odontocetes and the anterior ends of two mandibles of a smaller cetothere. Marl,[2] Calvert formation, middle Miocene.

Referred specimens: (1) Left humerus, essentially complete, and (2) the first dorsal and centra of two other anterior and one middle dorsal vertebrae (pl. 47); Pamunkey River, Hanover County, Virginia, AMNH 22669, coll. E. D. Cope, April 1895.

Diagnosis: Cope (1895a, p. 153) states that the mandibular ramus "has no large dental canal, but it is almost entirely filled with spongy bone of moderate coarseness. The gingival canals united into a single tube, which is not larger than one of the external gingival canals, and which runs about opposite to them or a little distance below the superior edge. In this disposition of the canals *Mesocetus* differs from any of the genera of Mystacoceti referred to in the preceding pages." This mandible was fractured while being excavated and subsequently repaired under Cope's supervision. It is not now possible to ascertain the actual internal structure. Close scrutiny, however, of similar mandibles confirms the belief that the type mandible of *Mesocetus siphunculus* does not differ appreciably from the internal canal arrangement described under *Siphonocetus priscus*.

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[2] A sample of matrix attached to the type specimen was submitted for heavy mineral analysis to Dr. Lincoln Dryden, Bryn Mawr College. Since the percentage of staurolite exceeded that of tourmaline and zircon, Dr. Dryden was inclined to believe that Cope collected this fossil material from a horizon near the base of the Calvert formation, possibly a foot or so above the contact with the Eocene.

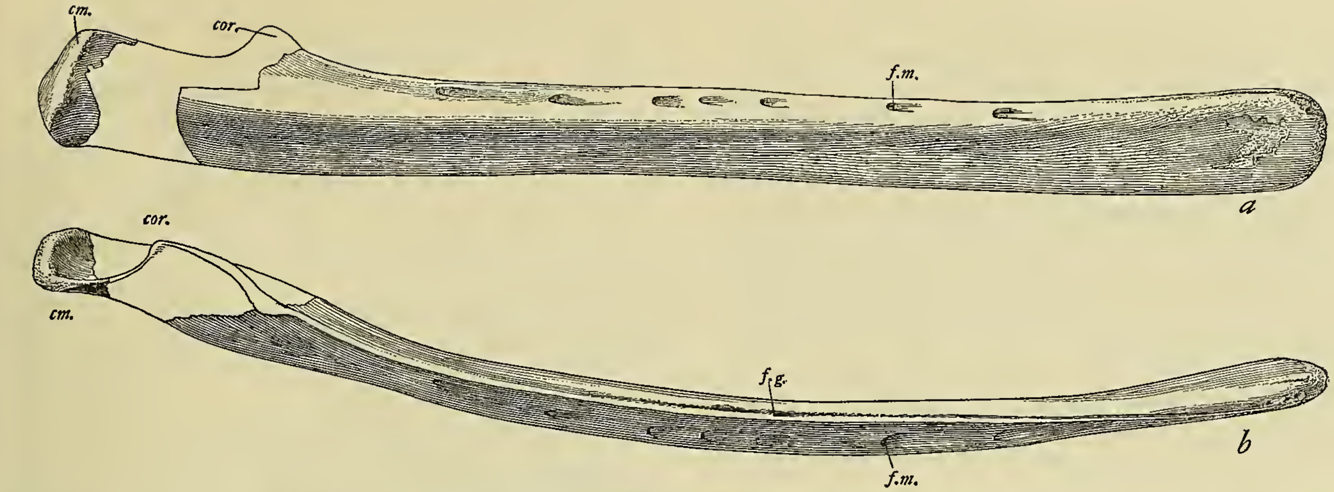

Figure 49.—Views of right mandible, AMNH 22665, of *Mesocetus siphunculus* Cope: *a*, external view; *b*, dorsal view. Abbrs.: cm., condyle; cor., coronoid process; f.g., gingival foramen; f.m., mental foramen.

Mandible

The type right mandible of *Mesocetus siphunculus* (fig. 49a) represents a larger cetothere than the left mandible of *Isocetus depauwii* (Van Beneden, 1886, pl. 70; length, 1128 mm.) whose vertical diameter at the distal end is 84 mm. in contrast to 99.5 mm. for the Virginia Calvert species, and 76 mm. 440 mm. behind the anterior end versus 89 mm. 500 mm. behind the anterior end for *M. siphunculus.* The vertebrae associated with the type mandible of *I. depauwii* have the epiphyses loose or detached from the centra, indicating physical immaturity. The type mandible of *M. siphunculus* is also smaller than that of *Mesocetus pinguis* (Van Beneden, 1886, pl. 44, fig. 10; length, 1642 mm.) and is intermediate in size between the latter and *Isocetus depauwii.* If not identical with *I. depauwii* it appears rather closely allied to this Belgian species. Both *M. siphunculus* and *I. depauwii* possess much narrower condyles on the mandibles than *M. pinguis.* The transverse diameters of the mandibular condyles are respectively: 61.5 mm. for *M. siphunculus,* 55 mm. for *I. depauwii,* and 96.5 mm. for *M. pinguis.* The shape of the condyle of *M. siphunculus* (pl. 47, fig. 2) is also somewhat similar to that of *I. depauwii* (Van Beneden, 1886, pl. 70, fig. 8). In making any comparison, it should be noted that the angle of the mandible is broken off below the level of the groove for the internal pterygoid muscle. The internal gingival foramina are not clearly recognizable on the mandible of *I. depauwii* (Van Beneden, 1886, pl. 70, fig. 1); they are situated normally on the internal face of the mandible of *M. siphunculus* (fig. 49b).

Although Cope states that the type mandible of *M. siphunculus* is not strongly convex either on the internal or external side, his diagrammatic figure (Cope, 1896, pl. 12, fig. 6) does not bear this out. The convexity of the external face does, however, exceed that of the internal.

Measurements (in mm.) of the type left mandible are as follows: greatest length in straight line when complete, estimated, 1200 ±; greatest length as preserved in a straight line, 1128; distance from anterior end to center of coronoid process along outside curvature, 1040; vertical diameter 100 mm. behind anterior end of ramus, 99.5; transverse diameter at same point, 32; vertical diamter 700 mm. behind anterior end of ramus, 89.5; transverse diameter at same point, 58; greatest vertical diameter of hinder end including condyle, 115; greatest transverse diameter of condyle, 61.5.

Humerus

Another skeletal element mentioned by Cope (1895a, p. 154) in his description of *Mesocetus siphunculus,* but not definitely referred to it, is a left humerus (AMNH 22669) which was found near the excavated anterior ends of two right mandibles (lengths, respectively, 167 and 225 mm.) which represent a somewhat smaller cetothere than the type mandible, since the vertical diameter near the anterior end of the longest specimen is 56 mm. This humerus has been split lengthwise but subsequently repaired and the greater tuberosity is eroded; both epiphyses are fused with the shaft. Cope remarks (1895, p. 154) that "the tuberosity is not produced beyond the head, and the olecranar facet is not distinguished by an angle from the remainder of the ulnar facet." Although worn, the conformation of the greater tuberosity does not differ materially from other larger and smaller Calvert humeri. The shape of the ulnar facet is not unusual. The articular surface of the horizontal portion merges with the vertical portion of the ulnar facet in a gradual curve. The features cited by Cope would not be regarded as diagnostic for Calvert cetotheres. Comparison cannot be made with *Isocetus depauwii* as the Belgian humerus was not illustrated by Van Beneden. Whether or not this humerus really belongs to *M. siphunculus* is uncertain.

This left humerus (fig. 50a) has a large, convex head, whose greatest diameter is 107 mm. As in other Calvert cetotheres, the head is placed obliquely on the shaft, facing outward and backward. Between the head and the radial or greater tuberosity there is a shallow groove on the external face that limits the articular surface of the former anteriorly. The small rugose area on the external face below this groove may have served for the attachment of M. mastohumeralis. There is also a large central swelling or knob at the proximal end of the internal face (fig. 50b). The rugose internal surface of the greater tuberosity presumably served as the area for insertion of M. infraspinatus and M. subdeltoideus, and the protruding knob below on the anterointernal angle for a portion of the insertion of M. deltoideus.

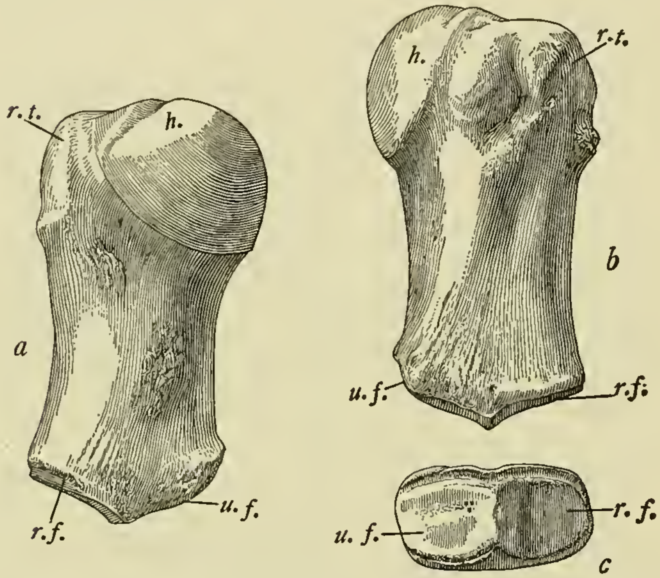

FIGURE 50.—Views of left humerus, AMNH 22669, of *Mesocetus siphunculus* Cope: *a*, external view; *b*, internal view; *c*, distal view. Abbrs.: h, head; r.f., radial facet; r.t., radial or greater tuberosity; u.f., ulnar facet.

Since the shaft was split lengthwise the median rugose area on the outer surface shown on the line drawing (fig. 50a) may have been over emphasized. This median rugose area may have served for attachment of the short head of M. triceps or M. teres major. A right humerus (USNM 23708) of similar dimensions from the Calvert formation, 1½ miles south of Plum Point, Calvert County, Maryland, lacks this rugose area.

The thick shaft is slightly constricted near the middle of its length, but is flattened exterointernally toward its distal end. At the transversely compressed distal end of the shaft (fig. 50c) the ulnar facet is approximately the same width as the radial facet and is extended upward on the posterior face of the shaft for a short distance. A low transverse crest separates the ulnar facet from the shorter radial facet.

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

	AMNH 22668 Left	*USNM 23708 Right*
Greatest length of humerus	233.5	229
Greatest anteroposterior diameter of proximal end	128	123
Greatest anteroposterior diameter of articular head	107	104
Greatest exterointernal (transverse) diameter of articular head	95	91
Least anteroposterior diameter of shaft	88	87
Least exterointernal (transverse) diameter of shaft	55.5	56
Greatest anteroposterior diameter of distal end	107.5	105
Greatest exterointernal (transverse) diameter of distal end	56.8	56
Greatest anteroposterior diameter of radial facet	57	55
Greatest anteroposterior diameter of ulnar facet (in a straight line)	69.5	65

Vertebra

DORSAL VERTEBRA.—Cope (1895a, p. 154) assigned provisionally to this species a "first dorsal" vertebra (AMNH 22669) "found in immediate contact with the posterior part of the ramus," that is, with the type specimen. The measurements published by Cope (1895a, p. 155) for the "first dorsal" are somewhat at variance with those of the sole anterior dorsal (pl. 47, fig. 1), which lacks both epiphyses, now associated with the type mandible. These measurements (in mm.) are as follows: anteroposterior diameter of centrum, 35; vertical diameter of centrum anteriorly, 56.5; transverse diameter of centrum anteriorly across demifacets, 87.5; greatest vertical diameter of neural canal anteriorly, 30.5; greatest transverse diameter of neural canal anteriorly, 49; and distance between outer ends of diapophyses, 159.5.

Consecutive series of dorsal vertebrae of at least three different Calvert cetotheres, ranging in size from the small *Parietobalaena palmeri* to the larger *Pelocetus calvertensis* are represented in the United States National Museum vertebrate paleontological collections. Structurally all the dorsal series of these Calvert cetotheres conform to one basic pattern. On each side of the anterior dorsals the pedicle of the neural arch is coalesced basally with the corresponding portion of the diapophysis; this combined structure is transversely widened and projects outward as much from the lateral as from the dorsal surface of the centrum on the first, second, and third, and, to a lesser extent, on the fourth dorsal. With the exception of the width (49 mm.) of the neural canal anteriorly, the vertebra (pl. 47, fig. 1) regarded by Cope as the "first dorsal" does not conform either in location or construction of the pedicle of the neural arch with either one of the first three dorsals, and the greatest distance between the outer margins of the postzygapophyses (55.5 mm.) would preclude allocation to any dorsal behind the fourth. The separation of the postzygapophyses is abruptly diminished behind the fourth dorsal.

As regards dimensions and essential characteristics, this dorsal vertebra resembles more closely the fourth dorsal of a smaller cetothere whose mandibles correspond in size with the anterior ends of the two mandibles mentioned previously. Rather frequently in these Calvert marls, bones of more than one individual are found associated in close proximity and at the same stratigraphic level.

Our present knowledge of the range of variation of skeletal elements of younger than physically mature fossil mysticetes does not permit a diagnostic generic characterization of this species which is based solely on one mandible, a doubtfully allocated humerus, and a dorsal vertebra. There is a strong probability, however, that this Calvert cetothere should be assigned to *Isocetus* rather than *Mesocetus* and tentatively bear the name *Isocetus siphunculus* (Cope).

METOPOCETUS Cope

Metopocetus Cope, 1896, Proc. American Philos. Soc., Philadelphia, vol. 35, no. 151, p. 141.

Type Species: *Metopocetus durinasus* Cope.

Diagnosis: Backward thrust of rostrum has carried median rostral elements (ascending processes of premaxillaries and the nasals) backward beyond level of center of orbit; exposure of frontals on median interorbital region eliminated; thin anterior process of parietal, which overrides basal portion of supraorbital process of frontal, extended forward beyond level of hinder ends of median rostral elements; attenuated posterior end of each ascending process of premaxillary mortised into median interorbital portion of underlying frontal, in close contact if not fused with corresponding nasal, and in contact laterally with the narrow projecting ledge contributed by the outward bent dorsal border of thin anterior process of parietal; nasal bones fused or coossified along median longitudinal line of contact, but each is elongated and attenuated toward posterior end; intertemporal region narrow.

The diagnostic characters of the genus *Metopocetus* were described in the key by Cope (1896, p. 141) as follows: "A temporal ridge; maxillaries little produced posteriorly; nasals not produced beyond frontal, coossified with the frontal and with each other." In the preceding descriptive text Cope cites other characters that also require attention, including lateral occipital (lambdoidal) crests continuous with anterior temporal crests which diverge forward. "Frontal bone elongate, not covered posteriorly by the maxillary, coossified with the nasals. Nasals short, coossified with each other, not projecting anterior to frontals." Cope's interpretation of the relationships of these bones will be reviewed under the diagnosis for the type species.

METOPOCETUS DURINASUS Cope

Metopocetus durinasus Cope, 1896, Proc. American Philos. Soc., Philadelphia, vol. 15, no. 151, p. 141.

Type Specimen: USNM 8518. An incomplete cranium with right periotic *in situ*. Deposited by Goucher College, Baltimore, in Division of Vertebrate Paleontology, U.S. National Museum. Collector, Arthur Bibbins.

Type Locality: Nomini Cliffs near mouth of Potomac River, Westmoreland County, Virginia. Marl, Calvert formation, middle Miocene.

Diagnosis: In reviewing the proposed generic characters, the presumed ankylosis of the frontal and nasal bones may first be given consideration. Winge (1909, pp. 27–28) very properly makes the point that this character is an indication of advanced age rather than a generic distinction. This is quite true, but it should be noted that such ankylosis appears to be rather unusual among mysticetes, at least, so far as can be observed among specimens in museum collections or those illustrated by various authors. While this peculiarity may not be of much importance, if correlated with others the tendency to ankylosis might possibly be regarded as a convenient distinguishing feature.

Should there exist any doubt regarding the validity of Cope's interpretations, a critical review of the cranial architecture of other Miocene mysticetes that either resemble or are closely related to *Metopocetus* should serve a useful purpose.

Skull

The supposed relations of the frontals and maxillaries are of somewhat greater significance than the temporal ridge and the lateral occipital crests. If the actual relationships of these bones were as Cope interpreted them, *Metopocetus* would be quite different from other genera of whalebone whales. By referring to Cope's illustration (1896, pl. 11, fig. 3) of this type cranium, one will note that the anterior borders of the broken off bones, labeled as frontals, were considered by Cope to represent the sutural contacts with the hinder ends of the premaxillaries and maxillaries and, accordingly, that these two last mentioned bones terminated opposite the anterior ends of the nasal bones. The actual relations of these bones are most certainly quite different.

Two alternative interpretations of the relations of the posterior ends of the premaxillaries and maxillaries may be considered. Assuming that the contact margins of each of the normally narrow attenuated posterior ends of the premaxillaries have been obliterated by coalescence with the corresponding nasal, the narrowed posterior end of each maxillary has then been thrust backward beyond the level of the posterior ends of the nasals.

The other assumption would be that the posterior ends of the premaxillaries have been broken off fortuitously opposite or barely posterior to the level of the anterior ends of the nasals. Breakage is clearly evident when one examines under a binocular microscope the eroded and broken bone surfaces. Each underlying frontal is then overlaid by the ascending process of the corresponding premaxillary and its posterior extremity extends backward to the short intertemporal region and almost to the vertex. The backward overriding of the frontal by the nasal and premaxillary in a similar manner may also be observed on the cranium of *Mesocetus longirostris* (Van Beneden, 1886, pl. 34, fig. 1).

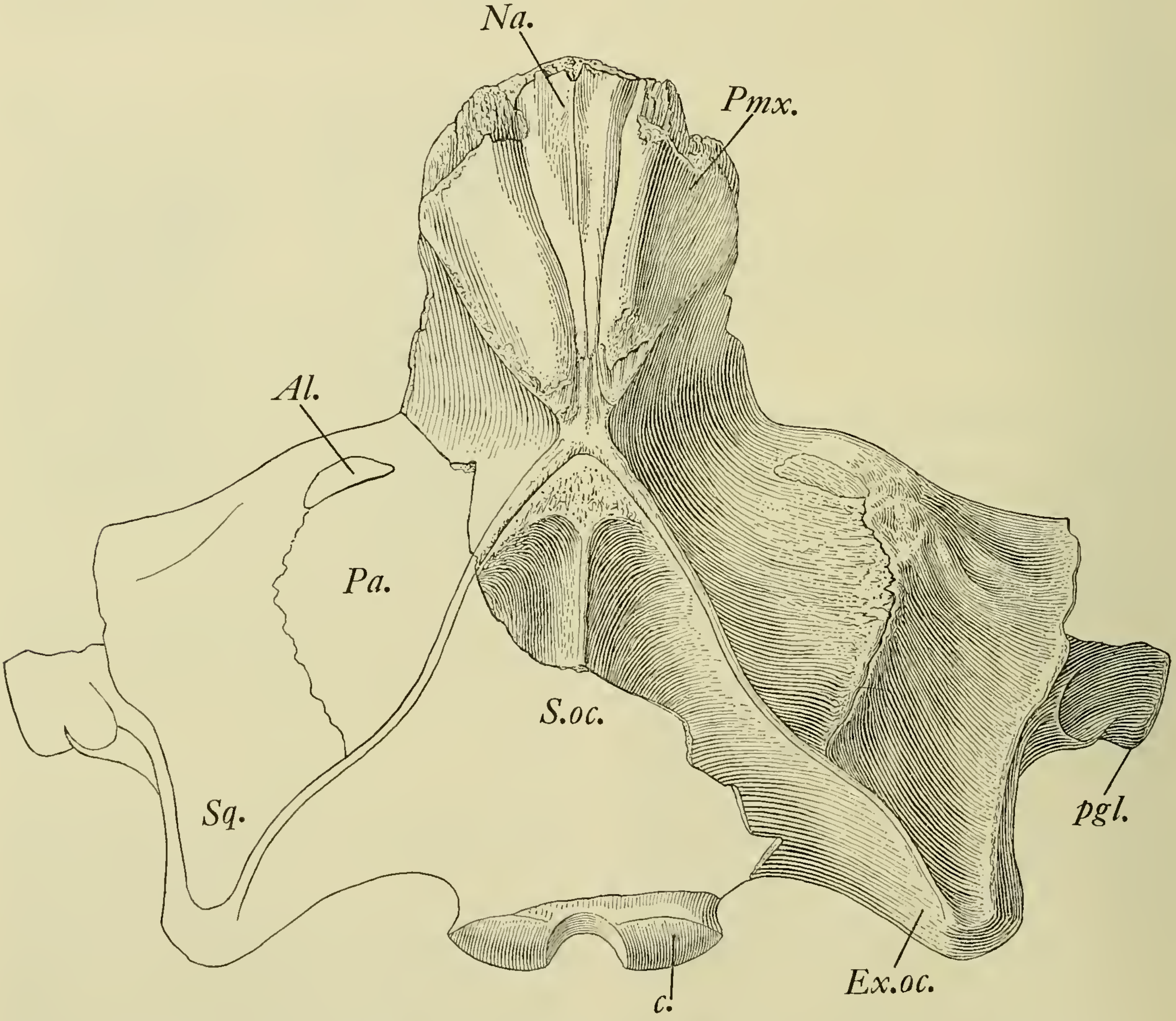

Figure 51.—Dorsal view of skull, USNM 8518, of *Metopocetus durinasus* Cope. Abbrs.: Al., alisphenoid; c., occipital condyle; Ex.oc., exoccipital; Na., nasal; Pa., parietal; pgl., postglenoid process; Pmx., premaxillary; S.oc., supraoccipital; Sq., squamosal.

On a *Mesocetus* skull (No. 5069) in the Zoological Museum at Amsterdam, The Netherlands, dredged up at a depth of 20 meters at Herenthals, Belgium, the nasals, strongly attenuated posteriorly but not co-ossified, are wedged in between but do not extend backward beyond the ascending hinder ends of the premaxillaries; these hinder portions of the premaxillaries are broken off at or just beyond the anterior ends of the nasals; and the ascending posterior end of each maxillary overlies the supraorbital process of the frontal alongside the hinder end of the premaxillary but does not extend as far backward. On the type skull of *M. durinasus* (fig. 51; USNM 8518) the supraorbital process of the frontal on each side, however, is broken off behind the posterior end of the maxillary and anterior to the hinder end of the ascending process of the premaxillary. A similar condition exists on the type skull of *Mesocetus longirostris* (MHNB 39; Van Beneden, 1886, pl. 34, fig. 1).

The two nasal bones of *M. durinasus* are fused longitudinally along the median line of contact, strongly attenuated posteriorly, wedged in externally between the posterior ascending ends of the premaxillaries, and are nearly complete anteriorly except for a narrow strip broken off dorsally. The posterior ascending portion of each premaxillary on each of these three fossil mysticete skulls is broader than normally on Miocene skulls and the backward thrust is restricted by the elevated temporal crest or ridge.

The skull of *Metopocetus durinasus* is of moderate size like those of Belgian fossil mysticetes assigned to the genera "*Heterocetus*," *Mesocetus*, "*Idiocetus*," and *Isocetus*. The cranium is larger than those of "*Heterocetus*" *brevifrons* and "*H.*" *sprangii*, and *Mesocetus latifrons;* smaller than *Mesocetus pinguis* and somewhat smaller than either *Mesocetus longirostris* (Van Beneden, 1886, pl. 34, fig. 1) or "*Idiocetus*" *laxatus* (Van Beneden, 1886, pls. 57–58).

The apical portion of the supraoccipital shield is attenuated on the skulls of *Metopocetus durinasus* (fig. 51) and *M. vandelli* (Kellogg, 1940, pl. 1), more abruptly so than on *Cetotherium rathkii* (Brandt, 1873, pl. 1, fig. 1), but all three types are quite unlike the more rounded and somewhat broader apical portion of the supraoccipital shield of *Mesocetus longirostris* (Van Beneden, 1886, pl. 34, fig. 1). The nasal bones on the skull of *Cetotherium rathkii* are not extended forward beyond the level of the preorbital angles of the supraorbital processes of the frontals; these bones are, however, noticeably extended forward beyond these angles on the skull of *Metopocetus vandelli* and possibly also on the skull of *M. durinasus.*

At the time when the type skull was described by Cope and later studied by True (1907) at the Woman's College (subsequently named Goucher College), Baltimore, Maryland, the left exoccipital, the left squamosal, and the right zygomatic process had been broken off from the strongly ossified cranium. Both occipital condyles and the adjoining basicranium, as far forward as the nasal choanae, were, however, attached to the cranium; these bones are now missing. Prominent knoblike lateral descending protuberances were present on each side of the now lost basioccipital.

The extent of the overriding of the cranial bones in the interorbital region by the median rostral bones suggests that the remodeling of the skull had advanced farther in *Metopocetus durinasus* than in *Mesocetus longirostris.*

Measurements (in mm.) of skull of USNM 8518 are as follows:

Transverse diameter of skull across outer surfaces of zygomatic processes, estimated	590±
Transverse diameter of skull between outer margins of exoccipitals, estimated	406±
Transverse distance between outer surfaces of occipital condyles	150
Vertical diameter of occipital condyle	95
Transverse diameter of foramen magnum	65
Greatest length of right nasal bone	155
Combined width of nasal bones, anteriorly	60
Distance from anterior end of nasal to articular surface of occipital condyle	450
Anteroposterior diameter of zygomatic process ventrally	115

In the above table, measurements of the occipital condyles, foramen magnum, zygomatic process, and the distance from occipital condyle to anterior end of nasal are those of either Cope or True, which were taken prior to subsequent breakage and loss of portions of the type cranium.

Periotic

The lateral protuberances on the basioccipital are much less strongly developed and the posterior process of the periotic of *M. durinasus* is quite differently shaped from that of "*Idiocetus*" *laxatus* (Van Beneden, 1886, pl. 54, figs. 3–4) which has a slender, elongated posterior process and a very short anterior process. The posterior process of *M. durinasus*, which is lodged between the postglenoid process of the squamosal and the exoccipital, has an unusually deep lengthwise groove for the facial nerve, which imparts a U-shaped outline to the distal end of this process, and in this respect exhibits a rather close resemblance to that of *Mesocetus longirostris* (Van Beneden, 1886, pl. 36, figs. 4–6). This Belgian left periotic (MNHB 1539) is characterized by the wide interoexternal groove for the facial nerve, which increases in width distally and imparts a spatulate appearance to the posterior process when viewed from the ventral side. From a posterior view, however, the posterior process is somewhat compressed anteroposteriorly and strongly attenuated toward the distal end. The length of this process is at least 95 mm. in contrast to 75 mm. for that of *M. durinasus.*

In addition to the resemblances observed in the posterior process, the right periotic of *Metopocetus durinasus* appears to approach *Mesocetus longirostris* in other characters as well. The *pars cochlearis* (pl. 48, fig. 3) of this Calvert cetothere is distinctly compressed in a dorsoventral direction and its ventral surface although convex is much less inflated than the same portion of the periotic of *Parietobalaena palmeri* (Kellogg, 1924, pl. 5, figs. 1–4). In this structural modification the periotic of *M. durinasus* seems to agree more closely with the periotic of *Mesocetus longirostris* than with those of other Belgian species.

The anterior process of *M. durinasus* is strongly compressed from side to side; the *pars labyrinthica* is rounded and nodular. From a ventral or tympanic view, the *fenestra ovalis* is concealed by the overhanging external face of the *pars cochlearis.* The shallow concavity for the reception of the head of the malleus is relatively large and is located between the fused base of the anterior pedicle of the bulla on the anterior process and the epitympanic opening of the Fallopian aqueduct.

Below the inward projecting wide but thin continuous rim of the circular internal acoustic meatus and the orifice of the Fallopian aqueduct, the cerebral face of the *pars labyrinthica* (pl. 48, fig. 4) is deeply depressed or excavated. This overhanging rim projects inward as much as 12 mm. beyond the very small orifice of the vestibular aqueduct and almost at a right angle to the cerebral face of the *pars labyrinthica.* The orifice of the cochlear aqueduct is actually slightly larger than the orifice of the vestibular aqueduct which opens into an unusually short slitlike depression.

The *fenestra rotunda* is almost as large as the internal acoustic meatus. A broad but short concave surface commencing above the posterior rim of the stapedial fossa and above the projecting shelf behind the *fenestra rotunda* extends across the posterior face of the *pars cochlearis* to the inner cerebral surface of the periotic. Van Beneden did not illustrate the internal cerebral face of the periotic of *Mesocetus longirostris.*

Measurements (in mm.) of periotic of *M. durinasus* (USNM 8518) and *M. longirostris* (Van Beneden, 1886, pl. 36; fig. 4–5, MNHB 1539) are as follows:

	USNM 8518, Type, Right	*MNHB 1539, Left*
Tip of anterior process to tip of posterior process	135	145
Epitympanic orifice of Fallopian aqueduct to tip of anterior process	51	48.3
Fenestra rotunda to tip of anterior process	59	61.8
Fenestra rotunda to tip of posterior process	89	103.3
Tympanic face of *pars cochlearis* to dorsal face of *pars labyrinthica*	44	46.5
External face of *pars labyrinthica* to cerebral face of *pars cochlearis* below internal acoustic meatus	32	36.5
Greatest length ventral face of *pars cochlearis*	41	—

Auditory Ossicles

Malleus.—The anteroposteriorly compressed slender stalk like anterior process is broken off above its point of ankylosis with the body of the right malleus. The two facets on the head of the malleus (USNM 8518; pl. 48, fig. 5) that articulate with the incus have the same shape and a similar position as the corresponding facets of *Balaenoptera borealis.* The nearly vertical hemicircular facet is above and separated by a groove from the somewhat horizontal smaller facet. At the internal end of the *processus muscularis* the manubrium is a short blunt nosed tubercle to which the ligamentary process of the tympanic membrane presumably was attached. The small, deep, circular pit on the anterior face near the internal end of the head of the malleus is situated in the usual area of attachment of the tensor tympani tendon. The head of this right malleus measures 15.5 mm. in length and 10.5 mm. in width. This malleus is not only larger than USNM 15575, but the internal end of the head is blunted and not attenuated.

Incus.—Two distinct facets on the body of the incus (USNM 8518) articulate with corresponding surfaces on the malleus, the largest of which (pl. 48, fig. 1) is shallowly concave, subcrescentic in outline and occupies the base of the body; it is separated from the smaller and more deeply concave facet on the internal side by a sharp-edged crest. The body of this right incus is rather bulbous in contrast to the short, bent outward *crus longum,* which has on the external face of its apex an ovoidal facet for articulation with the head of the stapes. The short *crus breve* is conical; its attenuated apical end rests in the minute *fossa incudis.* From the apex of the *crus longum* to the base of the body, the incus measures 9.5 mm., and the greatest diameter of the base is 6.3 mm.

Stapes.—The right stapes (USNM 8518; pl. 48, fig. 2) of this Calvert cetothere resembles rather closely the same inner ear bone of *Balaenoptera acutorostrata* (Doran, 1878, pl. 62, fig. 31). The intercrural aperture is small and connects the ovoidal concavities of the opposite sides. The footplate is closely fitted to the circumference of the *fenestra ovalis* and apparently permitted none or very limited side to side movement when in position. Nevertheless, only two of the 27 Calvert periotics examined retained the stapes in its normal position; it had been dislodged from the *fenestra ovalis* and lost on 24. A small scar on the posterointernal angle, which presumably marks the area of attachment of the tendon of the stapedial muscle, is less protuberant than in *B. acutorostrata*. The facet on the head of the stapes serves as the contact with the corresponding facet on the *crus longum* of the incus. The greatest length of this right stapes is 7.3 mm., and the greatest diameter of its footplate is 5 mm.

Vertebra

ATLAS.—"From the same locality and collection as the type skull" Case (1904, pl. 18, figs. 2a, 2b) figures a slightly eroded atlas (USNM 8518) whose dimensions correspond fairly closely to the greatest distance between the outside margins of the occipital condyles (150 mm.). The greatest distance between the outside margins of the anterior articlar facets of this atlas is 166 mm., and the dorsoventral diameter of the right articular facet is 107 mm. The dimensions of this atlas are similar to those of *Mesocetus longirostris* (Van Beneden, 1886, p. 47), except that it appears to be thinner, though this may possibly be the result of erosion on the posterior articular facets.

During the 70 years that have elapsed since the description of this type specimen, no other specimen that even remotely resembles this type of cranial architecture has either been added to the national collections or has been recognized among the many portions of skulls submitted for identification by local collectors. The construction of the skull and the peculiarities of the periotic, however, suggest a rather close affinity if not identity with the genus *Mesocetus*.

SIPHONOCETUS Cope

Siphonocetus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 140.

Type Species: *Balaena prisca* Leidy.

Diagnosis: Alveolar groove and dental [mandibular] canal distinct; alveolar groove roofed over and perforate. During the sequential developmental history of the mysticete mandible, failure of teeth to develop, according to Cope (1895a, p. 139), "would be accompanied by the loss of the interalveolar walls or septa, leaving the dental [alveolar] groove continuous and separate from the dental [mandibular] canal."

By having the alveolar "groove roofed over and distinct from the dental canal" this genus according to Cope represents a transitional stage following the loss of teeth and elimination of the intervening osseous septa between alveoli which would leave a continuous open groove separate from the dental (mandibular) canal. The genus *Siphonocetus* thus reputably had the dental (alveolar) groove "roofed over by the ossification of the gum and distinct from the dental [mandibular] canal." Gingival passages and foramina were present.

Winge (1909, p. 25; True, 1912, pp. 5–6) was certain "that Cope's interpretation of the canals in the lower jaw is incorrect," and pointed out that the furrow on the dorsal face of the mandible in which the fetal rudimentary teeth are lodged is closed, as in the adult finback, by growth of bony tissue. Furthermore, the mandibular canal through which the mandibular branch of the trigeminal nerve and associated blood vessels extend forward, is here described as being divided into an upper and lower passage or aqueduct in contrast to its usual undivided condition. From the upper aqueduct (the alveolar groove of Cope) branch channels on each side lead to the internal nutrient or gingival foramina and the external mental foramina.

Several Calvert cetothere mandibles had been broken transversely prior to excavation. Critical examination of these cross sections revealed that the position of the internal longitudinal mandibular canal as well as the distribution of the aqueducts leading to the external mental and the internal nutrient foramina correspond to the general arrangement in the Recent balaenopterine mandible. Ten interior dental arteries (branches of the mandibular artery) and their accompanying veins as well as multiple nerves were observed by Walmsley (1938, p. 143, fig. 35) in the mandibular canal of an adult finback (*Balaenoptera physalus*) cut transversely at about half way of its length.

SIPHONOCETUS PRISCUS Leidy

Balaena prisca Leidy, 1852, Proc. Acad. Nat. Sci. Philadelphia, vol. 5, no. 12, p. 308. (Preoccupied by *Balaena prisca* Nilsson, 1847, Skandinavisk Fauna, Lund, ed. 1, vol. 1 (Daggdjuren), p. 643. Fossil Fenhval. Type locality, sand near Ystad, Sweden, in 1722. Skull, atlas, dorsal vertebra and scapula.)

Balaenoptera prisca Cope, 1868b, Proc. Acad. Nat. Sci. Philadelphia, vol. 19, no. 4, pp. 144, 147.

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

Cetotherium priscum Cope, 1890, American Nat., vol. 24, no. 283, p. 616. (Not, *Cetotherium priscum* Brandt, 1842, Bull. Acad. Imp. Sci. St. Petersburg cl. phys.-math., vol. 1, nos. 10–12, p. 148.)

Siphonocetus priscus Cope, 1895a, Proc. American Philos. Soc. Philadelphia, vol. 34, no. 147, pp. 140, 141, 151, pl. 6, fig. 3.

Type Specimen: ANSP 12915. Fragment near middle of left mandible, presented by Robert H. Nash.

Type Locality: Westmoreland County, Virginia, Miocene.

Diagnosis: On October 21, 1851, two vertebrae and a piece of a mandible of a fossil cetacean [=*Balaena prisca* Leidy] as well as two vertebrae and two teeth of a saurian [=*Crocodilus antiquus* Leidy] from Westmoreland County, Virginia, were listed among the recent accessions to the Academy of Natural Sciences of Philadelphia as having been presented by Robert H. Nash (Proc. Acad. Nat. Sci. Philadelphia, vol. 5, 1851, p. 298). The fragment of the left mandible and a rather large caudal vertebra, which obviously did not belong to such a small setothere, formed

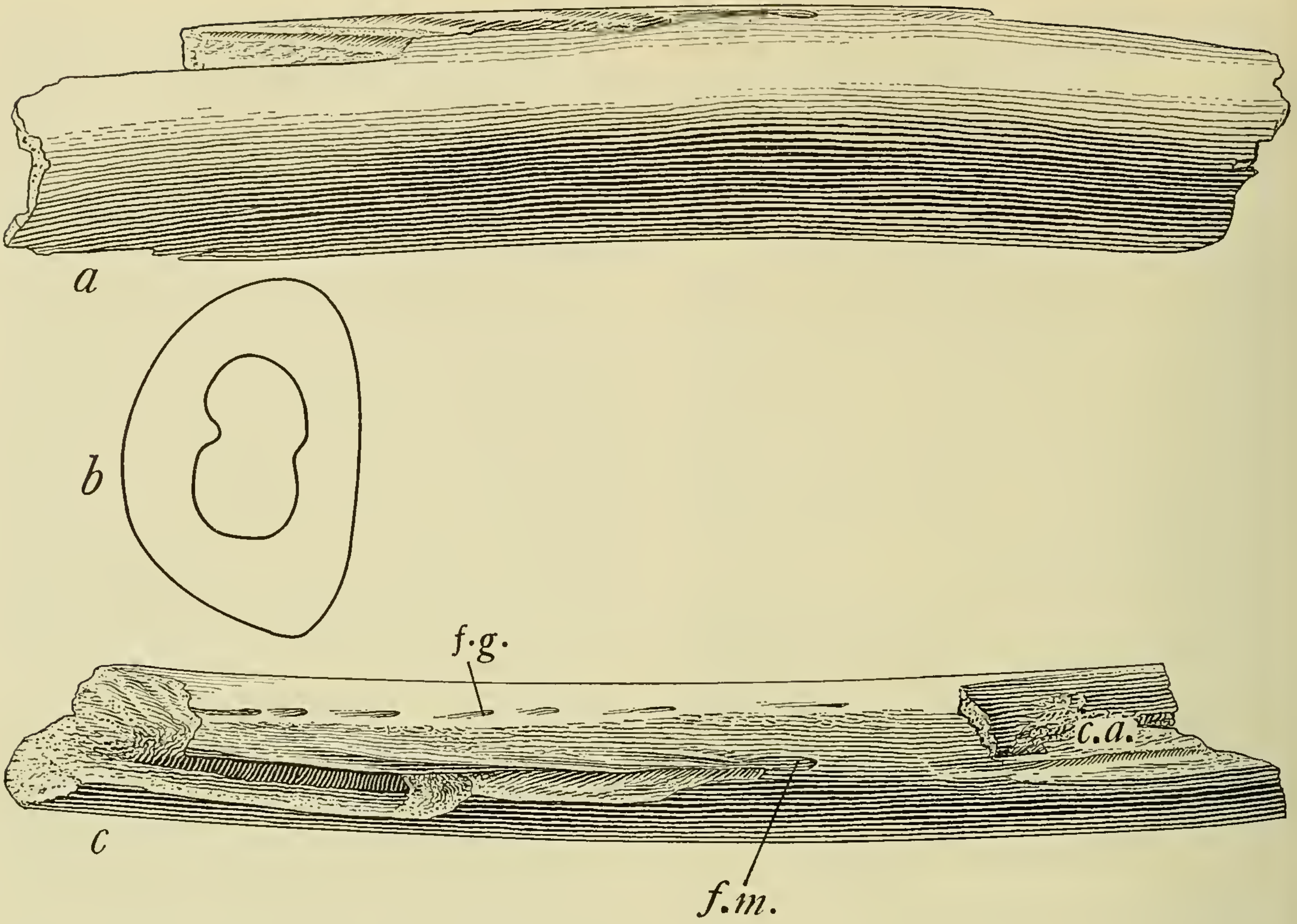

FIGURE 52.—Left mandible (type), ANSP 12915, of *Siphonocetus priscus* (Leidy): *a*, external view; *b*, cross section; *c*, dorsal view. Abbrs.: c.a., alveolar or mandibular canal; f.g., alveolar or gingival foramen; f.m., mental foramen.

the basis for Leidy's *Balaena prisca.* Leidy apparently did not originally publish precise measurements of the mandibular fragment (fig. 52) as will be noted from the appended measurements, but merely states that its length was 14 inches, vertical diameter 3 inches, and transverse diameter 2 inches. Subsequently, Leidy (1869, p. 442) published the following measurements of this mandibular fragment: Depth posteriorly, 34 lines [=71.9 mm.], anteriorly, 34 lines [=71.9 mm.]; thickness posteriorly, 24 lines [=50.8 mm.], anteriorly, 22 lines [=46.5 mm.]. Confirmatory measurements of the type mandible (ANSP 12915) are as follows: Maximum length, 375 mm.; vertical diameter at level of anterior mental foramen, 72 mm.; maximum transverse diameter at same point, 45.5; maximum vertical diameter 175 mm. behind anteriormost mental foramen, 72.5 mm.; maximum transverse diameter at same point, 50 mm. Six small internal nutrient (gingival) foramina in an interval of 190 mm.; five external mental foramina in an interval of 170 mm.

Cope (1869, p. 10), the same year, however, characterized the type mandible as follows: "upper edge broad, with outer series of foramina, and meeting inner edge at a right angle, which is the highest line, and with inner series of foramina just below it; most convex externally; large."

A label in the handwriting of Cope, now attached to this type mandible fragment, reads as follows: "*Siphonocetus priscus, Balaena prisca* Leidy. Neocene. City Point, Va. Rich'd Eppes, M.D." It is quite likely that this label was written in 1895. In that year Cope (1895a, p. 151) wrote that "Dr. Eppes discovered in the year 1854 the specimen which became the type of the *S. priscus* of Leidy." Cope obviously was mistaken both as to the date of collection and the collector, and also the locality, and some way confused the two mandibles that Leidy described at the meeting of the Academy of Natural Sciences of Philadelphia held on November 11, 1851. At that time, Leidy described *Balaena prisca* and *Balaena palaeatlantica.* The type of *Balaena palaeatlantica* was collected in 1851 by Dr. Richard Eppes on the south bank of the James River near City Point, Prince George County, Virginia, and presented by him to Professor W. E. Horner.

Cope (1895a, p. 140) made *Balaena prisca* the genotype of his new genus *Siphonocetus* which, with some other species, he established in part on theoretical grounds to meet with his interpretation of the relationships of the dental (mandibular) canal and the alveolar groove in different mandibles of fossil mysticetes. Cope (1895a, p. 139) considered that in the course of evolutionary development, after the lower teeth were lost, the alveolar septa were absorbed, leaving a continuous alveolar groove separated from the dental (mandibular) canal. He believed that in some instances this alveolar groove remained distinct from the dental canal and was roofed over by bone, while in others it united with the dental canal, and that this composite "gingivodental" canal was completely or partially roofed over by bone in some forms, but left open in others.

Those fossil mysticetes that have mandibles in which the alveolar groove and dental canal remained distinct or separate, but with the dorsal alveolar groove roofed over and perforated, Cope called *Siphonocetus.* Those in which the alveolar groove and dental canal were united into one gingivodental canal which was partially roofed over and with gingival passages and foramina on one side, he called *Tretulias,* while those which had the composite gingivodental canal open and no gingival passages, he called *Ulias.* Cope characterized the genus *Cetotherium* Brandt as having the alveolar groove and the dental canal combined and the resulting single gingivodental canal completely roofed over and perforated.

In summary the generic criteria proposed by Cope for the characterization of the genus *Siphonocetus,* which were based largely on theoretical considerations, have not been confirmed by examination of a number of Calvert mandibles of comparable dimensions and shape and are now regarded as erroneous and invalid. The asserted division of the mandibular canal into an upper and lower passageway by the intervening bone does not distinguish the type mandible of *Balaena prisca,* the type species of *Siphonocetus,* from that of *Cetotherium rathkii,* the type species of that genus. Furthermore, *Balaena prisca* Leidy, 1852, is antedated by *Balaena prisca* Nilsson, 1847. Leidy's type mandibular fragment has not been proven distinguishable from mandibles of other Calvert cetotheres and is, therefore, unidentifiable. In the absence of a recognizable osteological basis, the generic name *Siphonocetus* will not be employed in this review.

Caudal Vertebra

The caudal vertebra, which Leidy originally described as found associated with the mandibular fragment, and which he regarded as belonging to the same species, appears to be far too large as compared with the dimensions of the mandible to be referable to the same mysticete. As it is without the neural spine, and has never been illustrated, this caudal hardly merits further consideration. Leidy's measurements (1869, p. 442) of this caudal vertebra were as follows: Length of centrum, inferiorly, 67 lines [=141.77 mm.], superiorly, 67 lines [=141.77 mm.]; length of centrum, laterally, 77 lines [=163 mm.], in the axis, 82 lines [=173.5 mm.]; breadth of anterior articular end, 77 lines [=163 mm.]; depth of anterior articular end, 74 lines [=156.6 mm.]; breadth of posterior articular end, 78 lines [=165 mm.]; depth of posterior articular end, 74 lines [=156.6 mm.]; breadth of neural arch, 42 lines [=88.9 mm.]; and breadth of transverse process, 48 lines [=101.5 mm.].

Leidy's description (1869, p. 442) of this vertebra is as follows:

> "The caudal vertebra, from the anterior part of the series, is slightly longer than the breadth, and its articular extremities are near circular and convex. The posterior abutments of the chevrons extend nearly half the length of the body. The transverse processes projected from near the middle of the latter about an inch and three-fourths back of the edge of the anterior articulation. The spinal canal is narrow, not more than seven lines in width."

This very enticing theory, however, seems to be altogether erroneous. In all the mandibles examined the dental canal extends through the middle of the mandibular ramus as in other mammals, but gives off a complex series of branches to the dorsal portion of the ramus on both sides, the branches running obliquely forward and upward, and those of the inner side being generally much smaller than the outer ones. This arrangement may be likened to a trailing plant whose main stem or root (viz: *Cynodon,* Bermuda grass) runs horizontally a little below the surface of the ground, and sends out branches which extend upward and forward, and penetrate the surface at intervals. When studying broken fragments of mandibles one might readily be deceived into believing that the two superimposed passages or aqueducts which are visible at the end of a fragment are the openings of two separate canals (dorsal and ventral) running in a parallel line inside the mandible. In reality, however, the dorsal one is the broken end of a branch which united with the true dental canal at a point farther back. Looking carefully into such a fragment when the foramina are all free of matrix, one can see the various smaller branches extending out from the dental canal on both sides, and when a fragment of a mandible is broken off vertically their upward course can be traced with certainty. Examination of the broken ends of ten mandibles from the Calvert formation of comparable dimensions, as well as three that are split lengthwise confirms this explanation. It is true that in Recent right whales (Balaenidae) generally a groove or channel more or less deep will be observed on the dorsal surface of the mandible, but this is not to be confounded with the dental (mandibular) canal which is situated lengthwise as usual within the mandible.

Winge (1909, pp. 25–26) voiced his dissent from Cope's interpretation of the canals, but he seems inclined to accept the statement that the dental canal may be divided into an upper and lower passageway or aqueduct by a bony partition. He calls attention to the fact that Brandt's illustration (1873, pl. 1, fig. 9) of the type mandible of *Cetotherium rathkii* exhibits what appears to be this peculiarity, and remarks that the establishment of the new genus *Siphonocetus* was, therefore, unnecessary. If this division of the dental canal actually occurs, which seems improbable, this would not suffice to distinguish *Siphonocetus* from *Cetotherium*, and unless other characters can be found the genus has no validity. The mandibles that have been assigned by Cope to *Siphonocetus*, *S. pusillus*, *S. expansus*, and *S. priscus*, do not differ from one another in other acceptable diagnostic structural details. Hence the validity of the smaller species assigned to *Siphonocetus* by Cope, which were thought to be distinguishable among themselves on the basis of mandibular fragments chiefly by the number and arrangement of the gingival foramina on the inside of the upper margin of the mandibular ramus, has not as yet been confirmed by the acquisition of more complete mandibles. Although no detailed studies of the extent of individual variation in this respect have been made, it is questionable how far this character is reliable as a criterion of species. At present, however, about the only means of distinguishing the mandibles is size, since the greater or less convexity of the sides, though it may be of importance, is very difficult to appraise, as it varies considerably along the ramus from the anterior to the posterior end. The internal gingival foramina are in a single row and quite close to the dorsal margin of the mandible, and the external mental foramina rather more distant from that margin.

TRETULIAS Cope

Tretulias Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 143.

Type Species: *Tretulias buccatus* Cope.

Diagnosis: This genus was characterized by Cope as follows: "Dental canal obliterated, and dental groove without osseous roof. Gingival canals and foramina present at one side of the alveolar groove." *Tretulias*, like *Ulias*, was considered by Cope (1895a, p. 139) to have the dental (alveolar) groove fused with the dental (mandibular) canal, though the former retained the gingival passages and foramina.

TRETULIAS BUCCATUS Cope

Tretulias buccatus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 143.

Type Specimen: Cope based this genus and species on two fragments of mandibles, one "in fairly good preservation," and the other shorter and considerably worn. The last mentioned shorter specimen has not since been located. The longer specimen is part of a strongly weathered left mandible, length, 595 mm.; mandibular canal exposed on its entire length by erosion or disintegration of dorsal border of ramus; nine recognizable unusually broad (2–4 mm.) exposed gingival canals originating from mandibular canal and located on dorsointernal border of outwardly bowed ramus are directed forward. No. 9345, Division of Vertebrate Paleontology, United States National Museum (deposited by Maryland Geological Survey). Collector not known.

Type Locality: No definite locality recorded.

Diagnosis: According to Cope's interpretation, the mandibular canal has been obliterated and an open alveolar or gingivodental groove was not covered by a bony roof. Gingival foramina and their anteriorly directed horizontal grooves are present on the internal border of the ramus along the alveolar groove. Cope thought it possible that either the roof of the gingival groove failed to develop external to the gingival foramina or the roof was developed only above the gingival foramina, leaving the remainder of the gingival groove open. The external series of canals mentioned by Cope are not now recognizable on the type mandible.

Winge (1909, p. 27; True, 1912, pp. 6–7) has observed that Cope's interpretation cannot be correct and that his alveolar groove is unquestionably the mandibular canal. Breakage or erosion of the dorsal border of this type mandibular fragment has exposed the mandibular canal on its entire length. This canal is at least 23 mm. wide near the posterior broken off end and not more than 7 mm. at the anterior end of this fragment. The narrowing of this canal anteriorly and its greater width posteriorly indicate that this type fragment represents a section immediately anterior to the middle of the length of the complete mandible. Preservation of the gingival foramina and grooves may be attributed to uneven wear of the dorsal border of the ramus and this erosion was less effective in reducing the internal than the external wall of the mandibular canal. A longitudinal fissure or crack developed above the ventrointernal margin of this mandible was regarded as the Meckelian fissure by Cope and as an artificial crack by Winge (1909, pp. 28–29; True, 1912, pp. 7–8).

The ventral surface of this type mandibular fragment has also been eroded and, consequently, the vertical diameter of the ramus in this region when complete is uncertain.

The maximum transverse diameter at the posterior end is 75 mm. and 43 mm. near the anterior end. It seems obvious, however, that this section was part of a more robust or physically mature mandible than the type of *Ulias moratus*. The general conditions responsible for the weathered condition of this type specimen seem to have been similar to those for *U. moratus*. Whatever deterioration ensued during subsequent storage in the collections of the Maryland Geological Survey at The Johns Hopkins University, Baltimore, Maryland, was certainly of a minor nature. Both Winge and True regarded the validity of Cope's generic diagnosis as doubtful.

The type of *Tretulias buccatus* is a portion of a left mandible anterior to the middle of its length which is not distinguishable either in dimensions or in conformation from mandibles of comparable size of at least two Calvert cetotheres. Since this eroded type specimen lacks recognizable differential features, it is not identifiable and should be eliminated from the Calvert faunal list.

ULIAS Cope

Ulias Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 141.

Type Species: *Ulias moratus* Cope.

Diagnosis: This genus was characterized by Cope as follows: "Mandible with the gingivodental canal open throughout most if its length, closed only near its apex. Gingival foramina represented by a few orifices on the alveolar border near the distal extremity."

The mandible of *Ulias* was thus considered by Cope (1895a, p. 139) to represent a further degeneration from the condition attributed to *Siphonocetus* whereby the dental (alveolar) groove and the dental (mandibular) canal became united although the dental groove remained open. As a result of erosion, the few supposedly "gingival" foramina on the dorsal border near the distal end were misinterpreted inasmuch as they are unquestionably grooves or channels leading to external mental foramina in locations corresponding to those on the mandibles of USNM 23494.

ULIAS MORATUS Cope

Ulias moratus Cope, 1895a, Proc. American Philos. Soc., Philadelphia, vol. 34, no. 147, p. 141.

Type Specimen: USNM 10595. Right mandible, length along external curvature, 1645 mm.; dorsal border of the ramus is broken or worn off, exposing for a considerable portion of its length the wide open bottom of the mandibular canal; a section 230 mm. in length anterior to the level of the coronoid process is filled in by a hard cemented sandy marl matrix. Apparently the piece from the distal third of this ramus which was mislaid when Cope established the species, was subsequently located and attached correctly to the adjacent portions of the mandible. The measurements of the type mandible published by Cope (1895a, p. 143) should be disregarded. The type mandible has been illustrated by Case (1904, pl. 24, fig. 1a, 1b). Deposited by the Maryland Geological Survey in Division of Vertebrate Paleontology, United States National Museum; Collector not known.

Type Locality: No definite locality recorded.

Diagnosis: Cope (1895a, pp. 141–142) believed that this genus at maturity retained characters which are present in fetal right whales (Balaenidae) and asserted that the type mandible was characterized by these features: Gingivodental canal open throughout most of its length, closed near apex. Gingival foramina represented by a few orifices on the alveolar border near the distal extremity. Alveolar groove is continuous with the dental canal, and is permanently open. Long series of mental foramina characteristic of the true whales absent; terminal mental foramen at distal end of ramus retained.

True (1912, p. 5) correctly stated that no internal gingival canals were visible. At least three of the anteriormost external mental foramina and the grooves leading forward therefrom were not completely obliterated by erosion.

Examination of the type mandible alongside other Calvert cetothere mandibles clearly demonstrates that most of the mental foramina and their anteriorly directed external grooves, as well as the internal nutrient or gingival foramina, when the mandible was complete, were located on the missing dorsal border above the level of the preserved ventral portion.

Winge (1909, pp. 26–27; True, 1912, p. 6) commented that "Cope's interpretation is certainly not correct," and correctly concluded that the asserted lack of mental foramina raised reasonable doubts as regards the undamaged condition of the type mandible.

This weathered type mandible (Case, 1904, pl. 24, figs. 1a, 1b) presumably was submerged under water for some time; it agrees in general preservation with other portions of cetothere mandibles recovered from exposures along the lower portion of the Patuxent River, which have the mandibular canal filled with an indurated sandy matrix.

Neither Winge nor True were afforded an opportunity to actually handle this type mandible which, at the time their articles were published, apparently, was not readily accessible in the stored collections of the Maryland Geological Survey at The Johns Hopkins University, Baltimore, Maryland.

Additional measurements (in mm.) are as follows: Transverse diameter of ramus 100 mm. behind anterior end, 38; 300 mm. behind, 48; 400 mm. behind, 53; 700 mm. behind, 55; 900 mm. behind, 56; and 1200 mm. behind, 57.

Cope (1896, p. 141) suggested that the mandible on which the genus *Ulias* was founded might belong to either the genus *Metopocetus* or *Cephalotropis*, although there was no direct evidence to support this assumption. The length (1645 mm.) of the type mandible of *Ulias moratus* is almost the same as that of *Mesocetus pinguis* (1642 mm.). If Cope's view of the internal structure of the mandible of *Ulias* should be proven correct, which does not seem likely, no comparisons would be necessary, as this type mandible was supposed to have a deep dorsal conjoined dental (mandibular) canal and alveolar groove, entirely open above, while the mandible of *Mesocetus* is roofed over above the mandibular canal as in other cetotheres. Cope's interpretation of the *Ulias* mandible is unquestionably erroneous, as already mentioned, but at present the allocation of this type mandible to any contemporary species involves a certain amount of uncertainty. If roofed over, as it was undoubtedly in life, its vertical diameter at the distal end would be approximately the same as the mandible of *Mesocetus longirostris* (90 mm.), but much less than the same measurement of the type mandible of *M. pinguis* (123 mm.); otherwise, it is not feasible to make any precise comparisons. It seems certain, nevertheless, that *Ulias* represents some form of cetothere rather than a right whale allied to *Balaena*, in view of the transversely flattened anterior extremity and the presence there of a lower internal ledge. The shape of the entrance to the mandibular canal and the convexity of the outer wall of the mandible in this region are not materially different from mandibles of other Calvert mysticetes.

Both Winge and True regarded the validity of Cope's generic diagnosis as doubtful. The missing dorsal border above the mandibular canal on the entire length of the ramus most certainly contributed to this misleading generic diagnosis. The loss of the coronoid process and more especially the articular surface of the condyle and the ventral angle, in addition to the destroyed dorsal border of the ramus, render direct comparisons with other mandibles of comparable size useless. Nevertheless, in length and general form the type right mandible of *Ulias moratus* does not appear to have exhibited, when complete, appreciable differences from a Calvert formation right mandible (USNM 16760; length, 1650 mm.). This fossil mysticete mandible is not identifiable and hence *Ulias moratus* should be removed from the Calvert faunal list.

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6. A Hitherto Unrecognized Calvert Cetothere

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

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

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

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

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

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

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

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

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

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

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

DIOROCETUS, new genus[1]

Type Species: *Diorocetus hiatus*, new species.

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

DIOROCETUS HIATUS, new species

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

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

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

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

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

Skull

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

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

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

In the left maxillary of the detached rostrum (USNM 16871), one very large incisure (length, 142 mm.; depth 65 mm.) terminates externally about 47 mm. from the outer edge of this bone. Behind this incisure there are three

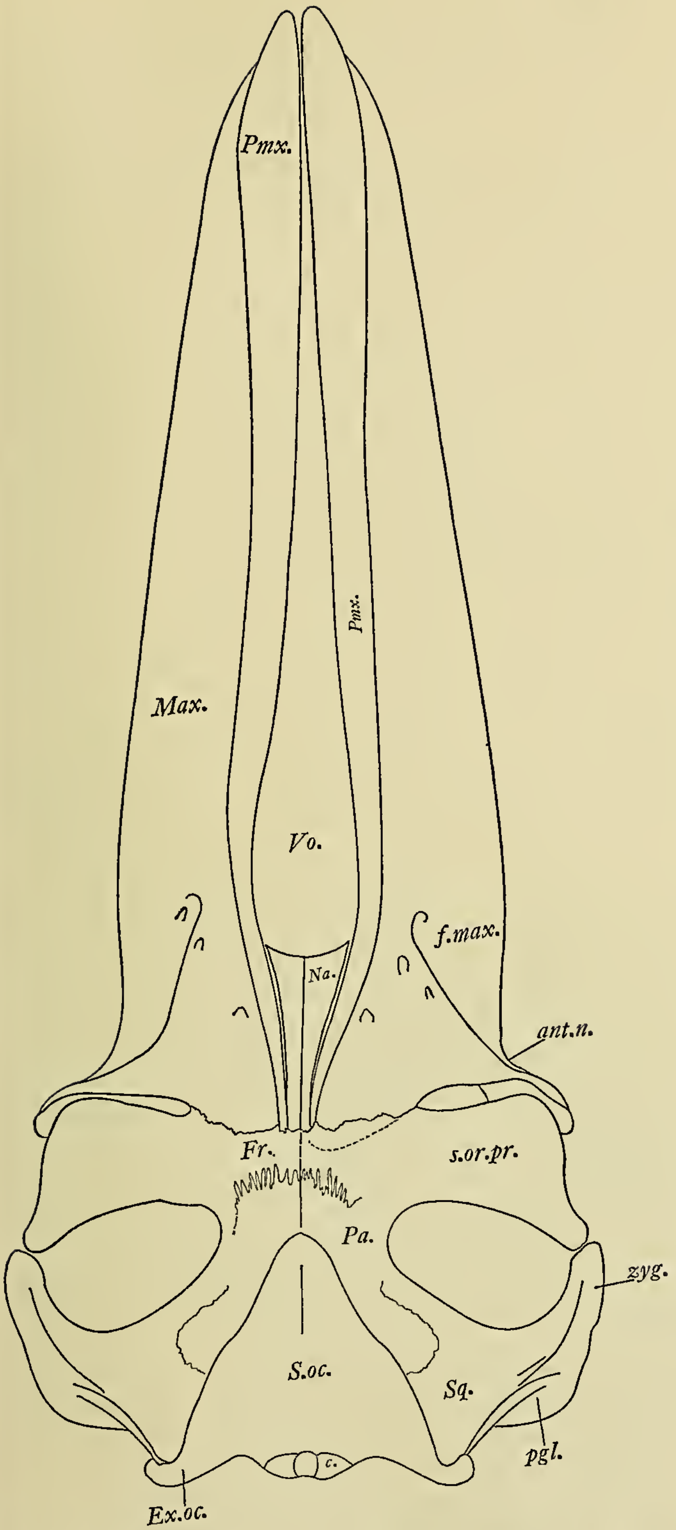

Figure 53.—Dorsal view of skull, USNM 16783, of *Diorocetus hiatus*, with left side of cranium restored. Abbrs.: ant.n., antorbital notch; Bo., basioccipital; c., occipital condyle; Ex.oc., exoccipital; f.m., foramen magnum; f.max., maxillary foramen or incisure; f.ov., foramen ovale; Fr., frontal; h.pt.,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

small foramina, and one in front of it. Most of the right incisure was destroyed when the posterior end of this maxillary broke off; this incisure terminates 52 mm. inside of the outer edge of this bone. Four smaller foramina are located anterior to the incisure.

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

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

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

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

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

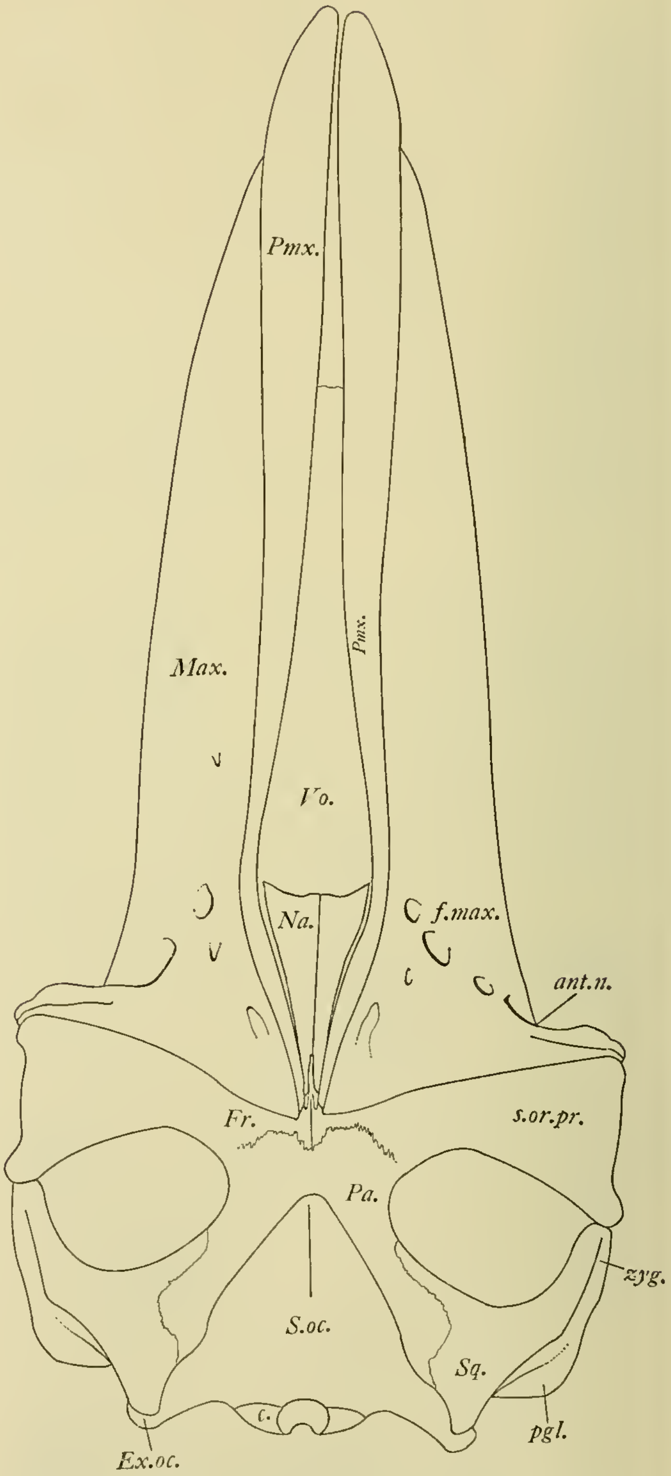

Figure 54.—Dorsal view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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

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

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

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

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

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

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

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

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

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

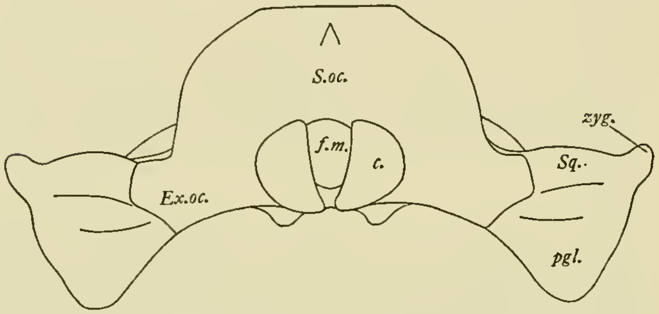

Figure 55.—Posterior view of skull, USNM 16783, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The inner edges of the opposite maxillaries diverge on the ventral surface of the rostrum 510 mm. behind the distal end of the right maxillary, which terminates 1200 mm. anterior to the posterior end of the vomer. The distance on the type skull from the anterior end of the right maxillary to the anterior edge of the optic canal at its point of origin is 1050 mm.

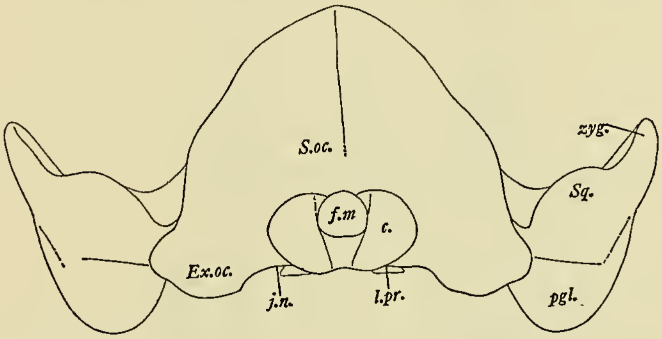

Figure 56.—Posterior view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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

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

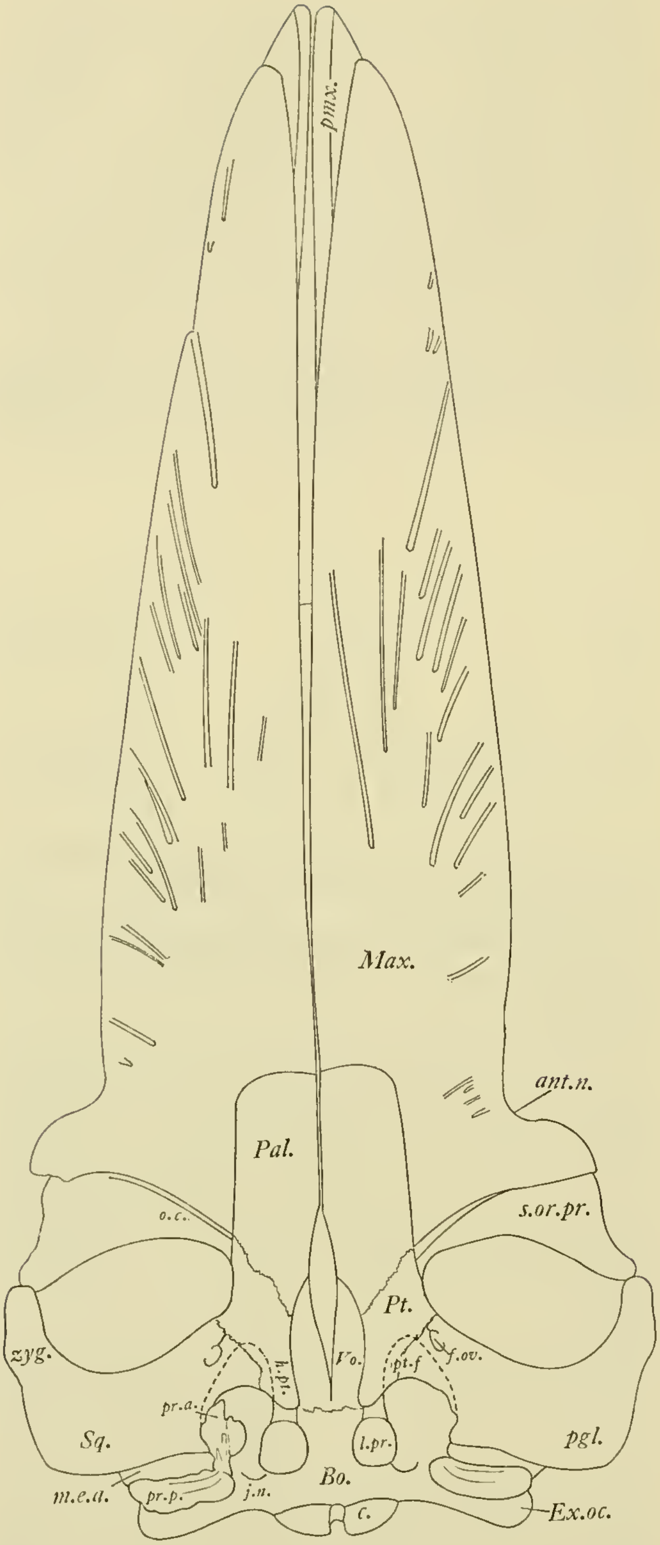

Figure 57.—Ventral view of skull, USNM 16783, of *Diorocetus hiatus*, with left side of cranium and hamular processes of pterygoid restored. For abbreviations, see figure 53.

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

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

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

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

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

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

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

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

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

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

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

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

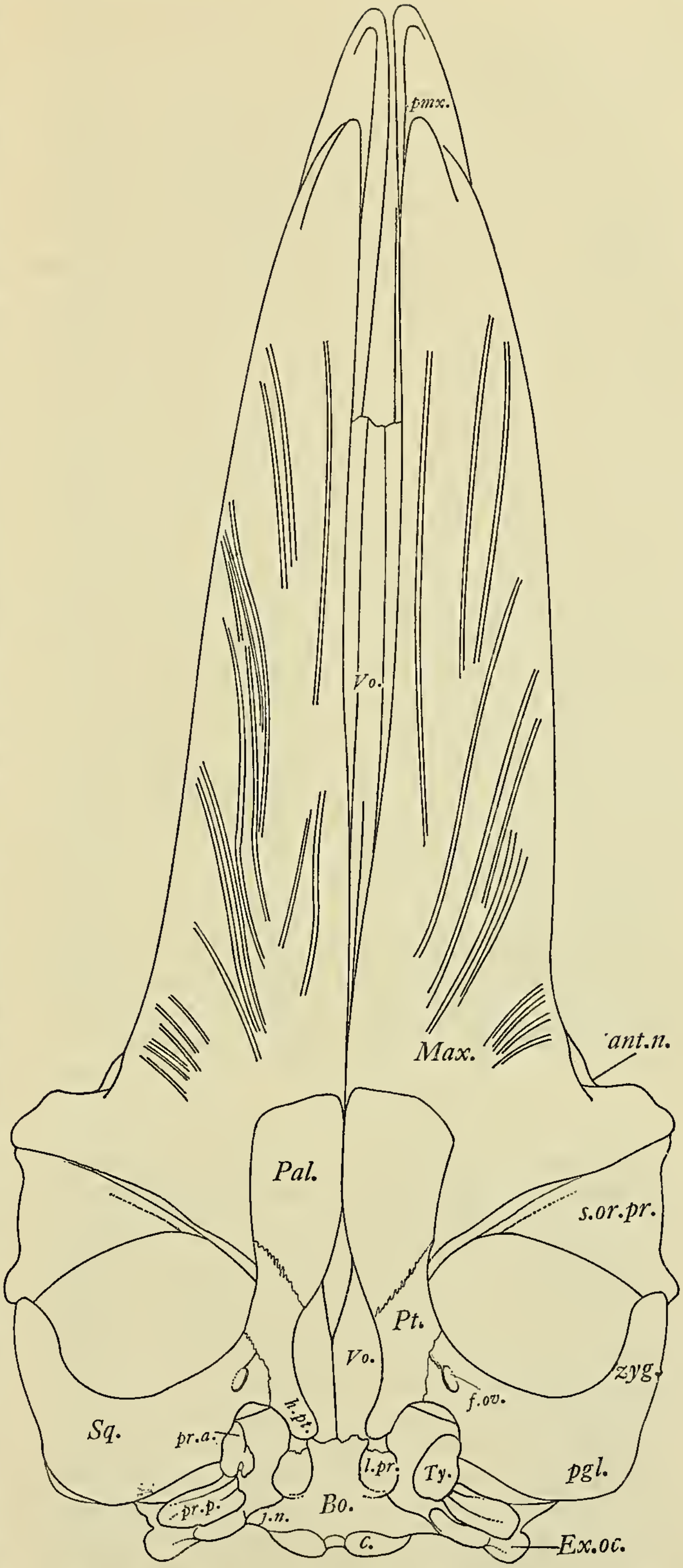

FIGURE 58.—Ventral view of skull, USNM 23494, of *Diorocetus hiatus*. For abbreviations, see figure 53.

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

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

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

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

Tympanic Bulla

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

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

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

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

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

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

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

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

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

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

Periotic

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

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

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

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

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

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

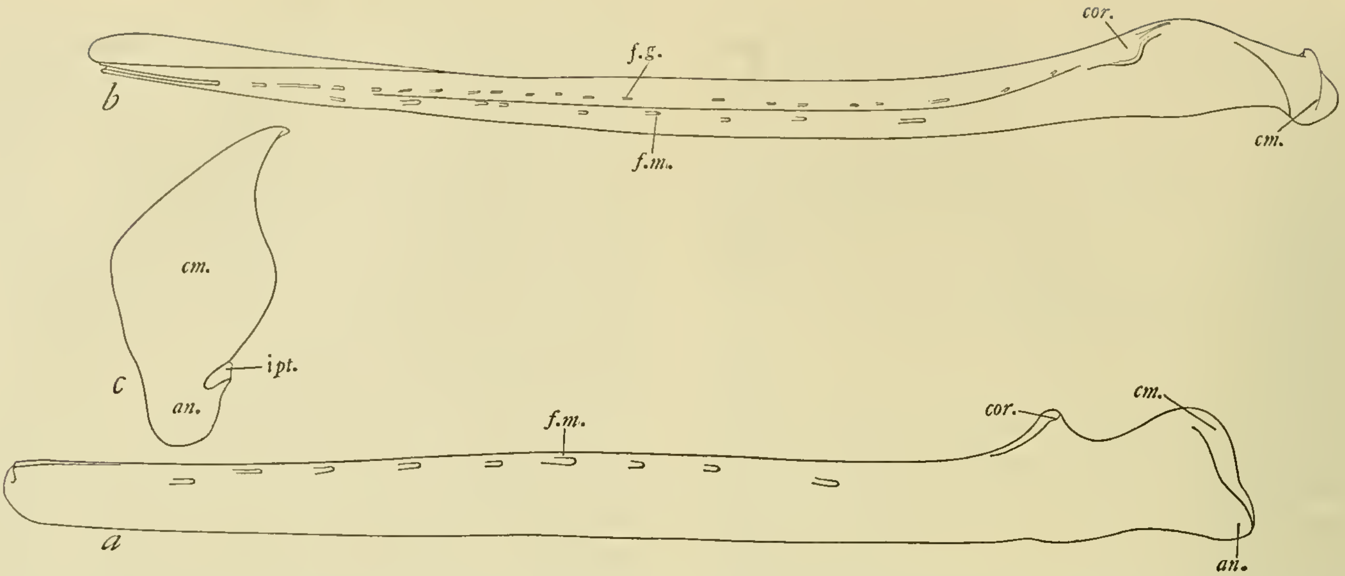

FIGURE 59.—Views of left mandible, USNM 23494, of *Diorocetus hiatus: a*, external view; *b*, dorsal view; *c*, condyle. Abbrs.: an., angle; cm., condyle of mandible; cor., coronoid process; f.g., gingival or alveolar foramen; f.m., mental foramen; ipt., groove for attachment of internal pterygoid muscle.

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

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

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

Mandibles

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

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

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

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

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

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

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

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

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

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

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

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

Vertebrae

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

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

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

estimated length (270 mm.; 10½ inches) of the seven consecutive cervical vertebrae is based on vertebrae of comparable size of several individuals from the Calvert formation of Maryland.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

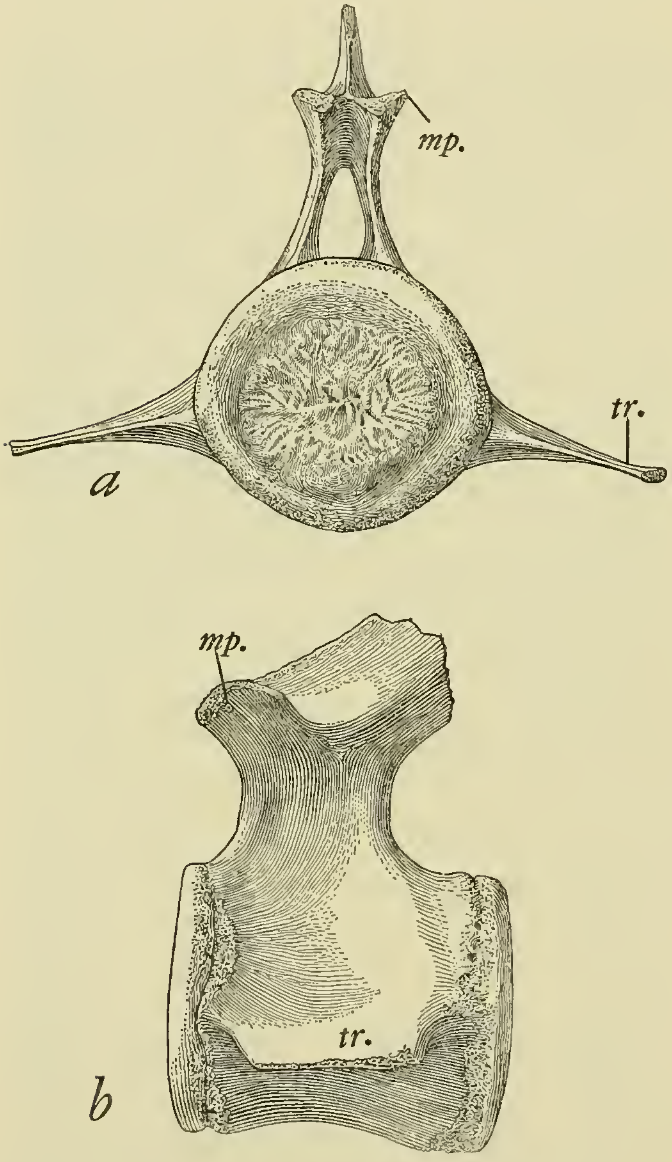

Figure 60.—Views of second caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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

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

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

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

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

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

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

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

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

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

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

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

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

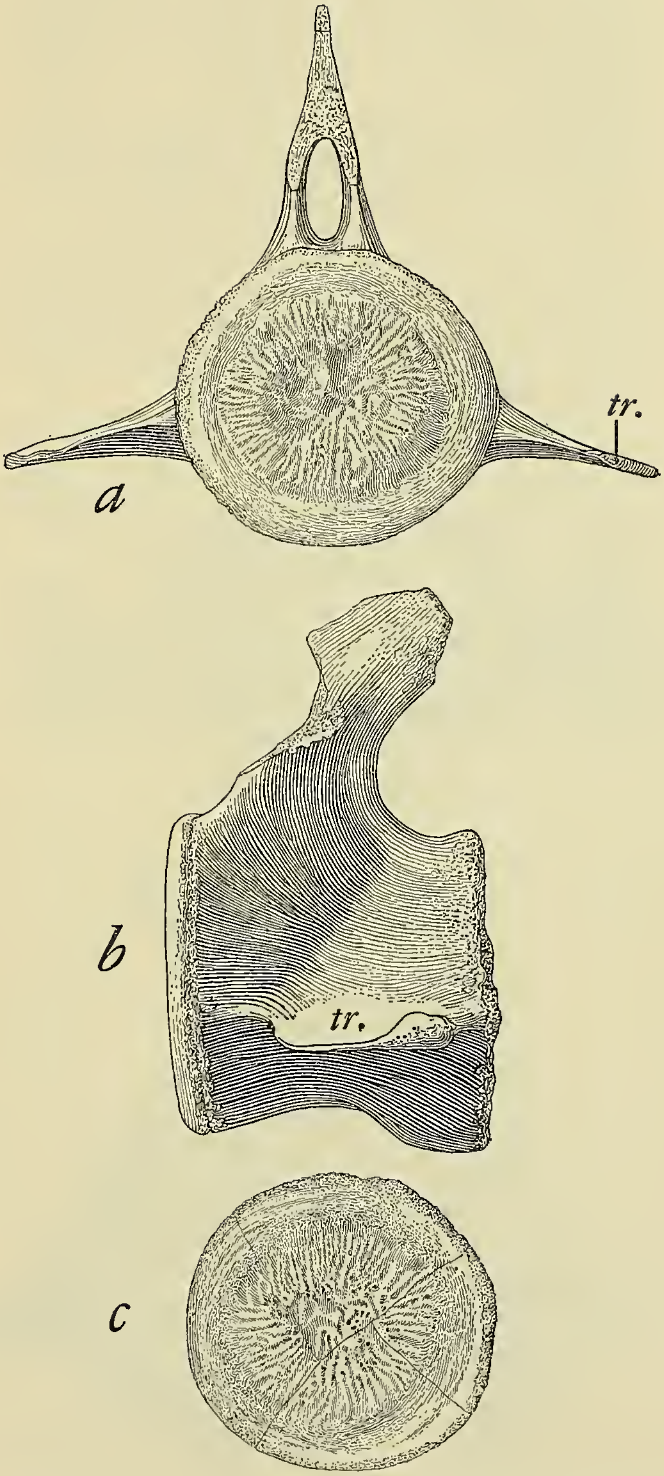

FIGURE 61.—Views of third caudal, USNM 16567, of *Diorocetus hiatus:* *a*, anterior view; *b*, lateral view; *c*, posterior epiphysis. Abbrs.: tr., transverse process.

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

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

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

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

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

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

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

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

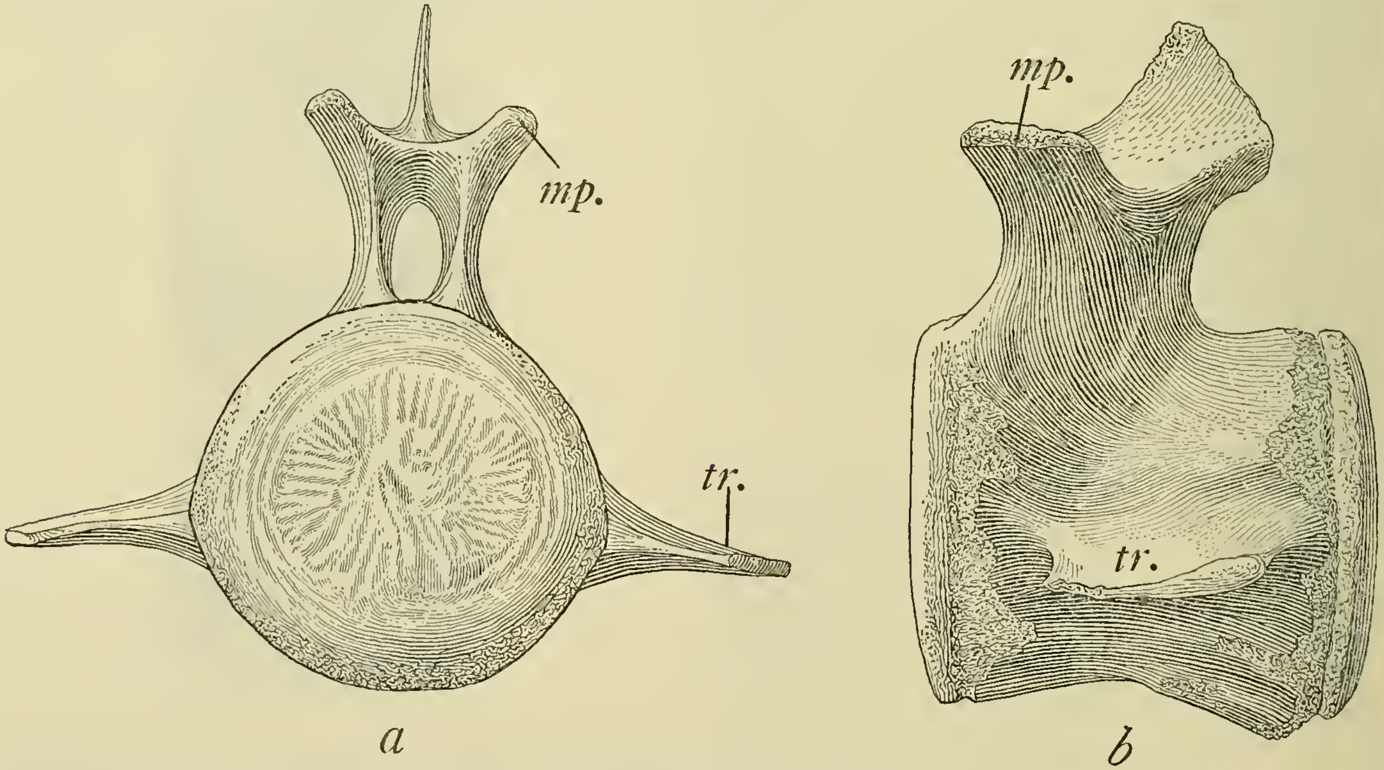

FIGURE 62.—Views of fourth caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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

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

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

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

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

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

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

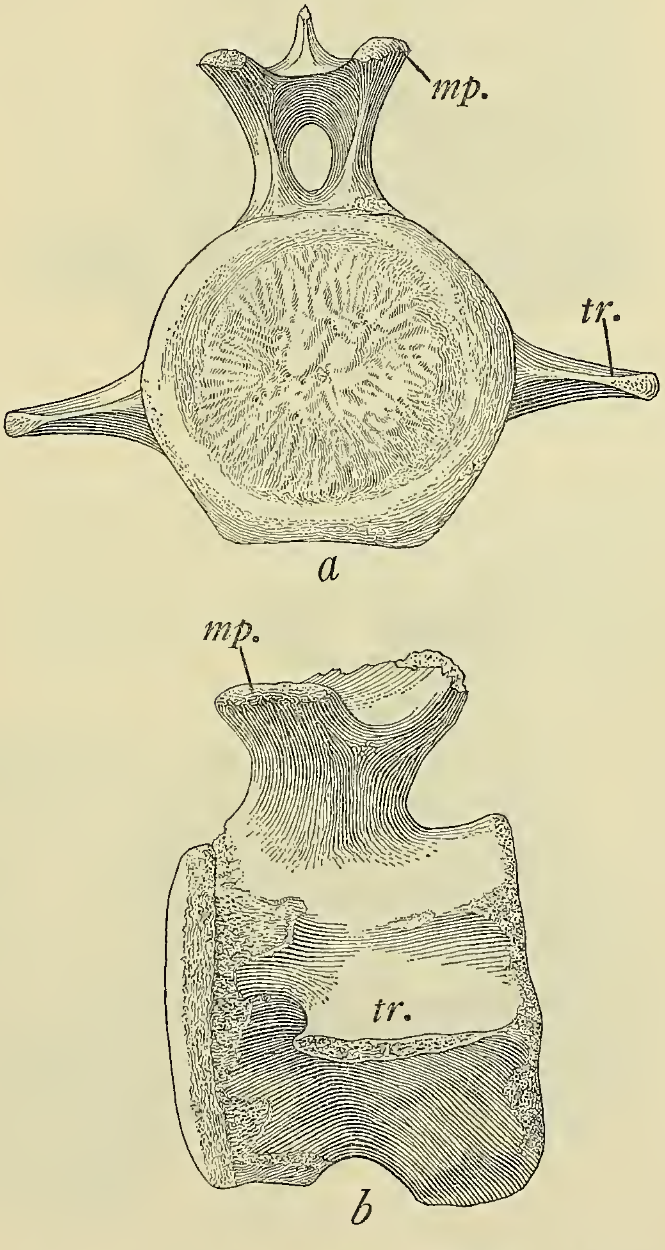

FIGURE 63.—Views of fifth caudal, USNM 16567, of *Diorocetus hiatus: a,* anterior view; *b,* lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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

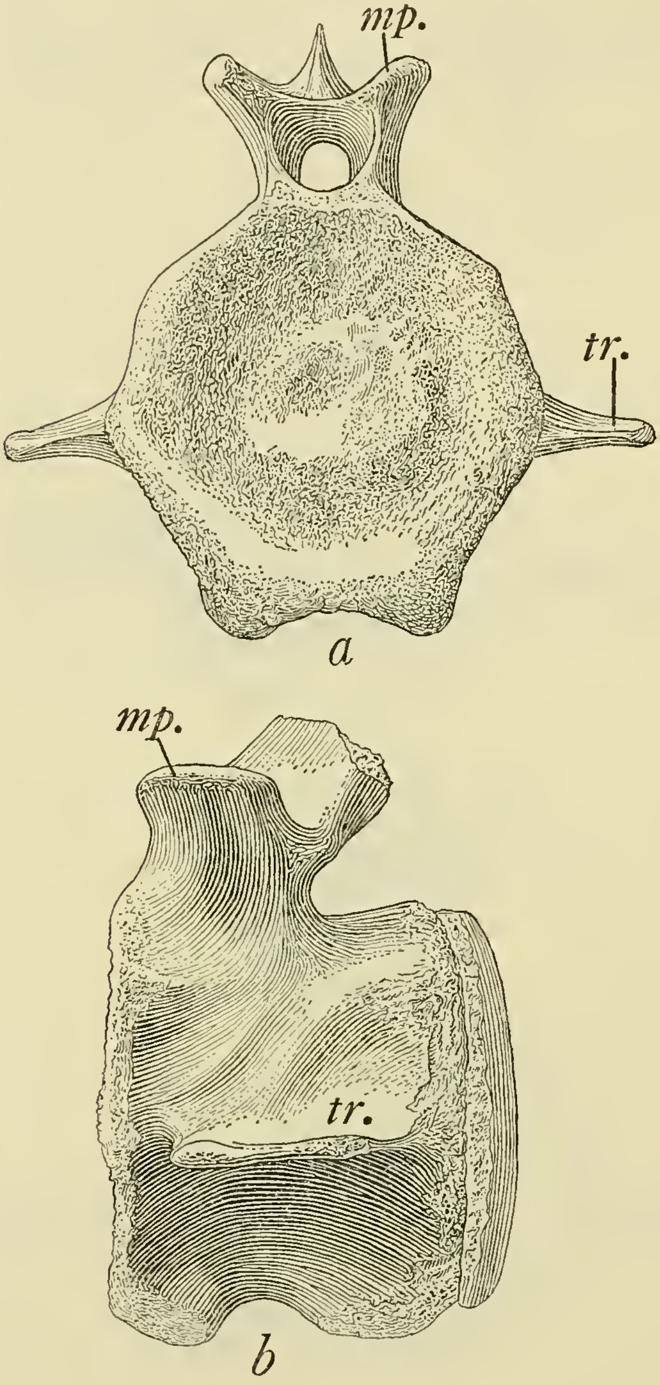

Figure 64.—Views of sixth caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.; mp., metapophysis; tr., transverse process.

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

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

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

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

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

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

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

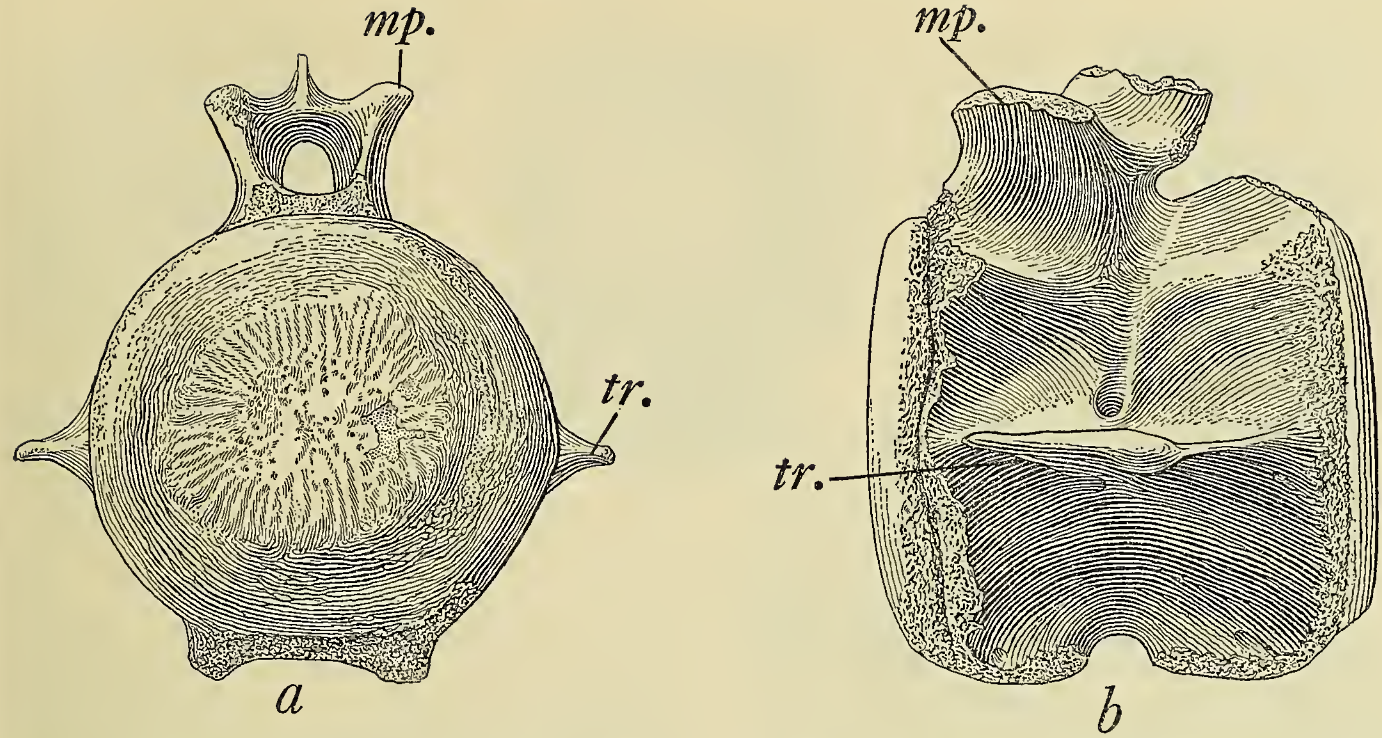

FIGURE 65.—Views of seventh caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view. Abbrs.: mp., metapophysis; tr., transverse process.

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

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

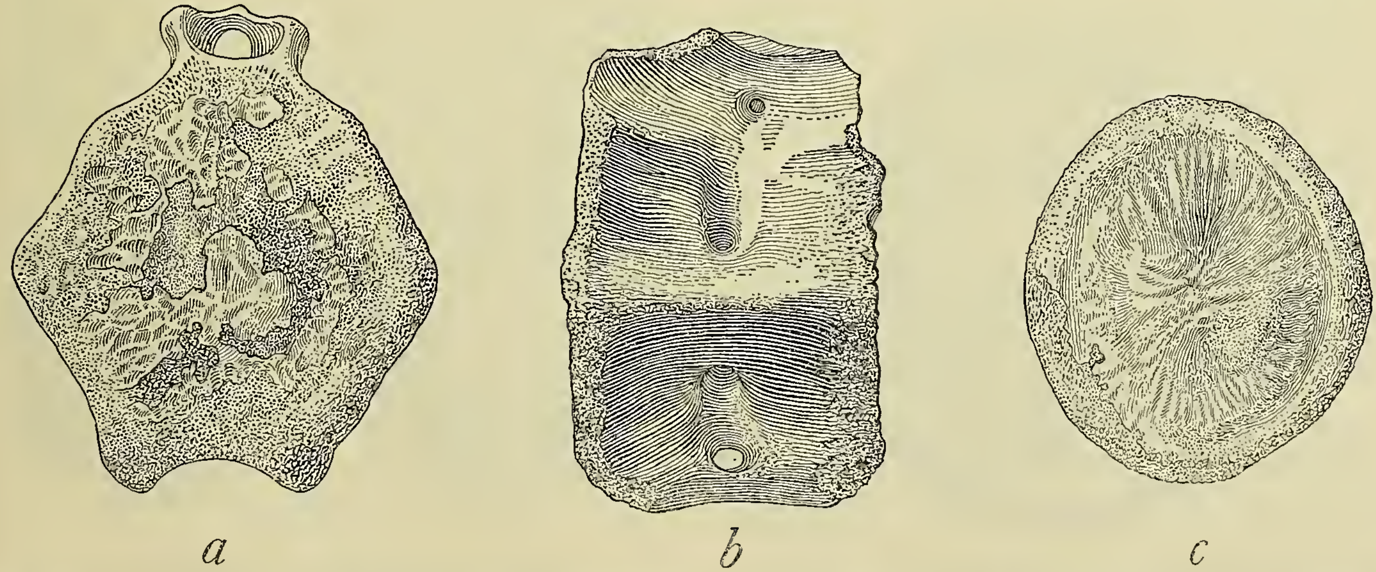

FIGURE 66.—Views of eighth caudal, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view, reversed; *c*, posterior epiphysis.

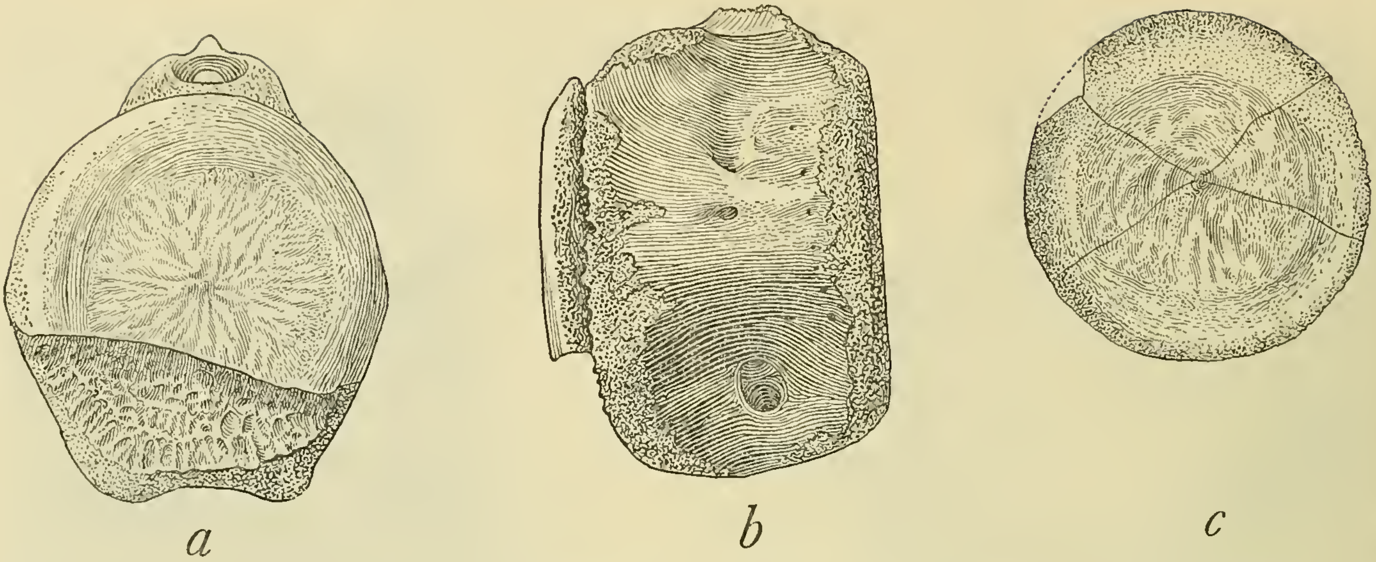

FIGURE 67.—Views of ninth caudal, USNM 16567, of *Diorocetus hiatus:* *a*, anterior view; *b*, lateral view; *c*, posterior epiphysis.

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

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

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

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

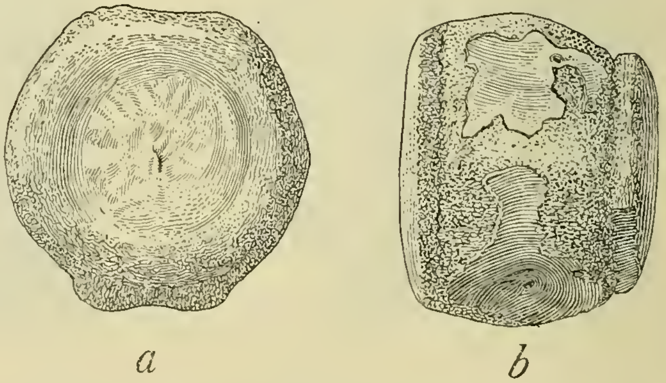

FIGURE 69.—Views of eleventh caudal, USNM 16567, of *Diorocetus hiatus:* *a*, anterior view; *b*, lateral view.

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

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

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

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

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

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

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

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

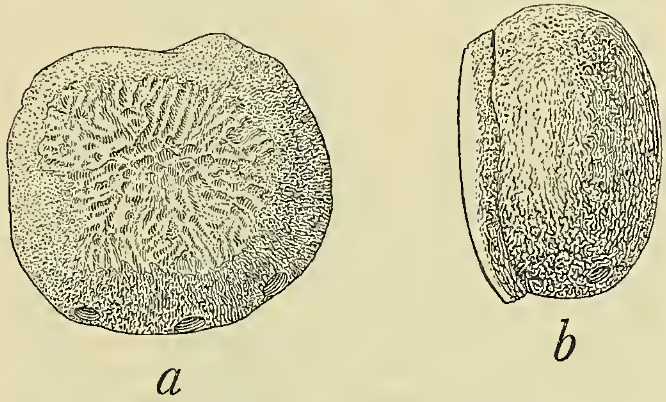

FIGURE 70.—Views of twelfth caudal, USNM 16567, of *Diorocetus hiatus: a,* posterior view; *b,* lateral view.

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

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

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

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

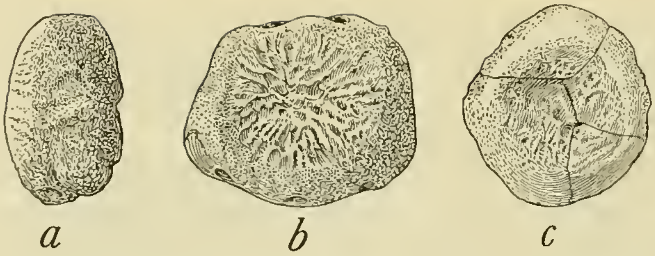

FIGURE 71.—Views of thirteenth caudal, USNM 16567, of *Diorocetus hiatus: a*, lateral view; *b*, posterior view; *c*, posterior epiphysis.

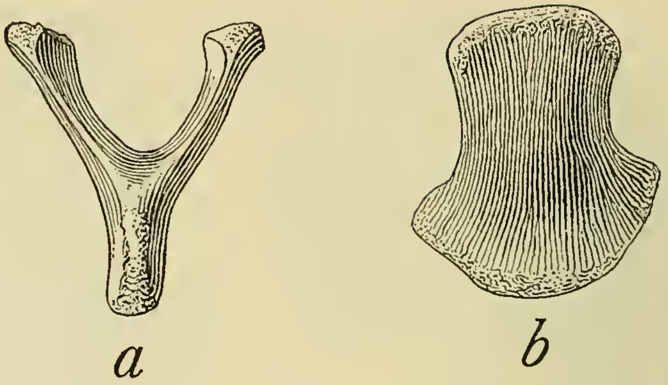

FIGURE 72.—Views of anterior chevron, USNM 16567, of *Diorocetus hiatus: a*, anterior view; *b*, lateral view.

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

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

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

Forelimb

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

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

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

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

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

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

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

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

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

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

Ulna.—The left ulna (USNM 23494) is complete and the right one lacks the dorsal portion of the olecranon process; both have the relatively slender and transversely compressed shaft curved from end to end. The greatest length of the left ulna (pl. 53, fig. 4) is 289 mm. and the distance from the upper margin of the radial facet (radial margin of greater sigmoid cavity) to the distal end of the shaft is 240 mm. The distal or carpal end of the shaft of this left ulna measures 64 mm. anteroposteriorly and 24 mm. transversely; this end is roughened for the attachment of the incompletely ossified epiphysis. The greater sigmoid cavity is pitted, indicating a cartilaginous covering layer and the same condition exists on the posterior curved face of the olecranon. The width of the greater sigmoid cavity decreases toward the dorsal attenuated end of the olecranon; the transverse width of the greater sigmoid cavity below and near its radial margin (36 mm.) is nearly twice the greatest width (22 mm.) of the olecranon posteriorly. The proximal facet for articulation with the radius is weakly developed.

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

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

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

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

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

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7. A Sharp-nosed Cetothere From the Miocene Calvert

Inadequacy of recovered skeletal remains of many described fossil mysticetes hampers comparable evaluation of attributed generic criteria. Continued uncertainty regarding the significance of observable differences in the telescoping or the slippage forward or backward of the cranial and rostral bones of the mysticete skull may persist until a larger number of representative types of mysticetes from successive geological faunas are recorded. It must be acknowledged that some skepticism is warranted regarding the validity of mysticete generic diagnoses based in whole or in part on such criteria as the conformation of the articular condyle of the mandible, the position of internal gingival (nutrient) and external mental foramina, the dimensions of the mandibles, unless comparable growth stages can be established, or the size of the tympanic bulla.

Notwithstanding such considerations it seems desirable to allocate a recognizably different specimen to a genus currently accepted as valid. The specimen hereinafter described is considered to be a smaller but geologically more recent member of the genus *Aglaocetus*. Lydekker in 1894 seems to have been the first to direct attention to the occurrence of the skull and associated vertebrae of a whalebone whale in a bed of mixed sand and clay belonging to the Patagonian (lower Miocene) marine formation at "el cerro del Castillo," opposite Trelew, province of Chubut, Argentina. A second skull from the same locality and a third skull (Kellogg, 1934), excavated on a small hill southwest of Pico Salamanca in the same province, have further elucidated the relations of the bones of the skull of this Patagonian *Aglaocetus moreni*.

AGLAOCETUS Kellogg

Aglaocetus Kellogg, 1934, Contrib. Palaeont., Carnegie Inst. Washington, publ. 447, p. 65. January 10, 1934.

Type species: *Cetotherium moreni* Lydekker.

AGLAOCETUS PATULUS, new species

Type specimen: USNM 23690. Skull (essentially complete, except for both lachrymals and jugals, and pterygoids in region of the pterygoid fossae), both tympanic bullae, left periotic, atlas, two cervical vertebrae, two dorsals, eight lumbars, and rib fragments. Collectors, Robert E. Weems, Frank C. Whitmore, Jr., and Albert C. Myrick, Jr.; April 6, 1966.

Horizon and Locality: About 3.5 feet above base of bluff in blue marly clay of zone 14, approximately 3.7 miles below mouth of Pope's Creek in Stratford Bluffs, about 1200 feet beyond swamp below (east of) "Big Meadows," Westmoreland Co., Va., Calvert formation, middle Miocene.

Referred Specimen: Two as follows: (1) USNM 13472; posterior portion of basicranium, apex of supraoccipital shield, right and left supraorbital processes of frontals, interorbital region of frontals, portions of maxillary and premaxillary, vomer, right and left periotics, right tympanic bulla, coll. Raymond M. Gilmore, C. Lewis Gazin and Remington Kellogg, August 9–10, 1933; in zone 14, Kenwood Beach cliff, about 428 yards south of road end at Governor Run, Calvert Co., Md., Calvert formation, middle Miocene. (2) USNM 23049; right squamosal incomplete, right periotic, ten lumbars, nine caudals, five chevrons, right scapula fragments, two metatarsals, two phalanges, rib fragments, coll. Wallace L. Ashby, jr., Frank C. Whitmore, jr., John E. Ott, Leroy Glenn, jr., and Remington Kellogg, July 15, 1963; base of zone 14, about 18 feet above beach level, 180 feet south of north end of first cliff south of mouth of Parker Creek, Calvert County, Md., Calvert formation, middle Miocene.

Diagnosis: Resembling *Aglaocetus moreni* (Kellogg, 1934, p. 66) in having the posteroexternal angle of the maxillary enlarged, its broad ventral plate underlapping the supraorbital process of the frontal. Resembling *A. moreni* and

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"*Idiocetus*" *laxatus* (Van Beneden, 1886, pl. 54) in the limited interdigitation of rostral and cranial elements as well as in the shape of the triangular occipital shield. Differing from the Patagonian lower Miocene species in the following features: rostrum wider, less attenuated and lateral profile more convex; ascending process of maxillary shorter, less extended backward; apex of triangular occipital shield carried farther forward to level of center of orbit; zygomatic process of squamosal more robust, directed more forward and less obliquely outward. Presence of large foramen near anterior end of nasal may have no especial significance. From the Belgian upper Miocene (Anversian) genus, this mysticete differs in having the interdigitation of median rostral elements with cranium on interorbital region less accentuated; apex of triangular occipital shield carried forward to level of center of orbit; shorter intertemporal constriction; and zygomatic process of squamosal more robust.

The following combination of characters serve also to characterize this mysticete: slender nasals located for most part anterior to preorbital angles of the supraorbital processes; limited backward overriding of median interorbital region carrying rostral elements (ascending processes of maxillaries and premaxillaries and the nasals) barely beyond the level of preorbital angles of supraorbital processes of frontals; rostrum broad at base, each maxillary having an enlarged posteroexternal angle and a broad ventral plate underlapping the supraorbital process of the frontal; a short intertemporal constriction formed by opposite parietals; exposure of frontals in interorbital region reduced to a narrow strip; lateral protuberance of basioccipital large, elongated; anteroposteriorly compressed extremity of postglenoid process thin. Dome of *pars cochlearis* of periotic neither enlarged nor prolonged ventrally; posterior process narrow, with deep longitudinal groove for facial nerve; labyrinthic region bulbous. Neural canal of posterior cervical vertebrae unusually low and wide; pedicles of neural arch short and much wider transversely than anteroposteriorly; neural spine short and thin; atlas lacks hyapophysial process.

Skull

Dorsal view.—Interlocking of the rostral and cranial portions of the skull (pls. 58–59) is effected in part by the splitting of the posterior extremity of each maxillary into a dorsal ascending process and a ventral plate. Behind the nasal fossa the relatively narrow internal ascending process of the maxillary is held in position in the rather deep sutural grooves on the upper surface of the interorbital portion of the corresponding frontal. Most of the dorsal surface of the relatively wide supraorbital process of the frontal is bare and not overridden by the hinder end of the maxillary.

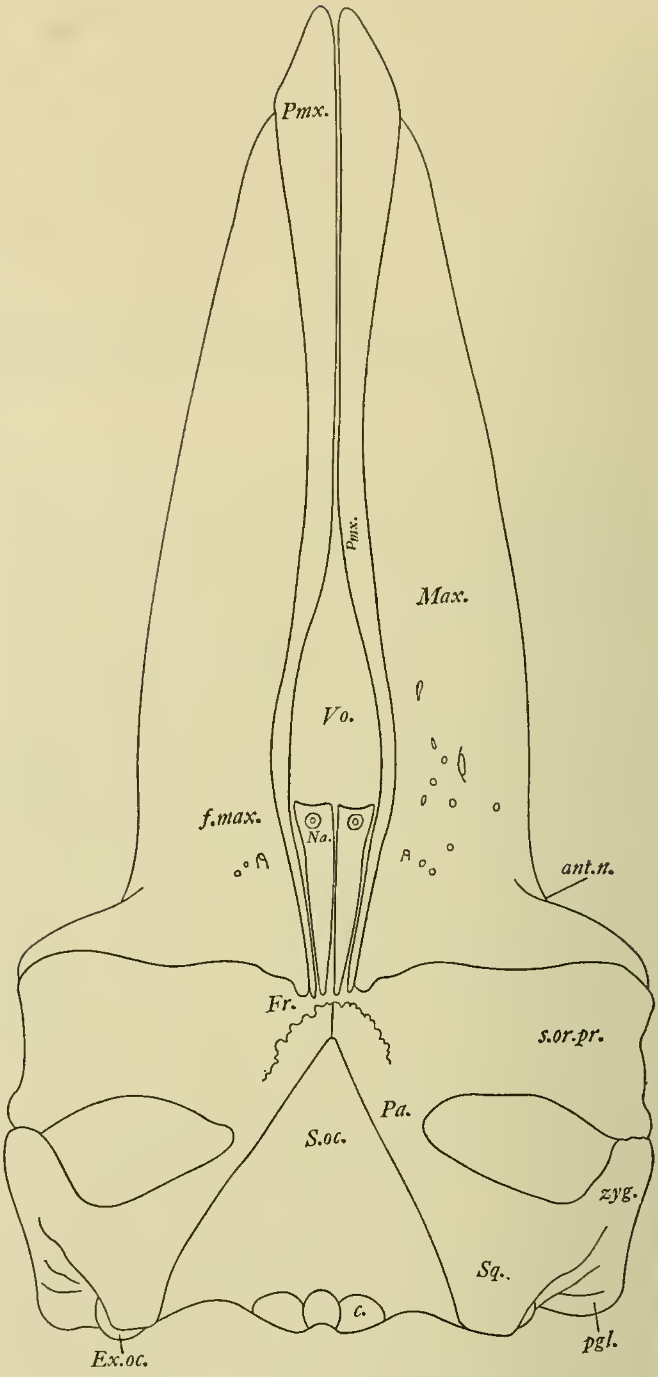

Figure 74.—Dorsal view of skull, USNM 23690, of *Aglaocetus patulus*. Abbrs.: ant.n., antorbital notch; Bo., basioccipital; c., occipital condyle; Ex. oc., exoccipital; f.m., foramen magnum; f.max., maxillary foramen or incisure; f.ov., foramen ovale; Fr., frontal; h.pt., hamular process of pterygoid; j.n., jugular notch or incisure; l.pr., lateral or descending protuberance of basioccipital; Max., maxilla; m.e.a., channel for external auditory meatus; Na., nasal; o.c., optic canal; Pa., parietal; Pal., palatine; pgl., postglenoid process; Pmx., premaxilla; pr.a., anterior process of periotic; pr.p., posterior process of

The broad ventral plate of the maxillary is extended backward beneath the anterior border of the ventral surface of the supraorbital process of the frontal almost to the optic channel.

At the base of the rostrum (fig. 74) the maxillaries are quite broad, attributable in part to the posteroexternal enlargement. In this respect this portion of the skull approximates the similarly widened posterior end of the maxillary of the lower Miocene Patagonian *Aglaocetus moreni* (Kellogg, 1934, fig. 2). The angle formed by the thin outer edge with this posteroexternal enlargement constitutes the antorbital notch of the maxillary, From the level of the longitudinal premaxillary maxillary contact the dorsal surface of each maxillary slopes downward to its outer margin. Along its internal border each maxillary is overlain by the corresponding premaxillary. At least the internal face of the hinder half of each maxillary abuts against the outer surface of the troughlike vomer. On this skull the backward overslippage above the narrow interorbital portion of the frontals by the median portion of the rostrum has carried the hinder ends of the ascending processes of the premaxillaries and maxillaries as well as the nasals behind the level of the preorbital angle of the supraorbital process of the frontal but not to the center of the orbit, the dorsal ascending process of each maxillary being short and rather narrow.

Behind the level of the anterior ends of the nasals, three or four foramina are present in each maxillary external to the premaxillary maxillary contact. At least twelve foramina are present in the right maxillary. The largest of these foramina on the right side is 50 mm. behind the anterior end of the nasal. There are four small foramina in an interval of 50 to 75 mm. in front of the right nasal. About 65 mm. internal to the outer margin and 110 mm. anterior to the antorbital notch two small foramina are present. These foramina are not located in the area corresponding to the oblique incisure on the skull of USNM 16783.

In front of the nasal fossa, each premaxillary is noticeably flattened and projects forward beyond the maxillary, Each premaxillary attains its greatest width (77 mm.) at the level of the anterior ends of the maxillaries. The dorsointernal edges of the opposite premaxillaries parallel one another from the extremity of the rostrum to the anterior end of the nasal fossa. Prior to the distortion resulting from crushing, each premaxillary rested in the groove on the dorsointernal edge of the corresponding maxillary along the dorsal nasal fossa. Each narrowed premaxillary is bent downward and is also curved outward and then inward to conform to the curvature of this fossa. The rather narrow ascending process of each premaxillary is lodged in two or three sutural grooves on the dorsal interorbital surface of the frontal. The troughlike vomer forms the floor of the elongated nasal fossa.

The relatively long (235 mm.) nasal bones taper from their anterior to their posterior ends and are wedged in between the ascending processes of the opposite premaxillaries. Their posterior ends are lodged in sutural grooves on the interorbital surface of the frontal and anteriorly they overhang the nasal fossa. For most of their length the nasals are projected forward above the nasal passages beyond the level of the preorbital angle of the supraorbital process of the frontal. They do not extend backward beyond the level of the posterior ends of the ascending processes of the premaxillaries and maxillaries. The anteroexternal angle projects forward beyond the anterointernal angle of the right nasal, forming a concavely curved anterior edge. A hole or foramen is present behind the anterior edge of each nasal (fig. 74), possibly the result of fortuitous damage.

The frontals are narrowly exposed in the median interorbital region and are excluded from the vertex by the parietals. Between the hinder ends of the median rostral elements and the intertemporal constriction contributed by the parietals, the frontals are exposed for about 10 mm. Each supraorbital process of the frontal slopes gradually from the median interorbital region to its orbital rim. No curved transverse temporal crest seems to have been present, although such a crest, if developed, may have been obliterated by crushing. A rounded preorbital angle, a thick postorbital projection, and a thin arched orbital rim characterize the supraorbital process of the frontal. The rostral wall of the cranium is contributed largely by the frontals. Posteriorly, the frontal is overspread by the thin anterior border of the corresponding parietal. The lachrymals and the jugals were not preserved with this skull.

The parietals, which meet medially to constitute the short (50 mm.) intertemporal ridge, are each overridden above and behind by the external border of the large triangular supraoccipital shield. Anteriorly, the thin anterior border of the parietal overspreads the frontal and the base of its supraorbital process and extends forward almost to the level of the posterior margin of the ascending process of the corresponding maxillary. The nearly vertical parietal constitutes a major portion of the lateral wall of the braincase.

The posterolateral portion of the cranium is constituted by the large thick squamosal. From its anterior sutural contact with the pterygoid, the squamosal curves backward, outward and forward to the extremity of its zygomatic process around the temporal fossa. The zygomatic process is stout and is directed obliquely forward. Erosion of the dorsal surface of both zygomatic processes prevents

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periotic; Pt., pterygoid; pt.f., pterygoid fossa; S.oc., supraoccipital; Sq., squamosal; s.or.pr., supraorbital process of frontal; Ty., tympanic bulla; Vo., vomer; zyg., zygomatic process.

determination of the existence of a lengthwise continuation of the lambdoid crest.

A strong forward thrust of the supraoccipital shield has carried its acutely pointed apex to the level of the center of the orbit. At the level of the foramen magnum the transverse diameter (360 mm.) of the supraoccipital exceeds the greatest distance (305 mm.) from the dorsal rim of the foramen magnum to the apex. Most of this dorsally attenuated shield is depressed medially below the level of its lateral margins.

The exoccipitals are, with the exception of their outer ends, concealed from a dorsal view by the posterior overhang of the lambdoid crest. The large flattened occipital condyles do not project backward beyond the level of the extremities of the exoccipitals.

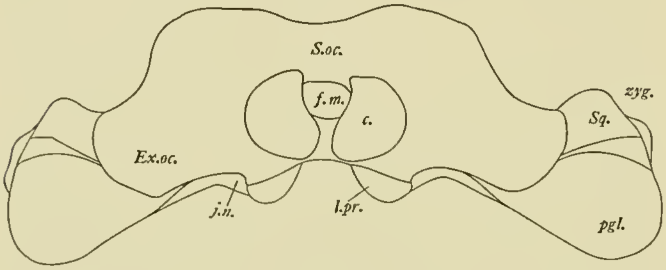

Figure 75.—Posterior view of skull, USNM 23690, of *Aglaocetus patulus*. For abbreviations, see figure 74.

Posterior view.—The dorsally attenuated triangular occipital shield (fig. 75), which constitutes essentially the entire posterior wall of the braincase, consists of the medially depressed supraoccipital and on each side of the foramen magnum the exoccipital. On each side the lambdoid crest on the posterior edge of the squamosal above the exoccipital curves upward and then forward along the external edge of the supraoccipital to its acutely pointed apex. No median vertical ridge is developed on this bone above the foramen magnum. Each exoccipital comprises a lateral wing of the posterior triangular shield.

From a posterior view it is seen that the foramen magnum is relatively large and ovoidal in outline. The large occipital condyles are less convex from side to side than from end to end. They are separated ventrally by a deep wide notch.

On each side of the median basicranial depression is the large downward projected lateral protuberance of the basioccipital. The external face of this protuberance constitutes the inner limit of the large notch or incisure for the jugular leash. External to the exoccipital the distally rounded postglenoid process extends downward 98 mm. below the level of the ventral edge of the occipital condyle and 70 to 82 mm. below the level of the ventral edge of the adjacent exoccipital. Except in the details just noted and in certain differences in the profiles of individual bones, the relations of the component parts of the hinder end of the cranium are similar to USNM 23494.

Lateral view.—The apex of the supraoccipital shield, the highest point of the dorsal profile, rises very little above the lateral margins of this shield, but more abruptly above the short intertemporal ridge. The slope from the median interorbital region to the extremity of the rostrum is very gradual. The greatest depth of the rostrum is at the anterior end of the palatines. The outer edge of the maxillary is thin throughout its length anterior to the antorbital notch.

The arched orbital rim of the supraorbital process of the frontal is dorsoventrally compressed, the preorbital angle is somewhat thinner than the underlying ventral plate of the maxillary and the postorbital angle is noticeably thickened dorsoventrally. The downward slope of the supraorbital process of the frontal from the median intertemporal region to the orbital rim is gradual.

The dorsoventral diameter of the basal portion of the postglenoid process (80 mm.) is almost twice the same measurement of the anterior end of the zygomatic process (44 mm.). Viewed from the side the posterior surface of the postglenoid process slopes obliquely downward and backward.

The nearly vertical parietal is concavely curved from end to end and contributes a major portion of the lateral wall of the braincase, meeting its opposite dorsally to form a short intertemporal ridge and overspreading the base of the frontal. The small alisphenoid is visible in the lateral wall of the braincase behind the base of the supraorbital process of the frontal above the pterygoid and below the parietal. The occipital condyles are not visible when the skull is viewed from the side.

Ventral view.—Except for the immediate region of the pterygoid fossa and portions of the ventral surface of the maxillaries, this skull (USNM 23690; pl. 59) is exceptionally complete. The major portion of the ventral surface of the rostrum is contributed by the maxillaries, which prior to deformation as the result of being shoved over the centra of dorsal vertebrae, met longitudinally along the midline of the rostrum, concealing the keel of the vomer. The presence of an unusually large posteroexternal angle on each maxillary has accentuated the narrowing of the rostrum. Flattening of the ventral surface of the maxillary is most obvious external to the median downward convex curvature, which conforms to the shape of the vomer against which it abuts. Along the anterior border, the supraorbital process of the frontal is underlapped by the thin posterior end of the corresponding maxillary. The ventral surface of each maxillary (fig. 76) is engraved by a series of grooves which, unfortunately as a result of poor preservation of the original surface in certain areas, cannot be traced in their entirety. The grooves near the posterior end of each maxillary opposite and in front of the palatine are quite short and are directed obliquely outward and backward. These grooves serve as channels for the nutrient vascular vessels and nerves that supply the palate and attached baleen of the living mysticetes. Except for a relatively few short ones more anteriorly along the outer border, the majority of the anterior grooves run lengthwise or nearly so. The right maxillary terminates 1370 mm. anterior to the posterior margin of the vomer and the right premaxillary extends 95 mm. beyond the maxillary. The distance from the anterior end of the right maxillary to the anterior edge of the optic channel at the base of the right supraorbital process is 1230 mm. The inner edges of the opposite maxillaries commence to diverge slightly on the ventral surface of the rostrum 115 mm. behind the anterior end of the right maxillary.

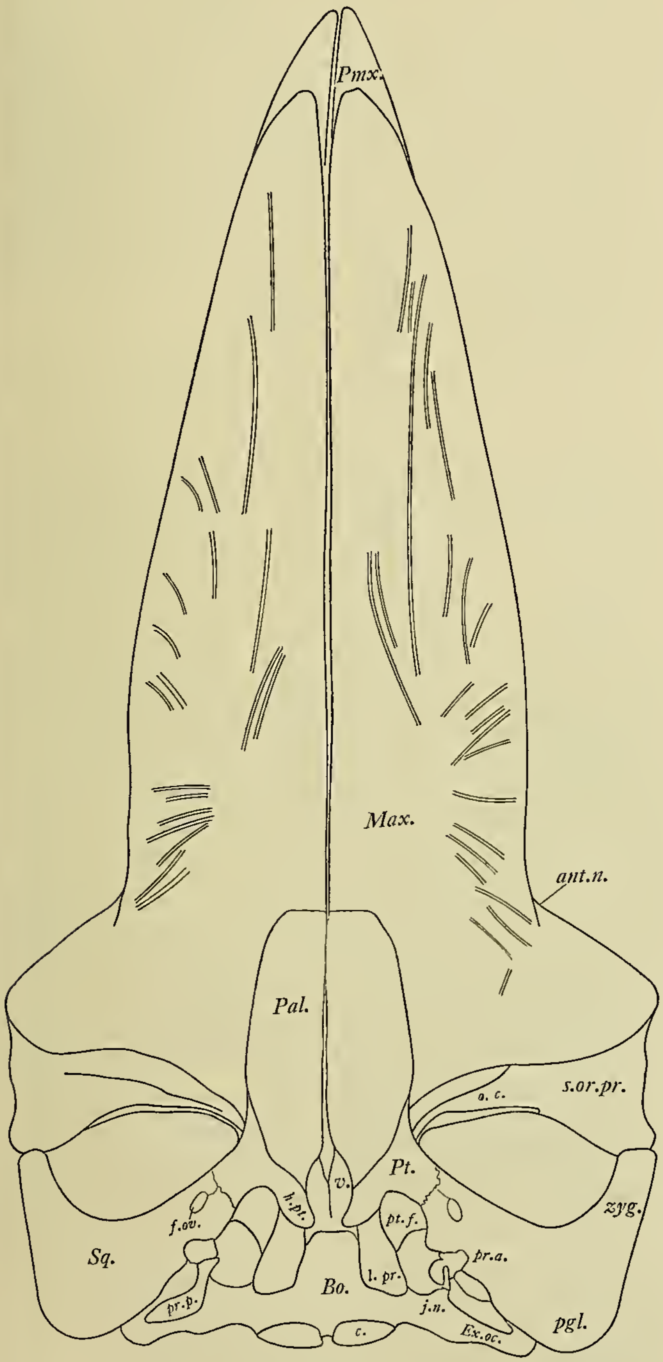

FIGURE 76.—Ventral view of skull, USNM 23690, of *Aglaocetus patulus*. For abbreviations, see figure 74.

At a point 130 mm. in advance of the posterior end of its horizontal plate the ventral keel of the vomer develops a narrow flattened surface, which is extended backward at the same horizontal level for 75 mm., and then, as a continuing thin vertical partition between the choanae, diminishes in vertical diameter until it disappears about at the posterior end of the vomer. The horizontal plate of the posterior end of the vomer conceals the basisphenoid from a ventral view and laterally is in contact with the corresponding edge of the vaginal process of the pterygoid.

Although the posterior border of each palatine is broken off and the precise termination of the anterior end uncertain on account of sloughing off of the thin borders of this bone, the anteroposterior diameter of each palatine was at least 300 mm. Each palatine anteriorly and externally overspreads the ventral surface of the corresponding maxillary. Posteriorly each palatine is suturally united with the pterygoid which contributes the missing internally projecting hamular process. The lachrymal and jugal bones were not attached to this skull and presumably were disassociated prior to burial by sediments.

The distally expanded supraorbital processes of the frontals are extended outward to the level of the large posteroexternal angles of the maxillaries. The deep channel for the optic nerve commences at the optic foramen and curves outward on the ventral surface of the supraorbital process of the frontal and, increasing in width, becomes very wide near the orbital rim of this process.

On the internal two thirds of its length this optic channel resembles a partly closed tube, being bordered posteriorly by a thin osseous wall up to 35 mm. in vertical diameter, which terminates about 100 mm. from the external orbital rim. This deep posterior wall of the optic channel, the proximal portion of which is certainly complete on both supraorbital processes, seems to be contributed by the frontal, since no sutural contact with either the alisphenoid or parietal could be detected. The anterior wall of this optic channel (vertical diameter near its origin as much as 30 mm.) is contributed by the dorsoventral thickening of the supraorbital process. In width on the left process, this channel increases from a minimum of 20 mm. near its origin to a maximum of 50 mm. at the point where the posterior wall vanishes on the rim. The relationship of the orbitosphenoid cannot be determined since its normal position within this partly closed optic channel is hidden from view.

The central exposure of the basioccipital between its large lateral descending protuberances (left, transverse diameter, 55 mm.) is rectangular; its line of contact with the basisphenoid is overspread by the horizontal plate of the vomer. The flattened external surface of the lateral protuberance slopes obliquely upward. Anteriorly each lateral descending process or protuberance is overspread by the hinder end of the corresponding vaginal plate of the pterygoid, which is also in contact along its dorsointernal edge with the horizontally widened plate of the posterior end of the vomer. This portion of the pterygoid also contributes the inner outer wall of the corresponding internal choana. Only the broken off basal portion of the right hamular process is preserved on this skull. The attenuated anterior portion of the pterygoid is extended forward beyond the level of the internal end (origin) of the optic channel and is also suturally united along its internal edge with the palatine. The main portion of the pterygoid is suturally united in front with the hinder end of the palatine and behind with the bifurcated end of the squamosal which encloses the foramen ovale. The greatest anteroposterior diameter of the left foramen ovale is 26 mm. and the greatest transverse diameter 15 mm. The pterygoid comes in contact with the lower surface of the alisphenoid on the inner wall of the temporal fossa and is also narrowly in contact with the parietal.

The small pterygoid fossa is bounded internally by the vaginal process of the pterygoid, anteroexternally by the downward curving thickened anterior and external borders of the pterygoid, and to a limited extent by the falciform process of the squamosal. The roof of this air-containing fossa and the floor also to some extent is formed by the pterygoid; it is continuous posteriorly with the tympanoperiotic recess. The extent to which the pterygoid contributes the floor of this fossa cannot be readily determined, since no remnants other than broken edges of this bone are present. The reconstruction of the pterygoid in the region of the pterygoid fossa shown on figure 76 is therefore somewhat conjectural.

The squamosal and its falciform process externally, the pterygoid anteriorly, the lateral protuberance of the basioccipital internally, and the exoccipital posteriorly enclose the tympanoperiotic recess. A broad notch or incisure on the exoccipital between the lateral protuberance and the *pars cochlearis* of the periotic corresponds to the posterior lacerated foramen for the jugular leash.

On the ventral surface the contact between the squamosal and the exoccipital is concealed by the posterior process of the periotic which is securely lodged in a deep groove. Between the posterior process of the periotic and the base of the hinder face of the postglenoid process is the rather broad (15 mm.) and shallow groove for the external auditory meatus.

The elongated zygomatic process is directed more forward than outward and is in direct contact with the postorbital projection of the supraorbital process of the frontal. Each postglenoid process is deflected obliquely backward and has its thin anteroposteriorly compressed extremity extended 55 mm. below the level of the lateral protuberance of the basioccipital. The posterior face of each postglenoid process is deeply concave and the anterior face is convex. The glenoid articular surface is concavely curved from extremity of postglenoid process to tip of zygomatic process (length, left process, 273 mm.). External to the excavation for the pro-otic portion of the periotic and in front of the sharp edged posterior rim, a relatively shallow concavity is present on the ventral surface of the squamosal.

The outer ends of the exoccipitals project backward slightly (12 mm.) beyond the level of the posterior articular surfaces of the occipital condyles. Although no definite paroccipital processes are developed for the attachment of each stylohyal, a small cavity is present on the corresponding area on the left exoccipital. The occipital condyles are not protuberant and are separated by a deep narrow (15 mm.) groove.

Measurements (in mm.) of the skull, USNM 23690, are as follows:

Greatest length of skull, anterior end of right premaxillary to level of posteroexternal angle of right exoccipital	1635
Distance from anterior end of right premaxillary to posterior articular face of right occipital condyle	1600
Distance from anterior end of right premaxillary to apex of supraoccipital shield	1253
Greatest length of right premaxillary	1167
Distance from apex of supraoccipital shield to posterior end of right nasal bone	68
Transverse diameter of skull across posteroexternal angles of supraorbital processes of frontals	775
Transverse diameter of skull across preorbital angles of supraorbital processes of frontals	770
Greatest anteroposterior diameter of extremity of left supraorbital process of frontal	205
Transverse diameter of skull across outer surfaces of zygomatic processes	760
Transverse diameter of skull between outer edges of exoccipitals	490
Transverse diameter between outer edges of occipital condyles	167
Greatest or obliquovertical diameter of right occipital condyle	85
Greatest transverse diameter of right occipital condyle	69

Greatest transverse diameter of foramen magnum	46
Distance from dorsal rim of foramen magnum to apex of supraoccipital shield	305
Distance between anterior end of right premaxillary and extremity of right postglenoid process	1615
Distance between anterior end of right premaxillary and edge of optic channel (groove) at origin	1230
Right nasal, length externally	235
Right nasal, length internally	230
Right nasal, width anteriorly	50
Right nasal, width at base	15
Greatest breadth of basioccipital across lateral protuberances, outside measurement	180 ±
Greatest length of left zygomatic process, extremity of postglenoid process to anterior end	273
Distance from posterior surface of right occipital condyle to posterior end of vomer	132
Distance from posterior surface of right occipital condyle to anterior edge of right palatine	520 ±
Posterior edge of vomer to anterior edge of right palatine	390 ±
Distance between opposite foramina ovale	292

Tympanic Bulla

The left tympanic bulla (USNM 23690) was crushed against the left periotic on the type skull. The right bulla (USNM 13472) was pushed partially into the tympanoperiotic recess on the referred skull.

The type bulla (pl. 60, figs. 3–5) differs from the referred bulla (USNM 13472) in having the posterior end pinched in medially and attenuated ventrally to form a broad V-shaped vertical depression, an acute projecting ventrointernal angle, a less abruptly backward bending extremity of the sigmoid process, and a broader vertical groove in front of the sigmoid process. On the ventral face of the type bulla a low crest, which is better developed near the ends than at the middle, extends obliquely from the posteroexternal to the anterointernal angle. No trace of his crest is visible on the referred bulla.

The posterior pedicle arises internally from the posterior end of the involucrum and externally, behind the low blunt conical apophysis, from the posterior end of the thin curved outer lip.

The involucrum is creased transversely near the middle of its length; the eustachian outlet of the tympanic cavity is moderately wide. Viewed from the external side, the ventral profile is nearly straight, and the anterior end is more obliquely truncated than the convexly curved posterior end.

Little if any correlation was noted between the dimensions of the bulla and the size of the skull among more than 40 bullae of Calvert cetotheres assembled for comparison. Tangible differential features that may serve to distinguish specifically the several species of Calvert cetotheres were not readily observable. The usefulness of minor or apparent inconsequential variations in the contour of the bulla for purposes of identification is certainly questionable in the present state of our understanding of the developmental history of these cetotheres.

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

	USNM 23690 Left	*USNM 13472 Right*
Greatest length of tympanic bulla	76	71.5
Greatest width of tympanic bulla	47	42.5
Greatest vertical diameter of external side, ventral face to tip of sigmoid process	60	57
Greatest length of tympanic cavity	53	51.5

Periotic

On the type skull (USNM 23690) the posterior processes of both periotics are firmly lodged in the groove between the exoccipital and the base of the postglenoid process of the squamosal. Except for the *pars cochlearis* of the right periotic, both periotics are otherwise complete. The left periotic, whose labyrinthic region apparently is deformed internally by exostosis, was detached from the type skull. Both periotics (pl. 51, figs. 1, 2) were detached for examination from the referred basicranium (USNM 13472).

The rather broad deep groove for the facial nerve (pl. 60, fig. 1) traverses the ventral face of the narrow posterior process from the external wall of the stapedial fossa to the extremity of this process. A short obtuse anterior process projects forward from the bulbous labyrinthic region which is markedly convex externally but flattened internally. This swollen anterior portion of the periotic is lodged as usual in a deep excavation in the squamosal external to and behind the pterygoid fossa.

The side to side compressed anterior pedicle of the tympanic bulla was attached to the ventral surface of the labyrinthic region 10 mm. in advance of the epitympanic aperture of the Fallopian aqueduct. The broken off basal portion of the posterior pedicle of the bulla remains ankylosed to the anterointernal angle of the ventral surface of the posterior process.

A broad, smooth concave fossa (vertical diameter, 11 mm.; length 27 mm.) extends from the posterorinternal angle of the posterior process inward across the posterior face of the *pars cochlearis* behind the stapedial fossa and above (dorsal to) the *foramen rotunda* and its projecting shelf to the cerebral face of the referred periotic (USNM 13472). This area is partially concealed by a bony exostotic outgrowth on the type periotic.

As viewed from the ventral aspect the *fenestra ovalis* is concealed by the oblique slope of the external face of the *pars cochlearis*. A deep narrow groove extends forward and inward from the *fenestra ovalis* between the *pars cochlearis* and the anterior process. The shallow cavity for reception of the head of the malleus is located in front of and external to the epitympanic aperture of the Fallopian aqueduct. The *fossa incudis*, which is situated external to the groove for the facial nerve, is unusually deep and is bounded internally by a thin elevated rim.

The dome of the *pars cochlearis* (pl. 60, fig. 2), although convex is not prolonged ventrally and is not enlarged. The cerebral face of the *pars cochlearis* is small. Above the circular internal acoustic meatus the cerebral face of the referred periotic is concavely depressed behind and above an ovoidal rugose depression. The cerebral aperture of the Fallopian aqueduct is quite large and in close proximity to the internal acoustic meatus. On the referred periotic the vestibular aqueduct opens into a large, deep, elongated depression behind and above the internal acoustic meatus. Below this depression is the aperture of the small cochlear aqueduct. The topography of this internal area on the type periotic, although obscured by exostosis, is identical with that of the referred periotic.

On another right periotic (USNM 23049) the usual groove for lodging an extension of the air sac system on the posterior face of the *pars labyrinthica* is completely shut off by an osseous wall from the posterior end of the stapedial fossa; this malformation resulted from the deep excavation of the internal end of the posterior process.

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

	USNM 23049 Right	*USNM 23690 Left*	*USNM 13472 Left*
Length of posterior process, distance from external wall of stapedial fossa to extremity	92	87	94
Greatest dorsoventral diameter of periotic from most inflated portion of tympanic face of *pars cochlearis* to most projecting point on cerebral side	55.5	56	53
Distance between epitympanic orifice of Fallopian aqueduct and extremity of anterior process	53	52	45
Distance from external end of posterior process to anterior end of anterior process (in a straight line)	143	147	143

Cervical Vertebrae

The atlas, the right half of the third cervical and a well-preserved fifth cervical were associated with the type skull (USNM 23690). Both epiphyses were detached from the third and fifth cervicals, an indication of physical immaturity.

Atlas: Large, moderately thickened anteroposteriorly (USNM 23690); neural arch with low, rugose, ridge-like neural crest; high (91 mm.) hourglass-shaped neural canal (pl. 61, fig. 1); reniform anterior facets for articulation with occipital condyles of skull deeply concave, slanting obliquely outward from internal to external margins and separated ventrally by shallow groove (minimum width, 22 mm.). On each side the neural arch is pierced, nearer the anterior than the posterior margin, by a vascular foramen which opens into a ventrally directed groove. Transverse processes short, slightly compressed anteroposteriorly and obtuse. Crescentic posterior articular surfaces (pl. 61, fig. 2) slightly constricted medially. No hyapophysial process is developed. An ill-defined upward slanting shallow depression for reception of odontoid process of axis; forward projecting median angle of neural arch of axis does not articulate with neural arch of atlas posteriorly.

Additional measurements (in mm.) of atlas are as follows: greatest distance between outer margins of anterior articular facets, 170; greatest distance between outer margins of posterior articular facets, 180; greatest vertical diameter of right anterior articular facet, 114; greatest vertical diameter of posterior articular facet, 104.

Third Cervical: The right side of this cervical (USNM 23690) shows that the centrum was broadly elliptical, the neural canal unusually wide, and the transverse curvature of the roof of the neural arch rather gradual. The pedicles of the neural arch are short, slender and anteroposteriorly compressed; they support the transversely widened prezygapophysial facets; the somewhat larger postzygapophysial facets (pl. 61, fig. 3) are located on the under surface of the arch and project backward beyond the level of the posterior face of the centrum. The slender upper transverse process (diapophysis) is short, attenuated and projects outward from the pedicle of the neural arch; the lower process (parapophysis) is elongated, dorsoventrally compressed beyond its base. Since the extremities of both the upper and the lower processes were broken off there is no certainty that they were united distally to enclose completely the large cervical extension of the thoracic *retia mirabilia.*

Fifth Cervical: The neural canal of this cervical (USNM 23690) is wider than that of the third cervical and the short pedicles of the neural arch are extended farther ventrally on the dorsoexternal face of the centrum. The thin roof of the neural arch (pl. 61, fig. 3) is narrow and from it arises a very short thin, neural spine. Slender attenuated diapophyses project outward from the pedicles of the neural arch. The ovoidal prezygapophysial facets are unusually small; the postzygapophysial facets on the ventral surface of the neural arch are large and elongate. The roof of the neural canal is less elevated (36 mm.) than on the third cervical (45 mm.) and its width (96 mm.) is greater. The dorsoventrally compressed parapophysis projects outward and slightly backward from the ventroexternal angle of the centrum and is abruptly widened between its base and acuminate extremity. The extremities of the upper and lower transverse processes are separated by a wide gap.

Measurements (in mm.) of cervical vertebrae, USNM 23690, are as follows:

	Atlas	*C.3*	*C.5*
Anteroposterior diameter of centrum	58	21[b]	23.5[b]
Transverse diameter of centrum anteriorly	195	—	107.5
Vertical diameter of centrum anteriorly	—	80+	93
Tip of neural spine to ventral face of centrum anteriorly	158	138+	149
Greatest vertical diameter of neural canal anteriorly	93	50	36
Greatest transverse diameter of neural canal anteriorly	49	—	96
Greatest distance between outer ends of parapophyses	237	—	234
Least anteroposterior length of pedicle of neural arch	51	—	11
Greatest transverse diameter of centrum posteriorly	185	—	105
Greatest vertical diameter of centrum posteriorly	114	—	92

[b] =Both epiphyses missing.

Dorsal Vertebrae

The vertebra identified as the ninth and eleventh dorsals were intermingled with lumbar vertebrae which were in close contact with the ventral surface of the skull.

Ninth Dorsal: On the ninth dorsal (USNM 23690; pl. 63, fig. 1), the broad transverse process (parapophysis), dorsoventrally thickened at the base, projects outward from the dorsoexternal surface of the centrum. The anteroposteriorly expanded (80 mm.) distal end of this process is thicker posteriorly (16 mm.) than anteriorly (9 mm.) and is roughened for attachment of the head of the ninth rib. The metapophyses, which project forward beyond the level of the anterior face of the centrum, rise at least 60 mm. above the floor of the neural canal and limit externally the elongated prezygapophysial facets. Backward projecting postzygapophysial facets are reduced. The neural spine (pl. 62, fig. 1) is strongly inclined backward, but rises at least 125 mm. above the roof of the neural canal. The pedicles of the neural arch are relatively thin (minimum width, 14 mm.; the transverse width, 47 mm., slightly exceeds the vertical diameter, 45 mm., of the neural canal). The profile of the anterior face of the centrum is definitely subcordate.

Eleventh Dorsal: Extremities of both transverse processes of this dorsal (USNM 23690) are broken off. At the base these processes project outward from the external face of the centrum at a lower level than on the ninth dorsal, but are likewise dorosoventrally thickened; the anterior edge is thin and the posterior edge thickened. The pedicles of the neural arch have increased in anteroposterior diameter (58 mm.). The thin metapophyses are larger and rise 68 mm. above the floor of the neural canal; they are also less widely separated. Neither pre- nor postzygapophysial facets are present. The rather broad (75 mm.) neural spine, which rises about 130 mm. above the roof of the neural canal, is strongly inclined backward and truncated distally. The anterior face of the centrum retains the subcordate profile.

Measurements (in mm.) of the ninth and eleventh dorsal vertebrae (USNM 23690) are, respectively, as follows: anteroposterior diameter of centrum, 102, 113; transverse diameter of centrum anteriorly, 115, 119; vertical diameter of centrum anteriorly, 90, 93; minimum anteroposterior length of pedicle of neural arch, 55, 58; transverse diameter of neural canal anteriorly, 47, 40; vertical diameter of neural canal anteriorly, 45, 45; distance between ends of transverse processes, 280±,—; tip of neural spine to ventral face of centrum posteriorly, 240±, 250; dorsal edge of metapophysis to ventral face of centrum anteriorly, 151, 163.

Lumbar Vertebrae

Arranged in serial sequence, the centra of the third to tenth lumbars increase very gradually in length, width, and height. No distinct longitudinal median ridge or keel is developed on the ventral surface of the centra of the six anterior lumbars (USNM 23690). Notwithstanding the damaged condition of the parapophyses of the anterior lumbars, the remnants show that these dorsoventrally compressed processes diminish in length, but increase in width behind the seventh lumbar. The vertical diameter of the neural canal exceeds the transverse on all eight lumbars. No functional pre- and postzygapophysial facets are present; the elongated thin lamina-like metapophyses project forward and more upward than outward. Backward slanting neural spines increase in anteroposterior width toward the hinder end of the lumbar series. The minimum anteroposterior length of the pedicle of the neural arch diminishes.

Third Lumbar: Increased elevation of the thin lamina like metapophyses, a greater vertical diameter of the neural canal, and a more circular profile of the anterior end of the centrum are the most obvious features distin-

USNM 23690–Lumbar Vertebrae	*L–3*	*L–4*	*L–5*	*L–6*	*L–7*	*L–8*	*L–9*	*L–10*
Anteroposterior diameter of centrum	109[p]	118	104[b]	115+[a]	126[a]	119[p]	128	129[p]
Transverse diameter of centrum anteriorly	118	120	123	121	125	121	121	125
Vertical diameter of centrum anteriorly	99	96	100	103	106	107	107	113
Minimum anteroposterior length of pedicle of neural arch	52	56	53	52	48	48	48	46
Transverse diameter of neural canal	35	36	35	32	30	30	29	31
Vertical diameter of neural canal, anteriorly	52	51	50	46	44	43	42	41
Tip of neural spine to ventral face of centrum posteriorly	243±	265±	282±	285±	300±	320±	305±	328±
Dorsal edge of metapophysis to ventral face of centrum anteriorly	175	167±	180	175+	200	195	188	195

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

guishing the third lumbar (USNM 23690) from the eleventh dorsal. No material alteration of the oblique backward slant of the neural spine is observable. A more noticeable dorsoventral compression of the basal portion of the parapophysis characterizes this lumbar and those that follow in the series.

Fourth Lumbar: This lumbar (USNM 23690) also lacks the distal end of the backward slanting neural spine whose anteroposterior width has increased. No change in the width of the parapophysis at the base is observable.

Fifth Lumbar: This lumbar (USNM 23690) lacks both epiphyses; the right parapophysis is broken off at the base as well as the distal ends of the neural spine and the left parapophysis. As compared with the preceding lumbar, the width and height of the neural canal have diminished slightly. The thin lamina-like metapophyses, which rise 80 mm. above the floor of the neural canal, project forward beyond the level of the anterior face of the centrum, and their dorsal edges are separated anteriorly by an interval of 35 mm. The left parapophysis is directed outward and slightly forward.

Sixth Lumbar: Behind the fifth lumbar the height and width of the neural canal gradually diminishes to the end of this series, and so does the minimum anteroposterior width of the pedicles of the neural arch. The thin metapophyses of the sixth lumbar (USNM 23690) project forward to but not beyond the level of the anterior face of the centrum. At both ends of the centrum the transverse diameter exceeds the vertical diameter. The right parapophysis is broken off at the base, the distal end of the left process is incomplete, the distal end of the left process is incomplete, and the anterior epiphysis is missing.

Seventh Lumbar: This lumbar (USNM 23690) lacks the anterior epiphysis, the distal end of the left parapophysis and all of the right except the basal portion, and the extremity of the neural spine. As compared to the preceding lumbar, the thin metapophyses are less widely separated, but rise higher (90 mm.) above the floor of the neural canal. A distinct median longitudinal keel is developed on the ventral surface of the centrum.

Eighth Lumbar: Measurements of the centrum (USNM 23690) are not materially different from the seventh lumbar. The extremities of both parapophyses are incomplete, the distal end of the neural spine (pl. 62, fig. 2) is broken off, and the posterior epiphysis is missing. The left parapophysis (pl. 63, fig. 5), which is the most complete, projects outward and obliquely forward; its distal end seems to have been expanded. The backward slanting neural spine is wider anteroposteriorly (85 mm.) than on the anterior lumbars.

Ninth Lumbar: This lumbar (USNM 23690) lacks the distal end of the neural spine and the extremities of both parapophyses are damaged. These subspatulate parapophyses were expanded distally and projected less downward than outward from the lateral surface of the centrum, their extremities not extending beyond the level of the anterior face of the centrum. The median longitudinal keel is very indistinctly developed on the centrum.

Tenth Lumbar: This vertebra (USNM 23690; pl. 62, fig. 3) lacks the distal end of the neural spine and the posterior epiphysis. The nearly complete left parapophysis (pl. 63, fig. 3) is dorsoventrally compressed, slightly constricted near its base, expanded on its distal half and its posterior edge curved forward to the anteroexternal angle which extends forward beyond the level of the anterior face of the centrum. A distinct median longitudinal keel is present on the ventral surface of the centrum. The profile of the anterior end of the centrum (pl. 63, fig. 6) is circular. The thin metapophyses do not extend forward beyond the level of the anterior face of the centrum.

Measurements (in mm.) of lumbar vertebrae, USNM 23690, are as indicated above.

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8. Supplement to Description of PARIETOBALAENA PALMERI

As many as eight species representing four genera of Recent mysticetes, are or were periodically or seasonally present off the Atlantic and Pacific coasts of North America according to recorded historical accounts. Adults of the little piked whale (*Balaenoptera acutorostrata*), the smallest of these Recent mysticetes, range from 22 to 33 feet in length. The blue whale (*Balaenoptera musculus*), the largest, measures from 75 to 85 feet off North American coasts, and as long as 100 feet in Antarctic waters. The others attain, according to species, lengths from 40 to 75 feet.

Skeletal remains representing six and possibly seven fossil mysticetes have been recovered from the Calvert Miocene deposits of Maryland and Virginia. The length of the smallest of these Calvert cetotheres, *Parietobalaena palmeri*, did not exceed 14 or 15 feet, and the largest, "*Eschrichtius*" *cephalus*, 31 feet by Cope's estimate. In addition to the seven free cervicals, so far as is known, not more than twelve dorsals were present in the vertebral column; twelve appears to be the maximum number of lumbar vertebrae and fourteen the number of caudals. A total of forty five comprised the vertebral column.

Skeletons of adult Recent mysticetes are not only larger, with one exception, but are also comprised of more vertebrae than the Calvert Miocene cetotheres. This increase in the number of vertebrae occurs notably in the caudal series. The vertebral formula is often as follows:

Balaenoptera musculus:
C. 7; D. 15; L. 14; ca. 28 =total 64
B. physalus:
C. 7; D. 15; L. 15; ca. 25 =total 62
B. borealis:
C. 7; D. 13–14; L. 13–15; ca. 20–23 =total 55–57
B. acutorostrata:
C. 7; D. 11; L. 12–13; ca. 17–20 =total 49
Eschrichtius glaucus:
C. 7; D. 14; L. 12; ca. 23 =total 56
Megaptera novaeangliae:
C. 7; D. 14; L. 10–11; ca. 19–22 =total 51–54
Eubalaena glacialis:
C. 7; D. 14; L. 10–13; ca. 23–26 =total 55–57

The capitulum of each of the seven or eight anterior pairs of ribs of physically mature individuals of these Calvert cetotheres has a definite articular contact with a well-defined facet on the posterolateral surface of the preceding vertebra. Rib articulation with the centrum of these anterior dorsal vertebrae has persisted in only one of the living whalebone whales, the gray whale (*Eschrichtius glaucus*). A distinct neck between the tuberculum and capitulum is present on five or six pairs of the anterior ribs. The corresponding ribs are unusually robust. This whale has been observed rolling in kelp beds along the shore and apparently it is not inconvenienced by occasional stranding in the shallow muddy lagoons of Baja California.

The reduction in the number of ribs having a capitular articulation with the centrum of anterior dorsals is another characteristic of Recent balaenopterid whales. Although three and occasionally four pairs of anterior ribs have a well-defined neck separating the tuberculum and capitulum, no distinct facet is developed on the centrum for an articular function.

This reduced capitular articulation by the ribs in the anterior thoracic region appears to be another one of the astonishing simplifications of bodily structure resulting from a long lost requirement for protective support for a thorax adapted to an exclusively buoyant existence. Were these large whales not buoyed up by water, their great weight would collapse the thorax and lungs, causing suffocation and death.

When cast ashore by incoming tide, a stranded living whale continues breathing with difficulty until death ensues; the crushing weight of the anterior portion of the body on the chest cavity must be lifted by exerting abnormal muscular effort each time air is drawn into the lungs. A cardiovascular overload results. Intrathoracic pressure resulting after muscular relaxation impedes the venous return to the heart in the chest cavity.

On the cetothere skull the supraorbital process of the frontal slopes gradually downward and outward to the orbital rim from the level of the dorsal surface of the interorbital region. On the balaenopterine skull the supraorbital process of the frontal is abruptly depressed at the base to a level below the dorsal surface of the interorbital region. This abrupt depression of an originally sloping supraorbital process makes its appearance geologically without any transitional or intermediate stage, or at least none has been described. The mechanical basis or necessity for this alteration is not readily apparent.

That the Miocene cetotheres were plankton feeders is certainly indicated by the grooves on the ventral rostral surface of the maxillaries which on skulls of Recent whalebone whales serve as channels for the vascular vessels and nerves supplying the lateral rows of baleen.

Among Recent mysticetes two general tendencies in the remodeling of skull architecture are noted. One end result is largely limited to the forward movement or thrust of the posterior cranial elements (Balaenidae), carrying the apex of the supraoccipital shield forward beyond the orbit and the associated very slight or limited backward movement of the rostral elements, the nasal bones being located entirely in front of the supraorbital processes of the frontals.

In the other type of remodeling (Balaenopteridae), the median rostral elements (ascending processes of maxillaries and premaxillaries and the nasals) in a backward movement override the frontals to or usually beyond the level of the preorbital angle of the supraorbital process of the frontal.

Among the Miocene antecedents of the Recent mysticetes are several types of interdigitation, including skulls on which the nasals are either almost entirely or only partially located anterior to the preorbital angle of the supraorbital process of the frontal, as well as either limited or extensive backward overriding by the median rostral elements.

PARIETOBALAENA Kellogg

Parietobalaena Kellogg, 1924, Proc. U.S. Nat. Mus., vol. 63, publ. 2483, p. 1. February 5, 1924.

Type species: *Parietobalaena palmeri* Kellogg.

Diagnosis: Parietals meet medially to form a ridge between the apex of the supraoccipital shield and the frontals; maxillary, premaxillary, and nasal sutural contact grooves extended backward on frontals beyond level of preorbital angle of supraorbital process; rostrum tapering toward extremity; transverse temporal crest developed on supraorbital process of frontal on mature skulls; nasals located for most part anterior to level of preorbital angle of supraorbital processes; zygomatic process of squamosal slender, attenuated anteriorly and extended forward to or almost to elongated postorbital projection of supraorbital process of frontal; postglenoid process directed more downward than backward, flattened on its posterior face and rounded distally; occipital condyles small; exoccipitals directed obliquely downward and backward, with lateral end projecting backward beyond level of articular surface of condyle on adult skulls; *pars cochlearis* of periotic with strongly convex dome or apex extended ventrally; a short narrow fossa of variable depth behind rim of fossa for stapedial muscle and above *fenestra rotunda* and its projecting shelf extends across posterior face of *pars labyrinthica* to its cerebral face. Tympanic bulla and periotic resemble in some details those of "*Idiocetus*" *laxatus* Van Beneden (1886, pl. 54, figs. 3–4). A deep groove for attachment of internal pterygoid muscle present below articular surface of condyle and above angle on internal surface of posterior end of mandible.

PARIETOBALAENA PALMERI Kellogg

Parietobalaena palmeri Kellogg, 1924, Proc. U.S. Nat. Mus., vol. 63, publ. 2483, p. 2.

Type specimen: USNM 10668. A cranium of a fairly young individual in a fair state of preservation; the nasals, jugals, and lachrymals, as well as the rostrum and its component parts, the maxillaries, premaxillaries, and vomer, are missing. Both periotics are attached to the cranium; incomplete left tympanic bulla is detached. Collector, William Palmer; August 14, 1913.

Type locality: From face of cliff near center of zone 11 and about 3 feet above beach level, approximately 1 mile north of Dares Wharf, Calvert Co., Md., Calvert formation, middle Miocene.

Referred specimens: Twenty, as follows: (1) USNM 7424: posterior end left mandible, length 395 mm., coll. William Palmer and A. C. Weed, May 31, 1912, in zone 11 at base of cliff about 150 yards north of old pier at Dare's wharf, Calvert Co., Md., Calvert formation, middle Miocene. (2) USNM 10677: skull, right and left mandibles, right tympanic bulla, right periotic, 18 ribs and fragments, coll. William Palmer and Norman H. Boss, September 1908, in zone 10 at base of cliff about ⅜ mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (3) USNM 10909: basicranium, portions of rostrum, periotics, coll. David B. Mackie, Aug. 10, 1908, in zone 10, about 2 miles south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (4) USNM 11535: cranium and portions of maxillaries, premaxillaries and vomer, both tympanic bullae, both periotics, right mandible, humerus, 6 cervicals, 1 dorsal, 1 caudal, 2 phalanges, and 10 ribs and fragments, coll. Norman H. Boss and Remington Kellogg, May 23, 1926, in zone 11, about a mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (5) USNM 12697: right and left mandibles, atlas, 1 cervical, 5 dorsals, 5 lumbars, 3 caudals, 5 epiphyses, radius and ribs, coll. William Palmer and Norman H. Boss, Dec. 6, 1913, in zone 10, about ½ mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (6) USNM 13874: hinder portion of basicranium, right and left tympanic bulla, right and left periotic, and atlas, coll. R. Lee Collins, Mar. 24, 1936, in zone 11, about 8 feet above base of cliff, one mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (7) USNM 13903: left mandible, lacking condyle, coll. Wm. F. Foshag and Charles W. Gilmore, July 12, 1936, in zone 12, about 600 feet south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (8) USNM 15576: left tympanic bulla, with malleus attached, coll. S. F. Blake, Mar. 27, 1938, in zone 16, about 3 feet above base of cliff at Calvert Beach, Calvert Co., Md., Choptank formation, middle Miocene. (9) USNM 16119: skull and portion of rostrum, right and left tympanic bulla; right and left periotic, 1 rib, coll. Wm. F. Foshag and Remington Kellogg, July 15, 1939, in zone 12, ⁹⁄₁₀ mile north of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (10) USNM 16568: right and left tympanic bullae, right and left periotics, portions of skull, right and left mandible, axis, 3 cervicals, 2 lumbars, coll. Wm. F. Foshag and Remington Kellogg, Aug. 5, 1940, in zone 12, 625 yards south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (11) USNM 16570: skull, right mandible, right periotic, 1 dorsal, 1 caudal, fragments scapula, coll. Charles W. Gilmore, Wm. F. Foshag, H. S. Bryant, and Remington Kellogg, June 7, 1940, in zone 12, 695 yards south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (12) USNM 16667: axis, 1 dorsal, 2 lumbars, 11 caudals, coll. Wm. F. Foshag and Remington Kellogg, July 17, 1941, in zone 10, about 1 mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (13) USNM 16838: Cranium, right and left tympanic bulla, right and left periotic, portions of rostrum, coll. R. Lee Collins, June 10, 1937, in zone 10, one and ½ miles south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (14) USNM 20376: right and left tympanic bulla, right and left periotic, squamosals, coll. W. Gardner Lynn, Nov. 4, 1933, about 1 mile south of Plum Point wharf, Calvert Co., Md., Calvert formation, middle Miocene. (15) USNM 23015: right tympanic bulla, right periotic, right squamosal, coll. A. C. Murray and John George, in zone 12, 700 yards south of mouth of Parker Creek, Calvert Co., Md., Calvert formation, middle Miocene. (16) USNM 23022: skull, both tympanic bullae, both periotics, coll. James R. Switzer, March 1958, in zone 13, 700 yards north of road end at Governor Run, Calvert Co., Md., Calvert formation, middle Miocene. (17) USNM 23055: right and left tympanic bulla, left periotic, portions of skull, right mandible, axis, 1 cervical, 5 dorsals, 1 caudal, portions of ribs, coll. Howard Hruschka, Nov. 17, 1963, in zone 13, 500 yards north of road end at Governor Run, Calvert formation, middle Miocene. (18) USNM 23203: posterior end right mandible, portions of skull, atlas, axis, 5 cervicals, 12 dorsals, 10 lumbars, 9 caudals, 2 chevrons, coll. Robert E. Weems, July 4, 1964, about 3.6 miles below mouth of Pope's Creek, Stratford Bluffs, Westmoreland Co., Va., Calvert formation, middle Miocene. (19) USNM 23448: 4 dorsal vertebrae, portions of ribs, coll. Albert C. Myrick, Jr., Feb. 13, 1965, in zone 14, 350 yards north of road end at Governor Run, Calvert Co., Md., Calvert formation, middle Miocene. (20) USNM 23725: skull, coll. Albert C. Myrick, Jr. and Charles F. Buddenhagen, June 1, 1966, in zone 10, Holland Cliffs, on Patuxent River, about ¾ mile north of Deep Landing, Calvert Co., Md., Calvert formation, middle Miocene.

Skull

The major portion of the left side of the restored skull (USNM 10677), now exhibited in the vertebrate paleontology hall of the United States National Museum, was destroyed prior to excavation. The length of this skull (pl. 65, fig. 3) is 1115 mm. Another skull (USNM 23022) possesses a fairly complete braincase, both zygomatic processes and the premaxillaries, but lacks the supraorbital processes as well as the external borders of both maxillaries. This skull (pl. 64, fig. 2) measures 1200 mm. in length. Another skull (USNM 16570; pl. 64, fig. 3) measuring 1250 mm. in length lacks the right zygomatic process and adjacent portion of the cranium, the major portions of both supraorbital processes, and most of the left side of the rostrum. The largest skull (USNM 11619; pls. 66 and 67) has a fairly well-preserved braincase and both zygomatic processes, but lacks most of the supraorbital processes and retains only portions of the rostral elements.

Dorsal view.—The skulls of this cetothere represent a less advanced stage in the modification of skull architecture by either forward or backward overriding of adjacent bones. On the skulls of young or adolescent individuals of this species the posterior ends of the median rostral elements extend backward to or slightly beyond the level of the preorbital angles of the supraorbital processes. With approach or attainment of physical maturity these median rostral elements (fig. 77) are extended backward nearly to the level of the center of the orbit.

In front of the nasal fossa (USNM 23022; length, 260± mm.) in the narrow mesorostral trough, the premaxillaries are in contact to their anterior ends. In front of the anterior end of the vomer (USNM 23022; length, 785 mm.), which terminates 310 mm. behind the extremity of the right premaxillary of this skull the opposite maxillaries do not meet on the midline to contribute the bottom of the mesorostral trough. The internal surface of each premaxillary, however, is concavely curved downward to form the dorsal portion of the lateral wall of the mesorostral trough.

Each premaxillary (USNM 16570) attains its maximum width (45 mm.) at the level of the anterior ends of the corresponding maxillary. The posterior ascending portion of each premaxillary rests in a narrow groove on the dorsointernal border of the adjacent maxillary and is lodged at the hinder end in the narrow grooves on the dorsal surface of the frontal. Dorsally, each relatively thin premaxillary is narrowed alongside the nasals. On each side the premaxillary follows the curvature of the nasal fossa and then progressively increases in depth and width. On the anterior three fourths (600± mm.) of the length of the rostrum (800± mm.) the dorsal surfaces of the premaxillaries are noticeably flattened. Poorly preserved nasal bones are present on two skulls (USNM 10677, 16119); they are detached and lost from all other skulls of this species in the collection. On the above-mentioned skulls, the grooves for sutural contact on the frontals and the interval between the posterior ends of the opposite premaxillaries also indicate their width.

This skull is also characterized by a narrow tapered rostrum, equivalent to two-thirds of the length of the skull (occipital condyle to end of premaxillary); slender zygomatic process; narrow postglenoid process; moderate forward thrust of the supraoccipital shield, the dorsal half being narrowed toward the acuminate apex; a sharp-edged intertemporal ridge formed by parietals at contact on midline; and wide temporal fossa.

The apex of the supraoccipital shield (fig. 77) projects forward to or beyond the level of the anterior ends of the zygomatic processes and these slender processes are directed obliquely outward and forward.

Each maxillary is abruptly widened at the base by the posteroexternal basal angle that projects laterally beyond the preorbital angle of the supraorbital process on Recent mysticete skulls. The lachrymal, which normally is lodged on the posterior face of this angle was not preserved. The thin lateral edge of each maxillary is slightly curved toward its anterior end. Except for its posterointernal extremity, each maxillary does not override the superaorbital process of the frontal dorsally, but does along the anterior border

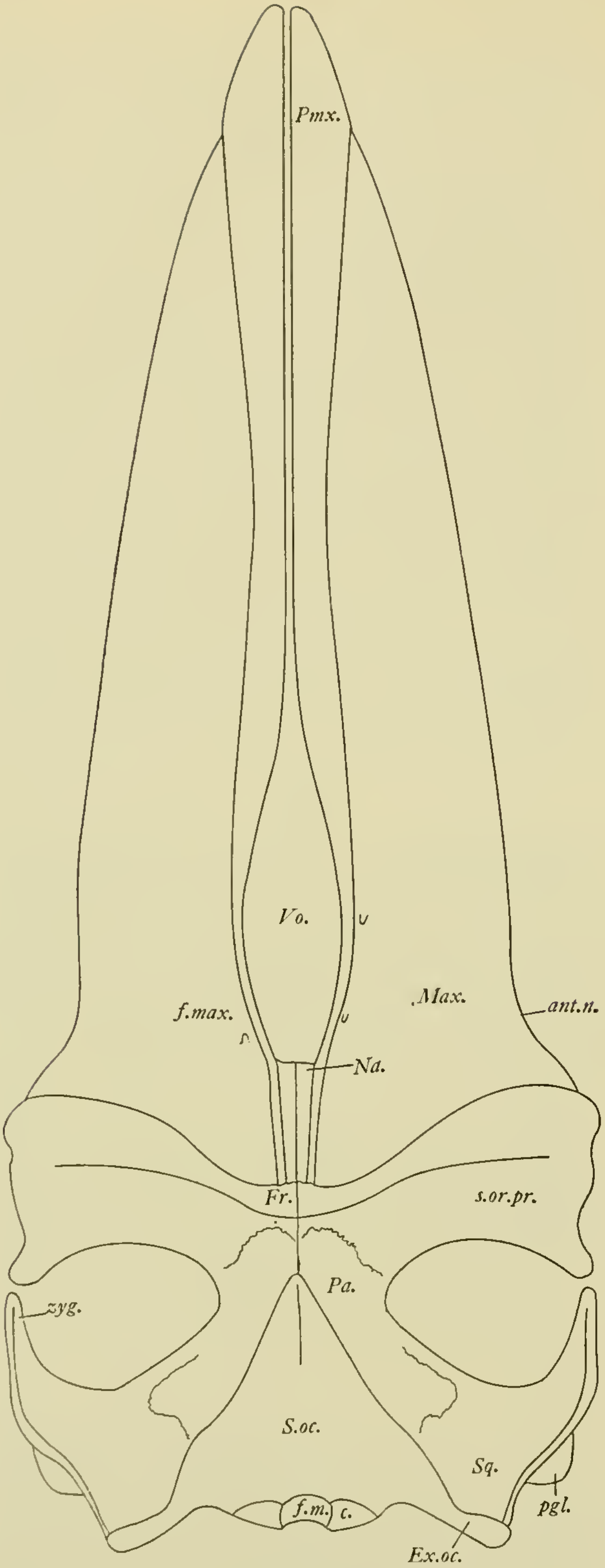

FIGURE 77.—Dorsal view of skull, USNM 16119, of *Parietobalaena palmeri* Kellogg. Reconstruction based on four skulls. For abbreviations, see figure 79.

ventrally. Two to four small nutrient foramina are located near the contact with the premaxillary on the posterior half of each maxillary. Jugal bones were not associated with any of these skulls.

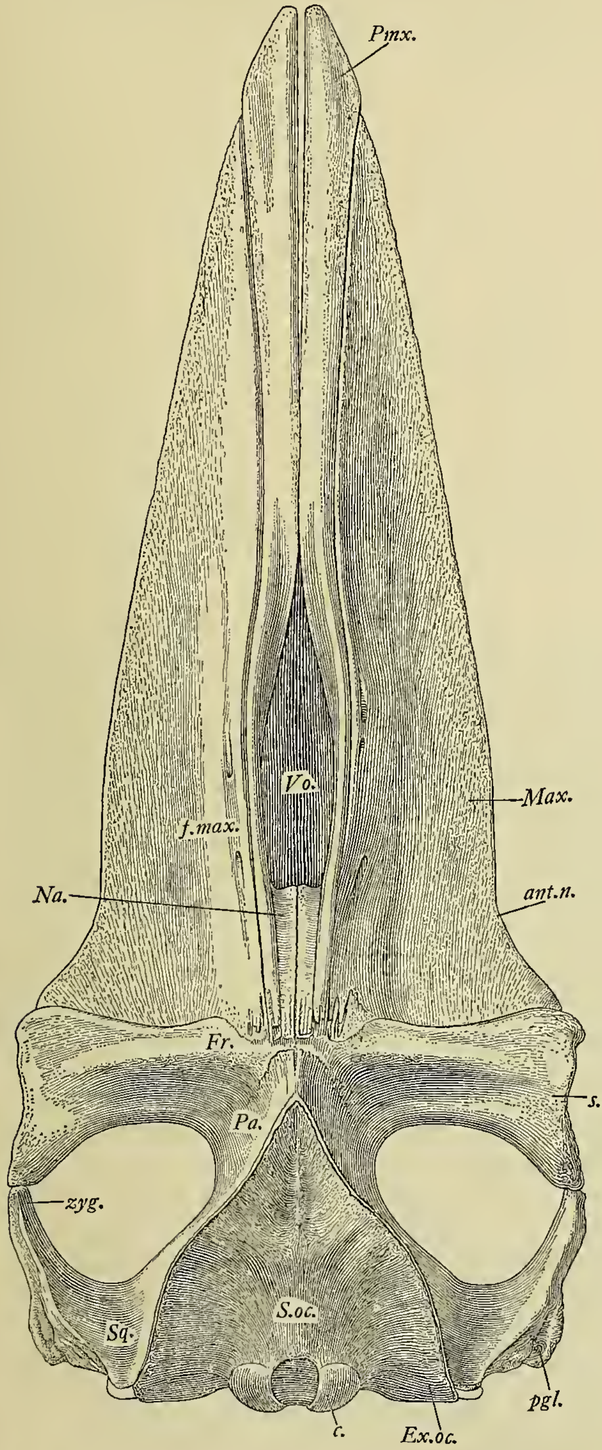

FIGURE 78.—Dorsal view of skull, USNM 10677, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

Between the intertemporal region contributed by the parietals and the posterior ends of the rostral bones, the frontal bones (USNM 10677; fig. 78) are exposed for an interval of less than 15 mm. Each frontal slopes gradually downward from the midline behind the nasals to the orbital rim of the supraorbital process of the frontal. The transverse ridge or crest is low and indistinctly developed on the supraorbital processes of all the skulls. Whether or not the rounded preorbital angle of the supraorbital process projected outward beyond the lateral extensions of the postero-external end of the maxillary cannot be determined since this region is missing on all the skulls. The stout postorbital projection of the supraorbital process is extended backward to the anterior end of the zygomatic process.

The opposite parietals meet on the midline of the cranium to constitute a sharp-edged ridge; they are also overlapped above and behind by the lateral borders of the supraoccipital shield. The thin anterior border of each parietal overlaps the interorbital basal portion of the corresponding frontal.

On each side the posteroventral portion of the braincase is constituted by the squamosal. Behind its contact with the pterygoid, the squamosal follows the curvature of the

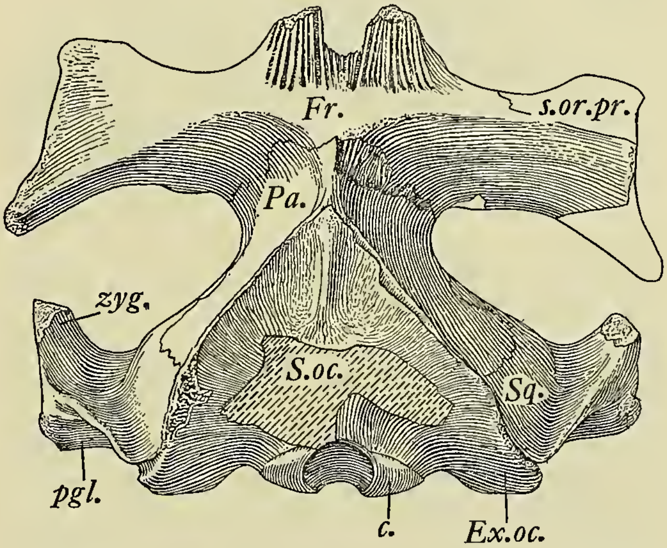

FIGURE 79.—Dorsal view of skull (type), USNM 10668, of *Parietobalaena palmeri* Kellogg. Abbrs.: ant. n., antorbital notch; Bo., basioccipital; Bs., basisphenoid; c., occipital condyle; Ex.oc., exoccipital; f.m., foramen magnum; f.max., maxillary foramen or incisure; f.ov., foramen ovale; Fr., frontal; h.pt., hamular process of pterygoid; j.n., jugular notch or incisure; l. pr., lateral or descending protuberance of basiocipital; Max., maxilla; m.e.a., channel for external auditory meatus; Na., nasal; o.c., optic canal; Pa., parietal; Pal., palatine; pgl., postglenoid process; Pmx., premaxilla; pr.a., anterior process of periotic; pr.p., posterior process of periotic; pr.s.p., presphenoid; Pt., pterygoid; pt. f., pterygoid fossa; S.oc., supraoccipital; Sq., squamosal; s.or.pr., supraorbital process of frontal; Ty., tympanic bulla; Vo., vomer; zyg., zygomatic process.

temporal fossa to the extremity of its zygomatic process. This slender zygomatic process is directed obliquely outward and forward to or almost to the end of the postorbital projection of the supraorbital process. The lambdoidal crest is continued forward on the dorsal edge of the zygomatic process.

Except at their extremities the exoccipitals on skulls of the immature individuals (fig. 79) are largely concealed from a dorsal view; the occipital condyles project backward beyond the level of the ends of the exoccipitals. On skulls of older individuals (fig. 77) the exoccipitals project backward beyond the level of the articular surfaces of the occipital condyles. The transverse diameter (250 mm.) of the triangular occipital shield on the largest skull (USNM 16119) at the level of the dorsal rim of the foramen magnum exceeds the greatest distance (195 mm.) from the dorsal rim of this foramen to the apex of this shield. On another skull (USNM 23022) these measurements are, respectively, 220 and 190 mm. The transverse diameter of this supraoccipital shield is progressively reduced above the middle of its height to the apex.

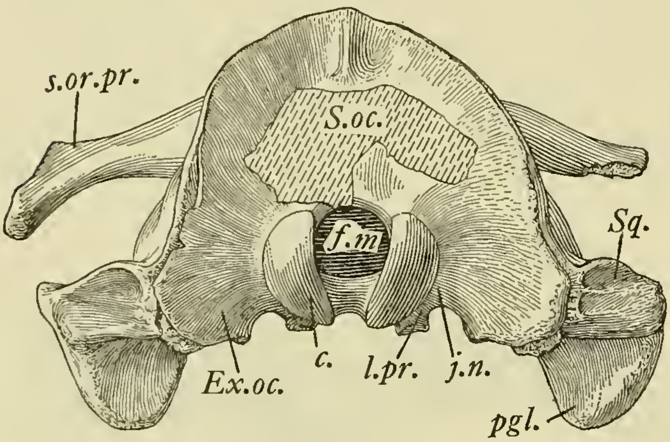

Figure 80.—Posterior view of skull (type), USNM 10668, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

Posterior view.—The ratio of height to the width of the braincase diminishes with growth and the exoccipitals become extended farther laterally. Depression of the top of the braincase increases with age.

The broad supraoccipital constitutes the major portion of the triangular shield which curves upward and forward. On the cranium (USNM 10668; fig. 80) of the young whale this shield from a posterior view appears more rounded than it is actually. The lambodidal crest (fig. 81) constituted by the lateral margins of the supraoccipital and exoccipital and the abutting edges of the parietals and squamosals, increases in prominence toward the apex of the shield; laterally it continues forward along the dorsal edge of the zygomatic process.

The occipital condyles are semi-elliptical in outline, broadest above the middle of their height, and their articular surfaces are convex in both vertical and transverse directions. The occipital condyles are less protuberant on the adult skull than on that of the young. Each postglenoid process is prolonged ventrally, flattened on its posterior face, and rounded distally.

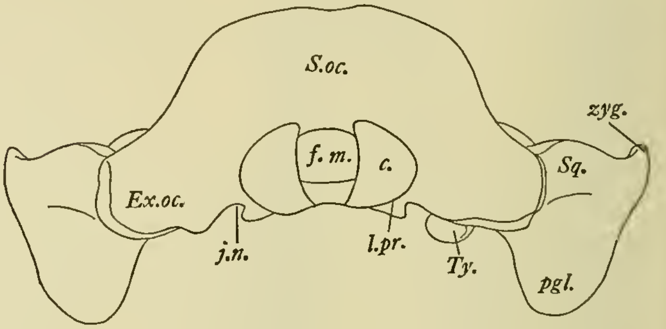

Figure 81.—Posterior view of skull, USNM 16119, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

Lateral view.—The highest point in the dorsal profile (USNM 10677; pl. 64, fig. 3) is behind the apex of the supraoccipital shield. In front of the apex, the intertemporal ridge slopes to the flattened median interorbital region; between this median region and the extremity of the rostrum the slope of the dorsal profile is very gradual. The greatest dorsoventral diameter of the rostrum is at the hinder end of the nasal fossa. The convex side to side curvature of the dorsal surface of the rostrum is gradually diminished toward the extremity; the ventral surface of the rostrum is quite flat on the distal one third.

The orbital border of the supraorbital process of the frontal is dorsoventrally compressed and shallowly arched. Elongation of the postorbital projection has lengthened the orbit and shortened the interval between the ends of this projection and the attenuated slender zygomatic process. The postglenoid process extends more downward than backward, its glenoid surface being slightly convex.

From a lateral view the contact of the parietal with the squamosal is almost horizontal ventrally and nearly vertical posteriorly. The opposite parietals meet on the midline of the intertemporal region, forming a sharp-edged ridge. On quite young skulls (USNM 16838), the ovoidal external end of the alisphenoid is located on the outer wall of the braincase between the pterygoid ventrally and the parietal. On more mature skulls (USNM 23022) the alisphenoid is more elongated and dorsoventrally compressed. In describing the relations of the bones in this region, Ridewood (1922, p. 262) comments that among mammals it is unusual for the squamosal to extend forward to meet the pterygoid, as it does on mysticete skulls, as is also the location of the foramen ovale in a cleft at the end of the squamosal behind the pterygoid.

The occipital condyles are not visible when the skull is viewed from the side.

Ventral view.—Description of the ventral aspect of the skull will of necessity be based on several specimens. The ventral surface of the cranium is best preserved on USNM 16119 (fig. 82); the relations of several individual bones are well defined on a young skull (USNM 10668), and the rostral bones are fairly complete on USNM 10677.

Of the several bones comprising the skull, the largest is the maxillary, which except for the thin proximal border is sufficiently complete on the right side of an immature skull (USNM 10677; pl. 65, fig. 4) to show the arrangement of the grooves for the nutrient vessels that supply the palate and the attached baleen. Most of these grooves are located on the flattened ventral surface external to the median downward curved internal border that is applied to the trough of the vomer. The longest of these grooves (fig. 83) are located chiefly on the anterior half of the rostrum and they are directed more forward than the shorter and more numerous oblique grooves. A few shorter curved grooves directed more transversely than those elsewhere on the palatal surface are present near the proximal end of the rostrum.

The vomer on the skull (pl. 65, fig. 4) is fortuitously exposed ventrally, by the separation of the maxillaries, for nearly its entire length on the rostrum. On all these skulls, a downward directed median vertical partition, mainly arising from the horizontal vaginal plate of the vomer and separating the choanae, diminishes in height behind the median divergence posteriorly of the opposite palatines. On the largest skull (USNM 16119), the flat ventral edge of this partition becomes visible 120 mm. in front of the posterior edge of the horizontal vaginal plate of the vomer and vanishes about 25 mm. anterior to this edge. This horizontal plate conceals, when present, the transverse ankylosis of the basioccipital and basisphenoid and also the sutural contact of the latter with the presphenoid (fig. 84). Laterally this horizontal plate is suturally in contact with the corresponding edge of the vaginal process of the pterygoid. The trough of the vomer is widest near the level of the anterior ends of the palatines.

Each elongated palatine meets its opposite on the midline, is applied to the ventral surface of the trough of the vomer, is in contact anteriorly and externally with the corresponding maxillary, and, posteriorly, is suturally united with the pterygoid. The posterior divergence of the posterointernal edge of the palatine commences on the vertical partition between the choanae about 120 mm. in front of the posterior edge of the vaginal plate of the vomer. The anteroposterior

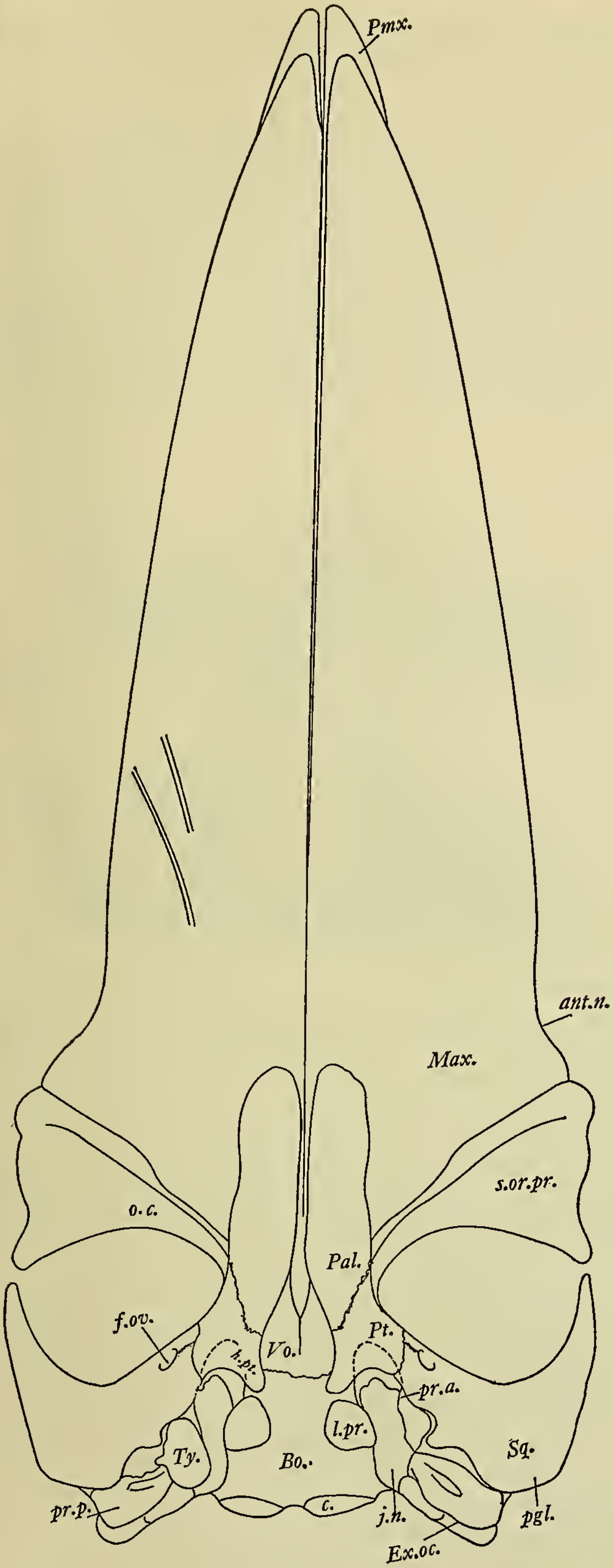

Figure 82.—Ventral view of skull, USNM 16119, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

diameter of the palatine is equivalent to about 17 (USNM 16570) to 20 percent (USNM 10677; fig. 83) of the length of the skull.

The supraorbital processes of the frontals are incomplete on all skulls except the young specimen (USNM 10668). On one (USNM 10677), the outer portion of the right process is well preserved (pl. 65, fig. 4). The preorbital angle of this process is rounded and the postorbital is extended backward to the end of the zygomatic process. On the young skull (fig. 84; USNM 10668) the channel for the optic nerve curves outward on the ventral surface of the supraorbital process of the frontal in the usual manner and increasing in width becomes widest at the orbital rim. Near its origin this channel is located on the posterior surface of this process but twists downward to the ventral surface and then on its outward course is located behind the well-defined anterior wall.

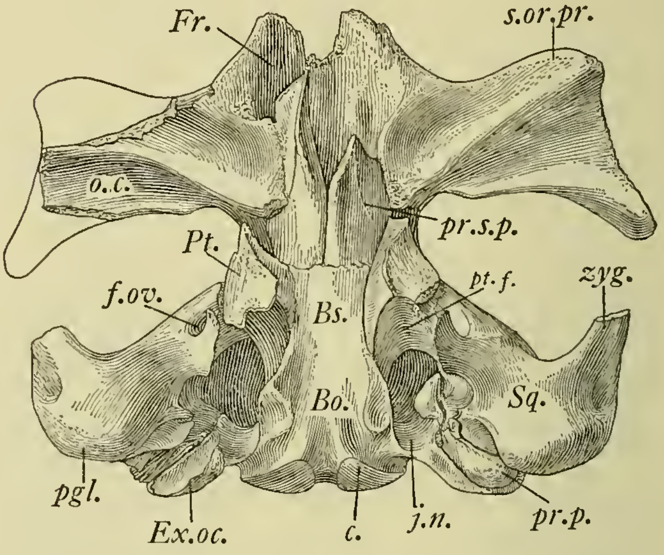

Figure 84.—Ventral view of skull (type), USNM 10668, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 79.

The ventral surface of the relatively narrow basioccipital is shallowly concave. On each side of this bone the lateral descending protuberance, although variable in shape possibly attributable to age, is convex internally and overlapped anteriorly by the vaginal process of the pterygoid. The basioccipital is so intimately fused with the basisphenoid, even on the young skull (USNM 16838), that the sutural contact is obliterated. A narrow gap separates the alisphenoid and the presphenoid at least until physical maturity. Both the alisphenoid and the presphenoid are hidden from a ventral view by the overspreading ventral horizontal plate of the vomer.

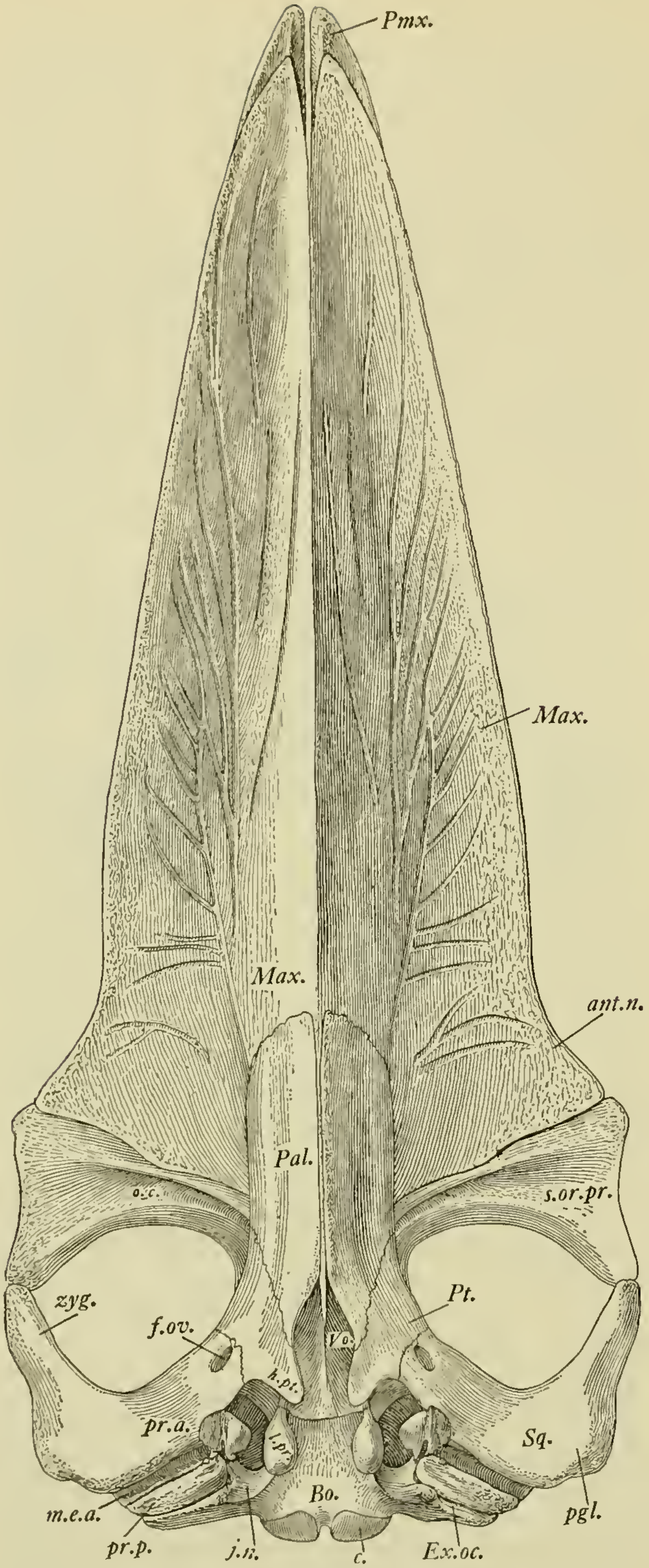

Figure 83.—Ventral view of skull, USNM 10677, of *Parietobalaena palmeri* Kellogg, restored. For abbreviations, see figure 79.

The pterygoid is intercalated between the posterior end of the palatine and the bifurcated anterior end of the squamosal. This bifurcation of the squamosal encloses the foramen ovale.

The relatively small pterygoid fossa is constituted by the vaginal process of the pterygoid internally, anteroexternally by the ventrally curving thickened anterior and external borders of the pterygoid, and to a limited extent posteroexternally by the falciform process of the squamosal. The pterygoid contributes the osseous roof of this fossa. This pterygoid fossa is continuous posteriorly with the tympanoperiotic recess, which is bounded by the squamosal externally, by the pterygoid anteriorly, by the lateral protuberance of the basioccipital internally, and by the exoccipital posteriorly. A broad notch or incisure on the exoccipital at the posterior end of this recess constitutes the posterior lacerated foramen for the jugular leash.

On the ventral surface the contact between the exoccipital and the squamosal is concealed by the posterior process of the periotic, which is securely lodged in a transverse groove on the squamosal behind the postglenoid process of the squamosal. At the base of the postglenoid process and anterior to the posterior process of the periotic is the transverse groove or channel for the external auditory meatus. On the ventral edge of the exoccipital external to the jugular notch is a narrow depression which constitutes the paroccipital process or area for attachment of the stylohyoid.

The slender anteriorly attenuated zygomatic process is directed outward and forward. The postglenoid process is not enlarged or thickened and is deflected obliquely backward. The flattened posterior surface of the postglenoid process contrasts strongly with the convexity of its anterior surface and the internal concave area on the adjacent ventral surface of the squamosal.

The skull (MHNB 4018) identified by Abel (1938, p. 28, fig. 4) as *Isocetus depauwii* has 420 mm. zygomatic width. As compared to this Calvert cetothere, the Belgian skull is characterized by a strongly attenuated and much narrower rostrum throughout its length; the zygomatic process is also more robust. Furthermore, the Belgian skull is distinguished by a somehwat different profile of the temporal fossa when viewed from the ventral side, the zygomatic process being turned forward abruptly almost at a right angle from the anterior temporal surface of the squamosal. A deep crease at this point on the anterior border of the squamosal distinguishes skulls of recent *Balaenoptera*.

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

	USNM 16119	*USNM 10677*
Greatest length of skull, anterior end of right premaxillary to level of posteroexternal angle of right exoccipital	1280+	1100
Distance from anterior end of right premaxillary to posterior articular face of right occipital condyle	1260±	1105
Distance from anterior end of right premaxillary and extremity of right postglenoid process	1240±	—
Distance from anterior end of right premaxillary and apex of supraoccipital shield	1050±	885
Greatest length of right premaxillary	—	817
Distance from apex of supraoccipital shield to posterior end of right nasal bone	80	60
Transverse diameter of skull across preorbital angles of supraorbital processes	—	454±
Greatest anteroposterior diameter of extremity of right supraorbital process of frontal	150±	143
Transverse diameter of skull across outer surfaces of zygomatic processes	496	442±
Transverse diameter of skull between outer edges of exoccipitals	345	265±
Transverse distance between outer edges of occipital condyles	138	—
Greatest or obliquovertical diameter of right occipital condyle	75.5	69
Greatest transverse diameter of right occipital condyle	47	42
Greatest transverse diameter of foramen magnum	48	—
Distance from dorsal rim of foramen magnum to apex of supraoccipital shield	193	208
Distance from anterior end of right premaxillary to anterior end of right nasal bone	—	708
Greatest length of right nasal bone	—	120
Transverse diameter of anterior end of right nasal bone	—	18.5
Transverse diameter of posterior end of right nasal bone	—	14
Combined width of nasal bones, anteriorly	—	38.5
Greatest transverse distance between outer margins of premaxillaries at level of anterior ends of maxillaries	—	88.5
Greatest breadth of basioccipital across lateral protuberances, outside measurement	125	—
Greatest length of left zygomatic process, extremity of postglenoid process to anterior end	214	—
Greatest anteroposterior diameter of left palatine	225	—
Greatest transverse diameter of left palatine	60+	—
Distance from posterior surface of right occipital condyle to posterior end of vomer	120	—
Distance from posterior surface of left occipital condyle to anterior edge of left palatine	390	—
Posterior edge of vomer to anterior edge of left palatine	273	—

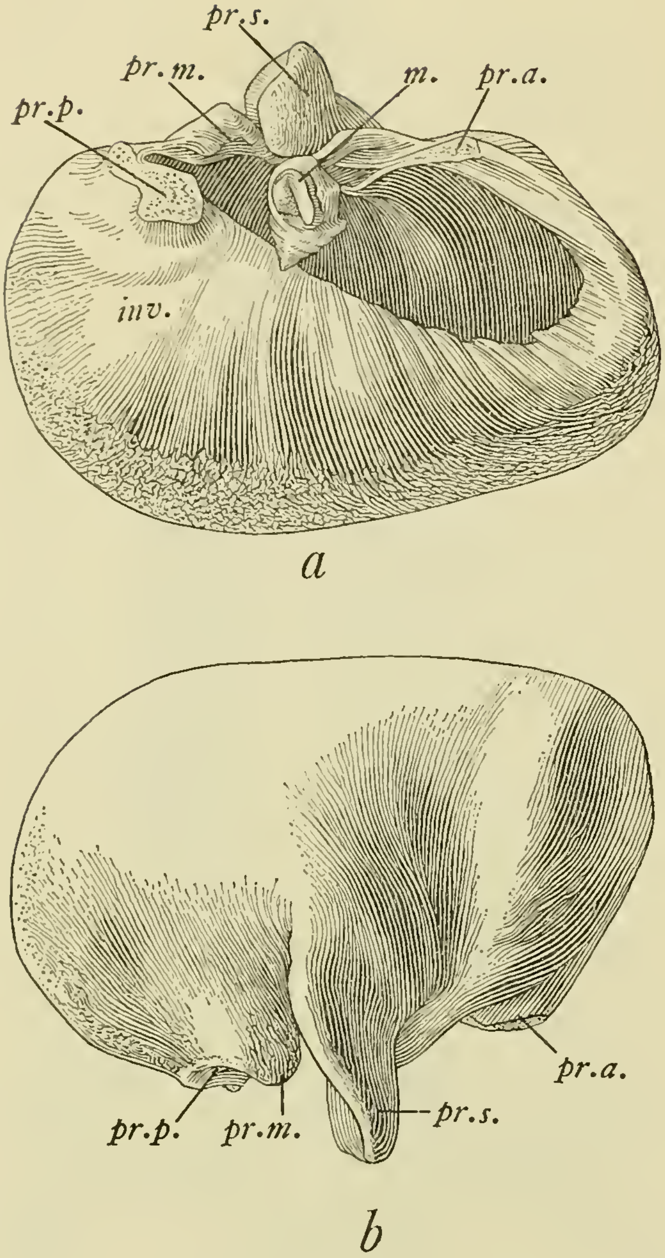

Figure 85.—Views of left tympanic bulla and malleus, USNM 15576, of *Parietobalaena palmeri* Kellogg: *a*, dorsal view; *b*, external view. Abbrs.: a.c., orifice of cochlear aqueduct; a.i.c.F., internal aperture of aquaeductus Fallopii; a.p., anterior pedicle of bulla; a.v., orifice of vestibular aqueduct; c.f., channel for facial nerve; f.a.s., fossa for extension of air sac system; f.c.m., fossa for head of malleus; fe.o., fenestra ovalis; fe.r., fenestra rotunda; inv., involucrum; m., malleus; m.a.i., internal acoustic meatus; p.c., pars cochlearis; p.p., posterior pedicle of bulla; pr.a., anterior process (pro-otic); pr.m., processus medius or conical apophysis; pr.p., posterior process (opisthotic); pr.s., sigmoid process; t.s.f., tractus spiralis foraminosus.

Tympanic Bulla

An undamaged tympanic bulla attached to the right periotic (USNM 13874), which was associated in the Calvert zone 11 with the hinder part of the basicranium and a left tympanic bulla with complete attached malleus (USNM 15576) found isolated from other skeletal elements in the Choptank zone 16 are the best preserved of twelve bullae referred to this species. The left tympanic bulla, which was associated with the type cranium (USNM 10668) of *Parietobalaena palmeri* in the Calvert zone 11 lacks a portion of the thin outer lip, the anterior pedicle, the sigmoid process, and the normally attached malleus. This bulla (greatest length, 57 mm.) is slightly smaller than either the above mentioned right bulla (USNM 13874; greatest length, 60.5 mm.) or another right bulla (USNM 10677; greatest length, 59 mm.) detached from a skull (length, 1107 mm.) excavated in Calvert zone 10.

The posterior pedicle (fig. 86a), located transversely on the tympanic bulla, is much thicker where it is ankylosed to the periotic than the thin longitudinal attachment of the anterior pedicle. This posterior pedicle may or may not be separated by a cleft from the low, blunt posterior conical apophysis (fig. 86a); in either condition it arises internally from the posterior end of the thickened involucrum and externally at the posterior end of the outer lip.

Viewed from the ventral aspect the posterior end of the bulla is obliquely truncated in an internoexternal direction, the transverse diameter of the anterior end is less than the posterior end, and a low faintly defined ridge extends obliquely from the posteroexternal angle to the anterointernal angle.

The thin overarching outer lip, whose anterior pedicle is ankylosed to the anterior process of the periotic, does not by its curvature abruptly reduce the width of the eustachian outlet of the tympanic cavity. The width of the involucrum (fig. 86a) is strongly diminished at its anterior end and transverse creases are indistinct except near the eustachian outlet.

Referring again to the outer lip, it would appear that some functional demand existed for twisting the rounded and thickened sigmoid process (fig. 85b) at right angles to the longitudinal axis of the bulla as well as for the presence of a deep groove between it and the posterior conical apophysis. The slender stalk-like anterior process of the malleus (fig. 85a) was attached in the normal position along the posterior border of the sigmoid process.

Viewed from the external aspect (fig. 86b) the depth of the rounded posterior profile exceeds that of the less convex anterior end.

Accumulation of a representative series of tympanic bullae during the past forty years from the Calvert formation, some isolated and others associated with crania, has shown that their lengths do not provide a reliable basis for identification. Lengths of the bullae of this species range from 52 to 63 mm. Other minor differences may be attributed to age factors.

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

	USNM 10668 Left	*USNM 16119 Right*	*USNM 10677 Right*	*USNM 13874 Right*	*USNM 15576 Left*
Greatest length of bulla	57	59.5	59	60.5	62.5
Greatest width of bulla	—	34.5	36	35	33
Greatest vertical diameter on external side, ventral face to tip of sigmoid process	—	43	43.5	45	49
Greatest length of tympanic cavity	44	42	44	41.5	46

Periotic

Likeness of cetothere periotics without some degree of relationship seems unlikely. The degree of affinity may be assessed by noting the extent of resemblance of auditory structures that appear to be less susceptible of modification during growth. For example the shape of the *pars cochlearis* of this species exhibits very little change in the growth stages from new born to adult. The most obvious alteration occurs in the shape and dimensions of the posterior process (fig. 84), which is firmly wedged in a deep groove between the exoccipital and the postglenoid portion of the squamosal. Nine periotics either attached to or associated with skulls or crania were selected to illustrate the range of individual variation. A similar type of *pars cochlearis* is found in the Belgian Anversian "*Idiocetus*" *laxatus* (Van Beneden, 1886, pl. 54, figs. 3, 4).

On the posterior face of the *pars cochlearis* above (dorsal to) the *foramen rotunda* and its projecting shelf and behind the stapedial fossa is a short, narrow fossa (vertical diameter, 4 to 8 mm.) of variable depth that extends from the internal end of the posterior process to the inner (cerebral) face of the periotic (fig. 87b). It is separated from the fossa for the stapedial muscle by the thin crestlike posterior ridge bounding the latter. This fossa extends upward and inward from the fossa for the stapedial muscle.

The *pars cochlearis* is relatively small, compressed slightly from side to side (fig. 88a), somewhat triangular in profile when viewed from the internal (cerebral) side; the dome or apex of the *pars cochlearis* (fig. 88b) is conspicuously extended ventrally. No discernible alteration in the size of the *pars cochlearis* during growth was noted among these periotics. The cerebral face of the labyrinthic region dorsal to the internal acoustic meatus is variable in appearance, smooth (flat or concave) or porous and rugose (USNM 16119).

On the internal face, the internal acoustic meatus is small, usually somewhat circular in outline at level of the cerebral rim, but occasionally ovoidal; this rim is 9 to 14 mm. above (dorsal to) the dome of the *pars cochlearis*. The vestibular aqueduct (fig. 87b) opens into an elongated or broad ovoidal depression of variable depth on the cerebral face. The cerebral aperture of the Fallopian aqueduct is either adjacent to the rim of the internal acoustic meatus (USNM 13874), at the anterodorsal angle of the *pars cochlearis* (USNM 10909; pl. 48, fig. 6), or small and within the cerebral rim of the internal acoustic meatus (USNM 20376).

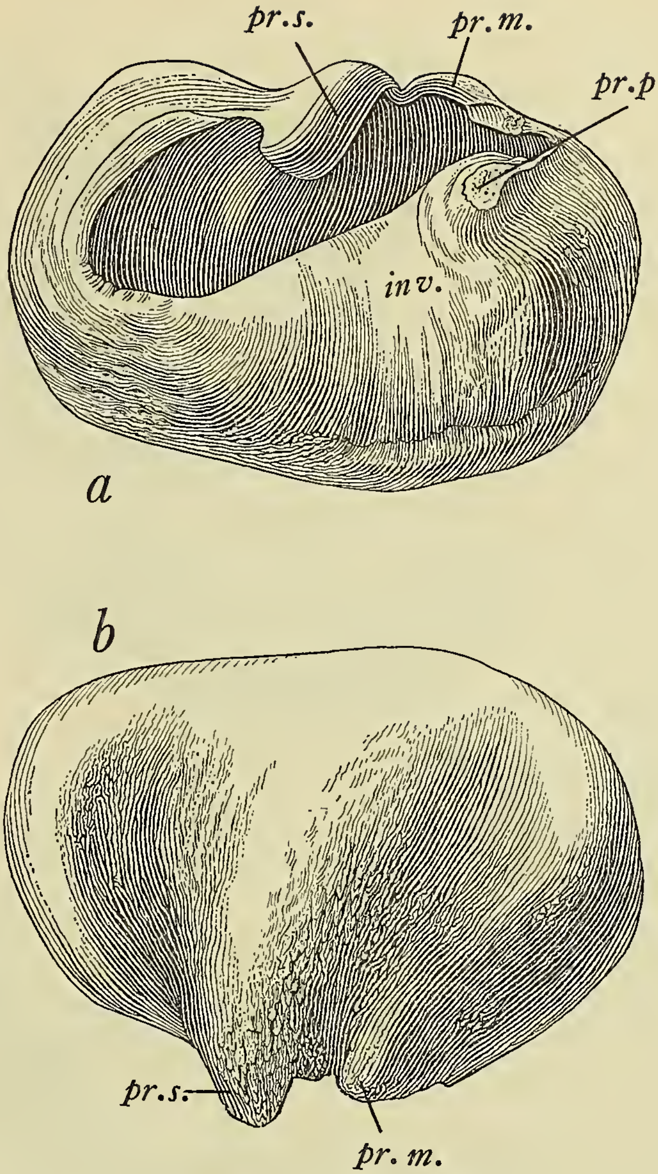

FIGURE 86.—Views of right tympanic bulla, USNM 10677, of *Parietobalaena palmeri* Kellogg: *a*, dorsal view; *b*, external view. For abbreviations, see figure 85.

The shape of the posterior process (opisthotic) appears to be quite variable, and this variation may not be entirely

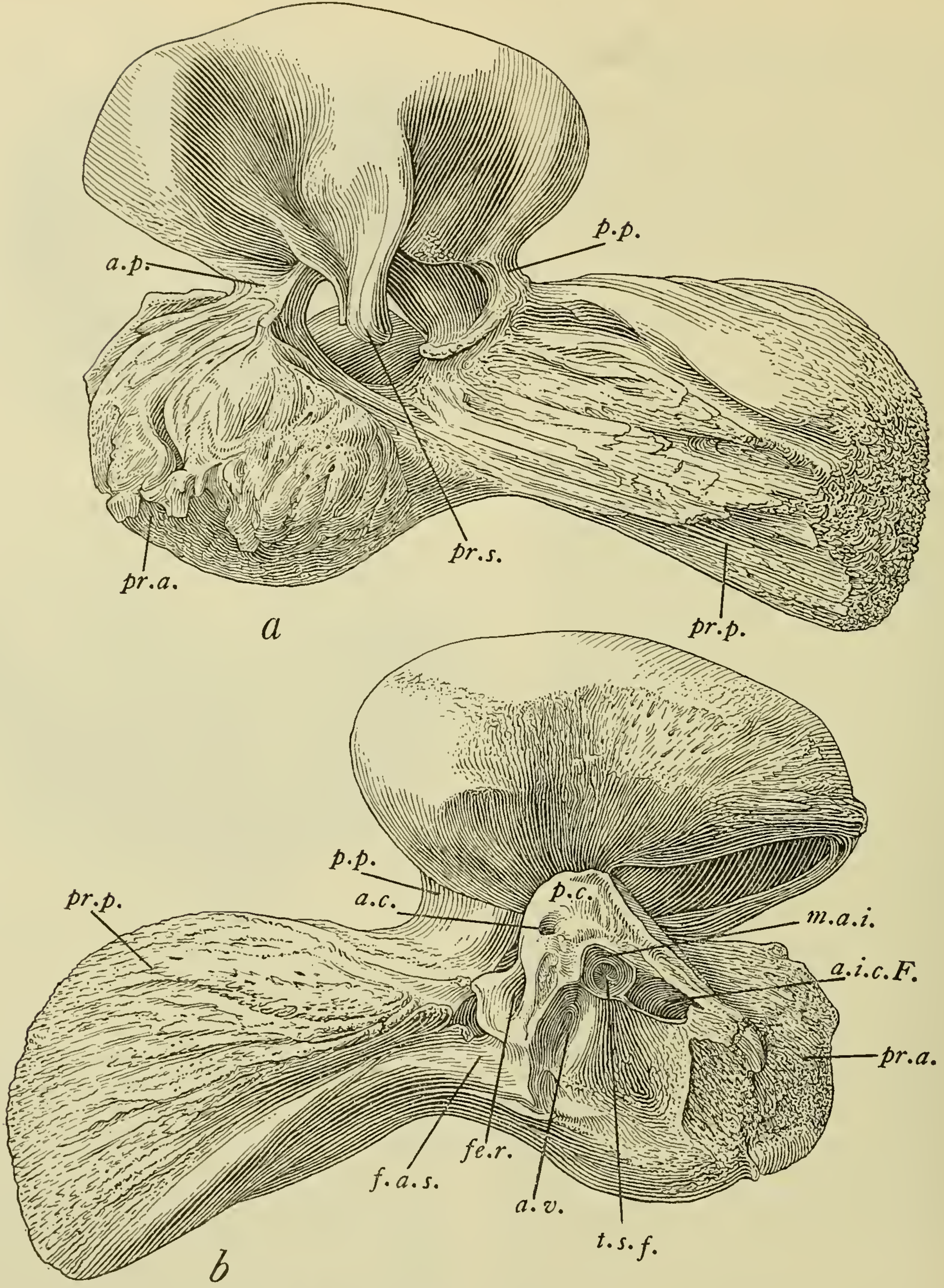

Figure 87.—Views of right tympanic bulla and periotic, USNM 13874, of *Parietobalaena palmeri* Kellogg: *a*, external view; *b*, internal view. For abbreviations, see figure 85.

attributable to age. On most skulls the posterior process (fig. 88b) is relatively short and abruptly expanded beyond the base; on others it is either gradually enlarged toward the extremity or slender and elongated (pl. 48, fig. 6). The posterior pedicle of the tympanic bulla (fig. 87a) before it was dislodged or broken off while in storage was ankylosed with the anterointernal angle of the posterior process. Behind this pedicle, the groove for the facial nerve extends outward toward the extremity of the ventral face of this process. The series of crania now available indicate that the lengthening of the posterior process continues to physical maturity. Enlargement of the posterior process seemingly cannot be attributed to old age. One physically immature individual (USNM 23203) has the posterior process (length, 90 mm.) unusually expanded toward its distal extremity (greatest diameter, 77 mm.). Epiphyses are ankylosed to the centra of only 3 of the 36 vertebrae associated with this specimen. Continued growth of the anterior process appears somewhat limited.

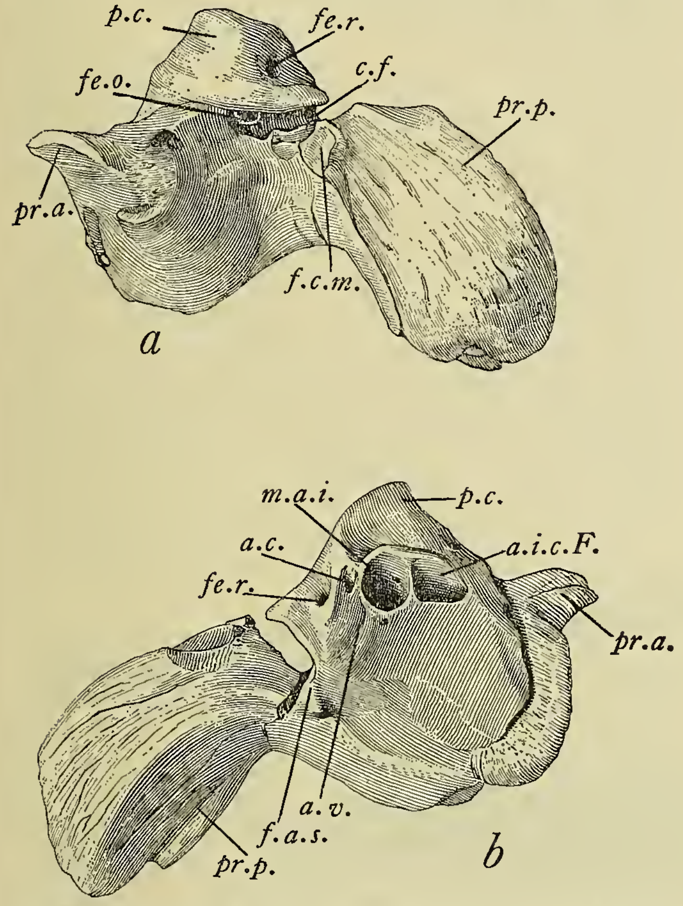

FIGURE 88.—Views of right periotic (type), USNM 10668, of *Parietobalaena palmeri* Kellogg: *a*, ventral view; *b*, internal view. For abbreviations, see figure 85.

The anterior process (pro-otic) is very short, dorsoventrally compressed distally; the labyrinthic region is enlarged, bulbous, and sculptured (fig. 87a). The relatively short anterior process and the adjoining labyrinthic region are securely lodged in an excavation on the cerebral face of the squamosal. The thin anterior pedicle (fig. 87a) of the tympanic bulla is fused with the epitympanic face of the anterior process in front of the fossa for reception of the head of the malleus. This shallow concavity for the head of the malleus is located either anterior to or alongside (USNM 23055) the epitympanic orifice of the Fallopian aqueduct. Overhang of the obliquely inclined external face of the *pars cochlearis* conceals the *fenestra ovalis* from a ventral view.

On some periotics (USNM 22995) an anteroposterior crease divides the external and internal portions of the tympanic or ventral face of the *pars cochlearis*, the outer portion being normally smooth and convex. On other periotics the internal or cerebral portion of this ventral surface is irregularly excavated or depressed (USNM 13874). On most periotics the smooth convex ventral surface of the tympanic face of the *pars cochlearis* does not extend inward as far as the rim of the internal acoustic meatus.

The small fossa for the stapedial muscle is slightly rugose and extends downward on the internal face of the base of the posterior process and on the external face of the *pars cochlearis*. On some periotics (USNM 22995) the functioning of the muscle attached in this fossa would appear to have been considerably restricted by the extent of the projecting ledge above the *fenestra rotunda*.

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

	USNM 10668 Right	*USNM 13874 Right*	*USNM 22995 Right*	*USNM 16119 Right*	*MHNB*[1] *29 Right*
Length of posterior process, distance from external wall of stapedial fossa to extremity	48	66	83	87	122
Greatest dorsoventral depth of periotic (from most inflated portion of tympanic face of *pars cochlearis* to most projecting point on dorsal face	43	43	53	52	53.6
Distance between epitympanic orifice of Fallopian aqueduct and extremity of anterior process	30	33	44	41	57.2
Distance from external end of posterior process to anterior end of anterior process (in straight line)	82	97	118	132	166

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[1] "*Idiocetus*" *laxatus* Van Beneden, No. 29, Musée royal d'Histoire naturelle de Belgique, Bruxelles.

Auditory Ossicles

Rather rare preservation of the auditory ossicles of Calvert mysticetes seems attributable in part to the fragile nature of the anterior and posterior pedicles that attach the tympanic bulla to the periotic. Tidal action, which periodically washed skulls cast on the beach, probably resulted in breakage except when favorable conditions lead to rapid burial, in sediments. In a relatively few instances skulls have been excavated that have the tympanic bulla crushed against the periotics in approximate normal position. In other instances, the tympanic bullae are found dislodged and shoved into the tympanoperiotic recess of the cranium or occasionally somewhere near the skull. The outer lip of the detached bulla is often fractured and it usually lacks both the anterior and posterior pedicles. Quite frequently the labyrinthic region of the periotic is broken off at the point of connection with its posterior process (opisthotic). All of these hazards of preservation have limited the possible recovery of the auditory ossicles.

Of the 34 Calvert tympanic bullae in the collection only one (USNM 15576) retained the malleus attached to the outer lip. A detached malleus was found in the matrix contained in the epitympanic cavity of one periotic (USNM 23015).

The slender stalklike processus anterior (Ridewood, 1922, pp. 241, 247) of the malleus is ankylosed at the base with the outer lip of the bulla (fig. 85a) along the anterior border of the sigmoid process (USNM 15576). The two facets on the head of the malleus that articulate with the incus have the same shape and relationship as the corresponding facets of *Balaenoptera borealis.*

The nearly vertical dorsal hemicircular facet meets the smaller horizontal facet at a right angle, and both facets are situated above the internal dorsal face of the prominent tubercle. At the internal end of the tubercle (*processus muscularis*) the short manubrium is more acuminate and less nipple-like and not as noticeably bent backward at its distal extremity as the corresponding process of *B. borealis,* although the scar for attachment of the ligamentary process of the tympanic membrane is likewise located ventrally at the distal end. A similar attachment has been reported for *Balaenoptera musculus* by Lillie (1910, p. 779). On each of the two small circular nodules on the anterior face of the head of the malleus there is a scar. To the scar on the nodule located anteriorly on the rounded tubercle of the head of the malleus the tensor tympani tendon was attached (Doran, 1878, p. 454). The scar on the adjacent nodule located anteriorly on the outer portion of the head of the malleus presumably served for attachment of a little ligament.

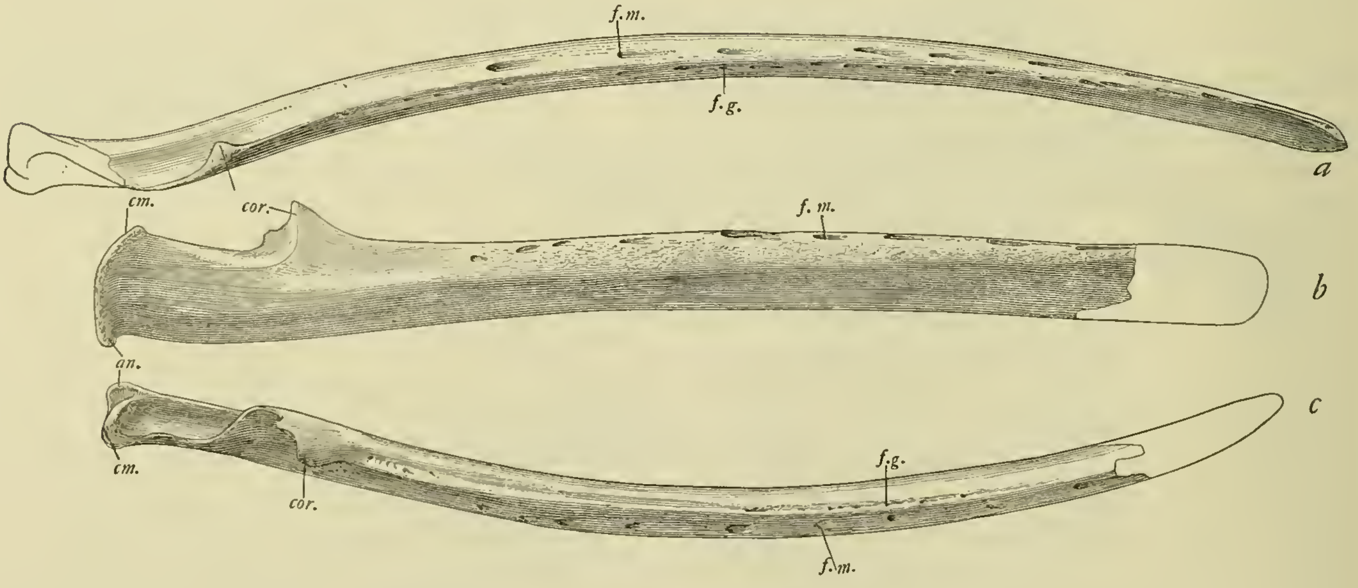

FIGURE 89.—Views of right and left mandibles, USNM 10677, of *Parietobalaena palmeri* Kellogg: *a,* dorsal view of left mandible; *b,* external view of right mandible; *c,* dorsal view of right mandible. Abbrs.: an., angle; cm., condyle of mandible; cor., coronoid process; f.g., gingival or alveolar foramen; f.m., mental foramen; ipt., groove for attachment of internal pterygoid muscle.

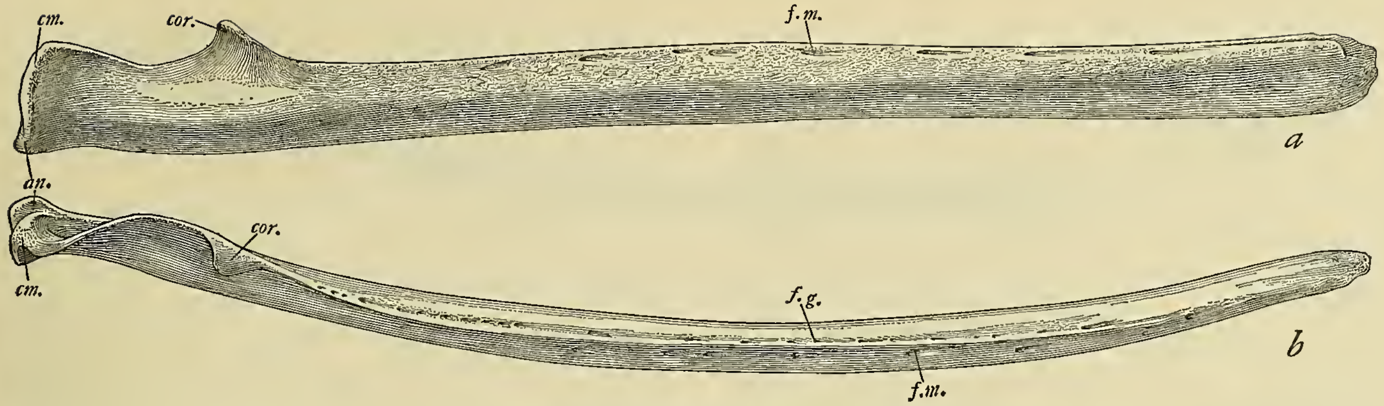

FIGURE 90.—Views of right mandible, USNM 11535, of *Parietobalaena palmeri* Kellogg; *a*, external view; *b*, dorsal view. For abbreviations, see figure 89.

These two small nodules are also located in the same relative position on the malleus of *B. borealis*. The head of the malleus measures 11 mm. in length and 7.2 mm. in width.

No incus was found associated with the ear bones of the Calvert cetotheres collected for the vertebrate paleontological collections. Quite probably this little ossicle may have been overlooked in some instances when the tympanic bulla or periotic have been freed from the enveloping matrix. On all periotics of this species examined the stapes had been dislodged and lost.

Mandibles

Both mandibles (fig. 89a–c were associated with one (USNM 10677) of the four more or less complete skulls (USNM 16570, 23022, 23725), but none were found near the type cranium (USNM 10668) that belonged to a rather young individual. A longer right mandible (USNM 11535), which was intermingled with a number of skeletal elements including a cranium, rostral bones, bullae, periotics, seven vertebrae, ribs, and a humerus, is essentially complete except for limited erosion of the articular face of the condyle. This individual was not physically mature, since the epiphyses were not ankylosed to the centra of the cervical vertebrae. Less complete mandibles provided supplementary information. One of the smallest (fig. 91 a, b) is a left mandible (USNM 12697; length 918 mm., anterior end missing) of a young whale about the same age as the type, whose greatest vertical diameter anteriorly is 58.5 mm.

When compared with the mandibles of the Belgian Anversian fossil mysticetes described by Van Beneden, the resemblances shown by the mandible of *Isocetus depauwii* to the Calvert mandible require more than a cursory assessment. The length in a straight line of the type left mandible of *I. depauwii* (MHNB 170; Van Beneden, 1886, pl. 70, fig. 1) is 1128 mm. and that of a Calvert right mandible (USNM 11535; fig. 90 a, b) is 1195 mm. The vertical diameter of the mandibular ramus of this Belgian species near the distal end is 84 mm., and the same measurements for this Calvert mandible is 73 mm. The Belgian mandible is thus slightly shorter but more robust than that of the Calvert cetothere.

The profile of the articular face of the condyle of the Calvert mandible compares favorably with that of *I. depauwii* (Van Beneden, 1886, pl. 70, fig. 8), which measures 55 mm. transversely. The greatest transverse diameter of the condyle of these small Calvert mandibles ranges from 55 mm. (USNM 11535) to 62 mm. (USNM 23203) and 80 mm. (USNM 23731). Increase in width certainly modifies the profile of the condyle (fig. 92a–c) and this fact leads clearly to the inference that unlimited reliance should not be placed on the condyle for defining mysticete genera, at least for related genera. More weight should be accorded to the sum or combination of less variable diagnostic characters.

During growth toward physical maturity, a widening of the mandibular condyle and its covering fibrous pad for the usual attachment to the glenoid articular area would accompany an increase in width of the postglenoid process. The maximum side to side expansion of the condyle may occur either above (USNM 23731) or below (USNM 7424) the middle of its vertical diameter. The articular surface

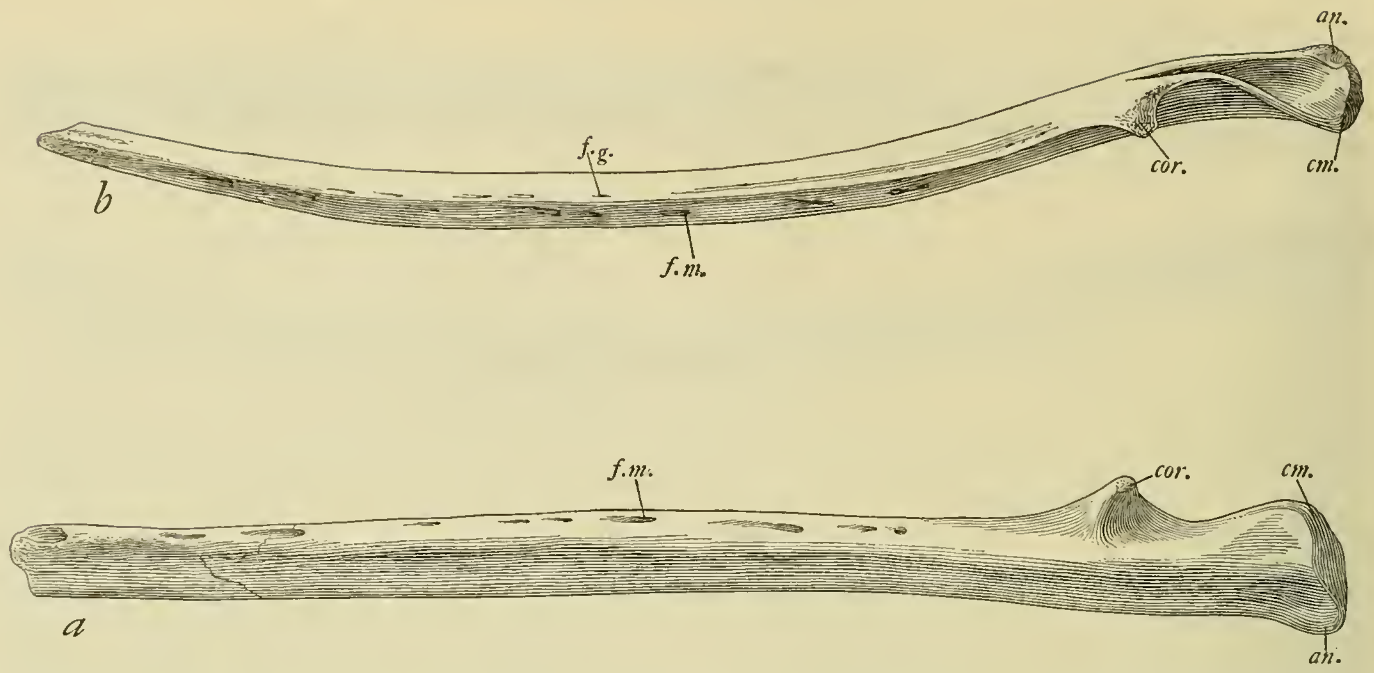

FIGURE 91.—Views of left mandible, USNM 12697, of *Parietobalaena palmeri* Kellogg, young individual: *a*, external view; *b*, dorsal view. For abbreviations, see figure 89.

of the condyle may be either somewhat flattened (USNM 23731) or convex (USNM 23203). On all the mandibles the condyle is bounded ventrally on the internal face of the ramus above the angle by the deep groove for the attachment of the internal pterygoid muscle. This groove is not extended across the posterior articular surface. With one exception the dorsal portion of the condyle is bent inward to conform with the curvature of the rim of the ramus behind the coronoid process; on this mandible (USNM 23203; fig. 92c) the rim is abnormally abruptly depressed some 20 mm. below the forward projecting dorsal edge of the condyle. On other mandibles, the forward curving external border of the condyle projects noticeably beyond the lateral surfaces of the adjacent portions of the ramus. Lengthening of the mandibular ramus is accompanied by an increase in the interval between the condyle and the coronoid process. On three of the mandibles, the posterior articular surface of the condyle is, respectively, 150 mm. (USNM 23203), 180 mm. (USNM 11535), and 200 mm. (USNM 7424) distant from the center of the apex of the coronoid process.

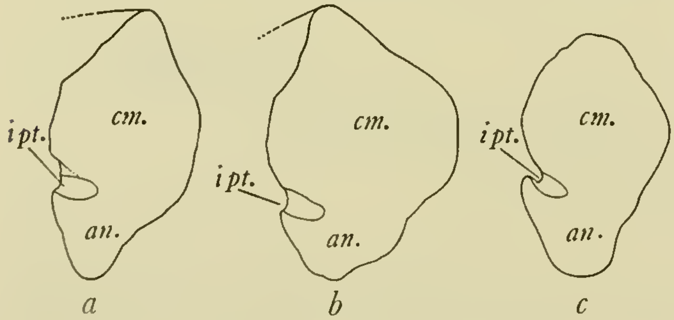

FIGURE 92.—Posterior views of condyles of mandibles of *Parietobalaena palmeri* Kellogg: *a*, right mandible (USNM 7424); *b*, right mandible (USNM 23731); *c*, right mandible (USNM 23203). For abbreviations, see figure 89.

The coronoid process (fig. 90b) is bent outward and less noticeably backward above and anterior to the entrance of the mandibular canal, terminating in an everted apex, convex internally and concave externally. For a distance of 650 mm. in front of the apex of the coronoid process a groove or rather a longitudinal ridge (fig. 90b) forms the dorsal edge of the horizontal ramus. The small internal nutritive foramina make their appearance posteriorly about 75 mm. anterior to the apex of the coronoid process and below its rising anterior rim; commencing at a level about 10 mm. below the dorsal edge of this rim they rise gradually to the dorsal surface anteriorly. At the anterior end of this ridge these small internal foramina and their anteriorly directed narrow grooves follow the dorsal surface to the extremity of the horizontal ramus, the terminal groove being more than 100 mm. in length. There are at least 20 of these small internal nutrient foramina on the right mandible (USNM 11535).

The most posterior mental foramen (fig. 90a) on the external surface of the right mandible (USNM 11535) is located 410 mm. anterior to the posterior articular face of the condyle. There are eight mental foramina on this mandible, each opening into an anteriorly directed groove of variable length (15 to 80 mm.). Eight mental foramina (fig. 89b) are present on both of the shorter mandibles (USNM 10677). A large terminal foramen (fig. 89a) is present below the dorsal edge at the end of the mandible. Spacing of the external mental foramina varies from 38 to 88 mm. on one mandible (USNM 11535), 60 to 117 mm. on another (USNM 13903), and 76 to 97 mm. on a third (USNM 10677). Similar variation in spacing is exhibited by the internal nutritive foramina.

Behind the distal one sixth (200 mm.) the lateral surfaces (fig. 93) of the mandibular ramus become progressively more convex dorsoventrally, the external more especially so than the internal surface. The convex curvature of the external surface ends abruptly where it meets at an acute angle (fig. 93e) the ventral limit of the internal surface. All mandibles referred to this species are bowed outward. Viewed from the side, the ventral profile of the mandible is almost straight. The symphysis was short. Above the ventral edge of the anterior one ninth of the horizontal ramus and below the short longitudinal crease, the lower border (dorsoventral depth, 20 mm.) of the internal face of the ramus is depressed.

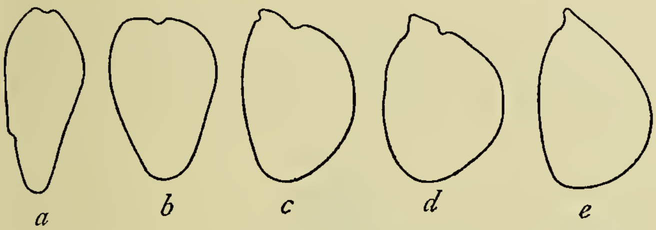

FIGURE 93.—Cross sections of right mandible, USNM 11535, of *Parietobalaena palmeri* Kellogg: *a*, 100 mm. behind anterior end; *b*, 300 mm. behind anterior end; *c*, 500 mm. behind anterior end; *d*, 700 mm. behind anterior end; *e*, 900 mm. behind anterior end.

The mandible being comprised internally to a varying extent of porous bone, depending in part on age and growth factors, and saturated in Recent mysticetes with oil, is susceptible to alteration and compression by the crushing effects of weight of overlying sediments. Allowance accordingly should be made for distortion in comparative measurements of the mandibles.

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

	USNM 11535 Right	*USNM 10903 Left*	*USNM 10677 Left*
Greatest length of mandible as preserved in a straight line	1195	1164	983
Greatest length of mandible as preserved along outside curvature	1230	1200+	1046
Distance from anterior end to level of center of apex of coronoid process along outside curvature	1035	1041	937±
Greatest vertical diameter 100 mm. behind anterior end of ramus	73	70.5	78.2
Greatest transverse diameter 100 mm. behind anterior end of ramus	30.5	29	32.5
Greatest vertical diameter 300 mm. behind anterior end of ramus	63.5	64.5	66
Greatest transverse diameter 300 mm. behind anterior end of ramus	42.5	37.5	44.2
Greatest vertical diameter 500 mm. behind anterior end of ramus	67	64.5	69
Greatest transverse diameter 500 mm. behind anterior end of ramus	48	43.7	46.2
Greatest vertical diameter 700 mm. behind anterior end of ramus	66.7	64.7	63.6
Greatest transverse diameter 700 mm. behind anterior end of ramus	52	45.5	49.5
Least vertical diameter of ramus between coronoid process and condyle	80	74	—
Greatest vertical diameter through coronoid process	116	98	128±
Greatest vertical diameter of hinder end of ramus including condyle	102	—	—
Greatest transverse diameter of condyle	55	—	—

Vertebrae

Thirty eight vertebrae (USNM 23203), including 7 cervicals, 12 dorsals, 10 lumbars, and 9 caudals of 1 skeleton, and 4 dorsals (USNM 23448) of another individual are referred to this species. The epiphyses of most of the vertebrae belonging to the first mentioned skeleton are detached, an indication of physical immaturity. The 4 dorsals, however, have all epiphyses firmly ankylosed and are obviously physically mature; their dimensions and structural features closely parallel those of the longer series. The measurements suggest that the 12 dorsals and the 10 lumbars are a consecutive series. Twelve dorsals and 11 or 12 lumbars were present in the vertebral column of the larger Calvert cetotheres.

The total length of the skeleton, including the skull (length, 1115 to 1250 mm.), from the extremity of the rostrum to and including the terminal caudal did not exceed 14 or 15 feet.

CERVICAL VERTEBRAE.—None of the cervical vertebrae (USNM 23203) were ankylosed to either the one in front or the one behind. All have the epiphyses detached from the centrum. The atlas has a vestigal ridge-like neural spine, and short, thick, and blunt transverse processes. The hyapophysial process, if present on the narrow splintered ventral strip, was reduced to a thin backward projecting shelf.

The roof of the axis is concave ventrally and ornamented dorsally with 3 thin longitudinal ridges, widened and truncated posteriorly, and deeply excavated anteriorly. The axis has a small obtuse odontoid process; the transverse processes are broad at the base, tapered toward their extremity, turned downward and backward, and imperforate. An irregular depression at base posteriorly on each process marks the former location of the foramen transversarium. Upper and lower transverse processes of the third cervical are not united distally by an osseous isthmus to enclose the cervical extension of the thoracic retia mirabilia; the slender attenuated lower process is bent more backward than downward. Extremities of upper and lower transverse processes of the fourth cervical are broken off and missing; the lower process is dorsoventrally compressed near its base, directed downward and slightly backward. Upper transverse process of fifth cervical is anteroposteriorly compressed near the base, attenuated distally; the lower transverse process is slender, bent more backward than downward; extremities of these processes are broken off and missing. All processes of the sixth cervical are broken off near the base; slender lower transverse processes were present; the anteroposteriorly compressed upper transverse processes were rather broad at the base. The seventh cervical lacks lower transverse processes; the anteroposteriorly compressed upper transverse process is broad at the base.

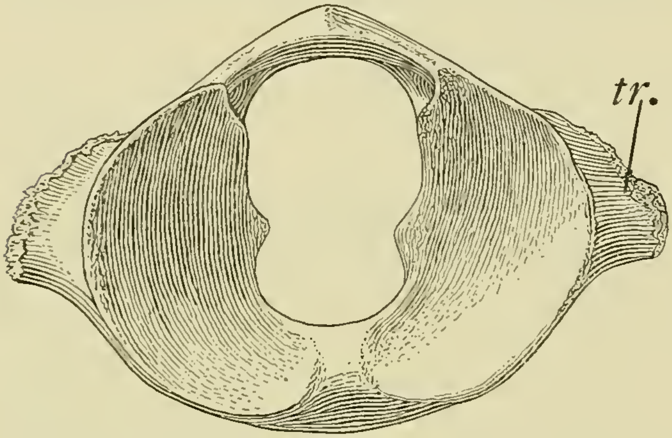

FIGURE 94.—Anterior view of atlas, USNM 11535, of *Parietobalaena palmeri* Kellogg. Abbr.: tr., transverse process.

Viewed from in front the profile of the centrum of the sixth and seventh cervicals is elliptical, the vertical diameter of the fifth (63 mm.) exceeds that of the preceding cervicals, and the fourth and third were widened transversely.

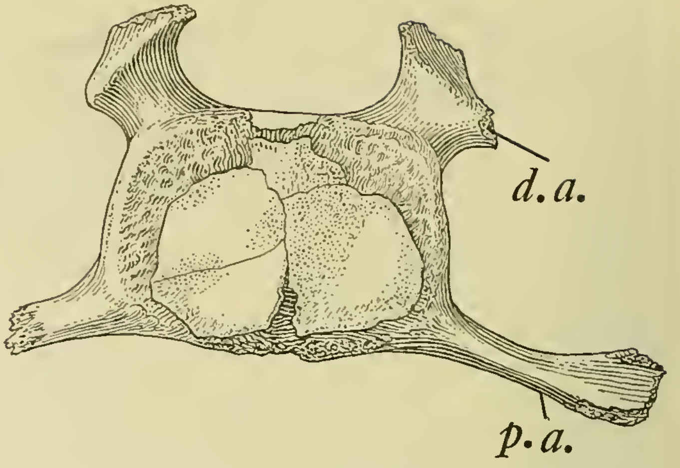

FIGURE 95.—Anterior view of third cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. Abbrs.: d.a., diapophysis; p.a., parapophysis.

The length of the 7 cervical vertebrae, including the cartilaginous intervertebral disks, is approximately 235 mm. (9¼ inches).

The distance (124 mm.) between the outer edges of the anterior articular facets of the atlas (fig. 94) of another physically immature specimen (USNM 11535) is less and

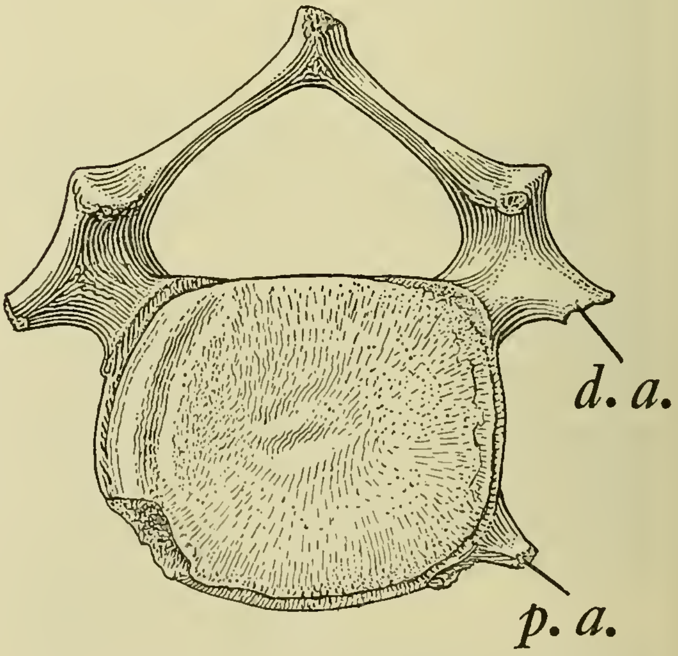

FIGURE 96.—Anterior view of fourth cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 95.

USNM 23203–Cervical Vertebrae	*Atlas*	*Axis*	*C.3*	*C.4*	*C.5*	*C.6*	*C.7*
Greatest vertical diameter of vtebra, tip of neural spine to ventral face of centrum	104	—	—	—	—	—	—
Greatest anteroposterior diameter of centrum	58	50[p]	25[a]	28[a]	30[a]	26[b]	26[b]
Greatest vertical diameter of centrum, anteriorly	—	—	65	59	64	62	56
Greatest vertical diameter or neural canal, anteriorly	64	—	—	—	—	—	—
Greatest transverse diameter of neural canal, anteriorly	44	47.5	—	—	—	—	—
Greatest distance between outer ends of parapophyses	150	192	—	—	—	—	—
Least anteroposterior diameter of right pedicle of neural arch	—	—	10	10.5	11	10.5	12
Greatest distance between outer magins of anterior articular facets	131	129	—	—	—	—	—
Vertical diameter of anterior articular surface	85	72	—	—	—	—	—
Greatest vertical diameter of centrum, posteriorly	45	54	65	60	62	58	57.5
Greatest transverse diameter of centrum, posteriorly	131	94	77	87	76	77	78

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

the centrum is much thinner (43 mm.) than USNM 23203. This atlas also lacks a neural spine and the shape of the transverse processes is similar. Four additional cervical vertebrae were associated with this specimen. The anterior profile of the centra of these cervicals is more rectangular and thus differs from the elliptical shape of USNM 23203. On the third cervical (fig. 95) the lower transverse process is directed outward, widened at the extremity and not bent backward; the basal portion of the combined pedicle of the neural arch and the diapophysis is narrow, noticeably less widened than on USNM 23203. The transverse processes of the fourth cervical (fig. 96) are slender and the upper process is not expanded dorsoventrally. Very slender upper and lower transverse processes are present on the fifth cervical (fig. 97); the neural spine on the complete neural arch is very short; and the centrum is quite thin (19 mm.). The centrum of the sixth cervical (fig. 98) is as thin as the fifth; the dorsovental diameter (18 mm.) of the combined basal portion of the pedicle of the neural arch and diapophysis is less than half the corresponding measurement (39 mm.) of USNM 23203. Growth and individual variability of the cervical vertebrae tend to minimize the accuracy of any identification of nonassociated specimens. Although the atlas is the most variable of the cervical vertebrae, the inclosure of the cervical extension of the thoracic retia mirabilia seems not to have resulted in any uniform modification of the upper and lower transverse processes.

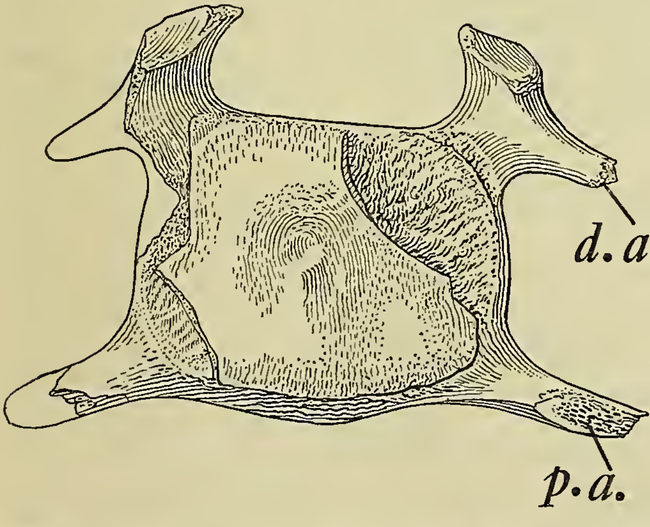

FIGURE 97.—Anterior view of fifth cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 95.

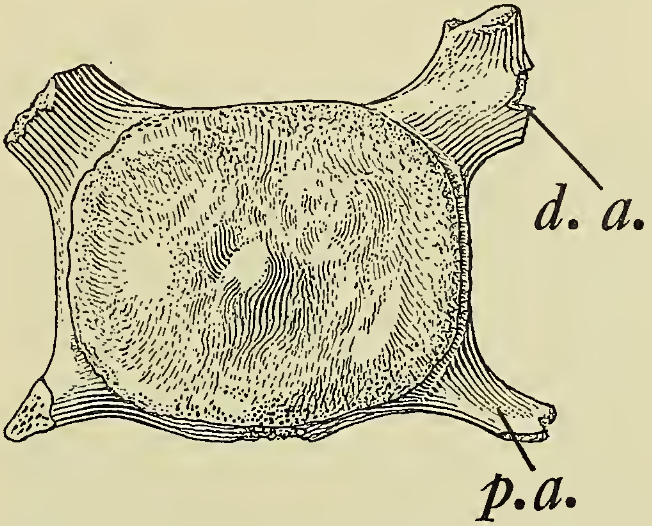

FIGURE 98.—Anterior view of sixth cervical vertebra, USNM 11535, of *Parietobalaena palmeri* Kellogg. For abbreviations, see figure 95.

Measurements (in mm.) of cervical vertebrae, USNM 23203, are as indicated above.

DORSAL VERTEBRAE.—Both epiphyses are detached from the centra of the 12 consecutive dorsals (USNM 23203) All of the epiphyses are, however, firmly ankylosed to the

USNM-23208 Dorsal Vertebrae

	D.2	*D.3*	*D.4*	*D.5*	*D.6*	*D.7*	*D.8*	*D.9*	*D.10*	*D.11*	*D.12*
Anteroposterior diameter of centrum	33[b]	43[a]	50[p]	47.5[b]	53[b]	64[p]	62[b]	79	78[p]	76[b]	85[p]
Transverse diameter of centrum anteriorly	82	84	76	78	81	81	83	74	73	77	69
Vertical diameter of centrum anteriorly	53	52	54	54	54	63	59	62	59	63	63
Tip of neural spine to ventral face of cantrum posteriorly	—	160	—	—	—	—	—	173+	172+	—	—
Minimum anteroposterior length of pedicle of neural arch	16	19.5	20	27.5	34	42	50	46	51	52	50
Transverse diameter of neural canal anteriorly	47	43	43	45	40	43	42	31	29	31	28
Vertical diameter of neural canal anteriorly	—	31	—	—	—	—	—	28	30	30	27
Distance between ends of transverse processes	193	181	166	—	146.5	148	158+	170	208	230+	231+
Dorsal edge of metapophysis to ventral face of centrum anteriorly	—	68	66	—	77.5	—	—	—	100	106	111
Transverse diameter of centrum posteriorly	86.5[df]	76[df]	89[df]	90[df]	90[df]	87[df]	77	76	79	78	79
Vertical diameter of centrum posteriorly	54.5	53	53	54	56	59	59	59	62	65	64

[a]=Anterior epiphysis missing. [b]=Both epiphysis missing. [p]=Posterior epiphysis missing. [df]=Posterior demifacet present.

centra of the 4 dorsals of another individual (USNM 23448). The anteroposterior diameters of the centra of the dorsals increase from the first to the twelfth and the transverse diameter of each exceeds the vertical diameter of the anterior end. From before backwards, the profiles of both ends of consecutive dorsal centra are modified from a dorsally flattened and transversely widened ellipse on the anterior dorsals to a more definite subcordate shape from the middle to the posterior end of this series.

On each side of the centrum of the first to seventh dorsals, inclusive, below the level of the floor of the neural canal and adjacent to or on the edge of the posterior epiphysis, there is an articular facet for the capitulum of the following rib. No vestige of this facet can be recognized on the eighth dorsal. The transverse diameter of the neural canal of the second dorsal (47 mm.) exceeds that of the twelfth (28 mm.); the vertical diameter of the neural canal is decreased less noticeably.

The pedicles of the neural arch are robust and wide on the anterior eight dorsals. The articular ends of the diapophyses progressively increase in width from the first to the eighth dorsal. On these eight anterior dorsals the diapophyses arise in part from the pedicle of the neural arch and in part from the dorsointernal portion of the centrum anteriorly. The parapophyses of the ninth to twelfth dorsals, inclusive, project outward from the lateral surface of the centrum and progressively increase in length. These processes are bent upward on the ninth, tenth, and eleventh dorsals. The neural spines are incomplete on all the dorsals; there is, however, a marked increase in the anteroposterior diameter of the neural spine at the base toward the hinder end of this series. The width of the interval between the opposite prezygapophysial facets decreases from the anterior to the posterior end of the dorsal series.

On the first six of the anterior dorsals, the articular facet on each metapophysis is flat; the demarcation of the outer edge of this facet by an anteroposterior crest becomes prominent on the seventh and presumably also on the eight, but certainly on the ninth this crestlike development has culminated in the inclination of each metapophysis to almost vertical. These side to side compressed metapophyses increase in size and rise higher above the floor of the neural canal from the eighth dorsal to the posteriormost lumbar.

The total length of the twelve dorsals, including the cartilaginous intervertebral disks, is about 760 mm. (30 inches).

Measurements (in mm.) of dorsal vertebrae, USNM 23203, are as indicated above.

Measurements (in mm.) of dorsal vertebrae, USNM 23448, are as follows:

	D.2	*D.5*	*D.6*	*D.7*
Anteroposterior diameter of centrum	36	51	56.4	61
Transverse diameter of centrum, anteriorly	82.5	82	84	84
Vertical diameter of centrum, anteriorly	54.5	54	58.5	59
Minimum anteroposterior length of pedicle of neural arch	13	25	33	41
Transverse diameter of neural canal, anteriorly	52	50	49	47
Vertical diameter of neural canal, anteriorly	27	29	22	20
Distance between ends of diapophyses	181	159	151	150
Dorsal edge of metapophysis to ventral face of centrum anteriorly	72	71	74	80

	D.2	*D.5*	*D.6*	*D.7*
Tip of neural spine to ventral face of centrum posteriorly	112	134	167	184
Transverse diameter of centrum posteriorly, including demifacets	86	93	95	95
Vertical diameter of centrum posteriorly	55	54	57	61
Distance between outer margins of prezygapophysial facets	81	68	65	54
Distance between outer margins of postzygapophysial facets	70	49	26	24

LUMBAR VERTEBRAE.—When excavated the epiphyses of the 6 anterior lumbars (USNM 23203) were detached; both epiphyses were attached to the centra of the seventh and eighth lumbars; and the anterior epiphysis was ankylosed to the centrum of the ninth and tenth lumbar. Four of the lumbars lack most of the neural arch, the neural spines of all the lumbars are either damaged, incomplete or missing; the first, second, fifth, and ninth lumbars possess an essentially complete left transverse process; and the metapophyses are preserved on the first and ninth lumbars, but are missing of the others.

A rather sharp-edged ventral median longitudinal keel is developed on the centra of the second to tenth lumbars, inclusive; no rudiment of this keel, however, is present on the first lumbar. In serial sequence, the centra increase in length from the first to the posteriormost lumbar, the transverse and vertical diameters of the neural canal diminish, and the transverse processes are shortened. The transverse processes of the first, second and fifth lumbars are slender, elongated and are directed slightly forward. As compared to the first and second lumbar, the left transverse process on the ninth lumbar is broader (minimum anteroposterior diameter, 45 mm.), shorter, and is directed more obliquely forward. The elongated thin lamina-like metapophyses project upward and forward beyond the level of the anterior face of the centrum and are inclined obliquely outward from ventral to dorsal edges. The neural spine of the ninth lumbar was more strongly inclined backward than that of the first lumbar. Assuming that at least 11 vertebrae comprised the lumbar series, the estimated length of this section of the vertebral column is 1125 mm. (44¼ inches).

Measurements (in mm.) of lumbar vertebrae, USNM 23203, are as indicated below.

CAUDAL VERTEBRAE.—Of the 9 caudal vertebrae (USNM 23203), the first to the sixth, inclusive, are consecutive; the remaining three are regarded as the ninth, tenth, and twelfth. The epiphyses were associated with but not attached to the centra or the first and second caudals. Eleven caudals (USNM 16667) of another individual are consecutive from the fourth to the fourteenth, the terminal vertebra. The epiphyses of the fourth and fifth caudals of this series were not ankylosed to the centra, but are firmly attached on the others. Associated with these caudals were 1 dorsal and 2 lumbars that lack epiphyses; this individual was not only smaller but also less mature than USNM 23203.

The anteroposterior, as well as the transverse and vertical diameters of the anterior end of the centrum, diminish from the first to the terminal caudal; the reduction of these dimensions is rather abrupt behind the tenth caudal. These four or five terminal caudals are embedded in the caudal flukes of Recent mysticetes. The interval between the dorsal edges of the opposite metapophyses progressively diminishes from the first to the sixth caudal; these processes are strongly reduced, almost vestigial on the seventh and eighth caudal. On the five anterior caudals, these metapophyses are curved upward and outward.

The neural spines of the 3 anterior caudals, although relatively short, project above the metapophyses; they diminish rapidly in height behind the first caudal and on the fifth to the eighth, inclusive, are reduced to a low crest. The neural canal, which has a roof as far backward as the eighth or ninth caudal, decreases in transverse and vertical diameter.

USNM 23203–Lumbar Vertebrae	*L.1*	*L.2*	*L.3*	*L.4*	*L.5*	*L.6*	*L.7*	*L.8*	*L.9*	*L.10*
Anteroposterior diameter of centrum	83 [p]	81 [b]	91	95.5	99	102	103	108	97 [p]	101
Transverse diameter of centrum anteriorly	72.5	71.5	68.5	65	73	74	76	79	75	85
Vertical diameter of centrum anteriorly	63	66.5	63	67.5	66	70	72	75	73	75
Minimum anteroposterior length of pedicle of neural arch	41	—	—	—	47	—	46	45	44	—
Transverse diameter of neural canal anteriorly	28	—	—	—	—	23	19	13.5	16	17±
Vertical diameter of neural canal anteriorly	30	—	—	—	35	—	28	24	19	—
Distance between ends of transverse processes	—	—	—	—	289	—	—	—	—	—
Dorsal edge of metapophysis to ventral face of centrum anteriorly	110	—	—	—	—	—	—	133	—	—
Transverse diameter of centrum posteriorly	79	74	71	74	75	75	77	78	80	86.5
Vertical diameter of centrum posteriorly	63	66	65	69	68.5	69	73	75	73	75

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

Measurements (in mm.) of caudal vertebrae, USNM 23203 and USNM 16667, are as follows:

USNM 23203–Caudal Vertebrae	*Ca.1*	*Ca.2*	*Ca.3*	*Ca.4*	*Ca.5*	*Ca.6*	*Ca.9*	*Ca.10*	*Ca.12*
Anteroposterior diameter of centrum	97 [p]	108	108	106	103	85 [p]	58 [b]	56.4	35
Transverse diameter of centrum anteriorly	83	83.5	82	81	87	89	74.5	67.5	46
Vertical diameter of centrum anteriorly	81.5	81.5	86	97	97	86.5	78.5	73.5	41
Tip of neural spine to ventral face of centrum posteriorly	152+	154	130	123	110+	102	—	—	—
Minimum anteroposterior length of pedicle of neural arch	45	43	46	48	45	54	15.5	—	—
Transverse diameter of neural canal anteriorly	16	14	14	11	12	14	10	—	—
Vertical diameter of neural canal anteriorly	16	16	9	10	9	5	—	—	—
Distance between ends of transverse processes	—	125+	158+	—	123	104	—	—	—
Dorsal edge of metapophysis to ventral face of centrum anteriorly	127	136	132	131	126	111	—	—	—
Transverse diameter of centrum posteriorly	—	81	87	86	86	—	70	63	43
Vertical diameter of centrum posteriorly	—	88	105	100	86+	89	74	65.5	35

USNM 16667–Caudal Vertebrae	*Ca.4*	*Ca.5*	*Ca.6*	*Ca.7*	*Ca.8*	*Ca.9*	*Ca.10*	*Ca.11*	*Ca.12*	*Ca.13*	*Ca.14*
Anteroposterior diameter of centrum	93	77+ [a]	86	83	78	68	51	34+ [p]	29 [p]	22 [b]	19
Transverse diameter of centrum anteriorly	84	84	81	82	82	70	62	60	51	44	38
Vertical diameter of centrum anteriorly	83.5	84	85	79	79	74	64	50	42	35	32
Minimum anteroposterior length of pedicle of neural arch	41.5	42	43	47	51	—	—	—	—	—	—
Transverse diameter of neural canal anteriorly	20	17	13	12	11	7	—	—	—	—	—
Vertical diameter of neural canal anteriorly	18	17	7	8	8	—	—	—	—	—	—
Distance between ends of transverse processes	148+	127	110	94	—	—	—	—	—	—	—
Dorsal edge of metapophysis to ventral face of centrum anteriorly, including haemapophyses	112.5	107	105	102	91	79	—	—	—	—	—
Tip of neural spine to ventral face of centrum posteriorly, including haemapophyses	127.5	113	109	104	94	—	—	—	—	—	—
Transverse diameter of centrum posteriorly	85	80.5	84	82	73.5	65	55	50	46	—	—
Vertical diameter of centrum posteriorly	85	82	83.5	80	76	69	57	48	41	—	—

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

The sharply defined median longitudinal ventral ridge on the centrum of the posterior lumbar is replaced on the first caudal (USNM 23203) by an anterior and posterior low central protuberance, but no distinct tubercles. A pair of large posterior haemal tubercles (hyapophyses) are developed on the second and third caudals. An anterior pair and a posterior pair of haemal tubercles are, however, developed on the fourth and fifth caudals. On each side of the haemal groove on these two caudals between the anterior and posterior haemal tubercle is a notch through which the segmented blood vessels pass on their upward course on the lateral surface of the centrum in front of the anterobasal angle of the transverse process and thence obliquely to the posterior end of the neural canal.

Commencing with the sixth or seventh and present, as well on the eighth, the anterior and posterior haemal tubercles on each side of the haemal groove are joined by an osseous isthmus which is pierced by a foramen for passage of the segmental blood vessels. The short transverse process of these caudals is pierced centrally at the base by a foramen for these blood vessels, which reach the posterior end of the neural canal. The caudals behind the ninth, the hindermost one to which chevrons were attached and the last on which the roof of the neural canal persists, are pierced by vertical passages from the ventral face to the dorsal neural depression or groove. Three orifices on the ventral surface and two on the dorsal surface of the centrum provide the passage for branches of the caudal artery and vein between the haemal groove and the terminal portion of the neural canal.

The horizontally outward directed transverse process is longer and narrower on the first than on the third caudal which has the terminal portion widened; it is quite short on the fifth, sixth, and seventh caudal. This process is obliquely truncated distally on the seventh and is pierced at the base by the vascular foramen. The transverse and vertical diameter of the last five in the caudal series exceed the anteroposterior diameter of the centrum.

The length of the fourteen caudal vertebrae, including the cartilaginous intervertebral disks, is about 1085 mm. (42¾ inches).

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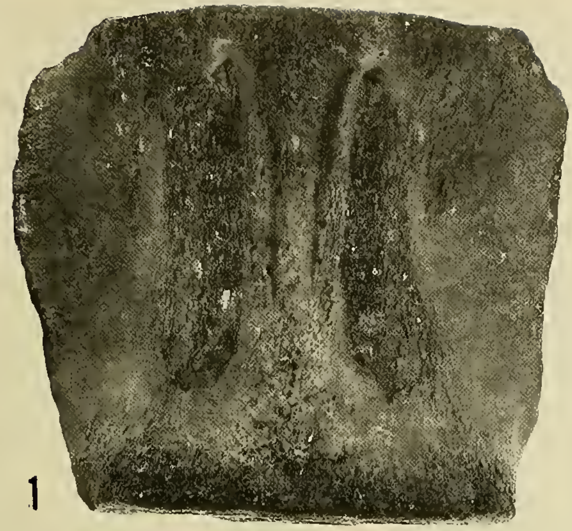
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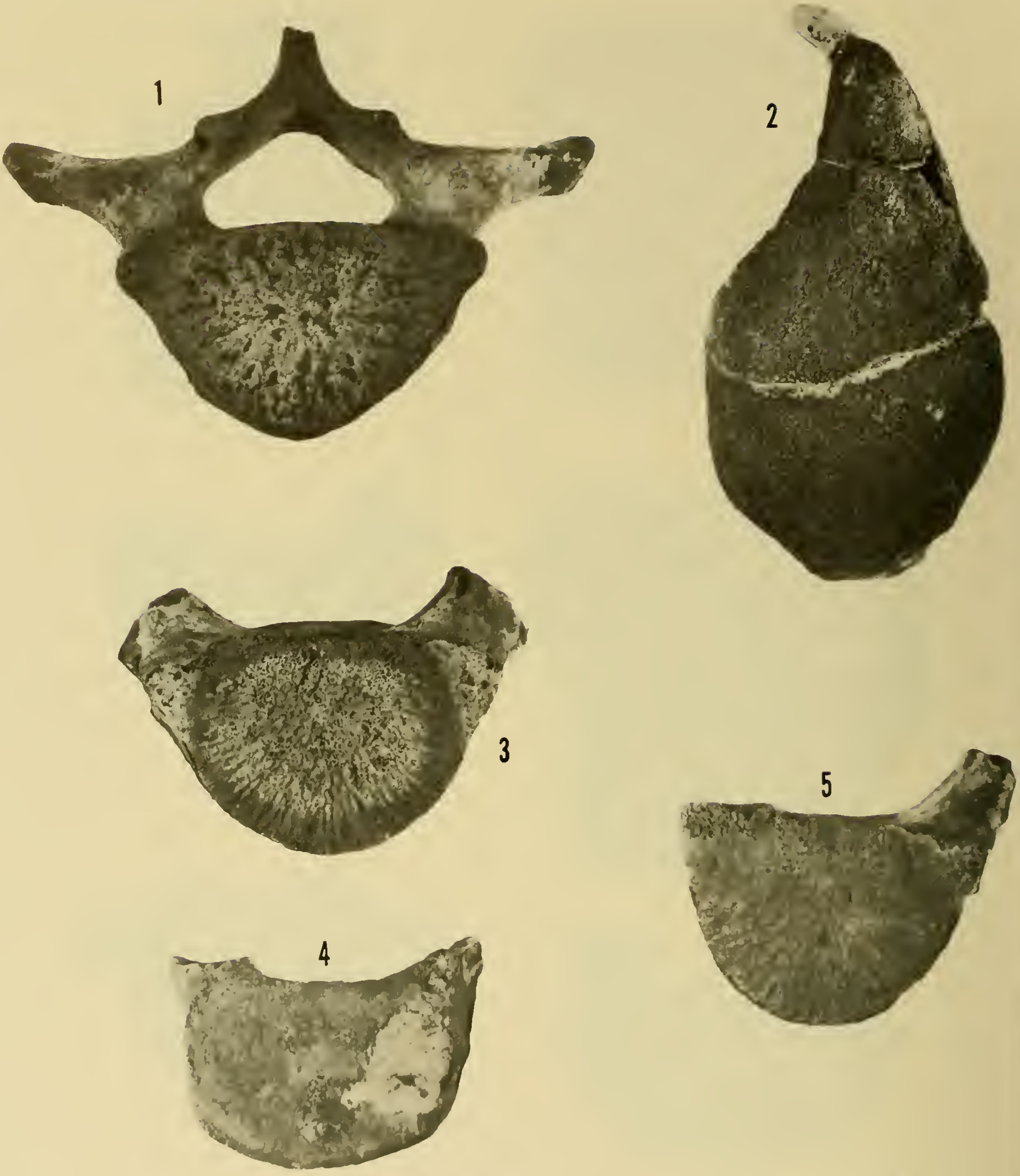
Lumbar and Caudal Vertebrae, ANSP 12769, Eschrichtius pusillus Cope (Type)

1, Dorsal view of lumbar; 2, lateral view of caudal; 3, dorsal view of dorsal vertebra.

Dorsal Vertebrae, ANSP 12769, Megaptera expansa Cope (type)

4, Anterior view of eighth dorsal; 5, anterior view of fifth dorsal; 6, anterior view of ninth dorsal.



DORSAL VERTEBRAE AND CONDYLE OF MANDIBLE OF MESOCETUS SIPHUNCULUS COPE

1, first dorsal, posterior view (AMNH 22669); 2, condyle of right mandible (AMNH 22665); 3, anterior dorsal, posterior view (AMNH 22669); 4, anterior dorsal, posterior view (AMNH 22669); 5, middle dorsal, anterior view (AMNH 22669)

Right Periotic and Auditory Ossicles, USNM 8518, Metopocetus durinasus

1, Incus with scar on crus longum and small crus breve on left side; 2, stapes; 3, tympanic or ventral view of right periotic; 4, cerebral or internal view of right periotic; 5, articular facet on malleus.

Left Periotic, USNM 10909, Parietobalaena palmeri

6, Cerebral or internal view; 7, tympanic or ventral view.

SKULL, USNM 16783, DIOROCETUS HIATUS

1, Dorsal view; 2, ventral view.

Skull, USNM 23494, of Diorocetus hiatus

1, Dorsal view; 2, ventral view.

RIGHT PERIOTICS

Aglaocetus patulus (USNM 13472): 1, ventral or tympanic view; 2, internal or cerebral view.
Diorocetus hiatus (USNM 23494): 3, internal or cerebral view; 4, ventral or tympanic view.

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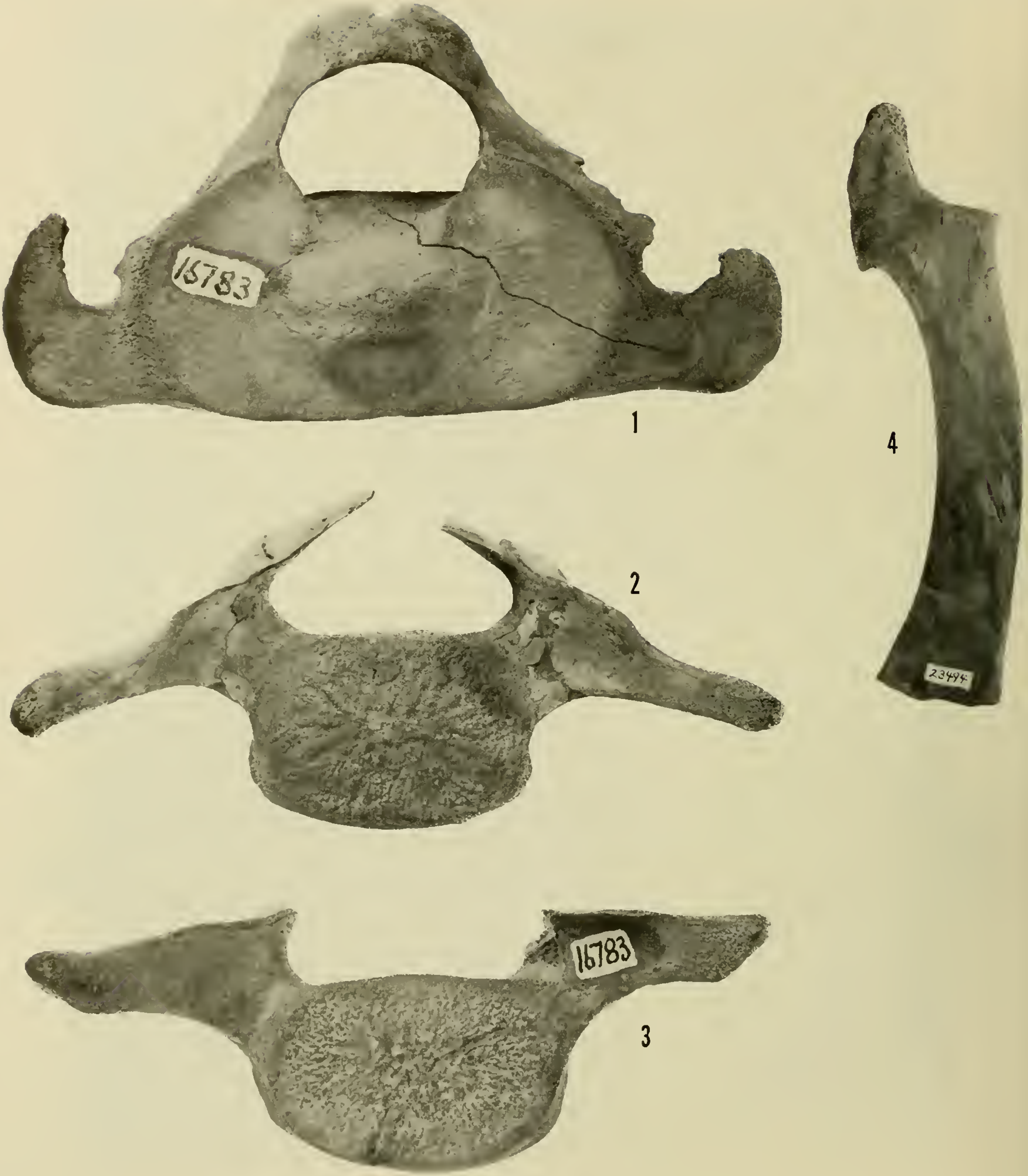
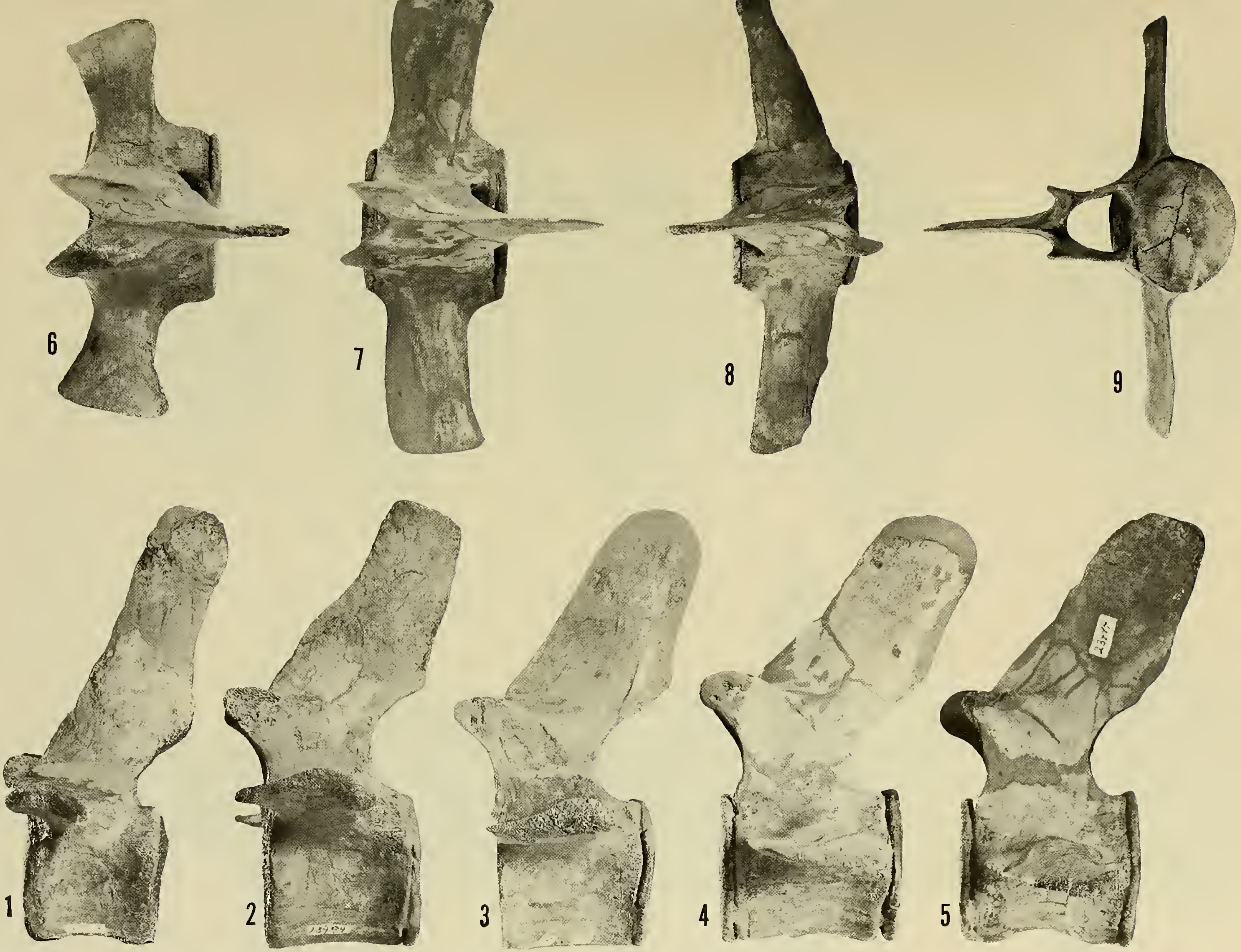
Right Scapula and Right Tympanic Bulla, USNM 23494, Diorocetus hiatus

1, Internal view of right scapula. Right tympanic bulla: 2, dorsal view; 3, ventral view; 4, external view.



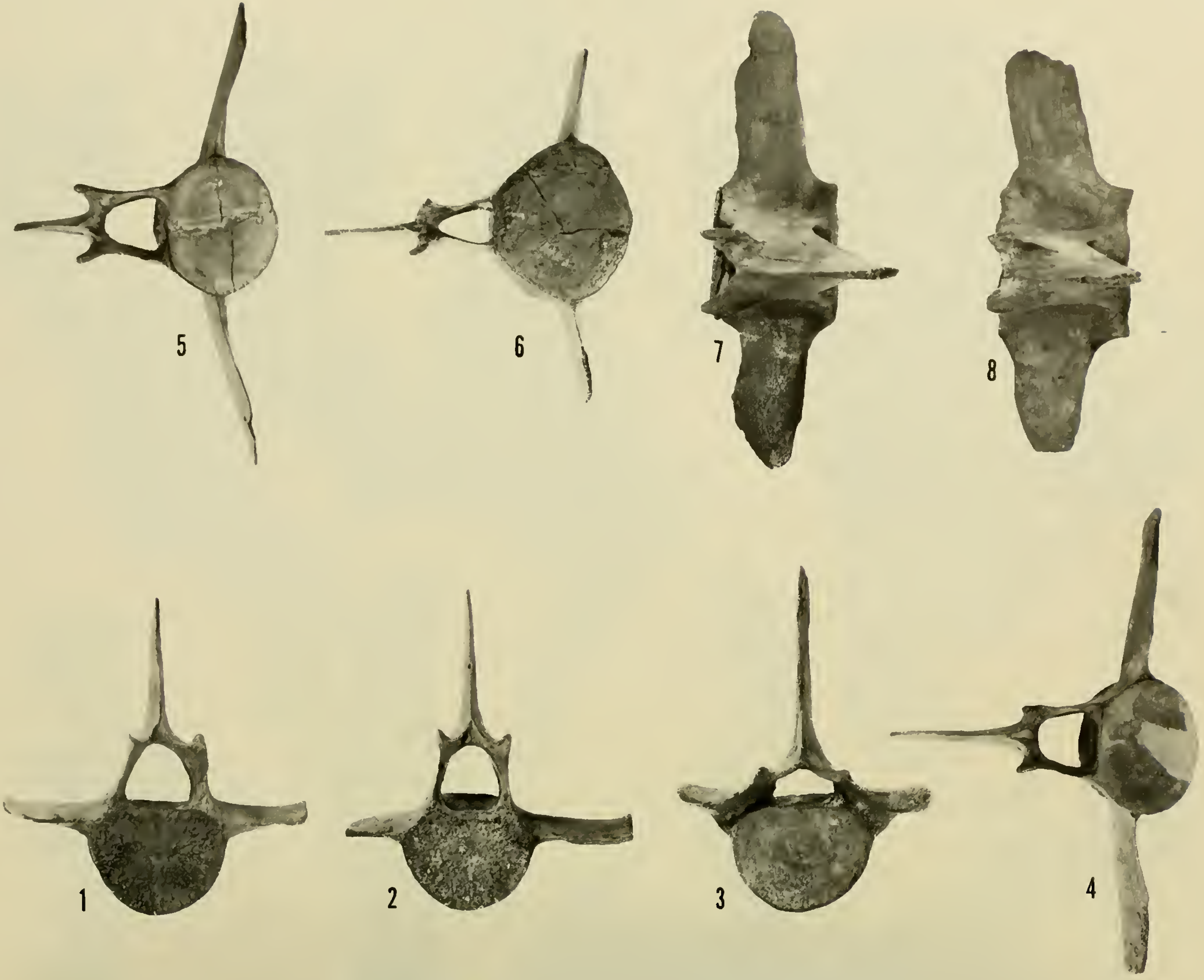
Cervical and Dorsal Vertebrae, and Ulna, Diorocetus hiatus

1, Anterior view of axis (USNM 16783); 2, anterior view of seventh cervical vertebra (USNM 23494); 3, anterior view of first dorsal (USNM 16783); 4, internal view of left ulna (USNM 23494).



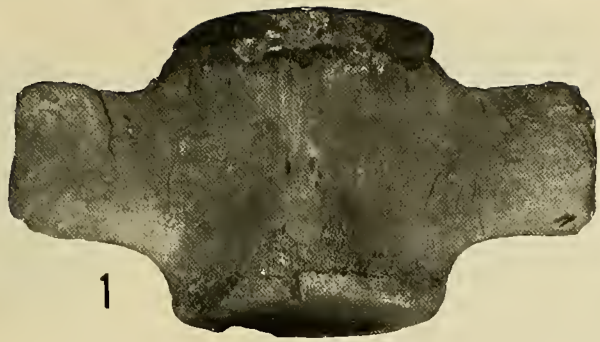
DORSAL VERTEBRAE, USNM 23494, DIOROCETUS HIATUS

Lateral views: 1, seventh dorsal; 2, ninth dorsal; 3, tenth dorsal; 4, eleventh dorsal; 5, twelfth dorsal.
Dorsal views: 6, ninth dorsal; 7, eleventh dorsal; 8, twelfth dorsal.
Anterior view: 9, eleventh dorsal.



Dorsal and Lumbar Vertebrae, USNM 23494, Diorocetus hiatus

Anterior views: 1, ninth dorsal; 2, tenth dorsal; 3, seventh dorsal; 4, twelfth dorsal; 5, second lumbar; 6, eleventh lumbar.
Dorsal views: 7, second lumbar; 8, ninth lumbar.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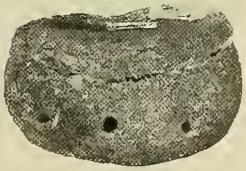
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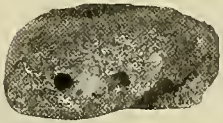
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VENTRAL VIEWS OF CAUDAL VERTEBRAE, USNM 16567, *DIOROCETUS HIATUS*

1, Second caudal; 2, third caudal; 3, fourth caudal; 4, fifth caudal; 5, sixth caudal; 6, seventh caudal; 7, eighth caudal; 8, ninth caudal; 9, eleventh caudal; 10, twelfth caudal; 11, thirteenth caudal.

METAPODIALS AND CHEVRONS, USNM 23494, DIOROCETUS HIATUS

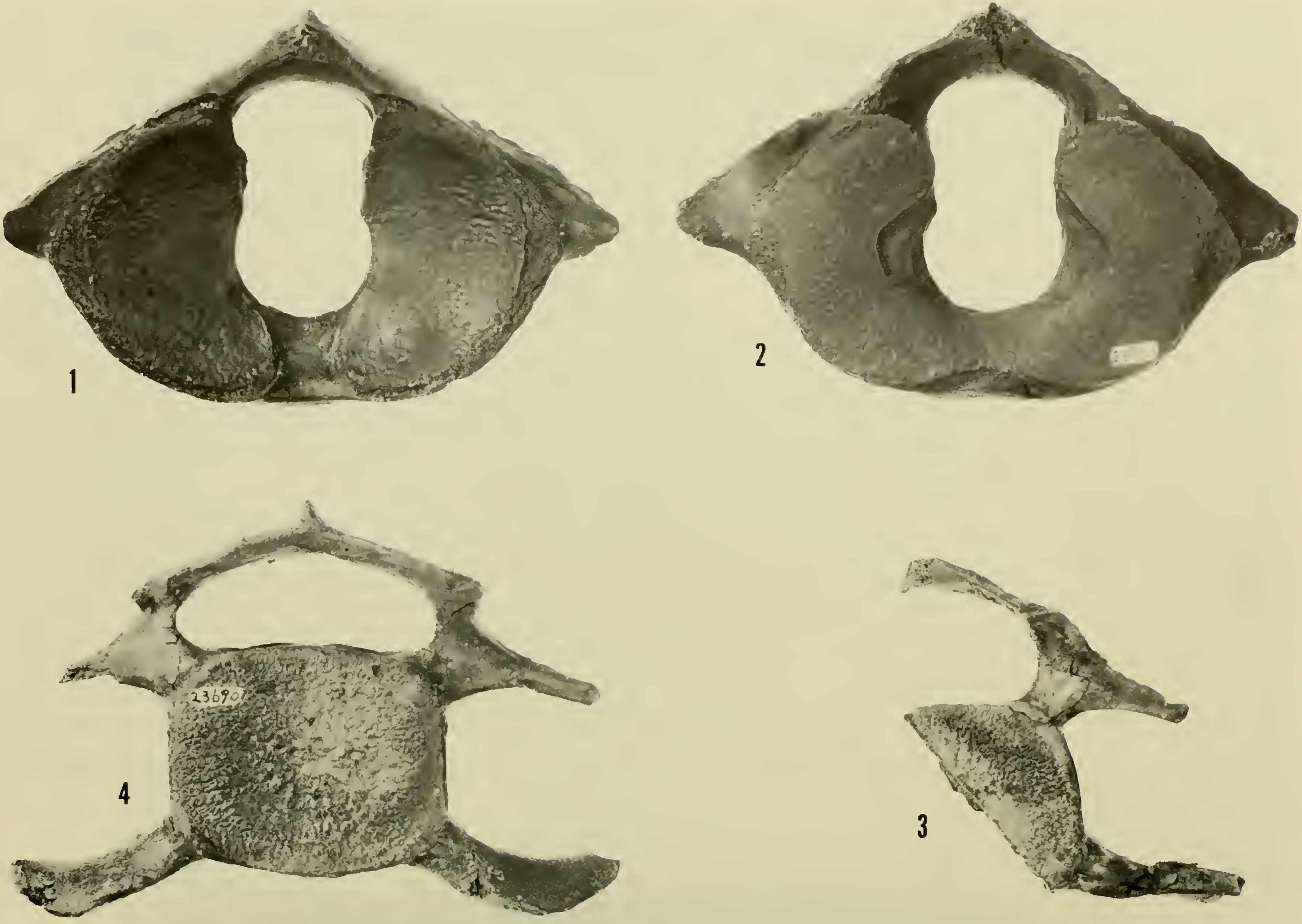
1, 2, 3, metapodials; 4, 5, phalages; 6, 7, lateral view of anterior chevron; 8, lateral view of first chevron; 9, 10, anterior view of anterior chevron; 11, anterior view of first chevron.

Dorsal View of Skull, USNM 23690, Aglaocetus patulus

Ventral View of Skull, USNM 23690, Aglaocetus patulus

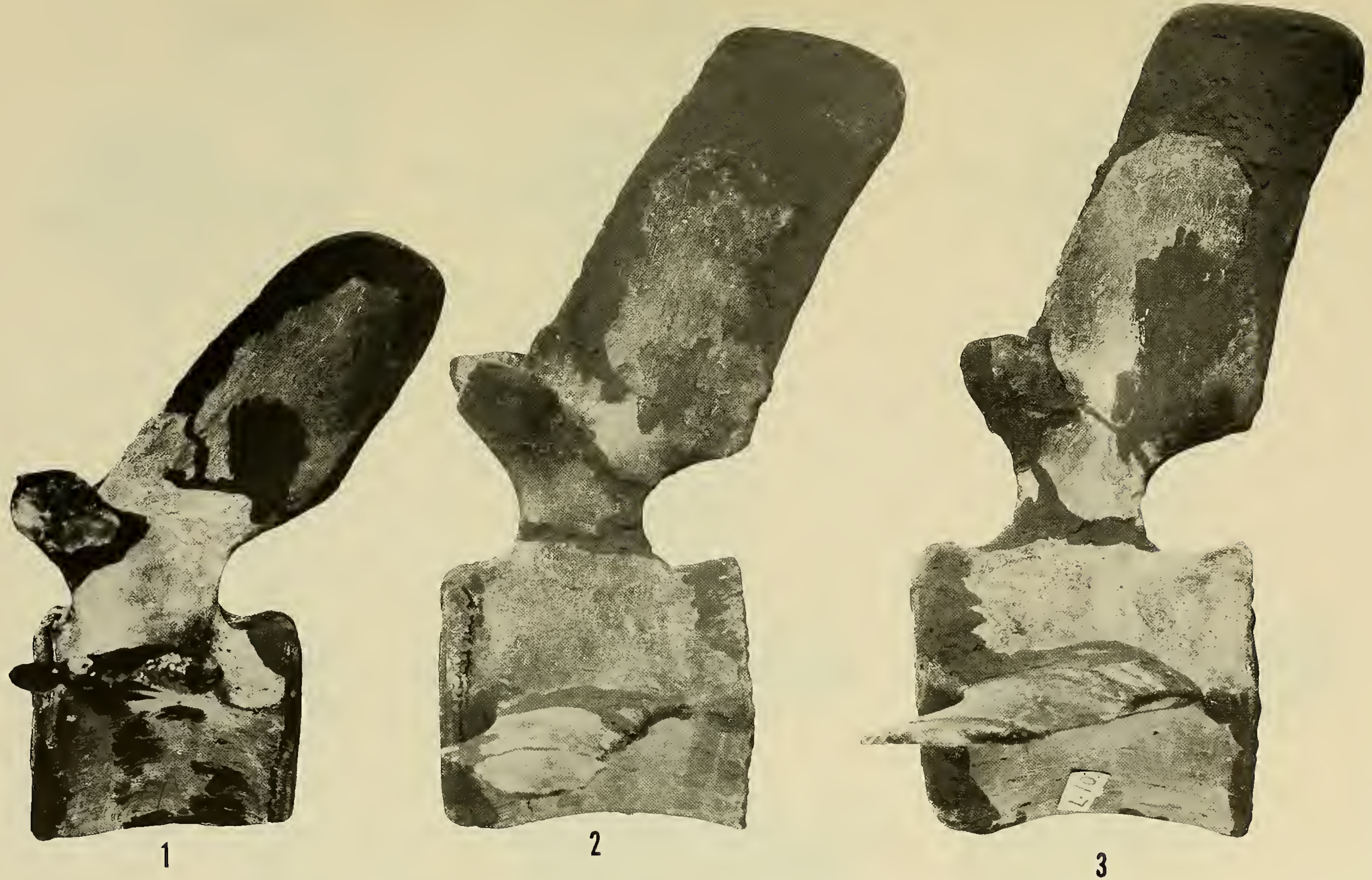
Left Periotic and Left Tympanic Bulla, USNM 23690, Aglaocetus patulus

1, Tympanic or ventral view of left periotic; 2, cerebral or internal view of left periotic; 3, external view of left tympanic bulla; 4, ventral view of left tympanic bulla; 5, dorsal view of left tympanic bulla.



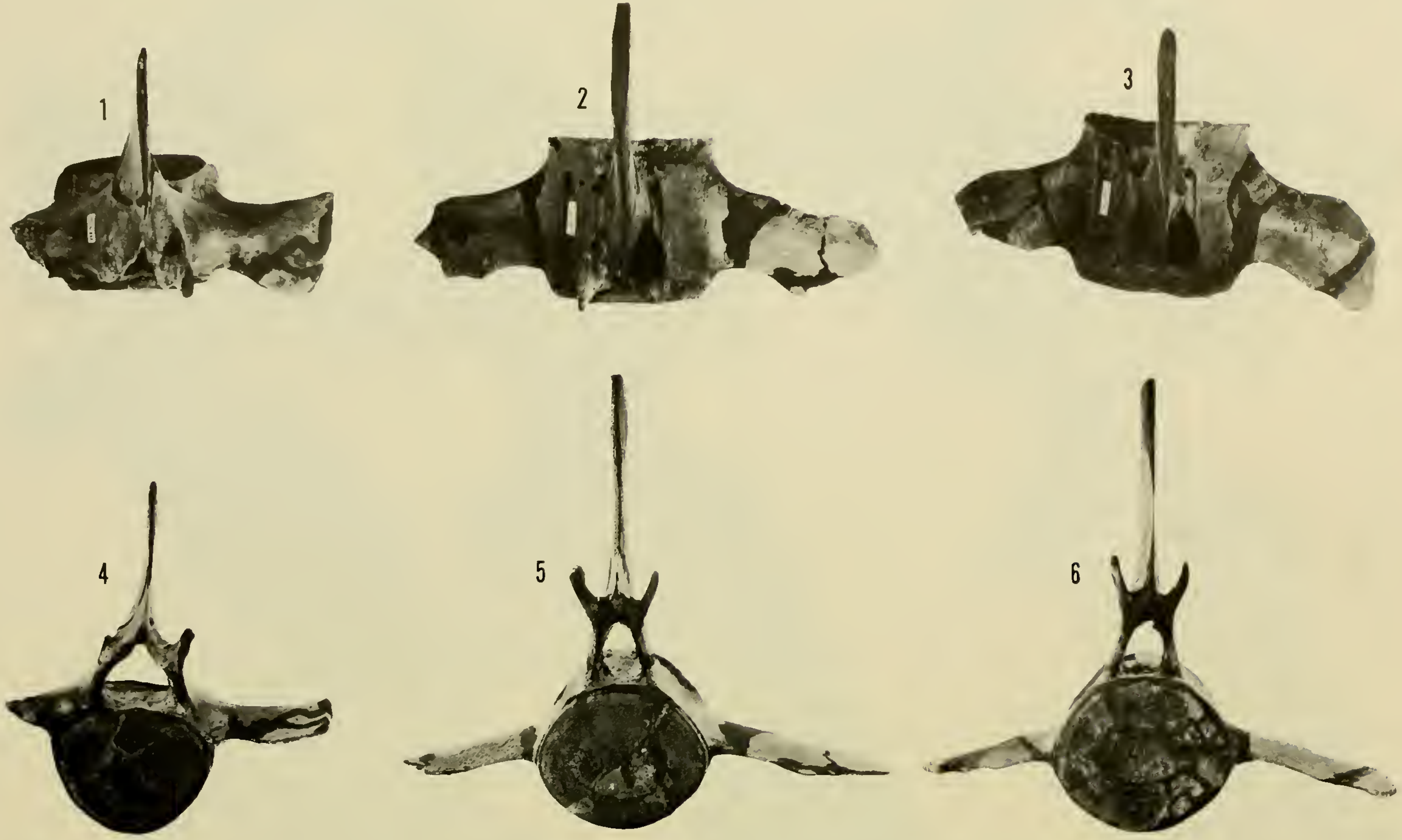
Cervical Vertebrae, USNM 23690, Aglaocetus patulus

1, Anterior view of atlas; 2, posterior view of atlas; 3, posterior view of third cervical; 4, posterior view of fifth cervical.



Lateral Views of Dorsal and Lumbar Vertebrae, USNM 23690, Aglaocetus patulus

1, ninth dorsal; 2, eighth lumbar; 3, tenth lumbar.



Views of Dorsal and Lumbar Vertebrae, USNM 23690, Aglaocetus patulus

Dorsal views: 1, ninth dorsal; 2, eighth lumbar; 3, tenth lumbar.
Anterior views: 4, ninth dorsal; 5, eighth lumbar; 6, tenth lumbar.

Skulls of Parietobalaena palmeri

1, Lateral view (USNM 10677); 2, dorsal view (USNM 23022); 3, dorsal view (USNM 16570).

SKULL AND MANDIBLES, USNM 10677, PARIETOBALAENA PALMERI, RESTORED

1. Internal view of right mandible; 2, internal view of left mandible; 3, dorsal view of skull: 4, ventral view of skull.

Dorsal View of Skull, USNM 16119, Parietobalaena palmeri

VENTRAL VIEW OF SKULL, USNM 16119, PARIETOBALAENA PALMERI

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[Names of new genera and species in italics; page numbers of principal accounts in boldface.]

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