A NEW ARCHAIC CETACEAN FROM THE OLIGOCENE OF NORTHWEST OREGON

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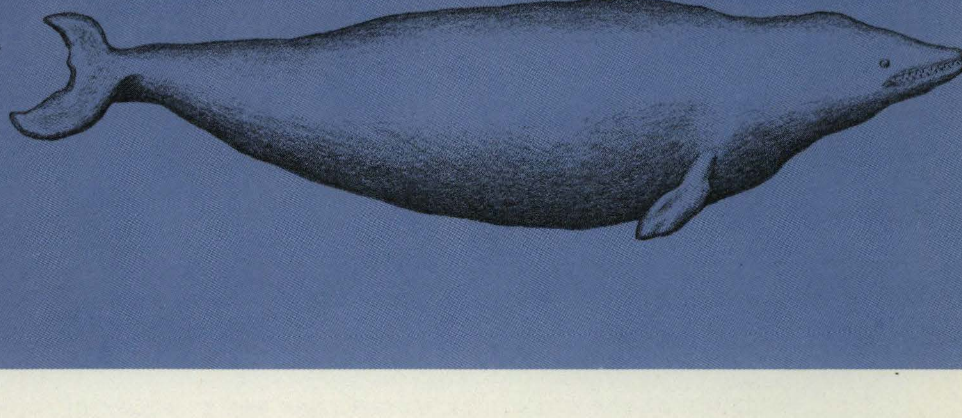

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J. ARNOLD SHOTWELL, *Director*
Museum of Natural History
University of Oregon

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Research Associate University of Oregon
Museum of Natural History

ABSTRACT

Intensive search by the author, in marine Oligocene formations of Oregon has resulted in the discovery of a very interesting cetacean skelton. This animal possesses so many distinctive features that it seems appropriate to propose a new family, the Aetiocetidae for its reception.

Although this mammal possessed a functional dentition, and bears some resemblance to cetaceans belonging to families Agorophiidae, Patriocetidae, and Microzeuglodontidae, its total compliment of dissimilarities from known cetaceans indicates that it is well differentiated from these families.

Many features appear to be definitely antecedent to those developed on members of the suborder Mysticeti. If it were not for the presence of functional teeth on this mature specimen, this cetacean could easily be placed in the suborder Mysticeti.

No morphological obstacles exclude this cetacean from mysticete lineage. Because of its lack of similarity to cetaceans referred to the Odontoceti, and the presence of several critical archaeocete affinities which are not retained on any known odontocete skull, this cetacean is referred to the suborder Archaeoceti.

INTRODUCTION

The cetacean described in this report was discovered in March 1964 by the author who excavated and prepared the remains during the rest of that year.

Fossil marine mammals described from Lincoln County, Oregon, include *Desmatophoca oregonensis* Condon (1906), *Desmostylus hesperus* Marsh (1915), and *Cophocetus oregonensis* Packard and Kellogg (1934).

In coastal Oregon no marine mammal remains complete enough for familial allocation have been described from formations older than the Astoria Formation of middle Miocene age. Only fragmentary vertebrae from Oligocene formations of Oregon have been mentioned in previous reports (Packard and Kellog 1934).

The specimen described here is apparently the first archaic cetacean to be named from pre-Miocene deposits of the Eastern Pacific region.

The upper Oligocene Yaquina Formation, in which this cetacean occurred, may be approximately correlative in age with the Aquitanian Stage of Europe. Sediments of this age near Lintz, Austria have yielded the remains of the archaic cetaceans *Patriocetus* (Abel 1913), and *Agriocetus* (Abel 1913), which bear some resemblance to the cetacean described in this report. However, close examination reveals features which exclude these Austrian cetaceans from familial relationship with this new discovery. Comparison with the Eocene cetacean *Archaeodelphis* (Allen 1921) as well as Miocene cetaceans also reveals familial dissimilarities.

I am deeply indebted to Dr. J. A. Shotwell, University of Oregon, and to Dr. Remington Kellogg, U. S. National Museum, for their technical advice and critical review of this manuscript, and for their generosity in supplying reference material used in preparing this paper. Without their assistance, I would have been unable to complete the study.

I am also much indebted to Mr. Parke D. Snavely, Jr., U. S. Geological Survey, for generously supplying geological data and ad-

vice in the preparation of this manuscript, and also to Dr. Edward Mitchell, Jr. for suggestions and advice extremely useful in my studies and in my evaluation of the cetacean here described.

OCCURRENCE

The cetacean skeleton described in this report occurred in place in the upper part of the Yaquina Formation of late Oligocene age (fig. 1). The specimen was obtained from a bedrock exposure about one mile south of the mouth of Beaver Creek, and one-half mile north of Seal Rock State Park, Lincoln County, Oregon (fig. 2) (UO Loc 2503). The locality is covered by beach sand during most of the year but winter storms occasionally remove the sand to expose the Oligocene bedrock. Two small creeks, about a hundred yards apart, enter the ocean at this point. The specimen was found about fifty feet north and 150 feet west of the mouth of the smaller creek, which is the most northerly.

The Yaquina Formation at this locality consists of fine-grained gray sandstone alternating with layers of siltstone and medium-grained light-gray sandstone. Thin layers of mussel shells and other mollusks are present, as well as beds of carbonized wood, thin seams of coal, and a few concretions containing *Teredo*-bored wood. About one-quarter of a mile southward toward Seal Rock the lower part of the Yaquina Formation is exposed. This part of the formation consists of massive coarse-grained micaceous sandstone that also contains wood fragments. This sandstone is exposed in ribs which rise about five feet above beach level, even during the summer months.

The Yaquina Formation was named by Harrison and Eaton (1920), and further described by Schenck (1927), and Vokes, Norbisrath and Snavely (1949). Most recently it has been reported on by Snavely and Wagner (1964). The type section of the Yaquina Formation is exposed along the Yaquina River, six miles north of the locality of interest in this paper. The lithology of the formation in both regions is

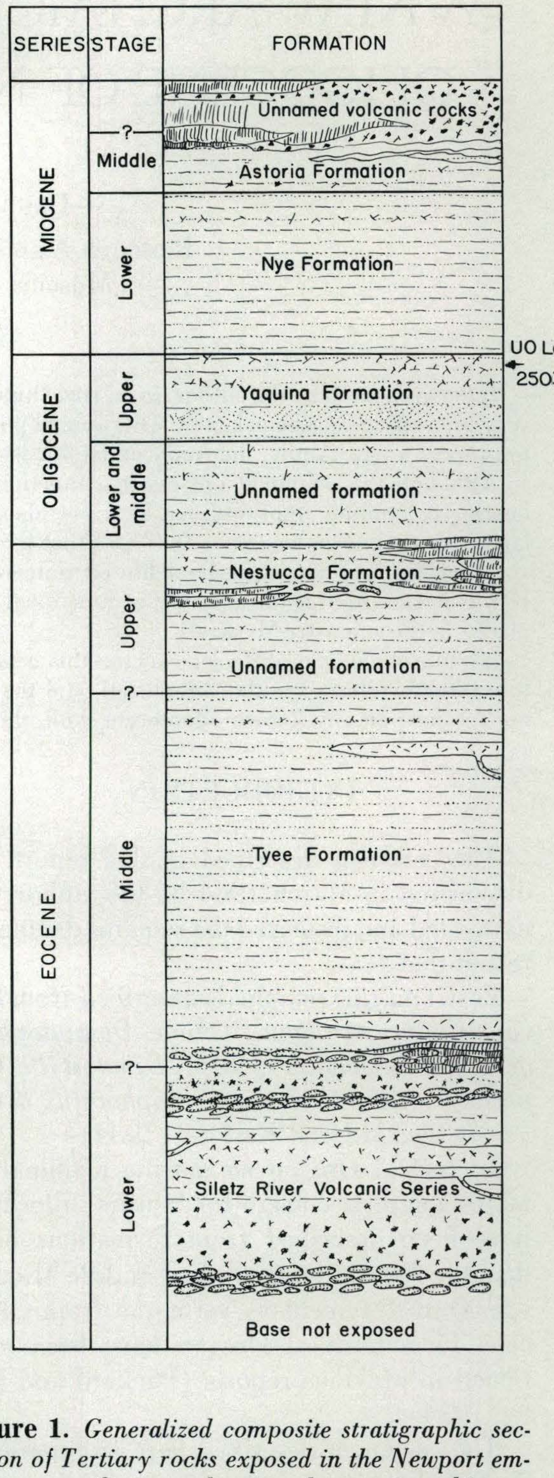

Figure 1. *Generalized composite stratigraphic section of Tertiary rocks exposed in the Newport embayment, Oregon, showing the stratigraphic position of the new cetacean discovery (From Snavely and Wagner, 1964, p. 7)*

rather similar. Vokes, and others (1949) found a large number of mollusks that indicate a latest Oligocene age, and suggests that the Yaquina is correlative with the Blakely Formation in Washington. The Yaquina Formation rests disconformably, or with little if any angular discordance, upon the upper member of the Toledo Formation of middle Oligocene age.

The Nye Mudstone, which conformably overlies the Yaquina Formation and is of early Miocene age, has been described from its type area at Yaquina Bay by Harrison and Eaton (1920), Schenck (1927), Vokes and others (1949), and most recently by Snavely and others (1964). The contact between the Nye Mudstone and the Yaquina Formation is exposed near the mouth of Beaver Creek at the base of the sea-cliff a little less than one-half mile north of the cetacean locality (fig. 1). This contact strikes southwest, and is offset by small faults in several places. The contact is visible west of the type locality at times of extreme minus tides, but is normally below tide level.

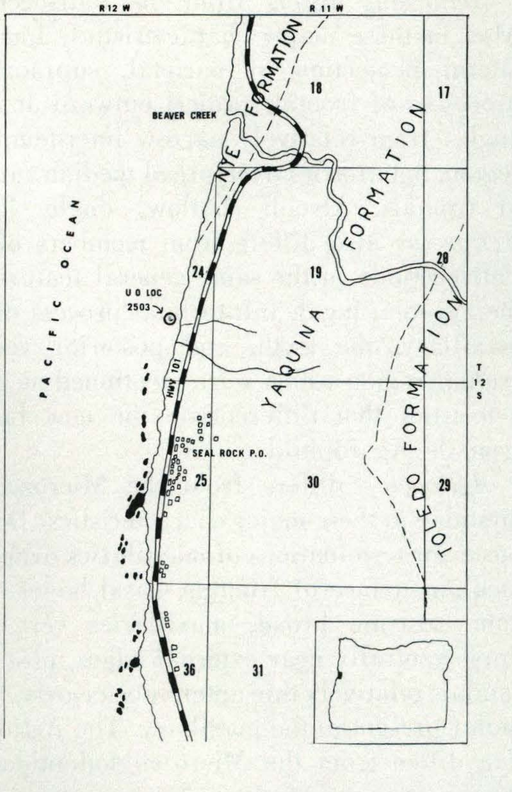

Figure 2. *Map showing the location of the new cetacean discovery and its relation to geologic formations (Geologic contacts from Vokes and others, 1949)*

SYSTEMATIC DESCRIPTION

suborder ARCHAEOCETI

Aetiocetidae new family

Definition: A toothed whale with the rounded apex of the supraoccipital, not thrust forward to the level of the postorbital projections of the frontals. The ascending process of the maxillaries over-rides the frontal in a V-shaped manner. The postero-ventral portion of the maxillaries under-rides the ventral anterior ends of the frontals. The dorso-ventrally thin plate of the infraorbital process extends outward slightly beyond the outer edge of the orbit. The jugal horizontally over-rides this plate on its outer edge. This relationship is maintained to the posterior termination of the maxillary plate located behind the level of the center of the orbit. The nasals are long. The posterior portion of the jugal is wedged between the median external surface of the zygoma and the ventral surface of the frontal.

Only the genus *Aetiocetus* is presently assigned.

The new family Aetiocetidae differs from known members of the family Agorophiidae, Abel in the following major features: Zygoma with strongly attenuated anterior extremity which projects forward beneath the postorbital projection of the frontal. Jugal firmly wedged between external (lateral) surface of zygoma and postorbital projection of frontal. Posterior portion of elongate jugal extends well behind level of anterior termination of zygoma. Infraorbital process of maxillary with strongly developed lateral extension which extends to outer edge of frontal, contacting jugal laterally. Dorsal posterior portions of maxillaries narrow markedly. Palatines, pterygoids, carina of vomer carried far posteriorly, roofing over choanae. Molars and premolars single rooted.

Aetiocetus differs from the Patriocetidae Abel in these major characteristics: Lack of lateral projection of parietal, supraorbital processes of frontals project outward at right angles from relatively narrow inter-temporal region, maxillaries overspread median surface of frontals. Alveoli shallow, single, large. *Aetiocetus* also differs from members of the Patriocetidae in the same general features of the zygoma, jugal, infraorbital process of the maxillary, the teeth, and posterior ventral cranial region which were mentioned as characteristics that differentiate the new family from the Agorophiidae.

Aetiocetus differs from the Microzeuglodontidae in these major characteristics: Dorsal posterior terminations of maxillaries over-ride median surface of frontals, nasal bones elongate, rostrum broad, maxillaries very thin dorso-ventrally near external edges, posterior caudals relatively thin antero-posteriorly, third molar present in the maxillary. The Aetiocetidae differ from the Microzeuglodontidae in the same general features of the zygoma, jugal, infraorbital process of the maxillary, teeth, and posterior ventral cranial region mentioned in comparison with the Agorophiidae and Patriocetidae.

TYPE GENUS: *Aetiocetus* gen. n.

AETIOCETUS COTYLALVEUS

gen.n. et sp. n.

GENOTYPIC SPECIES: *Aetiocetus cotylalveus* sp. n.

HOLOTYPE: University of Oregon, Museum of Natural History No. 26351, (Emlong collection No. 218).

The holotype consists of a skull in an excellent state of preservation, lacking a portion of the right side of the braincase, right exoccipital, squamosal, and tip of right supraorbital process of the frontal; it is otherwise complete, and remarkably well preserved; 39 vertebrae, complete, or nearly so; whole, or portions of 23 ribs; 6 detached teeth, and two teeth in place in the premaxillary; two sternal bones; two chevrons, all from one individual.

The skeleton was embedded in fine-grained sandstone with the right side of the braincase, and the ends of several ribs exposed. The skull and ribs were washed away from the almost completely articulated vertebra column before burial. The skull was upside down. The detached teeth were embedded in matrix below and behind the skull. The distal caudals were about four feet below the surface of the bedrock. The bones were highly silicified and suffered no decomposition before burial.

DIAGNOSIS: Generic diagnosis same as species. cies. Rounded apex of supraoccipital not thrust forward to the level of the postorbital projections of the frontals. Supraorbital processes of the frontal extend outward at right angles to the shortened, moderately narrowed intertemporal region. The ascending process of the maxillaries over-rides the frontal in a V-shaped manner, narrowing posteriorly. It closely resembles the ascending process on cetothere skulls. The posterior ends of the maxillaries do not closely approximate the outer edge of the orbit. The postero-ventral portion of the maxillaries under-rides the ventral anterior ends of the frontal, forming a well developed infraorbital process. A dorso-ventrally thin plate of this process extends outward slightly beyond the outer edge of the orbit, and this plate is well separated from the under surface of the frontal. The jugal horizontally over-rides this plate on its outer edge. This relationship is maintained to the posterior termination of the maxillary plate, located behind the level of the center of the orbit. This feature is unique among typical Cetacea, and resembles the Archaeoceti. The rostrum is broad at the antorbital notches, attenuated distally. The posteriormost alveolus is located anterior to the level of the preorbital angle of the frontal. The alveoli are shallow and large and extend to the outer edge of the maxillary and premaxillary. The nasals are long, the nasal cavity is located anterior to the level of the preorbital projection of the frontal. The zygoma have a very narrow anterior termination. The anterior termination under-rides, and closely approximates the outward flaring postorbital projection of the frontal. The posterior portion of the jugal is firmly wedged between the zygoma and the postorbital projection of the frontal. The posterior termination of the jugal projects well behind the level of the anterior end of the zygoma. The vomer has a prominent posterior ventral longitudinal carina. The pterygoid fossa is well developed. The palatines are narrow and elongate posteriorly, and broad anteriorly. The posterior process of the periotic is elongate. All teeth are single rooted. Small accessory cusps are present on the molars and premolars. The neural spines of the lumbars are short vertically and broad antero-posteriorly. The neural arches are very low on all vertebrae, and very broad on the cervicals and anterior dorsals. The anterior dorsals have short, heavy, rounded diapophyses. The transverse processes on the lumbars and the anterior caudals are very broad antero-posteriorly. A shelf is present on the outer portions of the transverse processes of the ninth and tenth lumbars, and the first and second caudals. At least fifteen pairs of ribs were present.

Skull

DORSAL VIEW: When the skull is viewed dorsally, one's attention is immediately directed to the antero-posterior shortness of the braincase. The transversely broad parietals slope forward, and downward to meet the frontals, which have thrust backward, shortening the intertemporal region, which is considerably depressed below the level of the posterior median portions of the parietals. The frontals extend backward farther on the dorsal surface of the intertemporal region than they do on the lateral surfaces of this region. The median frontal-parietal contact lies 35 mm anterior to the apex of the supraoccipital, and the parietals extend about 35 mm farther forward on each lateral wall of the intertemporal region, closely approximating the roots of the supraorbital processes of the frontals, which project outward at right angles to the moderately narrowed intertemporal area.

The supraoccipital shield is crescentic in shape. A small, narrow ridge extends downward for 24 mm from the apex of the supraoccipital shield, and a slight median occipital ridge extends for 31 mm posterior to the apex of the supraoccipital. The supraoccipital shield is much elevated above the intertemporal region, but does not extend forward to the level of the outward flaring postorbital projections of the frontal, or the frontal-parietal contact. The lambdoid crest slightly overshadows the posterior surfaces of the parietals. The entire braincase is constructed of dense, thickened bone.

The frontals slope outward and backward to form the supraorbital processes. The outward flaring postorbital projections of these processes curve downward, and over-ride the anterior ends of the zygomatic processes of the squamosal. The medial anterior exposed surface of the frontal is slightly concave near where it is over-ridden by the maxillaries.

The temporal fossa are irregularly oval, small in relation to the size of the skull, and shortened antero-posteriorly. The left temporal fossa measures 82 mm transversely, and 74 mm antero-posteriorly. (The transverse measurement is from the zygoma-frontal contact to the dorsal root of the frontal. The antero-posterior measurement is from the zygoma-frontal contact to the posterior edge of the fossa formed by the squamosal). The oblique measurement of this fossa is 102 mm (from the posterior end of the fossa to the dorsal root of the frontal).

A slight ridge marks the squamosal-parietal contact. Inside the posterior portion of the transversely thin zygoma, the squamosal forms an anteriorly deepened trough, which is bounded by the lambdoid crest posteriorly, and the temporal fossa, anteriorly.

The maxillaries, premaxillaries, and nasals have overridden the median anterior region of the frontal, and although the telescoping of these bones is not greatly advanced, the basic mysticete arrangement is clearly present. The convex hump, which comprises the ascending process of the maxillaries, premaxillaries, and nasals has the characteristic anteriorly broadened V-shape of the cetotheres. This contrasts with most primitive odontocetes. These archaic cetaceans have maxillaries which override the frontal, and rather than narrowing toward their posterior borders, run close and nearly parrallel to the outer edge of the orbit. This condition seems to have begun to develop even on the skull of the primitive odontocete *Archaeodelphis patrius* Allen (1921). The maxillaries of *Aetiocetus cotylalveus* terminate at about the level of the center of the orbit. They are very narrow at this point. Anteriorly, they gradually broaden. Their inner borders become more elevated above their outer borders. The outer borders then curve outward around the lachrymal.

The relatively large, transversely elongate lachrymal is wedged between the preorbital angle of the

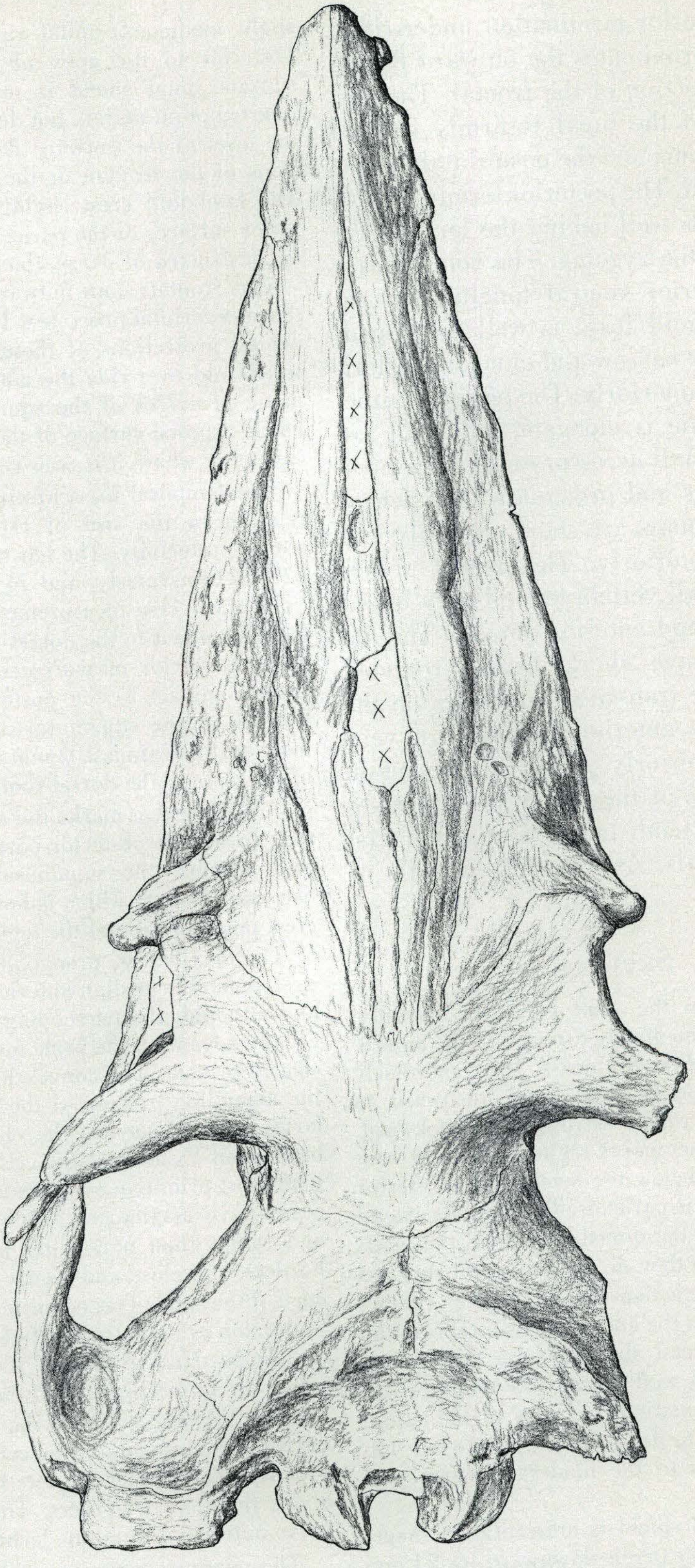

Figure 3. *Dorsal view of the skull,* AETIOCETUS COTYLALVEUS

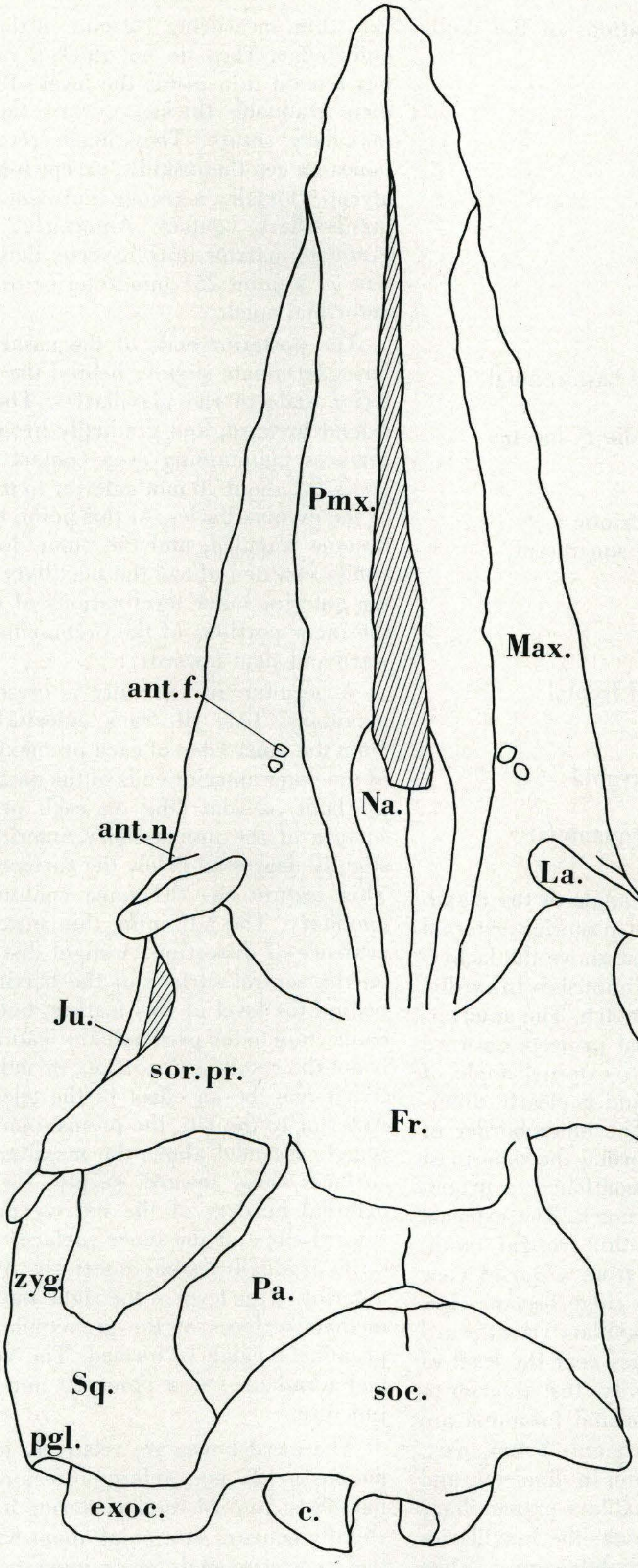

Figure 4. *Dorsal view of the skull,* AETIOCETUS COTYLALVEUS, *indicating relative positions of bones of the skull*

Abbreviations used in illustrations of the skull, Figs. 4, 6, and 7

Al.	alispheonid
ant. f.	antorbital foramina
ant. n.	antorbital notch
Bo.	basioccipital
c.	occipital condyle
exoc.	exoccipital
f. ov.	foramen ovale
Fr.	frontal
Ju.	jugal
La.	lachrymal
l. pr.	lateral protuberance of basioccipital
Max.	maxillary
m.e.a.	groove for external auditory meatus
Na.	nasal
Pa.	parietal
pr. p.	posterior process of periotic
pgl.	postglenoid process of squamosal
Pmx.	premaxillary
Pt.	pterygoid
pt. f.	pterygoid fossa
soc.	supraoccipital shield
sor. pr.	supraorbital process of frontal
Sq.	squamosal
ty.	tympanic bulla
v. pt.	vaginal process of pterygoid
V.	vomer
zyg.	zygomatic process of squamosal

frontal and the postero-external angle of the maxillary. The dorsal portion of the posterior external angle of the maxillary is elevated above the lachrymal, and forms a ridge which diminishes inwardly. This ridge forms the antorbital notch. The anterior-external portion of the lachrymal projects outward for 10 mm beyond the posterior external angle of the maxillary, on the left side, and is clearly differentiated from it at this point. The inner border of the left lachrymal lies 47 mm inside the outermost projection. As was previously mentioned, a prominent ridge forms the antorbital notch. The external posterior ventral edge of the thin rostral tooth-bearing maxillary is concealed from a dorsal view by a portion of this ridge. This ridge becomes less pronounced inwardly, and the maxillary rises toward its contact with the premaxillaries near the level of the posterior end of the nasal cavity. Just anterior to this point two small round antorbital foramina are present. On the right side, they are only 3 mm apart. The larger, innermost one is 8 mm in diameter, and lies 6 mm external to the maxillary-premaxillary suture. Anterior to these foramina, the maxillaries descend, then flatten, becoming slightly convex. They are dorso-ventrally compressed, their outer edges are very thin, measuring 1-2 mm on the average at the outer edge. They do not thicken rapidly inwardly, but remain thin inside the level of the alveoli, and then gradually thicken toward the maxillary-premaxillary suture. They much resemble the same bones on cetothere skulls, except for the presence of alveoli. Dorsally, a groove is present at the maxillary-premaxillary contact. Anteriorly, the maxillaries gradually narrow in transverse diameter, and terminate at a point 251 mm anterior to the level of the antorbital notch.

The posterior ends of the nasals and premaxillaries terminate slightly behind the level of the posterior ends of the maxillaries. The premaxillaries extend forward, and gradually broaden, their outer surfaces maintaining even contact with the maxillaries for about 70 mm anterior to the posterior ends of the premaxillaries. At this point, their outer edges become rounded, and the outer dorsal surface becomes elevated above the maxillary. At the level of the anterior outer terminations of the nasal bones, the inner portions of the premaxillaries turn downward and slant inward.

A peculiar discontinuity is present on each premaxillary. This rift runs anteriorly and outward from the inner edge of each premaxillary at the level of the outer anterior ends of the nasal bones. The rift is about 52 mm long on each premaxillary. The surface of the premaxillary anterior to this rift is slightly depressed below the surface behind the rift. This feature has the same contour on each premaxillary. The adjoining thin maxillaries show no evidence of distortion. A slight distortion is present on the ventral surface of the maxillaries somewhat behind the level of this feature, but has no obvious connection to the premaxillary feature. If this feature is not the result of distortion, or individual peculiarity, it may be an effect of the telescoping process. Anterior to the rift, the premaxillaries broaden and remain elevated above the maxillaries. Their inner surfaces slope inward steeply, forming the upper external borders of the narrow nasal cavity. The inward slope of the inner surfaces of the premaxillaries gradually lessens anteriorly. At a point 281 mm anterior to the level of the right antorbital notch, the median surfaces of the premaxillaries join, and a prominent ridge is formed. The rostrum narrows, and terminates at a point 70 mm anterior to this juncture.

The nasal bones are relatively long, the left one measures 125 mm antero-posteriorly, and they are narrowest toward their posterior borders. They are slightly convex. At a point about 85 mm anterior to their posterior ends, their inner borders dip below the level of the premaxillaries and curve strongly

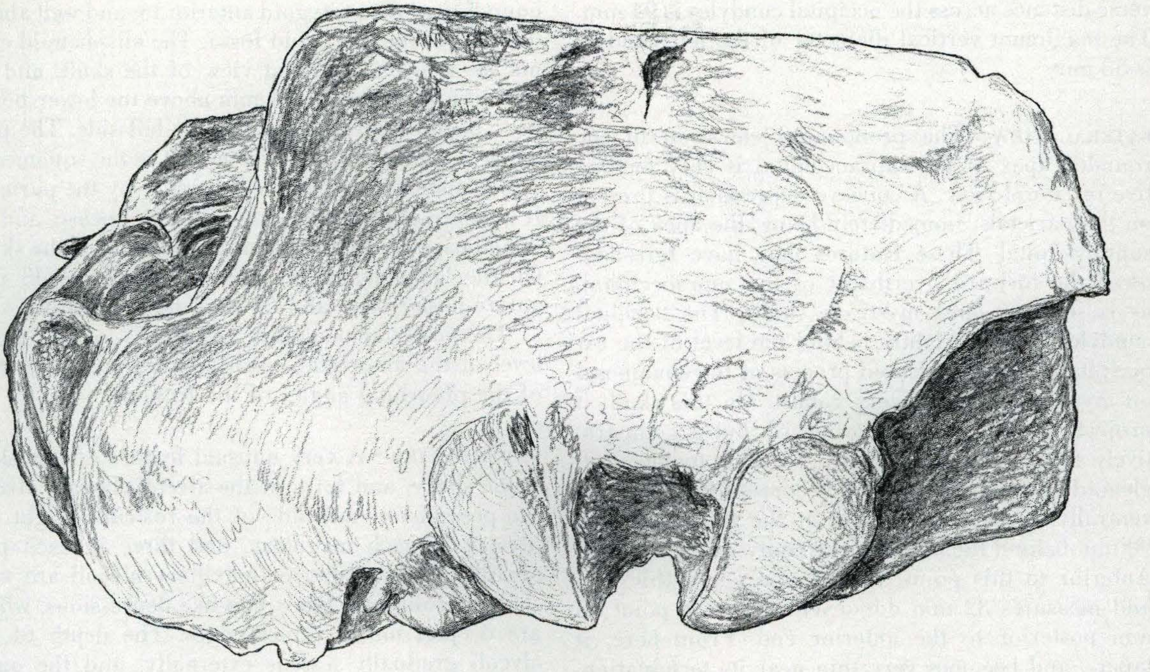

Figure 5. *Posterior view of the skull,* AETIOCETUS COTYLALVEUS

downward near their anterior terminations, forming the posterior end of the nasal cavity. The outer borders of the nasals are level with the adjoining premaxillaries for 90 mm, then depress to a much lesser degree than do the inward extensions, and terminate 32 mm anterior to the inward extensions. The nasal cavity is relatively narrow. The matrix was not removed to expose the vomer, as removal might damage the skull. A mesorostral gutter extends anteriorly from the nasal cavity, and terminates at a point 258 mm anterior to the posterior end of the nasal cavity.

From a dorsal view, the occipital condyles are rather large, their upper surfaces are far apart, being separated 52 mm.

POSTERIOR VIEW: The posterior wall of the braincase is depressed medially, forming a concave 'dish'. To either side, slightly above the center of this depression, a slight protuberance is developed on the braincase. The lower border of the left protuberance lies 33 mm below the edge of the lambdoid crest. The lambdoid crest projects backward to some extent, over-shadowing the exoccipital.

The left exoccipital extends outward, and downward. However, the outermost angle does not project downward as far as does the surface just external to the jugular notch. A sharp, downward projecting paraoccipital process is present at this point. The jugular notch is rather narrow, measures 5 mm transversely, at the posterior base. The inner portion of the jugular notch is filled with matrix. A small knob projects downward slightly between it and the lateral protuberance of the basioccipital. The dorsoventral height of the jugular notch from the base of this small knob is 12 mm (measurements of jugular notch taken externally, on the posterior portion of the skull). The deeper, matrix-filled inner portion is concealed from posterior view by bone. The external depth of the jugular notch from the ventral projection of the paraoccipital process is 35 mm. The left lateral protuberance of the basioccipital is well differentiated from the surrounding surface.

The squamosal is not as robust as on cetothere skulls. The postglenoid process projects outward beyond the level of the outer angle of the exoccipital, but does not extend downward below the level of the exoccipital.

The occipital condyles are heavily built, and are separated from the posterior surface of the exoccipitals by a thin groove. They project moderately outward. Their lower surfaces narrow considerably in transverse diameter. The most posterior portion of the basioccipital, which separates the ventral surfaces of the occipital condyles has been displaced by distortion, and shoved slightly upward into the foramen magnum. The upper and middle portions of the occipital condyles are broadest. The maximum transverse distance across the occipital condyles is 94 mm. The maximum vertical diameter of the left condyle is 58 mm.

LATERAL VIEW: The pronounced elevation of the rounded apex of the supraoccipital is very distinctive in lateral view. A concave depression is present on the parietals, immediately below the apex of the supraoccipital. These features may have foreshadowed the forward overthrust of the supraoccipital, as is seen on most mysticete skulls. The occipital condyles project slightly behind the level of the exoccipitals. The postglenoid process of the squamosal on mysticete skulls is very robust. On this skull, it projects rather strongly downward, but is comparatively thin antero-posteriorly. Anterior to the postglenoid process, the zygoma becomes thinner dorso-ventrally, measuring 21 mm at the thinnest point, 90 mm behind the anterior extremity of the zygoma. Anterior to this point, the zygoma again thickens, and measures 32 mm dorso-ventrally at a point 43 mm posterior to the anterior end. From here, it tapers, and becomes very thin near its termination. It is over-ridden for a distance of 25 mm by the post-orbital projection of the supraorbital process of the frontal.

The postorbital projection of the frontal is quite thick. It measures 30 mm dorso ventrally at its posterior extremity. Anteriorly, the dorsal outer edges of the frontals become undermined. This condition prevails all the way to the outer anterior end of the frontal.

The jugal is peculiarly constructed. Its posterior end lies firmly wedged between the tip of the post-orbital portion of the supraorbital process of the frontal, and the median-external anterior portion of the zygoma. Its posterior projection emerges behind the tip of the preorbital angle of the frontal, and projects outward and backward for 21 mm behind the level of the preorbital angle. Anterior to the level of the center of the orbit, the jugal thickens dorso-ventrally, and contacts the lower posterior edge of the lachrymal. The over-all length of the jugal is 123 mm.

The maxillaries are compressed dorso-ventrally, and the thinness of their outer edges is clearly evident from a lateral view. The premaxillaries at the tip of the rostrum are rather thick dorso-ventrally in their median region measuring 31 mm thick at the median ridge, 65 mm posterior to the tip of the rostrum.

The alisphenoid appears on the temporal wall of the braincase behind the base of the supraorbital process. It is triangular in shape, with the apex of the triangle projecting downward, touching the upper boundary of the pterygoid anterior to, and well above the level of the pterygoid fossa. The alisphenoid cannot be seen on a ventral view of the skull, and its ventral projection lies 21 mm above the lower boundary of the temporal fossa on the left side. The posterior boundary of the alisphenoid is the squamosal. The alisphenoid is bounded dorsally by the parietal. It is depressed on each side of the braincase, and its boundaries are well defined on each side of the skull. On the left side, the alisphenoid measures 43 mm antero-posteriorly, and 29 mm dorso-ventrally.

The posterior maxillary alveolus is located at the level of the antorbital notches, anterior to the level of the preorbital angles of the frontals.

VENTRAL VIEW: A very unusual feature of this skull is the shape, and form of the alveoli. Eleven alveoli are present on each side of the rostrum. Eight are present in each maxillary, and three in each premaxillary. The posterior maxillary alveoli are very shallow, roundish, large, cup-like depressions, which are deepest on the inner edges. The depth of the alveoli gradually lessens externally, and the outer edges of the alveoli have no well defined wall, so that the depressions merge with the very thin external border of the maxillary. Proceeding anteriorly each alveolus becomes slightly deeper than the one posterior to it. None of the posterior maxillary alveoli were deep enough to firmly hold the teeth. Much of the stabilization would have to have been accomplished by a firm gum. Anterior to each alveolus, the thin outer border of the maxillary and premaxillary curves slightly inward. On the surface of the maxillary, just inside the inner edges of the alveoli, a weak ridge is developed. This antero-posterior ridge is broken, and not pronounced.

The premaxillary alveoli are somewhat narrowed antero-posteriorly, and are slanted outward in an obliquely posterior direction. Their antero-internal ends are deepened. No well-defined outer wall is present on these alveoli, and their outer border is formed by the external edge of the premaxillary. The first incisor is present in the anterior alveolus of each premaxillary. The anterior premaxillary alveoli obviously held the teeth in place much more firmly than did the posterior maxillary alveoli. These characteristics would seem to foreshadow a tendency toward the elimination of the teeth.

The ventral surfaces of the broad maxillaries are shaped similarly to these same bones on cetothere skulls. Their postero-ventral portions have underridden the frontal. A slight distortion is present on the underside of the maxillary at about the level of the preorbital angle of the frontal. The posterior borders of the infraorbital extension of the maxil-

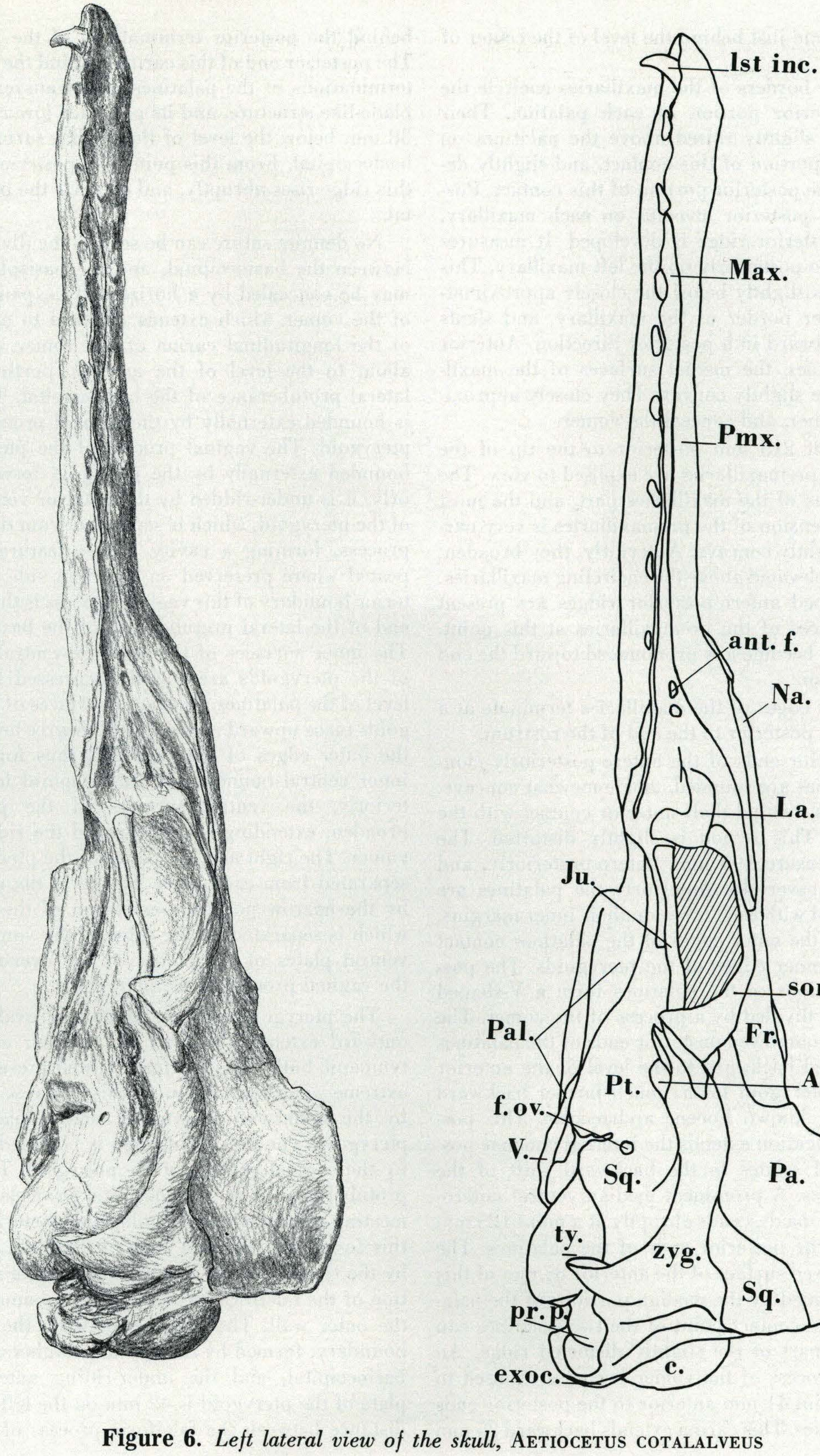

Figure 6. *Left lateral view of the skull,* Aetiocetus cotalalveus

laries terminate just behind the level of the center of the orbit.

The inner borders of the maxillaries encircle the rounded anterior portion of each palatine. Their surfaces are slightly raised above the palatines on the anterior portion of this contact, and slightly depressed on the posterior portion of this contact. Posterior to the posterior alveolus on each maxillary, an antero-posterior ridge is developed. It measures 36 mm antero-posteriorly on the left maxillary. This ridge extends slightly below the closely approximating thin outer border of the maxillary, and slants obliquely outward in a posterior direction. Anterior to the palatines, the medial surfaces of the maxillaries become slightly convex. They closely approximate each other, and conceal the vomer.

At a point 215 mm posterior to the tip of the rostrum, the premaxillaries are exposed to view. The inner surfaces of the maxillaries part, and the most posterior extension of the premaxillaries is very narrow, and slightly concave. Anteriorly, they broaden, and become elevated above the encircling maxillaries. Well developed antero-posterior ridges are present on the surfaces of the premaxillaries at this point. These ridges become less pronounced toward the end of the rostrum.

The outer edges of the maxillaries terminate at a point 82 mm posterior to the end of the rostrum.

The anterior ends of the antero-posteriorly elongated palatines are rounded, and somewhat concave, medially, just behind their anterior contact with the maxillaries. This region is slightly distorted. The palatines measure 195 mm, antero-posteriorly, and 114 mm transversely. Anteriorly the palatines are solidly united with each other on their inner margins. Posteriorly, the outer edges of the palatines contact the ventral inner edges of the pterygoids. The posterior extensions of the palatines form a V-shaped termination, divided by a process of the vomer. The transversely narrowed posterior ends of the palatines are prolonged backward to the level of the anterior end of the pterygoid fossa; much farther backward than on any known Eocene archaeocete. This posterior prolongation extends the internal choanae posteriorly, and relates to the backward shift of the external nares. A prominent median ventral antero-posterior carina descends abruptly at a point 125 mm anterior to the posterior ends of the palatines. The ventral exposed surface of the anterior 87 mm of this carina is formed by the median portions of the palatines, and the contact point of the two palatines can be seen on part of the slightly distorted ridge. An overlying process of the vomer becomes exposed to view at a point 41 mm anterior to the posterior ends of the palatines. This carina extends backward 25 mm behind the posterior terminations of the palatines. The posterior end of this carina, behind the posterior terminations of the palatines, is a transversely thin blade-like structure, and its posterior lower edge lies 38 mm below the level of the medial surface of the basioccipital. From this point, the posterior edge of this ridge rises abruptly, and contacts the basioccipital.

No definite suture can be seen as the dividing line between the basioccipital, and the basisphenoid. It may be concealed by a horizontally expanded plate of the vomer which extends outward to either side of the longitudinal carina of the vomer, and back about to the level of the anterior portion of the lateral protuberance of the basioccipital. This plate is bounded externally by the vaginal process of the pterygoid. The vaginal process of the pterygoid is bounded externally by the pterygoid fossa. Anteriorly, it is under-ridden by the anterior ventral plate of the pterygoid, which is separated from the vaginal process, forming a cavity. These features are repeated where preserved on the right side. The posterior boundary of this vaginal process is the anterior end of the lateral protuberance of the basioccipital. The inner surfaces of the anterior ventral portions of the pterygoids are slightly depressed below the level of the palatines. The outer surfaces of the pterygoids turns upward at nearly a 90 degree angle, as do the outer edges of the palatines, thus forming the inner ventral boundary of the temporal fossa. Posteriorly, the ventral surfaces of the pterygoids broaden, extending inward toward the ridge of the vomer. The right and left plates of the pterygoid are separated from each other 24 mm at the minimum, by the narrow posterior extension of the palatines which is separated by the ridge of the vomer. These ventral plates of the pterygoid are over-ridden by the vaginal process of the pterygoids.

The pterygoid fossa is irregularly oval, with an outward extension around the anterior end of the tympanic bulla. The left fossa is well preserved. The extreme anterior portion of this fossa is concealed by the under-riding anterior ventral plate of the pterygoid. The pterygoid fossa is bounded inwardly by the vaginal process of the pterygoid. The lateral protuberance of the basioccipital projects outward, meeting the tympanic, forming the posterior end of this fossa. The external edge of the fossa is formed by the tympanic, and antero-externally, a small portion of the falciform process of the squamosal forms the outer wall. The distance between the posterior boundary, formed by the lateral protuberance of the basioccipital, and the under-riding antero-ventral plate of the pterygoid is 42 mm on the left side. The distance between the falciform process of the squamosal, and the inner ventral edge of the pterygoid fossa is 33 mm.

Two distinct levels are present in the region of the pterygoid fossa. The posterior portion of this fossa is concealed from view by a dorso-ventrally thin plate of bone which may be a process of the pterygoid. This plate emerges into view above the outer edge of the under-riding vaginal process of the pterygoid, and extends outward, and is concealed by the tympanic externally, and is bounded by the lateral protuberance of the basioccipital posteriorly. The lateral protuberance of the basioccipital lies below the level of this thin plate. This relationship is not a result of distortion. A portion of the anterior outer edge of this extremely thin plate has been displaced slightly upward into the cavity of the fossa. The cavity of the pterygoid fossa is exposed to ventral view on its anterior exposed end. The dorsal roof of this cavity appears to be formed by another thin process of the pterygoid. However, this cannot be determined with certainty. As was already mentioned, the anterior end of this cavity is partially underlain by the posterior ventral plate of the pterygoid. The pterygoid fossa is for accessory air sinuses of the inner ear, and is a feature present on mysticete skulls.

The lateral protuberance of the basioccipital projects strongly downward. The right protuberance is eroded away. The left protuberance directs downward, and backward. Its postero-external edge rests against the inner edge of the tympanic bulla. It does not descend below the level of the exoccipital. It is relatively flattened, and broadened, transversely. The posterior extension of this lateral protuberance is well differentiated from the over-lying surface. The distance between the outer edges of the most posterior extension of the right and left lateral protuberances is about 75 mm. The distance between the posterior extension of the left lateral protuberance of the basioccipital, and the ventral tip of the paraoccipital process is 18 mm. The jugular notch is narrow and deep, as was previously mentioned.

The paraoccipital process projects ventrally, and a well marked depression is present just external to the downward projection. This depression is most strongly developed toward its anterior edge, where it contacts the posterior process of the periotic. This concavity is for the reception of the stylohyoid. External to this depression, the exoccipital narrows antero-posteriorly, and the posterior process of the periotic fits tightly against it, and extends nearly all the way out to the external edge of the exoccipital. Between the posterior process of the periotic, and the posterior face of the postglenoid process, a deep transverse channel for the external auditory meatus is present. This channel is narrow on its external end, and widens inwardly. It is concealed by the tympanic just posterior to the posteriorly twisted distal end of the *processus sigmoideus*, and disappears from view. The posterior side of this channel curves moderately downward, and meets the posterior process of the periotic, which extends below this level. The channel measures 43 mm transversely to where it disappears from ventral view over the tympanic.

The posterior face of the postglenoid process projects rather strongly downward, but is relatively thin antero-posteriorly, and rolls forward, forming a very concave glenoid fossa. This region is heavier than on other zeuglodont skulls, but not as thickened as on skulls of cetotheres. The distance between the most posterior extension of the exoccipital, and the most posterior extension of the temporal fossa is 90 mm. The distance between the external side of the zygomatic arch, and the protuberant portion of the falciform process of the squamosal is 78 mm transversely, in level with the posterior extension of the temporal fossa. The distance between the posterior extension of the glenoid fossa and the posterior extension of the temporal fossa is 40 mm.

The transversely thin falciform process of the squamosal descends 25 mm below the more level surface of the anterior internal portion of the squamosal. This process descends below the level of the anterior portion of the tympanic bulla. It is united with the pterygoid, anteriorly, forming the outer wall of the pterygoid fossa. An inwardly directed depression on the anterior internal portion of the squamosal, just external to the anteriormost part of the falciform process, appears to be an outer extension of the foramen ovale. This depression measures 15 mm antero-posteriorly on the shallow external portion, and narrows and deepens near where it runs inward over the falciform process, the actual foramen being obscured to ventral view by the falciform process. The distance between its outer border, which is the outer border of the ventral portion of the squamosal, and the point where it disappears from view over the falciform process is 13 mm.

The median ventral surface of the root of the zygomatic process is concave. The anterior inner edge of the zygoma is also concave, medially (anterior to the root of the process). At this area of median concavity, the upper portion of the internal surface of the zygoma turns moderately inward, and the lower (ventral) portion of this inner surface slants moderately outward. These features are developed at the point of maximum dorso-ventral swelling, just posterior to where the zygoma is overridden by the postorbital projection of the frontal, and anterior to the level of the posterior extension of

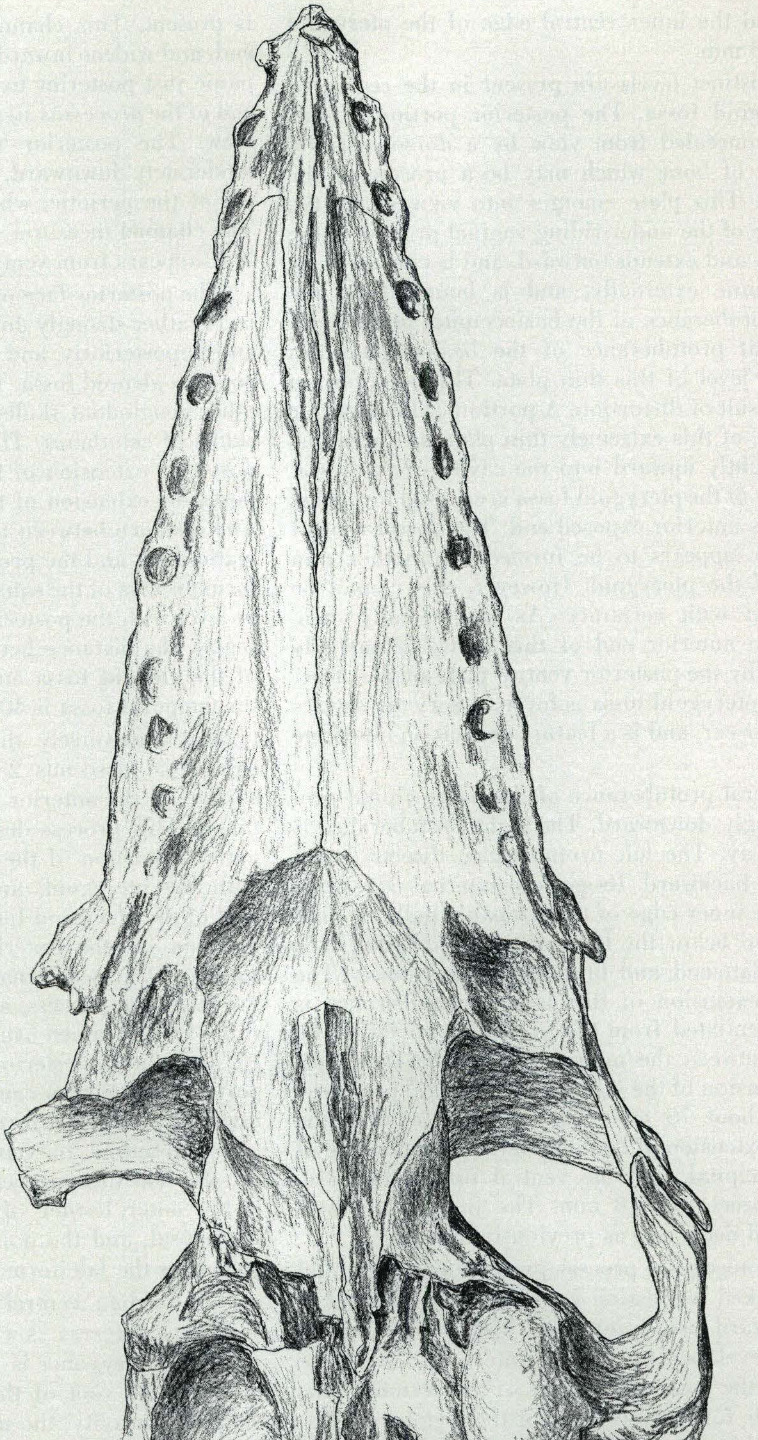

Figure 7. *Ventral view of the skull,* AETIOCETUS COTYLALVEUS

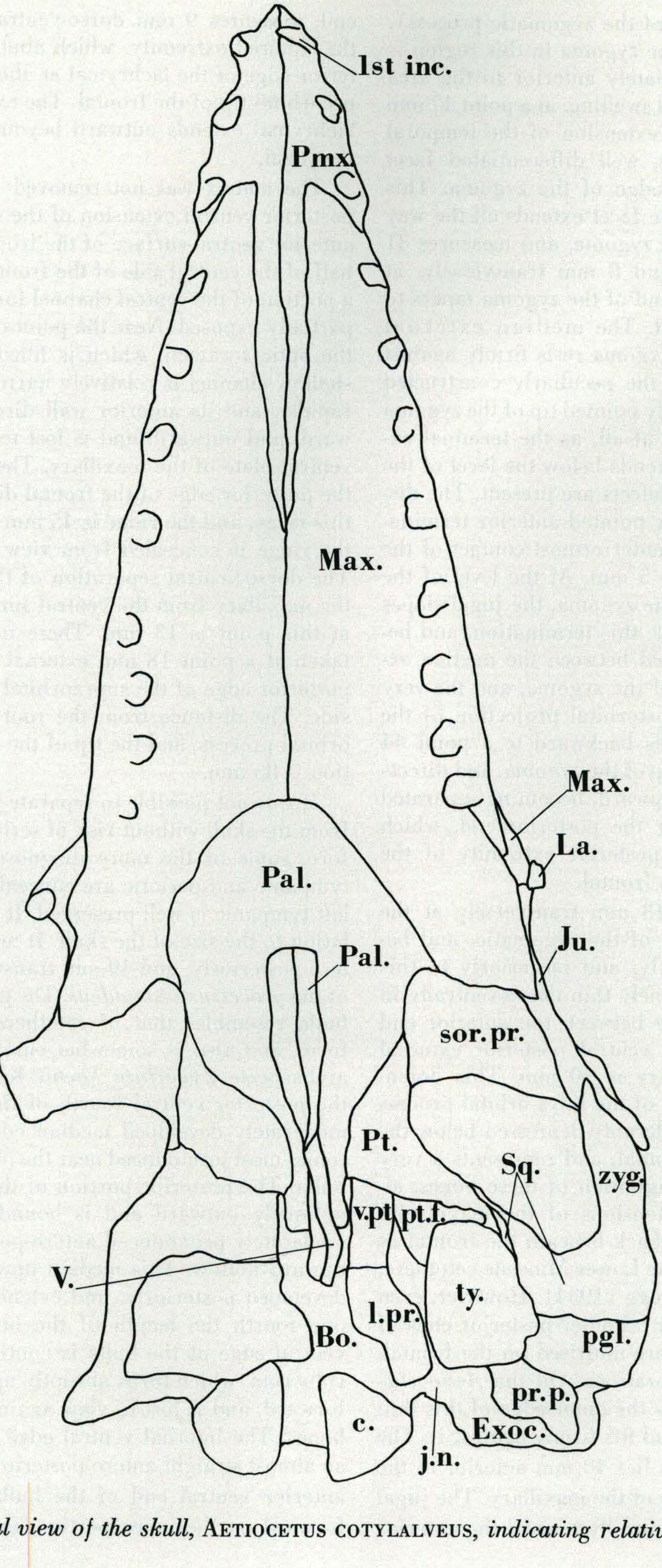

Figure 8. *Ventral view of the skull,* AETIOCETUS COTYLALVEUS, *indicating relative positions of the bones of the skull*

the temporal fossa (root of the zygomatic process). The external surface of the zygoma in this region is convex, medially. Immediately anterior to the area of maximum dorso-ventral swelling, at a point 47 mm anterior to the posterior extension of the temporal fossa, a slightly concave, well differentiated facet develops on the ventral edge of the zygoma. This antero-posteriorly elongate facet extends all the way to the anterior end of the zygoma, and measures 31 mm antero-posteriorly, and 8 mm transversely, at maximum. The anterior end of the zygoma tapers to an extremely sharp point. The median external (lateral) portion of the zygoma rests firmly against the posterior portion of the peculiarly constructed jugal. However, the sharply pointed tip of the zygoma does not touch the jugal at all, as the terminal extremity of the zygoma extends below the level of the jugal. No distortion, or defects are present. The distance between the sharply pointed anterior termination of the zygoma, and anteriormost contact of the zygoma with the jugal is 5 mm. At the level of the anterior termination of the zygoma, the jugal slopes moderately upward, above this termination, and becomes very solidly wedged between the median external (lateral) surface of the zygoma, and the very closely approximating postorbital projection of the frontal. The jugal extends backward to a point 44 mm behind the anterior tip of the zygoma, and directs obliquely outward, and upward, becoming separated from the zygomatic near the posterior end, which lies 21 mm behind the posterior extremity of the postorbital process of the frontal.

The jugal measures 13 mm transversely at the level of the anterior end of the zygomatic, and becomes narrower anteriorly, and posteriorly to this point. The jugal is extremely thin dorso-ventrally in this region. The distance between the anterior end of the zygoma, and the ventral posterior external extension of the maxillary is 40 mm. This dorso-ventrally thin outer plate of the infra-orbital process of the maxillary is considerably depressed below the ventral surface of the frontal, and represents a very early stage in the interdigitation of these bones, although these ventral extensions of the maxillaries are located about as far back beneath the frontal as they are on the skull of the Lower Miocene cetothere, *Cetotherium moreni* Kellogg (1934). However, even on this cetothere, the ventral outer posterior ends of the maxillaries actually are mortised on the frontal, as is shown on the restorations. On the *Aetiocetus* skull, the jugal over-rides the outer edge of this thin plate of the maxillary, and fits firmly against it. The anterior end of the jugal lies 48 mm anterior to the posterior outer extension of the maxillary. The jugal becomes thicker dorso-ventrally toward the anterior end, measures 9 mm dorso-ventrally (left side) at the squared extremity, which abuts against the posterior edge of the lachrymal at about the level of the preorbital tip of the frontal. The external edge of the lachrymal extends outward beyond its contact with the jugal.

The matrix was not removed from between the posterior ventral extension of the maxillary, and the anterior ventral-surface of the frontal. The posterior half of the ventral side of the frontal is exposed, and a portion of the ventral channel for the optic nerve is partially exposed. Near the point of emergence from the optic foramen, which is filled with matrix, the shallow channel is relatively narrow. It then widens rapidly, and its anterior wall directs obliquely forward, and outward, and is lost to view beneath the ventral plate of the maxillary. The distance between the posterior edge of the frontal directly posterior to this ridge, and the ridge is 45 mm at the point where the ridge is concealed from view by the maxillary. The dorso-ventral separation of the ventral plate of the maxillary from the ventral surface of the frontal at this point is 13 mm. These measurements were taken at a point 18 mm external to the root of the posterior edge of the supraorbital process of the left side. The distance from the root of the left supraorbital process, and the tip of the postorbital projection is 85 mm.

It was not possible to separate the tympanic bulla from the skull without risk of serious damage, therefore, some of the more diagnostic features of the tympanic and periotic are concealed from view. The left tympanic is well preserved. It is very large in relation to the size of the skull. It measures 70 mm antero-posteriorly, and 49 mm transversely, at the level of the *processus sigmoideus*. The general shape of the bulla resembles that of cetothere bulla in general form, and also is somewhat similar to bulla of the archaeocete *Zygorhiza kochii* Kellogg (1936). On the posterior ventral fourth of the bulla, there is a moderately developed median convexity, which becomes most pronounced near the posterior edge of the bulla. The posterior portion of this convexity slants obliquely outward and is bounded inwardly by a moderately pronounced antero-posteriorly elongated upward hollow. This median upward hollow is best developed posteriorly, and extends anteriorly about one fourth the length of the bulla. The posterior ventral edge of the bulla is continuous with the involucrum, which turns abruptly upward, and slightly forward, and is lost to view against the surrounding bones. The internal ventral edge of the bulla forms an almost straight antero-posterior line. The rounded anterior ventral end of the bulla projects farthest forward on the inner portion, and the external an-

TABLE 1

Measurements of the Skull

	mm
Greatest length of skull (tip of rostrum to posterior end of left occipital condyle	630
Tip of rostrum, to apex of superoccipital shield	525
Length of rostrum, level of antorbital notches to tip of premaxillaries	351
Greatest length of right premaxillary	418
Anterior end of left premaxillary, to anterior end of left nasal bone	300
Apex of supraoccipital shield to posterior end of left nasal bone	103
Greatest length of left nasal bone	125
Transverse diameter of nasal bones at posterior end of nasal cavity	37
Maximum transverse diameter of nasal cavity	30
Distance from posterior end of nasal cavity to anterior end of mesorostral gutter	258
Transverse diameter of left nasal bone near posterior end	10
Combined width of nasal bones near posterior ends	21
Transverse distance between outer margins of premaxillaries at level of anterior ends of nasal bones	79
Maximum transverse distance between outer margins of premaxillaries at level of anterior terminations of maxillaries	67
Transverse diameter of rostrum at level of antorbital notches	172
Transverse diameter of skull across preorbital angles of frontals	187
Minimum transverse distance across median orbital area of supraorbital processes	174
Transverse diameter of skull across postorbital projections of supraorbital processes	300±
Greatest antero-posterior diameter of left supraorbital process	115
Maximum transverse distance between outer surfaces of zygomatic processes	320±
Distance between outer edges of ascending processes of maxillaries at level of preorbital angles of frontals	128
Distance between outer edges of ascending processes of maxillaries at their poster terminations	47
Transverse diameter of skull between outer margins of exoccipitals	265±
Transverse distance between outer margins of occipital condyles	94
Greatest vertical diameter of left occipital condyle	58
Greatest transverse diameter of left occipital condyle	37
Transverse diameter of foramen magnum	36
Distance from upper margin of foramen magnum to apex of supraoccipital shield	104
Vertical distance from ventral carina of vomer to apex of supraoccipital shield	145
Greatest length of left zygomatic process, posterior edge of postglenoid process to anterior end of zygoma	125
Vertical distance from left exoccipital to level of apex of supraoccipital	153
Least transverse diameter of intertemporal region, dorsally	90
Least transverse diameter of intertemporal region ventrally	93
Greatest antero-posterior length of palatines	195
Greatest transverse diameter of palatines	114
Distance from posterior end of vomer to anterior end of palatines	222
Greatest transverse diameter of left pterygoid fossa	33
Greatest antero-posterior diameter of left pterygoid fossa	42
Maximum antero-posterior length of jugal	123
Distance from posterior dorsal termination of left maxillary to tip of rostrum	406

TABLE 1 (Continued)

Posterior ventral termination of left maxillary to tip of rostrum	432
Posterior extension of exoccipital to tip of postorbital projection of supraorbital process	162
Posterior external edge of left premaxillary to tip of rostrum	82
Posterior alveolus of left maxillary to tip of rostrum	347
Posterior edge of left occipital condyle to posterior extension of anterior ventral plate of left pterygoid	123
Anterior end of palatines to tip of rostrum	323
Posterior edge of right occipital condyle to posterior end of right palatine	112
Antero-posterior diameter of second left maxillary alveolus	13
Transverse diameter of second left maxillary alveolus	10
Depth of second left maxillary alveolus from ventral inner wall	3
Antero-posterior diameter of third left maxillary alveolus	12
Transverse diameter of third left maxillary alveolus	11
Depth of third left maxillary alveolus	5
Transverse diameter of second premaxillary alveolus	10
Antero-posterior diameter of second premaxillary alveolus	11
Depth of second premaxillary alveolus	9
Distance between posterior maxillary alveolus, and posterior edge of glenoid fossa	225
Posterior maxillary alveolus to posterior edge left exoccipital	278
Posterior ventral extension of maxillary to posterior edge of glenoid fossa	144
Maximum antero-posterior width of left lachrymal	16
Transverse diameter of left lachrymal	47
Dorso-ventral thickness of outer extremity of left lachrymal	25
Apex of supraoccipital shield to posterior end of nasal cavity	200
Posterior end of nasal cavity to tip of rostrum	322
Maximum dorso-ventral thickness of left supraorbital process of frontal at base	32
Antero-posterior length of bulla at maximum	70
Transverse width of bulla at maximum	49
Maximum dorso-ventral thickness of bulla	39
Antero-posterior diameter of *processus sigmoideus*	24
Free vertcial height of *processus sigmoideus*	22
Exposed length of posterior process of periotic	47
Maximum antero-posterior width of posterior process of periotic	27

terior edge curves outward and backward gradually, and is bounded by the falciform process of the squamosal, which fits tightly against the bulla, and extends below the level of the anterior ventral surface of the bulla. The anterior ventral end of the bulla is relatively wide, and does not have the attenuated projection seen in bulla of such archaeocetes as *Kekenodon onomata* Kellogg (1936), or most odontocete bullae. The anterior ventral end of the bulla is moderately convex, medially. This median convexity becomes much more pronounced, posteriorly. Immediately external to the before mentioned median upward hollow, the postero-ventral surface of the bulla becomes very convex, and projects downward in a protuberant manner. From this ventral convexity, the external ventral surface of the bulla turns rather abruptly upward. This upward slope is most abrupt on the posterior portion, and becomes more gradual anteriorly. The *processus sigmoideus* is located a little less than two-thirds of the way back from the anterior end of the bulla on its thin outer lip. The *processus sigmoideus* becomes differentiated from the rest of the bulla a little more than half way upward from the posterior downward protuberance, and the upper portion of this process curves posteriorly at nearly a right angle, as well as curving outward moderately. This area is relatively wide, and is flattened dorso-ventrally. The anterior edge of the sigmoid process curves slightly forward on the upper portion, but does not project outward. The antero-posterior diameter of the *processus sigmoideus* is 24 mm, which is unusual according to Kellogg (1936), as it exceeds the free vertical height of the process, which is 22 mm. This same basic feature is present on the tympanic bullae of the archaeocetes *Zygorhiza kochii*, and *Dorudon osiris* Kellogg (1936). The backward curved posterior upper portion of the *processus sigmoideus* is well differentiated from the *processus medius* on the tympanic of *Aetiocetus*.

The channel for the external auditory meatus is underlain by the *processus medius* of the tympanic, which lies just posterior, and inward from the *processus sigmoideus*. The upper edge of the bulla in this region is antero-posteriorly rounded, and turns downward. The distance between the posterior projection of the *processus sigmoideus* and the anterior edge of the posterior process of the periotic is 11 mm. The anterior process of the outer lip fits snugly against the thin posterior portion of the falciform process of the squamosal. The maximum dorso-ventral thickness of the bulla from the posterior-ventral protuberance to the uppermost portion of the sigmoid process is 39 mm. The posterior process of the periotic emerges into ventral view above the postero-external end of the tympanic, and is bounded at this point by the *processus posterius* on the anterior edge, and by the postero-external portion of the involucrum on the postero-internal side. The posterior process extends outward and backward, and is firmly wedged between the exoccipital and the squamosal. It extends outward nearly to the external edge of the exoccipital. The outward extension of this process seems to be about intermediate in development between the stage seen on the skull of the archaeocete *Basilosaurus cetoides* Kellogg (1936) and that developed on skulls of cetotheres. The posterior process of *Aetiocetus* is very broad, measuring 27 mm anterio-posteriorly at maximum. Its surface is roughened, and a very well developed groove is present medially, and extends to the outer edge of the process. The maximum antero-posterior width of this groove is 10 mm, on the inward portion. The posterior process of the periotic extends 47 mm outward from where it emerges from above the concealing tympanic. The anterior edge of this process descends 11 mm below the level of the adjoining squamosal at maximum.

Dentition

Six detached teeth were embedded in the matrix surrounding the skull. The posterior alveoli of the skull are too large and shallow for the placement of the teeth, thus the maxillary teeth were probably held in place mainly by a ligamentuous gum. Since the teeth could not be placed in the corresponding alveoli, and considering the fact that these teeth differ considerably from those of any living, or fossil cetacean, their allocation is highly uncertain, and must be regarded as tentative. It is assumed that all the preserved teeth are from the skull, and that none are from the missing mandibles. There is virtually no chance that they are from any other individual than that which they were associated with, as bones are extremely rare in this deposit.

Four premolars, and two molars are represented by detached teeth. The first incisor is in place in each premaxillary. Some of the crowns of these teeth are very well worn, indicating the maturity of the individual. The crowns of the molars and premolars are laterally compressed, but are heavily constructed, and equipped with moderately developed accessory cusps on both edges. These teeth bear a slight resemblance to those of *Patriocetus ehrlichi* Abel (1913). However, the roots of the molars and premolars of *Patriocetus* are double, and widely divergent near the base, whereas, the roots are completely fused on the teeth of *Aetiocetus*. Both these cetaceans had eight teeth in each maxillary and three in each premaxillary.

The single tooth preserved with the skull of *Agorophius pygmaeus* True (1907) does not bear any close resemblance to teeth of this cetacean. No strong inward curvature is developed in the *Agorophius* tooth. Inward curvature is strongly developed on the premolars of *Aetiocetus*. The *Agorophius* tooth appears to have been double rooted.

The left third premolar of this cetacean seems to bear some resemblance to the lower right third premolar of the zeuglodont *Kekenodon onamata*. The basic shape of the crowns, the inward curvature, and the swelling below the neck are similar in the two teeth. However, the *Kekenodon* tooth is double rooted. The other described teeth of *Kekenodon* do not bear any strong resemblance to those of this cetacean. All of the detached teeth of *Aetiocetus* appear to be from the left side of the mouth. This cetacean apparently had three molars, four premolars, a canine, and three incisors on each side of the rostrum which apparently coincides with the upper dentition possessed by the early cetacean *Patriocetus ehrlichi*.

The first tooth to be discussed appears to be the upper third premolar. The crown is considerably worn, the posterior edge being worn the most. The external surface of the crown is coated with smooth enamel. The tooth is curved strongly inward from the base of the root .It is slightly bowed antero-posteriorly, both ends being curved backward, slightly. The exact number of accessory cusps on the posterior edge of the crown is uncertain, as they have been worn greatly. Two very minute cusps are present at the base of the crown, and there were two, or three better developed ones above these. The anterior edge of the crown is less worn. One minute cusp is present just above the base of the crown, and three better developed ones are clearly visible above the minute one. None of these cusps were strongly developed when compared to the teeth of most zeuglodonts, and squalodonts. All these cusps show some degree of wear, the upper one is worn the most. The apex of the crown, or main cusp rises 3 mm above the base of the uppermost anterior cusp, and it is somewhat worn on the internal side. The crown of this tooth is rather low, and heavily constructed, when compared to the teeth of such cetaceans as *Agorophius*, or most squalodonts. The squalodonts have teeth which generally have much more prominent accessory cusps, and are generally relatively thinner in diameter through the base of the crown. The crown of this tooth, although laterally compressed, and not conical, is rather thick at the base, measuring 6.5 mm in external-internal diameter. The tooth measures 10 mm, antero-posteriorly near the base of the crown. The crown is widest slightly above the base. The apex of the crown rises 12 mm above the base. The internal surface of the crown enamel is sculptured with moderately pronounced vertical striations. The external side of the tooth is convex. The internal side of the crown is convex antero-posteriorly, but the entire internal side of tht tooth is concave relative to either end. The neck of the root is narrower antero-posteriorly than the base of the crown. Both roots have completely fused. A slight median groove on both the external, and internal sides runs from below the neck to the base of the root, and bifurcates the extremity of the root. The distance from the anterior termina-

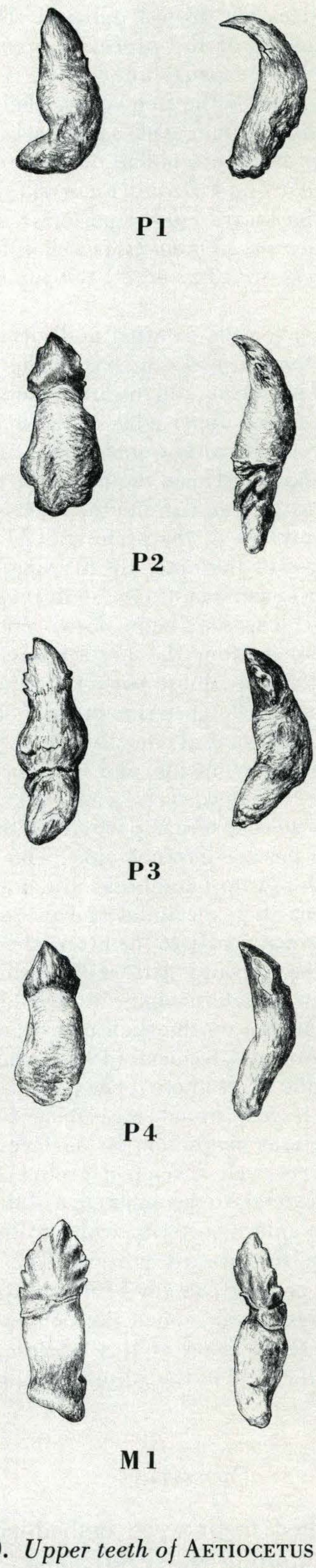

Figure 9. *Upper teeth of* AETIOCETUS COTYLALVEUS

TABLE 2

MEASUREMENTS OF THE TEETH

	RI1	LI1	P1	P2	P3	P4	M1	M3
AP of enamel crown	8	7	10	9.5	10	10	10	9
Tr of enamel crown			6.5	6.5	6.5	6	5.5	5a
AP of root, maximum	13	12	12	12	14	12	11a	8.5
Tr of root, maximum			10	8.5	8.5	9	8	6
Length root plus crown			28.5	33	30	28.5	32	19
Height of enamel crown	6a	11	12.5	11.5	12	11	11	7

a—incomplete

tion of the root to the apex of the crown is 28 mm. The distance from the posterior termination of the root to the apex of the crown is 30 mm. The upward indentation of this bifurcation is very slight. The root is very swollen below the neck, and expands outward most on the posterior edge. The distance from the area of maximum posterior swelling, to the posterior base of the root is 9 mm. This swelling is to accommodate the large alveolus. Only about a third of this tooth actually fitted in the alveolus. The external, and internal surface of the root below the maximum swelling point is pitted, and rugose. Above the maximum swelling point, it is relatively smooth. The antero-posterior diameter of the root at the maximum swelling point is 14 mm. The end of the root is completely closed on all the detached teeth.

The second tooth to be discussed may be the upper fourth premolar. It is very similar in shape to the upper third premolar. On the anterior edge, two minute cusps are present, just above the base of the crown. Above these, two worn cusps are present. The main cusp, or apex of the crown, projects 3 mm above the base of the uppermost anterior cusp. The fused double root is similar to that of the previously described tooth, except that it is not so strongly curved inward, and the root is not quite as swollen below the neck. The tooth is slightly bowed antero-posteriorly. The posterior edge of the crown is worn flat. No cusps are preserved but cusps were certainly present originally. The groove developed on the external and internal side of the root is similar to that described on the root of the third premolar.

The third tooth to be discussed appears to be the first premolar. The crown is narrower, and comes to a very sharp point, unlike the two teeth already mentioned. The crown curves strongly inward and backward. The posterior edge has a sharp-pointed accessory cusp, just above the base of the crown. The apex of the crown is very pointed, and rises 8 mm above the lowest, best developed posterior cusp. The anterior edge is free of cusps, except for a minute one just above the base of the crown. The anterior and posterior edges of this tooth between the cusps are very thin and sharp. The external side of the tooth is convex, and the enamel of the crown is smooth. The internal side of the crown is concave, and the enamel is striated vertically. A slight antero-posterior groove distinguishes the crown from the neck on the external side. The root is swollen below the neck. The tooth is strongly bowed in an antero-posterior direction, both ends directed posteriorly, as well as being curved strongly inward. The narrowed base of the root twists slightly outward, to add to the strange appearance of this tooth. No median grove is developed on the root, and no bifurcation is developed in the termination of the root.

The next tooth is considered to be the second premolar. The crown is sharply pointed. The crown curves strongly inward, and backward. On the posterior edge, three prominent, sharp accessory cusps are present. The cusp immediately below the apex of the crown is the most prominent. The second of these three cusps is worn. The apex of the crown is very pointed. It rises 3 mm above the base of the uppermost accessory cusp on the posterior edge. On the anterior edge of the crown, a minute cusp is present. A slightly larger one appears just above the minor one. These lie slightly above the base of the crown. The distance between the highest anterior cusp, and the apex of the crown is 8.5 mm. The internal surface of the crown is striated vertically. The root is swollen below the neck. Externally, the lower portion of the root is flattened antero-posteriorly. This lower region is not curved as strongly as the root of the previously described tooth, but the entire tooth is bowed in an antero-posterior direction, both ends point in a posterior direction, and the tooth also curves inward on either end.

The crown of the first molar is more laterally compressed than the other teeth preserved. The external surface of the crown is slightly curved inward near the apex. Both external and internal sides of the crown are coated with smooth enamel. Three accessory cusps are present on the posterior edge of the crown. These cusps are slightly worn, but were not strongly developed. The moderately pointed apex of the crown rises 3.5 mm above the base of the uppermost posterior cusp, and is not worn. On the anterior edge of the crown, three very minor cusps are present. The two roots of this tooth are completely fused. The posterior edge of the root was broken away during excavation. The root is broad antero-posteriorly, and the internal and external sides are relatively flat, only slightly convex. No median groove is present. The posterior side of the root projects downward slightly more than the anterior side. There is no inward curvature of the root. This contrasts with the before mentioned teeth. Also, there is none of the antero-posterior bowing in this tooth.

The sixth detached tooth is probably the third molar. It is much smaller than the others. The anterior side was badly broken during excavation. The crown is very low. Part of the inner side, and the anterior edge is missing. The posterior edge is well worn. Remnants of one accessory cusp appear on the anterior edge, just above the base of the crown. The posterior edge of the root is nearly vertical and straight-sided. No bowing, or inward curvative is present on the root.

As was before mentioned, the first incisor is present in each premaxillary. The left incisor is complete, but the crown is bent inward slightly more than it should be, by distortion. The root is swollen where it is lost to view in the alveolus. It measures 12 mm antero-posteriorly at maximum. The neck tapers. The crown measures 7 mm antero-posteriorly at the base, narrows rapidly, and the upper part of the crown is narrow, terminating in a sharp point. The crown measures 11 mm high, and the tooth measures 20 mm long from where it emerges from the alveolus. Some matrix was left on the internal side of the tooth to strengthen it. The right incisor is similar to the left, except that the upper portion of the crown was broken away before internment.

VERTEBRAE

The vertebrae column of this individual is remarkably complete. Only the atlas, and a few caudals are missing. It indicates that the total length of the skeleton, including the skull, was about twelve feet.

The vertebral formula of this cetacean appears to have been: 7 cervicals, 12 dorsals, 10 lumbars, and 15(?) caudals. With the exception of the caudals, little uncertaintly exists in this formula. The vertebrae were completely articulated from the axis to the ninth caudal, and the centra were separated by a half inch, or less. The tenth and eleventh caudals were deposited forward about a foot, and rested on the right side of the anterior caudals, a few inches from them. Just how many more caudals were present originally with the skeleton is highly uncertain, as some cetaceans had a number of antero-posteriorly thin terminal caudals.

The epiphyses of all the vertebrae are present, and are solidly fused with the centra. These vertebrae, particularly the lumbars and caudals are very large in proportion to the skull. Aside from the unique development of the ninth and tenth caudals, most features of the vertebrae resemble mysticete vertebrae more closely than they do modernized odontocete vertebrae. The neural arches are all rather low, and are particularly low, and transversely broad on the cervicals and anterior dorsals. The transverse processes of the lumbars are broadened antero-posteriorly. Neural spines of the lumbars are relatively short, are thick transversely, and long antero-posteriorly. The distal ends of these neural spines are considerably thickened transversely. The tail of this cetacean was very powerful.

The vertebrae are all essentially complete. Fragments are missing from a few of the processes, a few of the neural spines lack the distal end, and one vertebrae lacks one transverse process. Some of the neural spines, transverse processes, and metapophyses have been slightly displaced, causing slight discrepancies in their measurement. The neural spines of most of the lumbar and anterior caudal vertebrae would be slightly higher than the measurements show. Some of the neural arches are slightly distorted.

CERVICAL VERTEBRAE

The cervicals are all free, and distinct. The vertebral column was so well articulated in the matrix, that the neural arches overlap, and

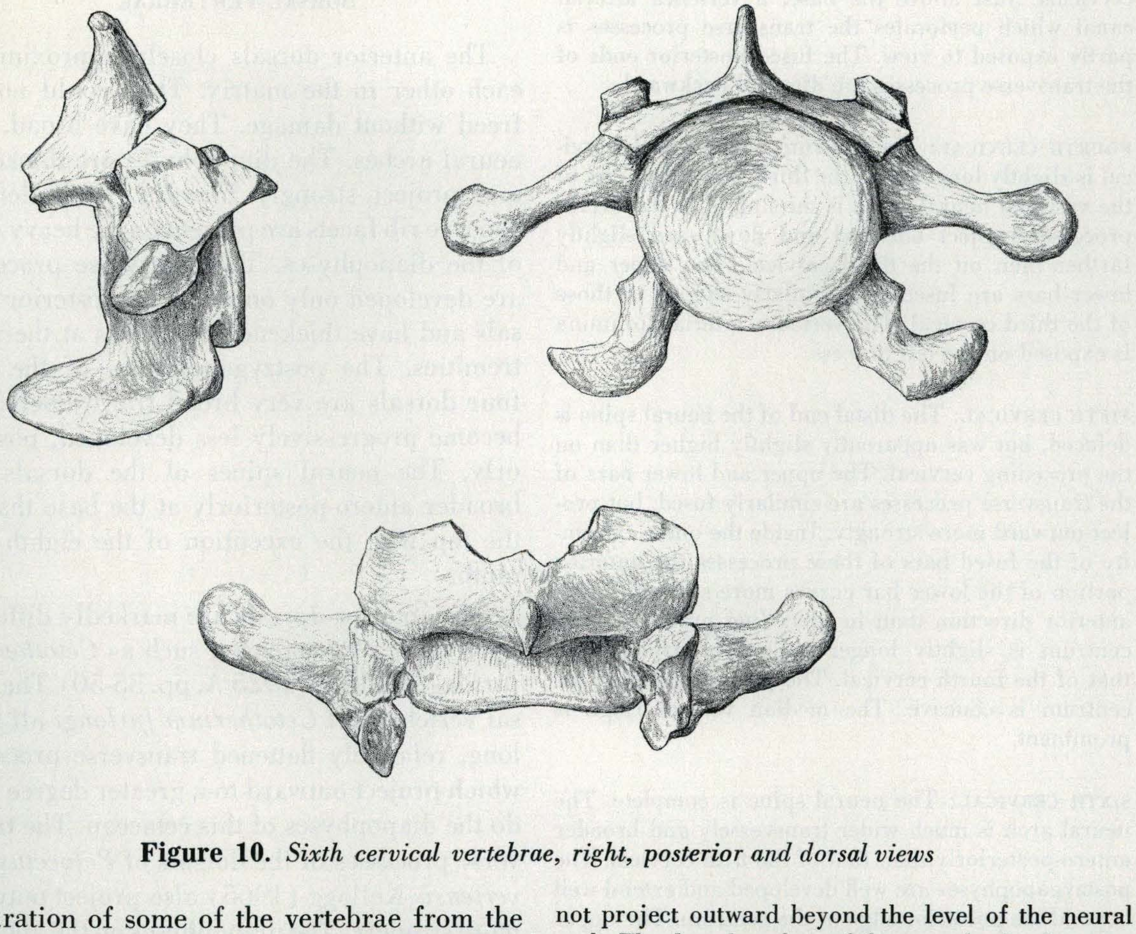

Figure 10. *Sixth cervical vertebrae, right, posterior and dorsal views*

separation of some of the vertebrae from the matrix would seriously damage them. The neural arches are transversely broad, and low. The postzygapophyses are rounded at their edges, and flattened, transversely. They project strongly backward.

AXIS: The axis is heavily constructed with a broad neural canal, which measures 38 mm transversely. The transverse processes are short, projecting more backward than outward. No foramina are present on their surfaces. On most cetotheres, the axis is much shorter antero-posteriorly, broader transversely, and the transverse processes project outward more. The anterior articulating facets of this axis are wide, transversely, and flattened toward their outer edges. The transverse distance across these facets is 104 mm. The odontoid process is large, with a median ridge running posteriorly into the neural canal. A concave depression lies to either side of this ridge. The antero-posterior diameter of the centrum, including the odontoid process is 64 mm. The postzygapophyses are flattened, antero-posteriorly, do not project outward beyond the level of the neural arch. The dorsal surface of the neural spine is somewhat eroded in places. The anterior end projects forward, narrowing at its tip. The posterior end is broad, and relatively flat, transversely. On the ventral portion of the centrum, posterior to the odontoid process, a well marked ridge runs antero-posteriorly. The posterior end of this ridge is thickened, and bifurcates. The posterior end of the centrum cannot be seen, as it rests against the third cervical in the matrix. This axis closely resembles the axis of the archaeocete *Zygorhiza kochii* in shape, the only noticeable differences being the greater outward extension of the postzygapophysis on *Zygorhiza* and the presence of foramina on the transverse processes of the *Zygorhiza* axis.

THIRD CERVICAL: The centrum is relatively thin. The neural spine is slightly defaced, and was vestigial. The neural arch is the thinnest, antero-posteriorly, of all the cervicals. The upper, and lower bars of the transverse processes are fused, and rounded at their ends. The bases of these processes are concealed by matrix and the overlapping processes of adjoining cervicals. Just above the base, a vertebra arterial canal which perforates the transverse processes is partly exposed to view. The fused posterior ends of the transverse processes are directed backward.

FOURTH CERVICAL: The centrum of the fourth cervical is slightly longer than the third. The distal end of the vestigial neural spine is missing. The transverse processes project outward and downward slightly farther than on the third cervical. The upper and lower bars are fused and similarly shaped to those of the third cervical. The vertebra arterial foramina is exposed on the left process.

FIFTH CERVICAL: The distal end of the neural spine is defaced, but was apparently slightly higher than on the preceding cervical. The upper and lower bars of the transverse processes are similarly fused, but project outward more strongly. Inside the outer extremity of the fused bars of these processes the anterior portion of the lower bar curves more strongly in an anterior direction than in preceding processes. The centrum is slightly longer antero-posteriorly than that of the fourth cervical. The posterior end of the centrum is concave. The median ventral ridge is prominent.

SIXTH CERVICAL: The neural spine is complete. The neural arch is much wider transversely and broader antero-posteriorly than that of the fifth cervical. The postzygapophyses are well developed and extend well beyond the posterior edge of the centrum. The upper bar of the transverse process is separated by a distance of 22 mm from the outer edge of the lower bar. The upper bar projects most strongly outward and is rounded. The end is directed obliquely upward anteriorly. The lower bar is elongate antero-posteriorly, and pointed on the posterior end. The posterior end of the right process projects 33 mm posterior to the posterior edge of the centrum. The level of the lower bar is much below the ventral surface of the centrum. The inner margin of the process is concave dorsally. The centrum is quite concave, and rectangular in outline. The anterior edge of the centrum is nearly round. The vertebrae were separated at this point during excavation.

SEVENTH CERVICAL: The neural spine is twice as high as that of the previous vertebra. The neural arch is broad transversely. There is no lower bar on the transverse process. The transverse process is little depressed below the level of the neural arch. It is rounded and heavy on its extremity, which projects outward and backward. The anterior face of the centrum is rounded, and slightly concave.

DORSAL VERTEBRAE

The anterior dorsals closely approximated each other in the matrix. They could not be freed without damage. They have broad, low neural arches. The diapophyses are thickened and project strongly forward. Well defined concave rib facets are present on the heavy ends of the diapophyses. The transverse processes are developed only on the three posterior dorsals and have thickened rib facets at their extremities. The postzygapophyses of the first four dorsals are very broad transversely, but become progressively less developed, posteriorly. The neural spines of the dorsals are broader antero-posteriorly at the base than at the top with the exception of the eighth and ninth.

The anterior dorsals are markedly different from those of cetotheres, such as *Cetotherium furlongi* Kellogg (1925 A, pp. 35-50).The dorsal vertebrae of *Cetotherium furlongi* all have long, relatively flattened transverse processes which project outward to a greater degree than do the diapophyses of this cetacean. The transverse processes of the dorsals of *Pelocetus calvertensis* Kellogg (1965) also project outward more strongly. The diapophyses on the anterior dorsals of *Aetiocetus* project more strongly forward than do those on most cetothere dorsals. However, the transverse processes on the three posterior dorsals of this cetacean are well developed, and resemble those processes on the same vertebrae of *Cetotherium furlongi,* and *Pelocetus calvertensis* to a considerable degree. The anterior dorsals of *Pelocetus calvertensis* are considerably thinner antero-posteriorly than those of the new cetacean. The third to seventh cervicals of most cetotheres are relatively thinner antero-posteriorly than those cervicals of the new cetacean. The centra of the eleventh and twelfth dorsals of *Aetiocetus* are quite elongate antero-posteriorly, and resemble the anterior lumbars in general dimensions. The neural arches of the anterior dorsals are broad, and transversely flattened. The postzygapophyses are flattened and rounded at the edges. The prezygapophyses of most of the anterior dorsals are concealed by the overlapping postzygapophyses of the preceding vertebra.

FIRST DORSAL: The centrum is slightly longer than the seventh cervical, and is broad transversely. Four antero-posterior ridges are present on the ventral surface of the centrum. These ridges are present to some degree on each of the first five dorsals. The antero-superior rib facet is minute, vertically elongate in an irregular oval. It is directed slightly backward as well as upward. The posterior superior facet is almost indiscernible. The neural spine is broader antero-posteriorly, higher and thicker than that of the seventh cervical, and rakes forward. The distal end of the spine is rounded antero-posteriorly. The neck of the diapophysis is short, and directed forward. The end is elongate antero-posteriorly, and directed downward posteriorly. The articular facet for the tuberculum of the first rib is a convex depression on the median portion of the head of the diapophysis. The lower edge of this convexity slopes inward, under the head of the diapophysis. The right articular facet measures 15 mm antero-posteriorly.

SECOND DORSAL: The centrum is considerably wider than long. The antero-posterior rib facet is larger and broader than on the preceding dorsal, but little higher. It rakes forward. The neural spine rakes forward. It is broader antero-posteriorly than the preceding dorsal, but little higher. The neural arch is flat, broad, and similar to that of the first dorsal. The neck of the diapophysis is long. The articular facet for the tuberculum of the second rib is strongly concave. It is broad at the top and narrows toward the bottom. The left facet measures 18 mm at its widest point antero-posteriorly.

THIRD DORSAL: The centrum is considerably longer than that of the second dorsal. The antero-superior rib facet is similarly shaped to that of the second dorsal, but slightly larger. The posterior rib facet is better developed, but still small, and is convex. The neural spine is much broader antero-posteriorly than in the preceding dorsal, but little higher. It rakes forward. The distal end is thinner transversely than on the second dorsal. The neural arch is not as broad and is slightly depressed at the base of the neural spine. The postzygapophyses are rounded at their edge, and project well beyond the posterior end of the centrum. The neck of the diapophysis is long and projects strongly anteriorly. The articular facet for the tuberculum of the third rib is concave, and more rounded than on the preceding dorsal. It measures 22 mm antero-posteriorly.

FOURTH DORSAL: The neural spine is broad antero-posteriorly, thin transversely and rakes forward. The neural arch is less broad than on the preceding dorsal. The centrum is longer, and heavier. The neck of the diapophysis is longer, and projects more strongly forward. The articular facet for the attachment of the tuberculum of the fourth rib is oval, and directed antero-posteriorly. It is concave. The left one measures 24 mm antero-posteriorly.

FIFTH DORSAL: The centrum is heavier, than that of the preceding dorsal. A rounded median ridge is developed on the ventral side. The antero-superior rib facet is diminuitive. The posterior superior facet measures 22 mm dorso-ventrally and 9 mm antero-posteriorly. The neck of the diapophysis is thickened, heavy, and directed strongly anteriorly. The facet for the tuberculum of the rib measures 25 mm antero-posteriorly, and 20 mm dorso-ventrally. It is rounded and concave. The neural arch is less broad transversely than on the preceding vertebrae. The neural spine is broader antero-posteriorly, and nearly vertical. The antero-posteriorly elongate postzygapophysisial facet faces obliquely downward. The postzygapophyses project slightly beyond the posterior end of the centrum.

SIXTH DORSAL: The centrum is nearly the same length as the fifth dorsal. The rounded ventral median ridge is more distinct. The upper borders of the centrum are just below the rib facets and are more concave. The anterior and posterior rib facets are both fairly small. The distal end of the neural spine is missing. The neural spine rakes backward. The neural arch is narrower transversely than on the preceding dorsal, and directed more upward. The articular facet for the tuberculum of the sixth rib is rounded and concave. It recedes upward on the lower edge. The diapophyses above the articular facet are protuberant, and separated by a groove. They extend forward. The postzygapophyses are much narrowed. The right articular facet for the tuberculum of the sixth rib measures 24 mm, antero-posteriorly.

SEVENTH DORSAL: The centrum is slightly longer than that of the sixth dorsal. Its posterior face is broader than the anterior face. The antero-superior rib facet is minute, and the posterior facet small. The diapophysis is heavy, and shorter, and does not project so far anteriorly. The articular facet for the attachment of the seventh rib is fairly small and crescent shaped.

It deepens sharply near its lower border. The right articular facet measures 18 mm antero-posteriorly. The first pair of metapophyses are present on this vertebra. They closely approximate the diapophyses, and do not flare strongly outward, but project forward beyond the anterior edge of the centrum. Their anterior surfaces are deeply pitted. The distal end of the neural spine is missing. The neural spine rakes backward. The posterior end of the centrum is slightly concave.

EIGHTH DORSAL: The centrum is little longer than that of the seventh dorsal. The anterior end is slightly convex. The antero-superior, and postero-superior rib facets are both small. The neck of the diapophysis is short. The facet for the tuberculum of the eighth rib is reduced to a small indentation in the end of the diapophysis. The metapophyses are slightly further separated from the diapophyses and project farther forward over the anterior end of the centrum. They project much farther anteriorly than do the diapophyses. A depression separates them from the diapophyses. The neural arch is narrow transversely. The neural spine rakes backward. The right articular facet for the tuberculum of the eighth rib feasures 17 mm antero-posteriorly.

NINTH DORSAL: The centrum is longer than the eighth dorsal. The posterior end is the same width as the anterior end. A small antero-superior rib facet is present. No postero-superior facet is discernible. The neck of the diapophysis is very short. The articular facet for the tuberculum of the ninth rib is similar to that on the preceding dorsal. The head of the diapophysis is smaller. The lower portion of the crescentic articular facet curves strongly inward. The metapophyses are somewhat further away from the diapophyses. A broad, concave depression separates the metapophyses from the diapophyses. The left articular facet for the tuberculum of the ninth rib measures 16 mm antero-posteriorly.

TENTH DORSAL: The centrum is longer than that of the ninth. No superior rib facets are present on this vertebra. A short, broad transverse process is present. These processes are thickened at their extremities and each possesses a well-developed rib facet. These facets are elongate antero-posteriorly. Just above the median portion of these facets, a round convex nob is present, which appears to be a weak remnant of the diapophysis. Another slight protuberance is present at the base of the metapophysis. The metapophyses are somewhat broadened transversely near their anterior extremities and are greatly elevated above the transverse processes. The neural spine is

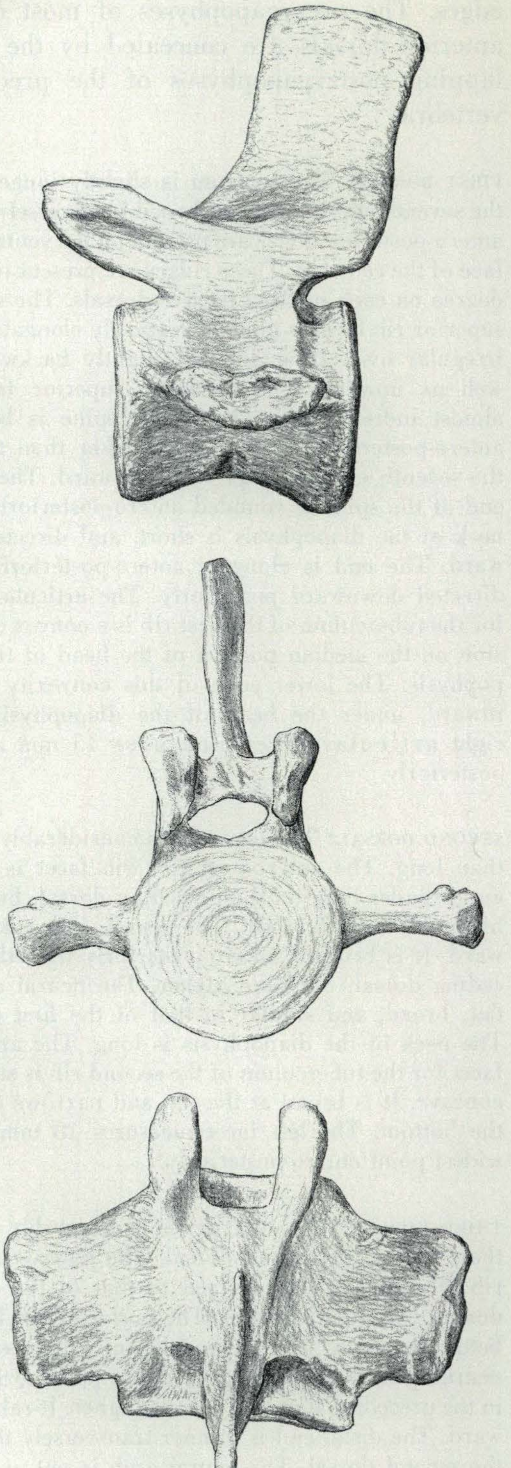

Figure 11. *Eleventh dorsal vertebrae, left, anterior and dorsal views*

TABLE 3

MEASUREMENTS OF THE CERVICAL AND DORSAL VERTEBRAE

	Cervical						Dorsal											
	Axis	3	4	5	6	7	1	2	3	4	5	6	7	8	9	10	11	12
AP centrum	64	25	27	31	34	36	43	44	50	54	53	56	70	61	65	73	78	82
Tr anterior face centrum	104				57	60	60	57	60	61	64	68	64	67	70	72	69	73
Dorso-ventral anterior face centrum	47				58	57							57	60		62	61	64
Tr posterior face centrum				61	65		58	54	57	61	67	69	69	70	70	70	75	75
Dorso-ventral posterior face centrum				60	60	66						58	58		62	62	65	67
Dorso-ventral neural canal anteriorly	54				6	11							25	25		17	11a	13a
Tr neural canal anteriorly	38				54	62												
Least antero-posterior pedicle neural arch	22				24	19	21	21	23	26	28	30	29	33	37	44	46	47
Tr across diapophyses							142	145	132	117	107	99	100	100	102	93		
Tr across transverse processes	111	114	123	145	160	168										112	167	213
Greatest total vertical height	112	89	77a	81a	91	126	149	150	159	163	172	125a	150a	188	190	170	168	171
Height of neural spine from dorsal neural arch	40				25	50							100a	105		112	98	98
Length transverse process (right)																23	49	70
Greatest AP neural spine	89			14	17	21	33	38	52	58	59	60	63	57	60	71	70	75
Greatest AP transverse process																51	52	55
Tr across external angles of metapophyses													67	58	52	61	63	65
Tr across postzygopophyses	55	59	65	74	89	97	90	83	71	59								

a—incomplete

elongate antero-posteriorly and thickened transversely near the extremity. It rakes backward. The left articular facet for the tuberculum of the tenth rib measures 39 mm antero-posteriorly, and 21 mm dorso-ventrally.

ELEVENTH DORSAL: The transverse process is longer than that of the tenth. These processes are thickened at their extremities and a well developed single rib facet is present on each process and is antero-posteriorly elongate. The posterior edge of the extremities of the transverse processes are thickest dorso-ventrally, the left one measures 23 mm dorso-ventrally. The centrum is elongate. A distinct median ridge is present on the ventral side. No remnants of the diapophyses are present. The metapophyses are slightly longer antero-posteriorly, fairly thin transversely. The postzygapophysis projects beyond the posterior end of the centrum, no strong facets are developed. The antero-posteriorly elongate neural spine rakes backward. The left articular facet for the tuberculum of the eleventh rib measures 34 mm antero-posteriorly, and 16 mm dorso-ventrally.

TWELFTH DORSAL: The transverse processes are longer and thinner, but their outer ends are thickened to form a well developed distal articulating facet for the twelfth rib. This antero-posteriorly elongate facet is less thickened dorso-ventrally than that of the eleventh dorsal. The centrum is longer, than that of the eleventh. It is also heavier than on the preceding dorsals. The metapophyses are slightly longer and broader. The neural spine is thicker transversely and longer antero-posteriorly. It rakes backward slightly. The postzygapophysis does not project beyond the posterior end of the centrum. The left articular facet for the tuberculum of the twelfth rib measures 35 mm antero-posteriorly, and 14 mm dorso-ventrally.

LUMBAR VERTEBRAE

The centra of the lumbars progressively increase in length and width. A median ridge is present on the ventral side of all the lumbars. These vertebrae are all complete, or nearly so. Small fragments are missing from some of the edges of the neural spines, and the left transverse process is missing from the second lumbar. There is a forward projection on the anterior edge of the transverse process of each lumber. This is most pronounced on the posterior lumbars. This projection is located about two thirds of the way out from the root of each transverse process. The transverse processes are all broad antero-posteriorly. The transverse processes of the lumbars, and anterior caudals project strongly outward, and relatively little downward and backward.

The metapophyses all project well beyond the anterior end of the centra and become transversely broader and flatter progressively. The neural arches are all low. The neural spines are relatively short vertically and very long antero-posteriorly. They are much thickened at the top transversely, especially toward the middle of the series. The first four neural spines are longest antero-posteriorly near the base. The postzygapophyses are weakly developed, but are present on all the lumbars. The best developed ones are little developed, and project only very slightly beyond the posterior edge of the centrum. Distinct facets are not present on any of the lumbar postzygapophyses.

FIRST LUMBAR: The transverse processes show no evidence of rib facets. Their outer edges are smooth, rounded antero-posteriorly, and thin dorso-ventrally. The pedicle of the neural arch is short, as it is on all the vertebrae. The neural spine is broad antero-posteriorly, and transversely thick at the distal end. The distal end is almost triangular in profile. It is highest medially. The neural spine rakes slightly backward.

SECOND LUMBAR: The left transverse process is broken off near the root. The right transverse process is widest at the level of the broad anterior projection, about two-thirds of the way out from the root. The neural spine rakes slightly backward, and is rounded antero-posteriorly at the distal extremity.

FOURTH LUMBAR: The distal end of the neural spine is wide transversely. It measures 11 mm wide at maximum.

FIFTH LUMBAR: Similar to the fourth lumbar it shows progression in dimensions. The neural spine rakes backward slightly. The median longitudinal carina on the ventral side of the centrum is pronounced, and is sharp in the middle portion, as well as toward the ends of the centrum.

SIXTH LUMBAR: The neural spine is nearly vertical, is much thickened transversely at the distal end, and is

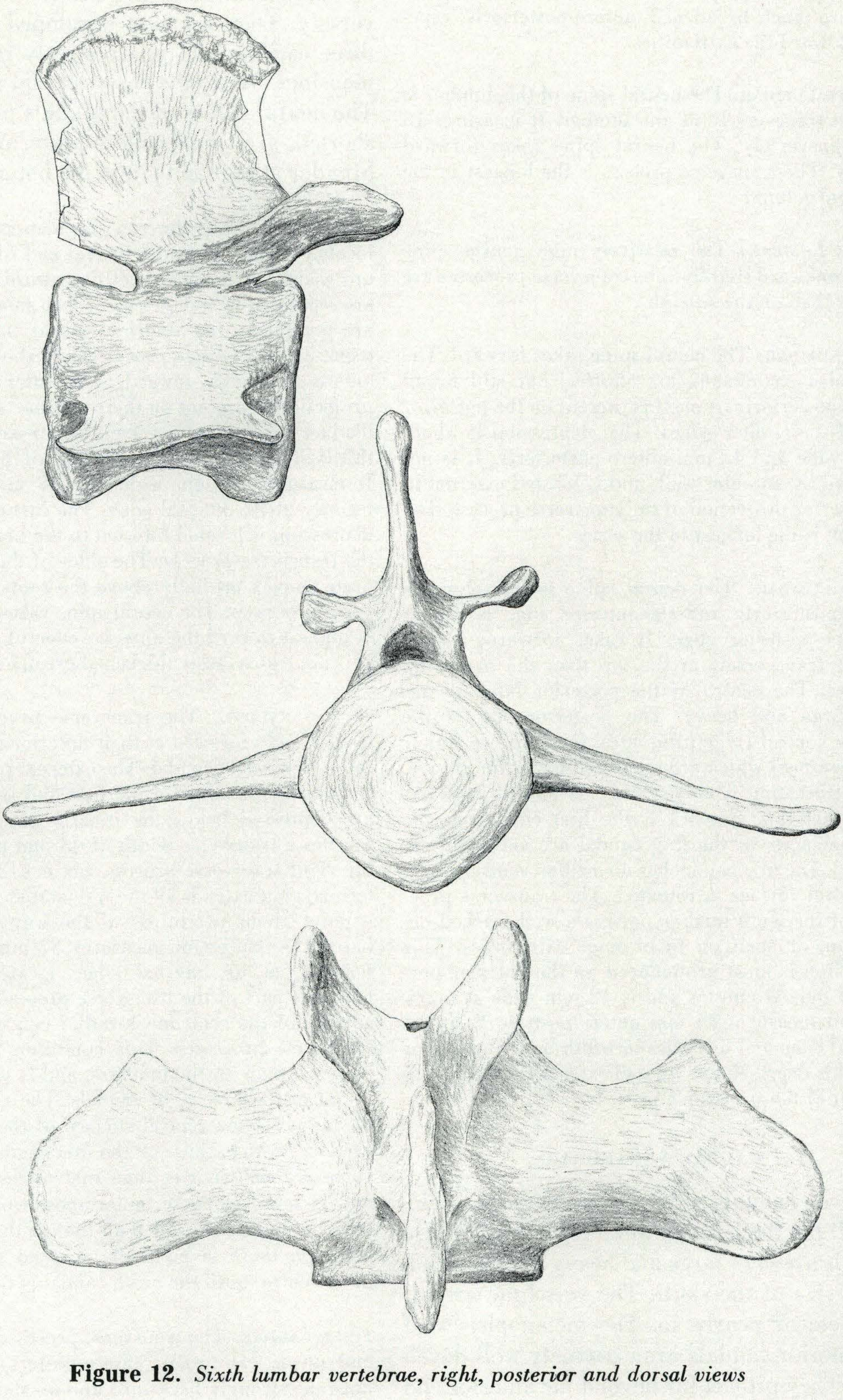

Figure 12. *Sixth lumbar vertebrae, right, posterior and dorsal views*

very broad, antero-posteriorly. The transverse processes are much broadened, antero-posteriorly, especially toward the extremities.

SEVENTH LUMBAR: The neural spine of this lumbar is thickest transversely of any lumbar. It measures 18 mm transversely. The neural spine rakes forward slightly. The transverse process is the longest in the vertebral column.

EIGHTH LUMBAR: The relatively high neural spine rakes backward slightly. The transverse processes are shorter than on the seventh.

NINTH LUMBAR: The neural spine rakes forward. The transverse processes are shorter, but still broad antero-posteriorly. A shelf is present on the posterior half of their outer edges. This depression is about 6 mm wide and 42 mm antero-posteriorly. It is not bounded by an outer wall, and is located external to the anterior projection of the transverse process. The centrum is the longest in the series.

TENTH LUMBAR: The neural spine is less elongate antero-posteriorly and its anterior edge is higher than its posterior edge. It rakes forward, and is thinner transversely at the top than the preceding lumbars. The centra of the posterior lumbars are very large and heavy. The posterior end of the median ventral ridge bifurcates, forming two minor protuberances which are separated by a thin groove. This bifurcation is very weakly developed. It is unlikely that this vertebra is the first caudal, as the chevron facets of the first caudal are very well developed. The first caudal has no median ventral ridge, its ventral surface is rounded. The transverse processes of the tenth lumbar possess a well marked depression, or shelf on their outer extremities. This depression is most pronounced on the anterior portion of the extremities and is 12 mm wide at maximum. It measures 55 mm antero-posteriorly at the internal edge and dwindles in width on the posterior end. This depression is located external to the broadest part of the transverse process.

CAUDAL VERTEBRAE

Eleven caudals were present with the skeleton, all but the last two were articulated. These caudals are very large and heavy in proportion to the size of the skull. The vertebrae are all complete or nearly so. The metapophyses of the anterior caudals are extremely well developed. They project far beyond the anterior end of the centrum and are broad and flat transversely. They are best developed on the first three caudals and progressively reduce in dimensions toward the posterior end of the series. The neural spines of the caudals progressively shorten, are broad antero-posteriorly and are broader at the top than at the bottom.

FIRST CAUDAL: The chevron (haemapophysial) facets located on the posterior ventral end of the centrum are well developed, project downward strongly and are separated by a depression. Two small projections are present on the anterior ventral end of the centrum. The transverse processes are shortened, broad antero-posteriorly toward their outer edges and a projection is present on their anterior extremities. A distinct depression, or shelf is present about two-thirds of the way out from the base of these processes. It measures 24 mm wide and 58 mm antero-posteriorly at its internal edge. The inner edge of this depression is located internal to the broadest part of the transverse process. The sides of the centrum are quite convex medially above the roots of the transverse processes. The neural spine rakes forward and is highest toward the anterior edge of its extremity. It is not transversely thickened greatly at the top.

SECOND CAUDAL: The transverse processes project less strongly forward at their anterior edges than do those of the first caudal. The external portions of the transverse processes of the first and second caudals are depressed below the inner regions. This shelf reaches a transverse width of 43 mm posteriorly on the right transverse process, becomes less wide, anteriorly, but extends all the way across the process at a point about two-thirds of the way out from the base. The depression measures 57 mm, antero-posteriorly, at its internal edge, located inside the broadest part of the transverse process. The median surface of the centrum is rather concave above the transverse processes. This condition is more pronounced than on the lumbars, and is well developed on all of the first eight caudals. The chevron facets on the posterior ventral surface of the centrum are even larger than those on the first caudal. The neural spine is much shorter than that of the first caudal, and is more elongate, antero-posteriorly. The centrum is slightly shorter than that of the first caudal, although there is no really marked shortening of these centra, until the ninth caudal is reached.

THIRD CAUDAL: The transverse processes are shorter, and much less broad, antero-posteriorly. They do not rake strongly backward and no shelves are pres-

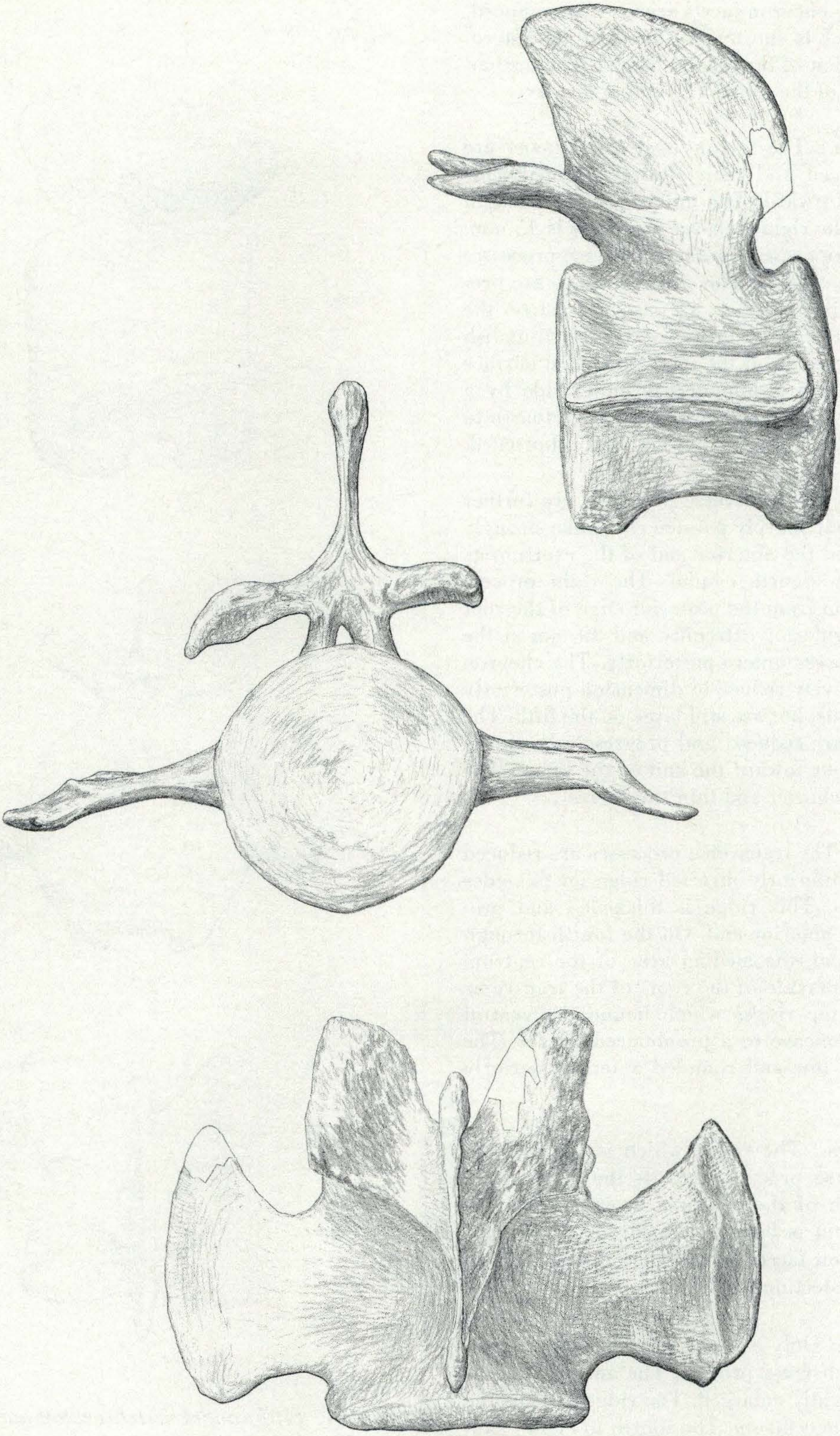

Figure 13. *First caudal vertebrae, left, anterior and dorsal views*

ent distally. The chevron facets are very pronounced. The neural spine is shorter, but is as broad antero-posteriorly as that of the second caudal. The median ventral surface of the centrum is rather concave.

FOURTH CAUDAL: The transverse processes are markedly reduced and their sharply pointed ends rake strongly forward. The antero-posterior length of the base of the right transverse process is 45 mm. No foramina are present on the transverse processes of any of these caudals. The chevron facets are pronounced. Two prominences are also present on the anterior ventral end of these caudals. A roundish depression is present on the median ventral surface of this caudal and is bounded to either side by a ridge. This feature is pronounced from the fourth to the eighth caudal. The centrum is slightly shortened.

FIFTH CAUDAL: The transverse processes are further reduced and their sharply pointed ends rake strongly forward, beyond the anterior end of the centrum as do those of the fourth caudal. The right process measures 61 mm from the posterior edge of the root to the curved anterior extremity and 39 mm at the base of the process antero-posteriorly. The chevron facets progressively reduce in dimension posteriorly along the caudals, but are still large on the fifth. The metapophyses are reduced and progressively diminish in dimensions toward the end of the series. The neural spine is shorter and thin transversely.

SIXTH CAUDAL: The transverse processes are reduced to an antero-posteriorly directed ridge on the sides of the centrum. This ridge is thickened and protuberant at the anterior end. On the fourth through the eighth caudal, the median area of the centrum between the underside of the roots of the transverse processes and the ridges which bound the ventral depression is concave to a pronounced degree. The neural spine is low and rounded antero-posteriorly at the top.

SEVENTH CAUDAL: The ridge, which is the remnant of the transverse process, extends the full antero-posterior length of the centrum, as it does on the sixth caudal, and is best developed on the anterior end. The chevron facets project to within 10 mm of the anterior projections.

EIGHTH CAUDAL: Only a slight ridge marks the remnants of the transverse process. The anterior end of this ridge is slightly enlarged. The ridge extends the full length of the centrum. The fourth to eighth caudals are slightly concave on their anterior ends. These caudals have centra which are slightly convex

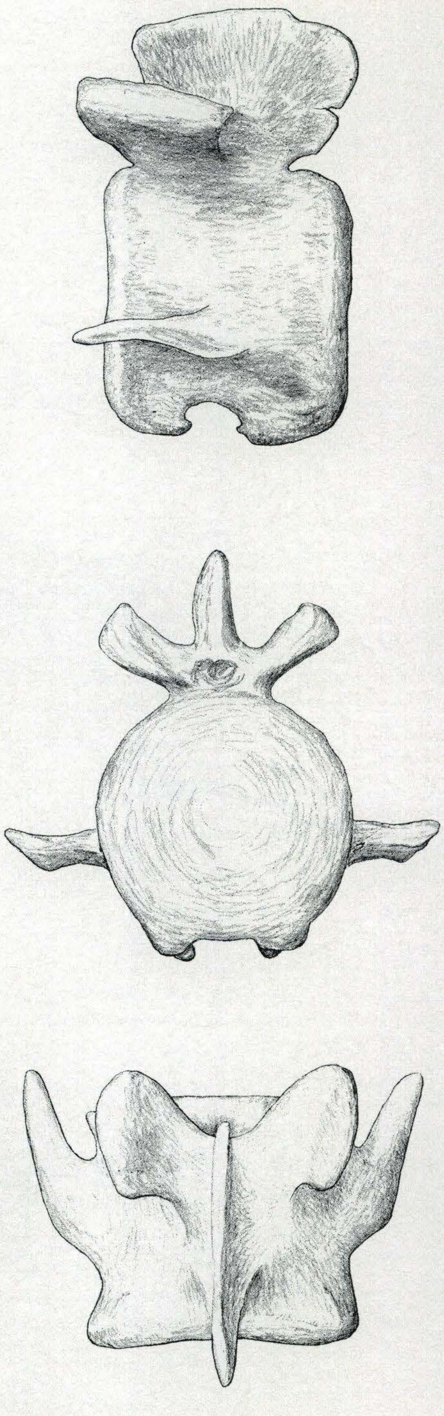

Figure 14. *Fifth caudal vertebrae, left anterior and dorsal views*

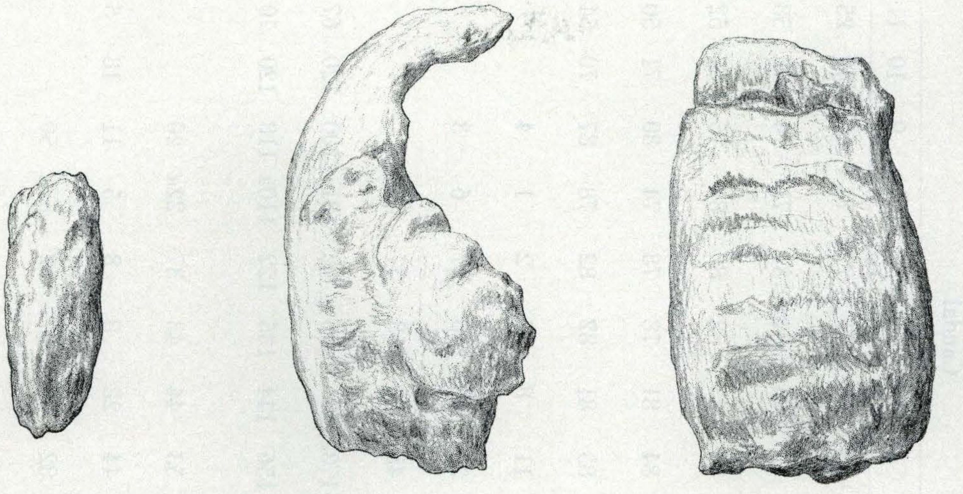

Figure 15. *Ninth, tenth, and eleventh caudal vertebrae right views*

on their posterior ends. The metapophyses are reduced to minor eminences which do not project beyond the anterior end of the centrum. The top of the neural spine is missing, but the spine is very reduced.

NINTH CAUDAL: The most peculiar feature of the entire vertebral column is the strange modification of the ninth and tenth caudals. Some of the abnormalities of these two vertebra are evidently the result of a bone disease, and cannot be considered diagnostic. A full evaluation of the peculiarities of these two caudals may await the discovery of another skeleton. Similar abnormalities on vertebrae of the cetothere *Pelocetus calvertensis* were attributed to bone disease. The ninth caudal is considerably broader transversely and vertically than the eighth, but is much shorter antero-posteriorly. The anterior end of the centrum is slightly concave. The neural spine is reduced to a thickened ridge. The metapophyses are represented by small rounded humps near the anterior end of the centrum. On each side of the centrum, extremely heavy ridges and grooves are present. They are most pronounced about half way to the top of the centrum and may be remnants of the transverse processes. These ridges run antero-posteriorly. These features are obviously developed for the attachment of very heavy muscles. The sides of the centrum are covered with small pits and knobs. A small round depression is present on the median ventral surface of the centrum. This depression measures 24 mm antero-posteriorly. A low, rounded projection is present at the anterior and posterior ventral edges of the centrum. No chevron facets are apparent. The posterior end of the centrum is convex and smooth on the right border, but the rest is roughened and depressed, and small fragments of bone protrude outward from it. It appears as if the ninth and tenth caudals were fused and that bone from both vertebrae had inter-mingled.

TENTH CAUDAL: The anterior face of the centrum is much broader transversely than the posterior face. The entire upper surface of the anterior face of the centrum is roughened and depressed in the same manner as is the posterior face of the ninth caudal. At a point about half way up each side of the centrum, a broad projection is present which extends backward well beyond the anterior edge of the centrum. These projections are broad dorso-ventrally. The left one measures 40 mm dorso-ventrally and projects 26 mm anterior to the anterior edge of the centrum. The left metapophysis was broken away before fossilization. The right metapophysis projects to a point 33 mm anterior to the anterior edge of the centrum. When the ninth caudal is placed against this vertebra, the metapophysis and transverse processes of the tenth caudal fit tightly against the sides of the ninth. The neural spine of the tenth caudal is represented by a very feeble ridge. The sides of the centrum are much roughened and slope toward the posterior end of the centrum. A small oval depression is present on the median ventral surface of the centrum. The posterior end of the centrum is convex, rounded and considerably smaller than the anterior end.

ELEVENTH CAUDAL(?): This caudal is very thin antero-posteriorly. The anterior end of the centrum is nearly the same size as the posterior end. It is nearly round, with a minor protuberance at the top which

TABLE 4

MEASUREMENTS OF THE LUMBAR AND CAUDAL VERTEBRAE

	Lumbar										Caudal										
	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	11
AP centrum	84	86	86	88	91	92	92	92	93	92	91	86	85	85	80	77	77	74	67	49	25
Tr anterior face centrum	73	73	76	75	78	82	82	83	84	85	84	83	88	85	84	84	81	71	74	95	58
Dorso-ventral anterior face centrum	67	70	73	75	77	79	81	84	87	85	85	84	85	84	83	82	82	81	75	102	52
Tr posterior face centrum	76	76	81	80	83	83	85	84	87	88	85	93	88	84	81	78	78	74	80	71	50
Dorso-ventral posterior face centrum	72	74	79	75	80	81	82	82	84	88	86	84	85	83	81	82	82	78	87	70	54
Dorso-ventral neural canal anteriorly	18a	18	21	18	17	20	19	17	15	15	16	18	15	11	8	7	2	1	4		
Tr neural canal anteriorly	32a	33	27	28	27	20	20	16	13	12	15	15	16	23	20	16	17	6	3		
Least antero-posterior pedicle neural arch	45	43	44	45	46	51	50	51	46	49	46	52	46	45	48	53	57	54			
Tr across transverse processes	269	293	298	297	297	294	302	281	262	232	210	207	194a	173a	131	95	92	81	100	120	67
Greatest total vertical height	180	176	189	176	187	177	192	193	195	200	181a	169a	155a	156	144	135	122	110a	118	120	70
Height of neural spine from dorsal neural arch	95	92	96	90	86	77	89	85	97	82	75	54	44	53	44	43	37	22a	20		
Length transverse process (right)	95	110	111	111	116	117	120	99	91	78	65	65	61	44	28	8	8	5	11	18	5
Greatest AP neural spine	55a	68	80	74	78	89	90	84a	84	81a	90	89	81	82	75	67	62	57a	50		
Greatest AP transverse process	61	65	65	67	73	77	76	83	80	77	81	72	57	70	61					37	
Tr across external angles metapophyses	73	80	77	77	80	92	84	87	94	92	96	105	100	89	82	70	63	48	42		

a—incomplete

is a remnant of the neural spine. No abnormalities are present. A very small oval depression is present on the ventral surface of the centrum. The sides of the centrum are roughened and pitted. The identification of this vertebra as the eleventh caudal is tentative, since it was washed slightly away from the rest of the series before burial. It is considerably shorter antero-posteriorly than the tenth caudal. However, the rounded, convex posterior face of the centrum of the tenth caudal is much smaller in transverse diameter than is the anterior face of that centrum, and agrees fairly well with the dimensions of the eleventh caudal if a relative progressive diminishment is taken into consideration.

Several more caudals were probably present originally with the skeleton.

Ribs

Articulating rib facets are present on all twelve of the dorsal vertebrae. At least three ribs were free in the flesh, as this cetacean apparently possessed no less than 15 ribs on each side of the rib cage. The ribs were scattered in the matrix. The left fifteenth rib was lodged beside the posterior lumbars. Twenty three complete, or partial ribs were preserved. The middle ribs of this cetacean are long, and quite heavily constructed. The second through the tenth rib possess well defined necks which separate the tuberculum from the capitulum. The most prominent part of the tubercular swellings on the ribs is located slightly external to the actual tubercular facet. Measurements other than those of the tubercular facet are based from the area of maximum swelling. The allocation of these ribs must be regarded as tentative, in that they were scattered in the matrix, and some are not complete. The dissimilarity of this cetacean to other forms, and the lack of comparative material further hampers deductions. The posterior ribs strongly differ from one another.

FIRST RIB: The first rib from the left side is incomplete. It lacks the head and the entire lower part of the shaft. This rib is very wide external-internally at the angle and tuberculum. It is thickened antero-posteriorly at the tuberculum, but very thin antero-posteriorly below the tuberculum and the protuberant angle. The tuberculum measures 17 mm antero-posteriorly at the thickest point. The tuberculum is located 75 mm above the most protuberant part of the angle. The tuberculum is convex except for a small concavity near its posterior edge. A small lip-like ridge projects anteriorly for a short distance just below the tuberculum on the external edge of the rib. The shaft narrows rapidly below the angle, becomes oval in cross section, measures 20 mm external-internally at the angle.

SECOND RIB: The second rib from the left side is preserved and is complete. The neck is fairly wide dorso-ventrally and thin antero-posteriorly. The tuberculum is thinner, measures 14 mm antero-posteriorly at maximum. It is protuberant on the outer end. No definite inner border to the tubercular facet is discernible although the slightly convex surface narrows toward the capitulum. The neck is relatively short, but is distinct. The capitulum is thickened, heart-shaped and protuberant on the inner edge. The median surface of the shaft inside the angle is concave on both the anterior and posterior side. The angle is less protuberant than on the first rib. The shaft is strongly curved, but tapers very gradually in external-internal thickness and remains thin antero-posteriorly below the angle. The thinnest point external-internally is 25 mm at a point 190 mm below the angle in a straight line. The distal end of the shaft is widened, measures 11 mm antero-posteriorly near the rugose distal end. The shaft is slightly twisted antero-posteriorly toward the distal end.

THIRD RIB: Both right and left ribs are preserved and are complete. The tuberculum is very proturberant and a distinct facet is developed which measures 18 mm antero-posteriorly and 16 mm external-internally. The area between the tuberculum and capitulum is thin antero-posteriorly. The neck is relatively longer, and less thick dorso-ventrally than on the second rib. The capitulum is expanded, heart-shaped and pointed on the inner extremity. The median surface of the rib is somewhat concave inside the angle. The shaft narrows somewhat, below the angle, but remains fairly wide external-internally and thin antero-posteriorly. The shaft is narrowest external-internally at a point 250 mm below the angle, where it measures 23 mm external-internally. It broadens out, measuring 31 mm external-internally and 14 mm antero-posteriorly near the faceted termination. The shaft near the distal end is strongly curved and somewhat twisted toward the distal end.

FOURTH RIB: The right rib is nearly complete, but lacks a portion of the shaft at the angle and the two sections do not fit together, making total measurements approximate. A distinct facet is present on the tuberculum. This facet measures 17 mm antero-posteriorly and 25 mm external-internally. The neck is relatively thin and the expanded capitulum is heart-shaped, and pointed inward. The angle is broken away. The shaft below the angle narrows and is oval in cross-section. A ridge is persent on the median anterior side and runs for about 75 mm. The shaft widens toward the distal end and a minor eminence is present on the external edge of the rib at a point 175 mm above the distal end, below which the shaft curves more sharply and twists slightly in a posterior direction. The slightly expanded distal end measures 25 mm external-internally and 13 mm antero-posteriorly at the roughened facet.

FIFTH RIB: The right fifth rib is complete. The tuberculum is protuberant. The tubercular facet measures 19 mm antero-posteriorly and 29 mm external-internally. The shaft is rather heavy, measures 17 mm antero-posteriorly at a point 185 mm below the angle and measures 28 mm external-internally at this point. Toward the distal end, the shaft rakes slightly backward. The distal end is not expanded. It measures 12 mm antero-posteriorly and 22 mm external-internaly at the rugose facet. A portion of the left rib is present but lacks both extremities.

SIXTH RIB: Only the distal third of the right rib is preserved. The shaft is slightly broader than the distal portion of the shaft of the fifth rib. It measures 27 mm external-internally at a point 84 mm above the distal extremity. The distal extremity measures 28 mm external-internally and 14 mm antero-posteriorly at the roughened distal facet. The shaft curves slightly backward toward the distal end.

SEVENTH RIB: This rib is the longest and heaviest in the series and lacks only the head. The tuberculum is prominent at the outer edge. The tubercular facet measures 19 mm antero-posteriorly and 25 mm external-internally. The shaft is less thick external-internally between the angle and tuberculum than in the preceding ribs, but is heavy antero-posteriorly and oval in cross-section. The shaft is expanded external-internally at a point 122 mm below the angle. It measures 29 mm external-internally at this point. It is also very heavy, measuring 20 mm antero-posteriorly. The shaft tapers in antero-posterior thickness toward the distal end, but remains broad external-internally with another slight expansion 130 mm above the distal end. The measurements at the roughened distal facet are 11 mm antero-posteriorly and 25 mm external-internally. The shaft curves backward slightly toward the distal end.

TABLE 5

MEASUREMENTS OF THE RIBS

	1L	2L	3L	4R	5R	6R	7R	8R	9R	10L	11R	12R	13L	14L	15L
Total length	145a	315	395	440a	458	227a	477	413a	427	430	240a	140a	125a	305a	348
Transverse shaft at angle	43	43	43		31		33	31	30	25		24	22		17
Outer protuberance of tuberculum to inner edge of capitulum		62	62	62	57				57	55		37		43	43
Transverse at distal extremity		31	31	25	22	28	25	21	15	15	16			15	16
External protuberance of tuberculum to angle	75	40	55		79		102		115	114		103			61

a—incomplete

EIGHTH RIB: The head and tuberculum is missing, otherwise, the right rib is complete. The shaft is very heavy. It measures 19 mm antero-posteriorly, 115 mm below the angle. The lower part of the shaft is very broad, measures 30 mm external-internally at a point 250 mm below the angle, but is relatively thin antero-posteriorly at this point. The distal end tapers and rather than terminating in a squared facet, the internal edge of the end is pointed and slants upward to the external edge of this thinner, more rounded termination which measures 21 mm external-internally and 5 mm antero-posteriorly. The distal end of the shaft rakes backward. The left rib is represented by the distal third of the shaft. This shaft is slightly smaller than the right one, but the distal termination has the same basic shape.

NINTH RIB: Both right and left ribs are preserved and each is complete. The external edge of the tuberculum is still fairly prominent, but less so than on the anterior ribs. The large tubercular facet measures 21 mm antero-posteriorly and 24 mm external-internally. The neck of this rib is thick antero-posteriorly, measures 22 mm at the narrowest point and 13 mm external-internally. The capitulum is semi-triangular, but elongate toward the posterior edge. The shaft at the angle is narrower than on preceding ribs and is almost rectangular in profile. The shaft immediately below the angle is narrow and almost round in profile. The shaft then broadens and measures 27 mm external-internally at a point 226 mm below the angle. The shaft is relatively thin antero-posteriorly at this point. Below this point, the shaft again narrows, and terminates in a slightly rounded end which measures 17 mm external-internally and 9 mm antero-posteriorly. The right rib is very similar except that the distal termination is slightly thinner antero-posteriorly.

TENTH RIB: Both right and left ribs are preserved, and are complete except for a tiny portion of the distal end of the right rib. The tuberculum is less protuberant. The tubercular facet measures 21 mm antero-posteriorly and 29 mm external-internally. The capitulum is elongate antero-posteriorly. It measures 32 mm in this direction. The neck is similarly shaped to that of the ninth rib. The shaft between the angle and tuberculum is heavy. The rib widens external-internally toward the distal end and is widest at a point 250 mm below the angle. Here it measures 28 mm external-internally. The distal end tapers and measures 15 mm external-internally and only 2 mm antero-posteriorly at the squared end. The distal portion rakes in a posterior direction. The right rib is similar to the left.

ELEVENTH RIB: Only the distal two-thirds of the shaft of the left rib is preserved. The shaft is broad external-internally. The broadest point is located 155 mm above the distal end and measures 28 mm external-internally. The distal end tapers. It measures 17 mm external-internally and 7 mm antero-posteriorly at the squared distal end. The distal end rakes backward. The right rib is represented by its distal portion. It is similar to the left rib, except the distal termination is thinner antero-posteriorly.

TWELFTH RIB: The upper portions of the right and left ribs are preserved. On the left rib, the tuberculum is differentiated from the capitulum by a groove which measures 2 mm at its minimum width. The tuberculum has no distinct facet, the swelling measures 20 mm external-internally and 15 mm antero-posteriorly and is convex. A slight concavity is present on the rounded capitulum. The distance between the tuberculum and angle is 99 mm. The shaft is strongly curved at the angle and is oval in cross-section at the broken point 60 mm below the angle.

THIRTEENTH RIB: A small fragment of what is apparently the left rib is preserved. This fragment lacks both extremities. A weakly developed angle is present.

FOURTEENTH RIB: A nearly complete left rib is preserved which may represent the fourteenth rib. A fracture during excavation occurred and a small section of the shaft below the angle was lost. The tuberculum is separated from the capitulum by 3 mm at a minimum. The convex tubercular swelling measures 30 mm external-internally and 15 mm antero-posteriorly. No facet is developed. The surface of both the capitulum and tuberculum is convex and rugose. The shaft tapers markedly below the tuberculum and no swollen angle is present. The shaft measures only 20 mm external-internally at a point 197 mm above the distal end. The shaft is oval in cross-section at this point. Below this point, the shaft broadens external-internally and becomes thinner antero-posteriorly, measuring 29 mm external-internally at a point 60 mm above the distal end. The distal extremity is tapered. It measures 15 mm external-internally and 4 mm antero-posteriorly at the slightly rounded end which rakes slightly backward.

FIFTEENTH RIB: This rib was lodged beside the posterior lumbar vertebrae on the left side. It somewhat resembles the innominate bones of some cetaceans, but is most likely a rib because of the thickened head, and the lack of a clearly defined pubic process. It is from the left side. The capitulum and tuberculum are completely fused. A slight angle is developed at a point 61 mm below the tuberculum, and the shaft is thin external-internally. Below the angle, this peculiar rib curves in an anterior direction for 70 mm, and a second angle is developed which is broad, measuring 22 mm external-internally. From here, the shaft curves slightly in the opposite direction for 61 mm. At this point, a third external-internal swelling is developed, measuring 23 mm. Below this point, the direction of the curvature is again reversed. A groove runs obliquely downward from the external (dorsal) surface of the shaft, begining at a point 232 mm below the tuberculum. The shaft is broad external-internally, and thin antero-posteriorly just above the distal end. The distal end is narrower external-internally, slightly indented medially, measures 16 mm external-internally, and 3 mm antero-posteriorly.

Haemapophyses

Two chevron bones are preserved with the skeleton. Their exact placement beneath the caudal vertebrae is uncertain. The first chevron to be discussed is nearly complete, but slightly eroded along part of the ventral edge and the posterior end of the haemal spine. The upper articular facets of the arms of the haemal spines are very far apart. They are somewhat broadened and flattened on their anterior edges. This chevron is quite elongate vertically. The length of the haemal canal is 60 mm. It is filled with spine extends beyond the end of the haemal canal. The external surfaces of the arms of this chevron are concave between the upper region and the ventral edge of the haemal spine. The other preserved chevron is incomplete, lacking most of the left arm and small portions of the right arm and ventral spine. The upper ends of the arms of the haemal spine were much closer together than those of the first mentioned chevron. The bone is shorter vertically. The ventral edge of the haemal spine is very thin. The upper edge of the left haemal spine rises 50 mm above the ventral edge at its maximum height.

Sternal Bones

MANUBRIUM: This bone is heavily constructed. The two surfaces comprising the anterior end are pointed obliquely outward and downward. The right extension is broken away above the base. Dorsally, the medial portion between the two outward projections is concave and curves downward. This bone is very pitted and rugose, particularly on the edges. Posteriorly, the median dorsal surface curves upward and becomes convex antero-posteriorly, but still concave transversely. The bone is narrowest transversely about half way to the posterior end. The posterior end has two concave depressions to either side and a third median one. Laterally, two antero-posteriorly elongate depressions are present on the posterior half of the bone. The median ventral surface of this bone is slightly convex transversely and antero-posteriorly.

TERMINAL SEGMENT (?): An elongate bone which may be the terminal segment of the sternum was preserved. This bone is antero-posteriorly long, constricted slightly, medially, with the dorsal side convex, and the ventral side concave. The anterior end possesses three facets, the median one is largest. The outer ones face obliquely outward. The posterior end is trianguar and tapers to a rounded point.

TABLE 6

Measurements of the Haemapophyses

	1	2
Dorso-ventral diameter	90a	58a
Antero-posterior diameter right articular facet	35	17
Tr across arms	61	34a
Antero-post right arm	50	50

a—incomplete

TABLE 7

Measurements of the Sternal Bones

	Manubrium	Terminal
Greatest antero-posterior	127	69
Transverse at anterior end	90a	37
Transverse at midpoint	46	35
Transverse near posterior end	66	
Dorso-ventral near posterior end	25	
Dorso-ventral near anterior end		17

a—incomplete

COMPARISONS

This archaic cetacean appears to be a definite antecedent to the mysticetes. The cranial architecture shows no tendency toward the remodeling necessary for the development toward any modernized odontocete skull. It is very unlikely that this animal would possess so many mysticete features if it were not directly in mysticete lineage.

Skulls of the archaic cetaceans *Archaeodelphis, Agorophius, Patriocetus,* and *Agriocetus* all have broad rostra, and resemble *Aetiocetus* in general form. However, it is possible that some of these resemblances are due to convergence. Presumably, all cetaceans had to pass through a similar stage of cranial remodeling to adapt to marine environment. Both the broad snouted *Agorophius* and the archaic cetaceans *Xenorophus* and *Microzeuglodon,* which have narrow rostra, are thought to belong to the generalized odontocete stock. Therefore, the broadness of the rostra of some archaic cetaceans is not necessarily indicative of mysticete relationship. The critical features would appear to be the inter-locking maxillary which would prevent the pronounced backward thrust of the rostral elements over the frontal, the elimination of the teeth, and the elongate posterior process of the periotic, a feature of all mysticetes. The skull of *Agorophius pygmaeus* from the upper Eocene of South Carolina (True 1907) much resembles mysticete skulls in general form, but features such as the pronounced spread of the maxillaries over the frontals exclude it from any close mysticete relationship.

The archaic cetacean *Patriocetus ehrlichi* has been suggested as a possible mysticete antecedent, but aside from other peculiarities, the maxillary has no ascending process, and instead, slides under the frontal. The premaxillaries over-ride the frontal to a point well behind the orbit.

A contemporaneous near-relative of *Patriocetus,* the genus *Agriocetus* is represented by a very incomplete skull. If the restoration is correct, the maxillaries over-ride the dorsal surface of the frontals to about the center of the orbit. They are shown to taper toward their posterior ends, rather than remaining broad as on the *Agorophius* skull. If correctly restored, the *Agriocetus* skull resembles *Aetiocetus* in this very important feature. However, the maxillaries, premaxillaries, and nasals are not preserved on the type skull of *Agriocetus,* and the sutures are heavily coated with sand grains, making interpretations uncertain. The supraorbital processes of *Agriocetus* and *Patriocetus* do not have flaring postorbital projections, and meet the parietals in a manner that exclude these cetaceans from any close relationship to the cetacean described in this report. On the *Patriocetus* skull, and the *Agriocetus* skull a thin ledge-like projection of the parietal extends backward from the supraorbital process to the supraoccipital, and overhangs the temporal fossa, whereas on the *Aetiocetus* skull, there is no ledge-like projection of the parietal. The frontals meet the parietals on a constricted intertemporal area, and the supraorbital processes extend outward abruptly, at right angles, anterior to the frontal-parietal contact. On the skulls of *Agriocetus* and *Patriocetus,* the supraorbital processes of the frontals extend gradually outward from their direct contact with the parietals. This relationship bears little resemblance to that of *Aetiocetus.* Neither *Patriocetus* or *Agriocetus* has a greatly elevated supraoccipital shield as is possessed by *Aetiocetus.*

Both *Patriocetus* and the new cetacean had eleven teeth on each side of the rostrum. The molars and premolars of *Patriocetus* are double rooted, whereas, the roots are single on all the teeth of this cetacean. The nature and form of the alveoli of *Aetiocetus* are among the strongest indications of its mysticete tendencies, as the very shallow posterior alveoli would have little known functional value that would not be equally, or more adequately supplied by deeper alveoli, and a thicker maxillary. The form, and position of the palatines, and pterygoids, and most of the rest of the posterior ventral cranial region of *Patriocetus* are dissimilar to this region on the *Aetiocetus* skull. No full ventral view of the rostrum of *Patriocetus* is available for comparison, but it appears from the lateral, and partial ventral view that the alveoli do not have most of the peculiarities possessed by those of this cetacean.

Of all known cetaceans, the incomplete skull of *Archaeodelphis patrius* seems to bear the most resemblance to the cetacean described in this report. *Archaeodelphis* is considered by Kellogg (1928) to be the most primitive known cetacean excepting the zeuglodonts. The skulls of *Archaeodelphis* and *Aetiocetus* both possess an interlocking maxillary, with infraorbital and ascending processes; both have an elongate posterior process of the periotic. The rounded supraoccipital shields are similar, however, the supraoccipital shield of *Archaeodelphis* is apparently not greatly elevated above the intertemporal region. Both cetaceans possess a large orbit, and strongly outward flaring postorbital projections of the frontals. The form of the intertemporal regions are rather similar, and the parietal-frontal contact is somewhat similar. Both cetaceans have large pterygoid fossa. However, even though the maxillaries of *Archaeodelphis* have only telescoped backward to near the center of the orbit, their posterior ends remain relatively wide. They show no evidence in either the dorsal restoration (Kellogg 1928, p. 28) or in the published photographs and restoration (Allen 1921) of the marked narrowing toward their posterior terminations, as is seen on the *Aetiocetus* skull, and all mysticete skulls. Rather, they run close to, and nearly parallel to the edge of the orbit. This is an odontocete feature. The narrow ascending portions of the premaxillaries and the long, narrow nasal bones are somewhat similar to the same bones on the *Aetiocetus* skull, and on known mysticete skulls. In odontocetes there is a tendency toward shortening of the nasal bones. The entire rostrum of *Archaeodelphis* is missing, and the teeth are unknown.

The *Archaeodelphis* skull is thought to be from the upper Eocene. If this age determination is correct (based solely on examination of the matrix), *Archaeodelphis* is considerably older than this cetacean. An important feature which differentiates these two skulls is the zygomatic arch. On the new species, the zygoma is relatively elongate, and under-rides the supraorbital process of the frontal for a distance of 25 mm, and tapers to an extremely thin point. On the *Archaeodelphis* skull, the zygoma is very short, and does not taper to a thin, sharp point. Rather, the end is bluntly rounded, and points upward. It does not approach the posterior end of the postorbital projection of the frontal. The missing jugal of *Archaeodelphis* was probably shaped quite different from that of this cetacean, because on the *Aetiocetus* skull, the very narrow anterior end of the zygoma is directed obliquely downward, and the posterior portion of the jugal is firmly wedged between the median external surface of the zygoma, and the ventral surface of the frontal. It does not contact the tip of the zygoma, but rather, projects backward and upward along the median external surface of the zygoma to a point well behind the anterior tip. The jugal of *Archaeodelphis* could not have this relationship, and probably under-rode the postorbital projection of the frontal, without contacting it as the zygoma does not closely approximate the postorbital projection. The zygoma of *Archaeedelphis* has the same type of bluntly rounded point as is present on typical odontocete skulls. Therefore, there is no reason to think that the zygoma-jugal contact was any different than on other odontocete skulls in which the posterior end of the jugal contacts the rounded anterior tip of the zygoma squarely, and does not extend behind it.

On the *Patriocetus* skull, the anterior tip of the zygoma is bluntly rounded, and terminates much behind, and below the level of the postorbital projection of the supraorbital process of the frontal. The posterior termination of the jugal, as is shown in the restoration (Abel 1913) rests squarely against the blunt anterior end of the zygoma. Its anterior end is shown to rest against the posterior external border of the maxilary, which terminates at the level of the preorbital angle of the supraorbital process of the frontal. No lateral outward extension of the maxillary runs posterior to the level of the preorbital angle of the frontal, and only the very tip of the anterior extremity of the jugal touches the maxillary. The jugal remains far below the level of the postorbital projection of the frontal, and no contact was present between these surfaces.

The upper Oligocene odontocete *Microzeuglodon* aff. *caucasicum* (Riabinin 1938) resembles *Aetiocetus* in some respects. The zygomatics on the *Microzeuglodon* skull extend forward to the level of the postorbital projections of the frontals. The parietal-frontal contact is similar on both cetaceans. Both have an infraorbital extension of the maxillary. In each the occipital condyles are widely separated at the top. The left exoccipital of both cetaeans is similarly proportioned. The two cetaceans are approximately the same size. The *Microzeuglodon* skull is badly deformed, and many of the sutures are unclear. Most of my comparisons are derived from the illustrations, as the published photographs do not reveal sufficient detail. Confirmation of some of the bone relationships shown in the illustrations of the Russian cetacean may await the discovery of a better preserved skull.

The general form of the crowns of the upper first molar and upper fourth premolar are similar. However, the crowns of the anterior premolars of *Aetiocetus* are narrower anterio-posteriorly, and are more sharply pointed, and exhibit more inward curvature. The roots of the teeth of both cetaceans have strong inward curvature. The posterior premolars and the molars of *Microzeuglodon* have two roots, contrasting with *Aetiocetus*. *Microzeuglodon* has one less molar in each maxillary than does the new cetacean. The molar teeth of early archaeocetes, so far as known including *Protocetus*, *Prozeuglodon*, *Basilosaurus*, *Dorudon*, and *Zygorhiza* are located on the posterior end of the maxillary beneath the supraorbital process of the frontal and not anterior to this process as in *Patriocetus*, *Microzeuglodon* and *Aetiocetus*, and probably *Agorophius* and *Archaeodelphis*.

On the *Microzeuglodon* skull, the posterior dorsal portion of the maxillary is shown to terminate anterior to the level of the preorbital angle of the frontal. Furthermore, this portion of the maxillary does not narrow abruptly. Both these features contrast with *Aetiocetus*, but are characteristic of *Patriocetus* (as restored Abel 1913). The premaxillaries do not overspread the frontal on the *Microzeuglodon* skull, but do on *Aetiocetus*. According to Riabinin (1938), the nasal bones on the *Microzeuglodon* skull were probably very short. They are long on *Aetiocetus*. The supraoccipital of *Aetiocetus* is rounded. That bone is triangular on the *Microzeuglodon* skull.

Although the zygomatics on the *Microzeuglodon* skull do extend beneath the postorbital projections of the frontals, these zygomatics are bluntly rounded on the anterior extremity, and are under-ridden by a portion of the postorbital projection of the frontal. The postorbital projection of the frontal does not extend below the level of the anterior ventral surface of the zygoma on the new cetacean skull. The right zygomatic of *Microzeuglodon* appears to be slightly more attenuated distally than is the left one, but does not approach the extreme attenuation that is characteristic of the left zygomatic of *Aetiocetus*. The *Aetiocetus* zygomatic is much thinner transversely and dorso-ventrally, when compared with *Microzeuglodon*. On the restoration of *Microzeuglodon* (Riabinin 1938, p. 169), the jugal is shown to be in direct contact with the anterior tip of the zygoma, and does not extend behind that contact. The jugal is shown to lie well below the level of the postorbital projection of the frontal, having no contact with the latter. If the restoration is correct, that bone has the same relationships and form as is present on odotocete skulls, contrasting with the new cetacean in this very important complex of features. When compared with the *Aetiocetus* skull, the postorbital projection of the frontal on the *Microzeuglo-*

don skull projects more sharply downward, and less strongly outward relative to the anterior outer edge of the frontal. No lateral outward extension is present on the infraorbital process of the maxillary of *Microzeuglodon.* The jugal could not have the lateral contact with the maxillary that is present on the new cetacean skull. The posterior maxillary alveoli of *Microzeuglodon* are double. They are single on the new cetacean, as well as being much shallower and larger. On the *Microzeuglodon* skull, the outer edges of the maxillaries are much thicker dorso-ventrally and the rostrum is narrower.

The basioccipital of *Microzeuglodon* is similarly shaped to that of *Archaeodelphis,* lacking the differentiated lateral protuberance seen on *Aetiocetus.* The posterior ventral portion of the vomer terminates much farther forward on *Microzeuglodon,* and it does not appear that a strong downward projecting keel or carina was developed. The palatines of *Microzeuglodon* are located much farther forward, and their anterior portion extend far forward in a narrowed strip, bearing no resemblance to *Aetiocetus.* The ventral plates of the pterygoids are widely separated in *Microzeuglodon,* exposing the posterior narial channel to ventral view. On the skull of the new cetacean, that channel is roofed over and obscured to ventral view by the carina of the vomer, and the pterygoid and palatine bones. These three bones are carried far posterior to the level they occupy on *Microzeuglodon.* The lachrymal is not shown to be dorsally exposed on the restorations of the *Microzuglodon* skull, and no dorsal extension of the maxillarly is shown in the region of the lachrymal, differing from *Aetiocetus* on both these points.

The transverse process of the first lumbar vertebrae of *Microzeuglodon* extends outward to a sharp point posteriorly, and slants obliquely inward anteriorly, whereas the distal extremity of the transverse process of the same vertebra of the new cetacean is more rounded antero-posteriorly. No strongly develop anterior projection is present on the distal extremities of the transverse processes of the posterior lumbars and anterior caudals of *Microzeuglodon.* The lumbers of *Microzeuglodon* possess relatively longer centra, and higher neural spines. Their metapophyses project strongly upward, and are not relatively flattened transversely as in *Aetiocetus. Microzeuglodon* is shown to possess two more lumbars than *Aetiocetus.* The posterior caudals in the *Microzeuglodon* restoration are shown to be elongate antero-posteriorly, differing markedly from the antero-posterior thinness of the posterior caudals of the new cetacean. The transverse processes of the third and fourth caudal of *Microzeuglodon* are much more reduced than those of the same caudals of *Aetiocetus,* and possess dorso-ventrally thickened crests, contrasting with *Aetiocetus.* The neural spines of the anterior caudals of *Aetiocetus* are much more elongate antero-posteriorly than those of *Microzeuglodon.* The neural spines of the lumbars of *Microzeuglodon* were apparently not greatly thickened transversely at their distal extremity.

The features of the maxillary and premaxillary, the zygoma-jugal form and relationships, and the form and position of the palatines appear to be major criteria, which when considered in conjunction with the other features of the skull and skeleton would appear to exclude *Microzeuglodon* from close relationship with *Aetiocetus. Microzeuglodon* appears to be a relative of the Agorophiidae and Patriocetidae and differs from *Aetiocetus* in most of the same general features as do the Agorophiidae and Patriocetidae. Thus, it may be assumed that *Microzeuglodon* is probably a member of the odontocete stock.

The zygoma-jugal relationship of *Aetiocetus* is apparently unique among known Cetacea. The extremely narrow point present on the anterior termination of the zygoma is unlike that of any known odontocete, or mysticete. Nor does any known odontocete, or mysticete have a jugal in which the posterior end projects well behind the level of the anterior termination of the zygoma; yet on this skull, the posterior end of the jugal extends 44 mm behind the anterior termination of the zygoma. The zygomatics of all known zeuglodont skulls have an attenuated anterior termination, but on these skulls, the tip of the zygoma is located well behind the level of the postorbital projection of the frontal.

Another feature that differentiates *Aetiocetus* from *Archaeodelphis*, and *Patriocetus*, and other true cetaceans is the presence of a lateral extension of the infraorbital process of the maxillary. This dorso-ventrally thin plate extends outward, slightly beyond the edge of the orbit. The lateral portion of this plate is well separated from the ventral surface of the frontal, and extends posteriorly 48 mm behind the anterior end of the jugal. The ventral surface of the jugal rests firmly, and evenly against this maxillary plate, and this relationship is maintained evenly from the anterior end of the jugal to the posterior edge of the maxilliary plate. This is a most important relationship. It is not duplicated on any typical cetacean skull, but is somewhat similar to the maxillary-jugal relationship on Eocene zeuglodont skulls, on which the infraorbital process has a lateral extension that resembles the one present on the new species. However, on Eocene zeuglodont skulls, this process bears teeth, whereas, the posterior alveolus on each maxillary on this cetacean skull is located anterior to the preorbital angles of the frontals, and no teeth were present on the infraorbital extensions of the maxillaries. On other zeuglodont skulls, the anterior termination of the jugal projects under the lachrymal. This is not the case on the skull of *Aetiocetus*, as the squared termination of the jugal rests against the posterior edge of the lachrymal. However, the ventral surface of the jugal is in contact with the outer posterior extension of the maxillary, while on other zeuglodont skulls the inner portion of the jugal maintains direct contact with the posterior outer extension of the maxillary. The infraorbital plate on some cetothere skulls, such as *Pelocetus calvertensis* extends outward to the outer edge of the frontal, but is firmly attached to the ventral surface of the frontal, and does not contact the jugal in the manner present on the *Aetiocetus* skull.

The position of the infraorbital plate on the skull of the new species could foreshadow the condition seen on cetothere skulls because the outward extension is retained. It could progressively lose its connection with the jugal, and become firmly attached to the ventral surface of the frontal. As was previously mentioned, an outward extension is not present on the infraorbital process of the maxillary on other suggested mysticete antecedents, such as *Archaeodelphis* and *Patriocetus*.

On the *Aetiocetus* skull, the lateral protuberance of the basioccipital projects outward, downward, and backward, and the posterior extremity is differentiated from the surrounding bone surface externally, interiorly, and posteriorly. The posterior portion is relatively flattened, and broadened, transversely, and only slightly convex medially. On the skull of *Archaeodelphis*, as is shown in the published photograph (Allen 1921), the outer edges of the thin descending plate of the basioccipital forms a transversely thin ridge to either side of the median posterior trough of the basioccipital, and the ventral side of the basioccipital slopes evenly upward, and inward, to form the median trough, with no irregularity, or transversely expanded projecting posterior protuberance to break the even continuity of the smooth surface. This plate has no observable differentiation from the median trough, except for the even slope. In this important feature, the basioccipital of *Archaeodelphis* resembles that of the squalodonts ,and modernized porpoises. The basioccipital of *Aetiocetus* resembles the same region on cetothere skulls more than the basioccipital of *Archaeodelphis*. On cetothere skulls, the lateral protuberances of the basioccipital are well developed, transversely expanded, and well differentiated from the surrounding bone surface.

In *Archaeodelphis*, the pterygoids are widely separted and at their level the posterior narial channel is wide open. This channel also separates the posterior inner margins of the palatines. Both the pterygoids and the palatines are located considerably anterior to the level they occupy on the *Aetiocetus* skull. This region differs strongly on the *Aetiocetus* skull, on which a very well developed downward projecting carina of the vomer separates the posterior inner margins of the palatines, and also separates the inner margins of the pterygoids, and extends backward behind them, forming a transversely thin blade-like keel that descends 38 mm below the level of the basioccipital. A similar feature is present on cetothere skulls. In contrast, the carina of the vomer on the *Archaeodelphis* skull terminates far forward, at the level of the median posterior extensions of the maxillaries, and does not project strongly downward. As previously mentioned, the open narial channel separates all but the anterior third of the palatines.

In *Patriocetus*, the edge of the descending plate of the basioccipital does not appear in restoration (Abel 1913) to be relatively flattened transversely. It appears to slope abruptly, and evenly inward from the outer edges. However, the posterior portion of the outer edge of the descending plate does turn outward more abruptly than on the *Archaeodelphis* skull. A ventral longitudinal carina of the vomer is present on *Patriocetus*, but terminates at a point much anterior to the one on the ventral surface of the skull of *Aetiocetus*. The posterior extensions of the palatines terminate much father anterior on the ventral surface in *Patriocetus* than they do in *Aetiocetus*. The pterygoids of *Patriocetus* are very widely separated. The posterior external portions of the pterygoids are located far behind the posterior termination of the palatines. This differs strongly from the new cetacean. The dorsal surface of the rostrum in *Patriocetus* somewhat resembles that of *Aetiocetus*, but the outer edges of the maxillaries do not appear to be as thin in *Patriocetus*. *Patriocetus* has an elongate posterior process of the periotic. Kellogg (1928) suggested the possibility that the *Patriocetus* skull may have had an ascending process of the maxillary, which was destroyed on the type skull without leaving a trace. However, Abel's restorations do not show any evidence of this. As pointed out by Kellogg (1928), the relationships shown on Abel's restorations would be structurally unsound, as the maxillary would only be supported by the ascending process of the premaxillaries, and the vomer. Regardless of whether the *Patriocetus* skull had an ascending process of the maxillary, or not, it is distinguished from *Aetiocetus* by the major differences in the zygoma-jugal relationship, the parietal-frontal relationship, the lack of an outward extension on the infraorbital process of the maxillary, the double-rooted teeth, the maxillary-jugal relationship, and the palatines, pterygoids, and vomer.

The zygoma-jugal relationship, the ventral form of the vomer, the lack of an outward extension of the infraorbital process, and the probable lack of contact between the maxillary and jugal demonstrate the dissimilarity of *Archaeodelphis* to *Aetiocetus*. *Archaeodelphis* is considered to be a near relative of *Agorophius*. The type of telescoping seen on the *Archaeodelphis* skull would lead to the development of a skull similar to that of *Agorophius* more simply than to one similar to *Aetiocetus* as no great reversals of trends already established would be necessary. Elimination of the infraorbital process would be a progressive change when related to the many odotocete-like features present on the *Archaeodelphis* skull. The tendency toward broadening of the ascending portions of the maxillaries in *Archaeodelphis* has already begun. Once started, it is likely that this trend would continue on its descendants.

An inconsistency in the argument that the infraorbital process, when considered separately, would impede development toward modernized odotocete-type crainial telescoping from archaic cetaceans, appears when it is recognized that the infraorbital process is present on all known zeuglodont skulls, and is a normal mammalian relationship. Therefore, regardless of whether or not the zeuglodonts are antecedent to modernized odontocetes, the infraorbital process was in all probability present on the ancestral stock of odontocetes and would have to have been eliminated at some point in their development in any case. Therefore, when considered alone, the infraorbital process or for that matter the presence of an elongate posterior process of the periotic, which is developed on some zeuglodont skulls, may not be a good indication of close mysticete affiliation of *Patriocetus*, and *Archaeodelphis*. These features may simply be primitive. All that these two features really indicate is that mysticete remodeling would be possible, whereas, it would not be likely after these features were eliminated. A definite tendency toward the mysticete line would only be indicated when prerequisites, such as an infraorbital process of the maxillary and an elongate posterior process of the periotic, are coupled with a very large number of other mysticete features, including indications that the teeth were to be reduced. *Aetiocetus* exhibits more mysticete features than any other known toothed cetacean, and the peculiarities of the alveoli give added evidence as to its differentiation from odontocetes.

The lachrymal frontal-maxillary relationship on this cetacean differs from that on the *Archaeodelphis* skull for the lachrymal of *Archaeodelphis* contacts the maxillary only on its internal edge. No raised postero-external extension of the maxillary partially encircles the anterior exposed edge of the lachrymal, and on the *Archaeodelphis* skull, the maxillary is shown to be about as transversely broad immediately posterior to the lachrymal as it is immediately anterior to it. This is in direct contrast to the *Aetiocetus* skull. According to Kellogg (1928) the lachrymal of *Archaeodelphis* is actually over-ridden dorso-internally by the maxillary. This is not the case on either the Aetiocetus skull, or the skull of the archaeocete *Zygorhiza kochii* (Kellogg 1936). The external edge of the lachrymal on the *Aetiocetus* skull is well differentiated from the frontal, and projects outward well beyond the preorbital angle of the frontal. This is not the case in *Archaeodelphis*. The position, and form of the lachrymal of *Aetiocetus* more resembles the relationship on the skull of the mysticete *Balaenoptera borealis* (Kellogg 1928) than that of *Archaeodelphis*. However, the form, and position of the lachrymal on the new cetacean is essentially primitive, and is very similar to the lachrymal of *Zygorhiza kochii* (Kellogg 1936), bearing much more resemblance to the lachrymal of this archaeocete than to the lachrymal of any typical cetacean.

The alisphenoid is not exposed in the wall of the pterygoid fossa on the skull of *Aetiocetus*. The alisphenoid has no ventral exposure at all. On the skull of *Archaeodelphis*, the alisphenoid-pterygoid relation is entirely different, and the alisphenoid helps to form the outer wall of the pterygoid fossa on the ventral side of the skull.

The upper Oligocene Yaquina Formation may be about contemporaneous with the Aquitanian stage of Europe in which *Patriocetus* and *Agriocetus* were discovered. A cetothere, *Cetotheriopsis lintianus* (see Kellogg 1928), also occurs in sediments of this European stage. This fact does not exclude *Aetiocetus* from direct mysticete lineage because this genus could have survived from an earlier epoch, and could have given rise to mysticetes in the early or middle Oligocene. Long survivals are not uncommon among cetothere genera.

Most early cetotheres had antero-posteriorly elongate, narrow supraoccipital shields, as does the genus *Cetotheriopsis*. The cetothere *Aulocetus sammarinensis* as illustrated, (see Kellogg 1928) has a skull with a rounded supraoccipital similar to that of *Aetiocetus*. Furthermore, the basic shape of the ascending processes of the maxillaries, premaxillaries and the nasal bones are similar, except that they are telescoped further backward on the *Aulocetus* skull. The preorbital angles of the frontals on the skull of *Aulocetus* flare outward strongly and are under-ridden by the zygomatics, which, however, are more robust than those of *Aetiocetus*. The braincase, so far as can be seen in the illustration is also similar in *Aulocetus.*

The mysticete-like features of the new species are not confined to the skull alone. The vertebral formula, closely coincides with that of *Cetotherium furlongi* Kellogg (1925A). This early Miocene cetothere had seven cervicals, twelve dorsals, ten lumbars, and twelve caudals. The strong projection of the anterior edges of the antero-posteriorly broad transverse processes of the lumbar, and anterior caudal vertebrae is also a prominent feature on the lumbar, and anterior caudal vertebrae of *Cetotherium furlongi.* The antero-posterior elongation of the low neural spines is another cetothere-like feature present on the vertebrae of the new cetacean. The low neural canals, and their transverse broadness on the cervical, and anterior dorsal vertebrae are other major features suggestive of the mysticetes. The well-marked depressions present on the distal portions of the transverse processes of the ninth and tenth lumbar, and first and second caudal vertebrae are unusual among the typical cetacea, and may indicate that the pelvis was better developed than on some modernized cetaceans. The transverse processes on the sacral vertebrae of the archaeocete *Basilosaurus cetoides* bear slight modifications to accommodate the pelvis (Kellogg 1936). Most cetotheres apparently possessed only twelve pairs of ribs. The modernized mysticete, *Neobalena marginata* possessed seventeen pairs (Kellogg 1928). This cetacean possessed at least fifteen pairs, and the archaeocetes *Basilosaurus cetoides,* and *Zygorhiza kochii* both possessed fifteen pairs of ribs (Kellogg 1936). Odontocetes, such as the porpoise *Kentriodon pernix* (Kellogg 1927) possessed only eight pairs. The porpoise *Eurhinodelphis bossi* Kellogg (1925B) probably had eleven pairs, according to Kellogg. The manubrium of *Aetiocetus* bears a strong resemblance to the manubrium of *Basilosaurus cetoides.*

When comparisons are made between this cetacean, and other cetaceans referred to the Archaeoceti, it must be remembered that to date, our knowledge of this suborder has been almost exclusively limited to Eocene forms. No Oligocene archaeocete skull has previously been described, and only a few, generally fragmentary bones and teeth are known from deposits later than Eocene. Few major conclusions can be drawn from this scanty material. The form of the entire squamosal bone of *Aetiocetus* is essentially primitive and more resembles the same bone on Eocene archaeocete skulls, such as *Zygorhiza kochii,* and *Basilosaurus cetoides* than the squamosal of modernized cetaceans. On cetothere skulls, the inner ventral portion of the squamosal (anterior to the root of the zygoma) is expanded laterally. This region is less developed on the new cetacean skull, and is quite similar to that region on Eocene archaeocete skulls. The foramen ovale is not exposed on ventral views of early archaeocete skulls, and the same is the case on the *Aetiocetus* skull. The foramen ovale on early archaeocete skulls is obscured to ventral view by the downward projecting falciform process of the squamosal, also a feature of the *Aetiocetus* skull. On cetothere skulls, the foramen ovale is prominently exposed to ventral view, and the squamosal does not project strongly downward on the inner edge of this foramen. The postglenoid process of cetothere skulls is more robust than on the new cetacean skull. The glenoid fossa of this cetacean is more similar to that on Eocene archaeocetes, than to modernized Cetacea, but is more strongly developed than on early archaeocetes. It is deeper and wider transversely, and antero-posteriorly. The postglenoid process has the general shape typical of the Archaeoceti, being relatively thin antero-posteriorly, with a strongly downward curved projection (see *Zygorhiza kochii* Kellogg 1936). The contact of the zygoma with the jugal differs on Eocene archaeocetes, but as was already mentioned, the narrow anterior termination of the zygoma is a feature of older archaeocetes, as well as a feature of the new species. The close underriding of the zygoma beneath the postorbital projection of the frontal, and the peculiarities of the jugal on the *Aetiocetus* skull are probably mainly the result of the constriction of the intertemporal region, and the downward compression of the frontal. The lambdoid crest of the *Aetiocetus* skull does not flare backward as strongly as on skulls of Eocene archaeocetes, but the rounded supraoccipital is characteristic of early archaeocetes.

The posterior dorsal terminations of the maxillaries, premaxillaries, and nasal bones are similar in general form, and position to the same bones on Eocene archaeocete skulls, except that they have telescoped backward on the *Aetiocetus* skull. The same V-shaped hump comprises the posterior extensions of these bones, on the new cetacean skull, as is present on earlier archaeocete skulls. The posterior dorsal portions of the maxillaries of *Zygorhiza kochii* narrow posteriorly and are almost identical in shape to those on the *Aetiocetus* skull. It should be particularly emphasized that both the dorsal and the ventral terminations of the maxillaries, plus the general basic shape and position of the premaxillaries, and the elongated nasal bones on the *Aetiocetus* skull have the same basic configuration as is present on Eocene archaeocete skulls, and that these same general features are present on mysticete skulls, with the exception that they are telescoped backward on mysticete skulls, and the infraorbital process is completely fused to the under-surface of the frontal. On some Eocene archaeocete skulls, the posterior portions of the nasal, and premaxillary bones terminate slightly anterior to the posterior ends of the maxillaries, differing from *Aetiocetus*, and most mysticetes. However, these minor dissimilarities are not comparable to the radical departures in the form of these bones on modernized odontocete skulls, such as the much shortened nasal bones, and the dorsal posterior broadening of the maxillaries.

The palatines, pterygoids and vomer on the *Aetiocetus* skull have undergone much modification, and are located much further back on the skull than are these bones on Eocene archaeocete skulls. A large pterygoid fossa is developed on the skull of the archaeocete *Dorudon* (Kellogg 1936), and is suggestive of mysticete affiliation according to Kellogg (1936). As was before mentioned, the pterygoid fossa is developed on the new cetacean skull, but it is more similar in shape to the pterygoid fossa on cetothere skulls than to that feature on the *Dorudon* skull, the fossa being very long, and narrow antero-posteriorly on the *Dorudon* skull. The anteriorly broadened, and anteroposteriorly elongated palatines on the *Aetiocetus* skull are similar to those bones on cetothere skulls except that the posterior terminations of the palatines on the new cetacean skull retain the transversely narrowed V-shape characteristic of earlier archaeocetes. The form of the exoccipital, and its relation to the squamosal, on the *Aetiocetus* skull is similar to the corresponding features on the skull of *Basilosaurus cetoides*. *Basilosaurus* has a well developed paraoccipital process, as does the new cetacean. The external auditory channel is very similarly proportioned on both these skulls, and the posterior process of the periotic on the *Basilosaurus* and *Aetiocetus* skulls has a similar shape, and also very similar relationship with the auditory channel. The posterior process of the periotic is slightly longer, and broader, however, on the new cetacean skull. The postero-external wall of the external auditory channel on the *Aetiocetus* skull is formed by a protuberant, dorso-ventrally directed, ridge of the squamosal. This ridge is differentiated both anteriorly, and posteriorly, being distinct from the postglenoid process anteriorly, and is very distinct from the exoccipital, posteriorly. This feature is similarly developed on *Basilosaurus*, but is not on the Agorophiidae, or most modernized Cetacea.

The upper portions of the occipital condyles of Eocene archaeocetes are widely separated. This is also the case on the new cetacean skull. The jugal on all known archaeocete skulls extends behind the level of the postorbital projection of the frontal, and the same is the case on the *Aetiocetus* skull. Other known archaeocetes have ten teeth in each upper jaw, whereas the new cetacean has eleven. The postorbital projections of the frontals are strongly developed on most Eocene archaeocete skulls, as is the case on the *Aetiocetus* skull. On Eocene archaeocetes, a narrow process of the premaxillary extends posteriorly on the median ventral surface of the skull, to a point well behind the outer posterior ventral terminations of the premaxillaries. This feature is strongly developed on the *Aetiocetus* skull. Due to the fewer dorsal, lumbar, and caudal vertebrae, *Aetiocetus* was quite obviously much shorter in relative body proportion than the long bodied archaeocetes, such as *Basilosaurus* (Kellogg 1936). The lumbars and caudals of *Basilosaurus* are much more elongate than are those vertebrae of the new cetacean. The lumbars and anterior caudals of *Zygorhiza kochii*, a short bodied zeuglodont (Kellogg 1936), are shorter antero-posteriorly than are those vertebrae of *Aetiocetus*. However, *Zygorhiza* possessed seven cervicals, fifteen dorsals, fifteen lumbars, and twenty one caudals, and was apparently slightly longer in relative body proportion than *Aetiocetus*. The new cetacean was probably much fatter dorso-ventrally than the early archaeocetes, and perhaps more resembled the mysticetes in post-crainial body form, due to the heavy construction of the low, antero-posteriorly elongate neural spines, the relatively large size of the centra of the lumbar and caudal vertebrae, and also the dense bone structure of the relatively long middle ribs. The skull of *Aetiocetus* is small in proportion to body length when compared to the mysticetes, which have large crainia relative to the rest of the body, but the new cetacean skull is relatively larger in proportion to the rest of the body when compared to other archaeocetes.

TAXONOMIC POSITION

Five widely divergent genera of the families Agorophiidae, Patriocetidae and Microzeuglodontidae have the typical zygoma-jugal relationship of the odontocetes. This, in conjunction with the other differentiating features must be full considered when comparisons are made between *Aetiocetus* and archaic odontocetes. The zeuglodont-like lateral extension of the infraorbital process of the maxillary, and its direct parallel contact with the jugal, is retained on the upper Oligocene *Aetiocetus* skull. This primitive relationship is not known on archaic odontocete skulls by upper Eocene times, nor is it present on later members of the line, such as the upper Oligocene *Patriocetus*. When these factors are considered together, they indicate that *Aetiocetus* was at least separated from the typical odontocete line for a long time, and suggest the possibility that this cetacean may have descended from a somewhat different ancestoral stock. This differentiation of the progenitors of the two stocks from one another may have occurred in the Archaeoceti. The rate of evolution in the two stocks may have also differed. Kellogg (1936) referred to a statement by Stromer which suggested that the mysticete line may have been detached from the common stem before the appearance of the primitive archaeocete *Protocetus*. On the ventral side of the new cetacean skull, the ventral roofing of the posterior narial passage by the palatines and the hamular process of the pterygoids has been carried far posteriorly. This is also a feature of the Archaeoceti and Mysticeti. This feature is not well developed on any odontocete group except the Ziphidae, a modernized family of cetaceans far removed from *Aetiocetus* in other characteristics. The fact that this feature is not well developed on the more primitive odontocetes gives added evidence as to the long separation of the new cetacean from the odontocete line.

I have two other well preserved skulls, and partial skeletons of Oligocene cetaceans. One of these (Emlong collection No. 240) is from the upper Oligocene Yaquina Formation, and the other is from the middle Oligocene Toledo Formation. (Emlong collection No. 80) Both these skulls have zygomatics which are almost identical to the zygomatic on the *Aetiocetus* skull. Both the other skulls have the same extremely narrow anterior termination of the zygomatic, which projects under, and closely approximates the postorbital projection of the frontal. The backward overthrust of rostral elements on these two skulls is less advanced than on the *Aetiocetus* skull, and much less advanced than on any agorophiid skull. Other importance features are similar to those of this cetacean, but some features of these other two skulls such as the very narrow, and elongated intertemporal region on both skulls are very suggestive of the Archaeoceti. These skulls bear little resemblance to any known archaic cetacean other than *Aetiocetus*. The intertemporal regions, and zygomatics of Eocene agorophiids are shortened, in contrast with these two Oligocene skulls. The teeth of these Oligocene skulls closely resemble the teeth of *Aetiocetus*. The undescribed Yaquina skull has a rostrum that is nearly as broad as the one possessed by *Aetiocetus*. The older skull has a much narrower rostrum that is more similarly shaped to the rostra of Eocene archaeocetes. I plan to make detailed studies of both these specimens in the near future, and they will give added clarification to the relationships of the cetacean described in this report.

The manner of implanation of the teeth in the very shallow alveoli at the outer edge of the extremely thin, fragile maxillaries indicate that *Aetiocetus* may not have been adapted to the rigors necessary in procuring large prey. Some early sperm whales, such as *Idiophyseter merriami* Kellogg (1925 A) had teeth present in the upper jaws, and these teeth were apparently implanted rather loosely in alveoli that slightly resemble those of the new cetacean. However, the alveoli of these early predaceous sperm whales do not extend to the outer edges of the maxillaries. The teeth probably did not slant outward to a great degree, and the edges of the maxillaries on these sperm whales are much thicker dorso-ventrally, and much better suited for stress. The large conical teeth of sperm whales are well suited for grasping large prey. The slight similarity of the alveoli of *Idiophyseter* to those of this cetacean is convergence because the crainial and skeletal features of the new cetacean show no significant resemblance to those of sperm whales. The teeth in the upper jaws of Miocene sperm whales, such as *Idiophyseter* were reduced, and the living *Physeter catodon* has no distinct alveoli in the upper jaws. However, the loss of teeth in both jaws would not aid sperm whales because these whales are presently very well adapted to environment in their present feeding habits.

Aetiocetus may have fed upon small fish, or other easily caught prey. The wear on some of the crowns suggests that they were subjected to considerable abrasion. Though possibly coincidental, numerous crab carapaces are present in the fine grained sandstone at the type locality. The food habits of this early cetacean could have been important to the direction of its evolutionary tendencies. For example, the consumption of easily caught prey, such as crustaceans, etc., rather than the pursuit of large, fast moving prey could help to establish tendencies toward adaptation of mysticete characteristics.

Aulocetus sammarinensis is not necessarily a direct descendant of *Aetiocetus*. However, a continuation of the type of telescoping present on the *Aetiocetus* skull would lead to a cranium similar to that of *Aulocetus*. *Aulocetus sammarinensis* is from the early, or middle Miocene of Italy. However, constriction of the supraoccipital shield would not be a difficult step. An upper Miocene cetothere *Aulocetus latus* was tentatively referred to the genus *Aulocetus* by Kellogg (1940). The features of this skull, aside from the supraoccipital shield, are similar to those of the *Aulocetus sammarinensis* skull, but the supraoccipital shield has the triangular shape characteristic of the majority of cetotheres. The shape of the supraoccipital shield is not among the most diagnostic of features, and is extremely variable in some species of mammals because of factors such as age, sex, and individual variation.

The zygoma-jugal form and relationship, and the form and relationship of the infraorbital plate of the maxillary differentiate *Aetiocetus* from all known agorophiids. These two major relationships also differentiate this cetacean from all odontocete groups other than the Agorophiidae. In view of the inconsistencies which would be present in the allocation of this form to the Agorophiidae, it seems appropriate to erect a new family, the Aetiocetidae, for the reception of this cetacean. The placement of this new family within the suborder Odontoceti would not be consistent with either the advanced, or primitive features of the cranium, or skeleton of the species described in this report. The presence of a functional dentition on this mature specimen precludes allocation within the Mysticeti. The two previously mentioned major differentiating features of the zygoma-jugal form, and relationship, and the form, and relationship of the infraorbital plate of the maxillary are more primitive than those same bones on any known odontocete, or mysticete skull, and are strongly suggestive in many respects to those bone relationships on archaeocete skulls. In view of the presence of these features on a skull which is also strongly differentiated from odontocete skulls in many other respects, I am placing this family in the suborder Archaeoceti. This form is obviously far advanced when compared with other described archaeocete families, and the degree, and trend of telescoping of cranial bones, and any of the features of the skeleton are more suggestive of the Mysticeti than of the Archaeoceti. However, when all considerations are carefully evaluated, the most logical deduction is to regard this form as an aberrant late survivor of an archaeocete line, and a close antecedent to the Mysticeti. Future studies of the two undescribed Oligocene cetaceans mentioned in this report will add a great deal to our knowledge of this group.

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