

FOSSIL MARINE MAMMALS

From the Miocene Calvert Formation
of Maryland and Virginia

Parts 3 and 4

REMINGTON KELLOGG

Research Associate, Smithsonian Institution

3. New Species of Extinct Miocene Sirenia

4. A New Odontocete From the Calvert
Miocene of Maryland

3. New Species of Extinct Miocene Sirenia

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

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

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

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

Knowledge of the early geological history and geographic distribution of the Sirenia in the western hemisphere is limited to sporadic occurrences of somewhat divergent and apparently not closely related types. From the supposedly

deep water lower Eocene (Manasquan formation) marl pits along Shark River, Monmouth Co., N.J., Cope (1869, pp. 190–191, pl. 5, fig. 6) described a portion of a tooth, which resembled the incisor tusk of a dugong, as *Hemicaulodon effodiens*. The identity and relationship of this tooth fragment will be dealt with in the description of the dentition of the Calvert sirenian.

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

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

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

Another dugongid represented by a considerable portion of the skeleton was excavated in a fuller's earth mine in Gadsden County, Fla. Simpson (1932a, p. 426) named this middle Miocene (Hawthorn formation) sirenian *Hesperosiren crataegensis*. The skull is characterized in part by the absence of incisors, slightly deflected rostrum, nasals separ-

ated in midline by frontals, and supraoccipital nearly or just meeting the foramen magnum.

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

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

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

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

THE CALVERT MIOCENE DUGONG

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

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

damalis stelleri). This vertebra is now referred to the Calvert sirenian herein described.

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

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

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

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

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

Crocodile (*Thecachampsa*) teeth are of fairly frequent occurrence and these reptiles were sufficiently numerous to play an important predatory role. Teeth of this Miocene crocodile like those of its notably aggressive Recent relative are not adapted for chewing. Although the crocodile can eat anything that can be swallowed whole, if the victim is too large the crocodile tows it away with its clamplike jaws to a hoarding spot where it will decay and become

soft enough to be readily torn apart. Flesh and bones when swallowed are rapidly digested and no telltale remnants would survive to puzzle some future fossil hunter. The rather frequent intercalation of layers of sand in the Calvert formation should have provided suitable nesting habitats for the Miocene crocodile. Recent crocodiles lay their eggs in holes or depressions in sun-warmed sand where they remain covered until they hatch.

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

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

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

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

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

FELSINOTHERIUM Capellini

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

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

Type Species: *Felsinotherium forestii* Capellini.

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

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

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

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

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

Simpson (1932a, pp. 451, 469) in describing *Felsinotherium ossivallense* from the lower Pliocene Bone Valley formation at Mulberry, Fla., defends this generic allocation on the basis that the upper molariform teeth are wider

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

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

HALIANASSA Studer

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

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

Type Species: *Halianassa studeri* Studer.

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

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

1934, p. 190] whose corresponding tooth measured 18 mm. in length and 14 mm. in width. The measurements of the same tooth of the middle Miocene (Helvetian) *Hippopotamus medius* of Cuvier were recorded as 28 mm. in length and width. This Flonheim molar has since been allocated to the Oligocene *Halitherium schinzi* Kaup.

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

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

Linz which Fitzinger (1842, p. 61) named *Halitherium cristolii*.

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

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

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

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

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

M¹: narrow transverse lake between rim of anterior cingulum and the continuous rim encircling the protocone, protoconule, and paracone; transverse valley deflected by forward thrust of metaconule; continuous rim encircles metaconule, hypocone and posterior cingular lake; metacone conical, apex behind metaconule.

M²: anterior cingulum wide, rolled over backward; anterior lake narrow, transverse; protocone, protoconule, and paracone almost in straight transverse row; transverse valley narrow, curved forward medially; hypocone prominent, continuous with metaconule and separated from smaller conical metacone by narrow curved cleft; apex of metacone behind metaconule; posterior cingulum minutely cuspidate.

M³: apices of protocone, protoconule and paracone in straight transverse row; incipient parastyle on thick crest of anterior cingulum separated from paracone by a deep cleft; anterior transverse lake narrow, deep; transverse valley curved, similar to that of M².

METAXYTHERIUM Christol

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

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

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

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

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

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

Christol, however, in 1834 (p. 274 and p. 277 explanation for pl. 13) had referred the sirenian from Montpellier and

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

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

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

Skull: Braincase relatively long, high, and narrow; rostrum deflected downward to some degree; nasal bones separated at posterior end of mesorostral fossa on midline by the paired frontals; lachrymal present; no lachrymal duct; supraorbital processes of frontals relatively long, slender and little expanded; temporal crests lyriform, either well separated or closely approximated on parietals; median

area of paired frontals flattened; supraoccipital narrowly reaching downward to foramen magnum; external palatal projection of maxillary suturally united with jugal as in *Dugong*; skull as long as 600 mm. Mandible deep and robust.

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

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

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

METAXYTHERIUM CALVERTENSE, *new species*

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

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

Referred Specimens: Ten, as follows: (1) USNM 9346: adult sirenian, left radius and ulna (figured by Case, 1904, pl. 26, fig. 1); Fairhaven, Anne Arundel Co., Md., diatomaceous earth, Calvert formation, middle Miocene. (2) USNM 12596: adult sirenian, 2 dorsal vertebrae, 8 more or less complete ribs and fragments of others; coll. Norman H. Boss and Remington Kellogg, June 19, 1932; at beginning of cliff south of Plum Point wharf, Calvert Co., Md., in zone 12 at contact between zone 12 and 11, 4 feet above shell band (zone 10), Calvert formation, middle Miocene. (3) USNM 16630: young sirenian, both mandibles, anky-

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

Skull

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

DORSAL VIEW.—The skull (fig. 32) is characterized in part by elongation in conformity with the normal sirenian construction, the top of the braincase being narrower than the rostrum. The cerebral cavity as compared to that of the Recent dugong is more elongated, somewhat com-

pressed from side to side, truncated at both ends, and rather flat dorsally.

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

The somewhat horizontal dorsal surface of the braincase is slightly depressed longitudinally between the low flat-

tened temporal crests. These crests strongly converge some 55 mm. anterior to the supraoccipital crest, where they are separated by a minimum 15 mm. interval; they then gradually diverge anteriorly until an interval of 50 mm. separates them, and these crests become indistinct.

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

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

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

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

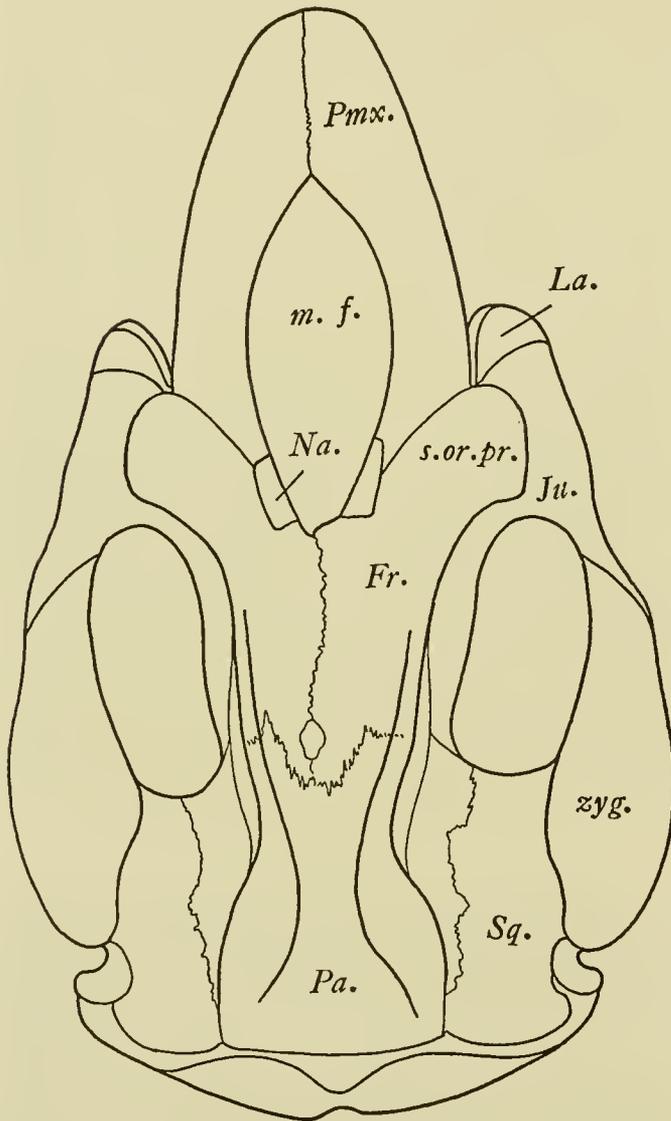


FIGURE 32.—Dorsal view of skull, USNM 16757, of *Metaxytherium calvertense*, with left jugal restored and rostrum corrected for distortion. Abbrs.: Fr., frontal; Ju., jugal; La., lachrymal; m.f., mesorostral fossa; Na., nasal; Pa., parietal; Pmx., premaxillary; s.or.pr., supraorbital process of frontal;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

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

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

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

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

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

POSTERIOR VIEW.—Viewed from the rear, this skull (fig. 33) resembles somewhat closely that of *Felsino-therium serresii*

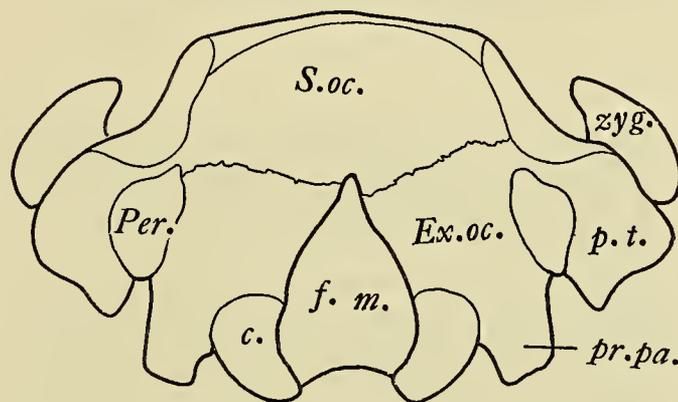


FIGURE 33.—Posterior view of skull, USNM 16757, of *Metaxytherium calvertense*, with right exoccipital and occipital condyle restored. Abbrs.: c., occipital condyle; Ex.oc., exoccipital; f.m., foramen magnum; Per., periotic; pr.pa., paroccipital process; p.t., posttympanic process of squamosal; S.oc.,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

(Depéret and Roman, 1920, fig. 2(4)), its greatest width being above the level of the occipital condyles. The dorsal border of the supraoccipital is truncated horizontally and the rather sinuous curvature of the lateral lambdoid crest is concave dorsally and convex ventrally. The contour of the left occipital condyle is reniform, and the petrosal is visible in the gap between the supraoccipital, the exoccipital and the ventral projection of the squamosal. The foramen magnum is relatively large, higher than wide.

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

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

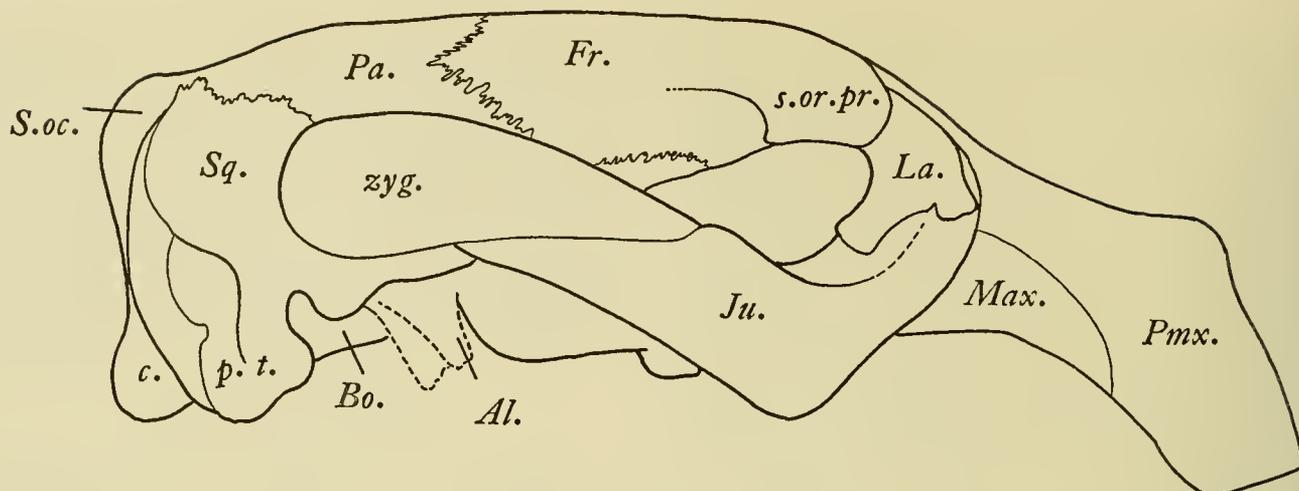


FIGURE 34.—Lateral view of skull, USNM 16757, of *Metaxytherium calvertense*, with rostrum corrected for distortion. Abbrs.: Al., descending pterygoid plate of alisphenoid; Bo., basioccipital; c., occipital condyle; Fr., frontal; Ju., jugal; La., lachrymal; Max., maxillary; Pa., parietal; Pmx., premaxillary;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

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

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

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

The jugal is a rather long bone (length 168 mm.), whose anterior portion is bent almost at right angles to the posterior horizontal portion. This bone constitutes the

ventral rim of the orbit and its anterior end is intimately pressed against the external surface of the premaxillary.

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

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

Flot (1886, p. 510) describes the lachrymal of *Metaxytherium cuvierii* as a nearly triangular bone, 32 mm. long and 15 mm. high whose posterior border descends vertically from the supraorbital process of the frontal and joins in

front the jugal and the maxillary. On the type skull of *Halianassa* [= *Metaxytherium*] *vanderhoofi*, according to Reinhart (1959, p. 33; see also pp. 57-58), the lacrymal is 30 mm. long dorsally and 32 mm. high anteriorly.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Ear Bones

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

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

Externally, the periotic is abruptly truncated, and thickened dorsoventrally (39 mm.), constituting the mastoid

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

Auditory Ossicles

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

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

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

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

Mandible

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

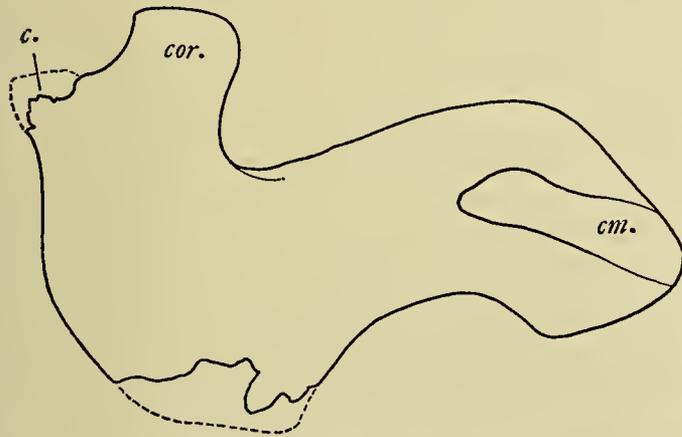


FIGURE 35.—Right mandible, USNM 16757, of *Metaxytherium calvertense*. Abbrs.: c., condyle; cor., coronoid process; cm., external orifice of mandibular canal.

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

Alveoli for the roots of at least three cheek teeth are partially preserved on the mandible of the immature sirenian (USNM 16757). Juvenile Recent dugongs have four pairs of slender conical teeth lodged in alveolar cavities which are concealed beneath the horny plate covering the downward deflected and squarely truncated symphyseal ends of the mandibles. These teeth are absorbed before maturity. Immature and even old adult dugongs retain these alveoli partially filled with osseous replacement. Three dorsal pairs and one ventral pair at the end of the symphysis is

the normal complement. One specimen (USNM 284458) has four dorsal pairs and one ventral pair and another (USNM 284456) has three alveoli on the right side and four on the left side of the dorsally placed alveoli and the usual one ventral pair. The ventral pair of alveoli are located at or below the level of the external orifice of the large mandibular canal.

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

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

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

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

Dentition

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

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

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

On the incomplete tusk (length, 150 mm.; maximum width, 74 mm.; least width, 45 mm.) of *Hemicaulodon effodiens* (Cope, 1869, pl. 5, fig. 6), the compressed pulp cavity is open at the basal end; the cross section at the broken end shows the osteodentine filling the pulp cavity, which is surrounded by a thick layer of dentine and it in turn by a thin circumferential layer of cementum. Annuli-form ridges on the circumference of the dentine core are exposed by the flaking off of an area of external cementum. A single large longitudinal groove is present on the external face of the tusk. All of the above described characteristics, with exception of the dimensions, can be matched by a Calvert tusk (USNM 8457) as well as by a Florida Tertiary tusk (AMNH 9852). It is now suggested without hesita-

tion that the type tooth was not derived from the middle Eocene Shark River marl. Tusklike incisors of similar dimensions and configuration made their appearance in sirenian developmental history at a time later than the Eocene. Inasmuch as the Miocene Kirkwood formation overlaps the Shark River marl (Manasquan formation), the association of any specimen picked up on the surface alongside or in a marl pit being worked could readily be misinterpreted. The dimensions of the type tusk of *Hemicaulodon effodiens*¹ correspond more closely with those of the Aquitanian *Rytiodus capgrandi* than with those of other American extinct dugongids.

On the right side of the skull (USNM 16757)M¹ has a well worn crown (pl. 34, fig. 2), alveoli for three roots indicate the size of M², and the more elongated M³ is not fully erupted. If Pm⁴ was present in the young, its alveolus has now been obliterated by closure. The length of the maxillary molar row is 68.5 mm.

It should be noted, however, that the young of the Pliocene (Plaisancian) *Felsinotherium serresii* (Depéret and Roman, 1920, p. 8) possessed five upper cheek teeth, two premolars and three molars, but Pm³ disappeared in the adult and its alveolus is completely obliterated.

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

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

On the palate of the lower Miocene (Burdigalian) *Halianassa studeri* four cheek teeth are in place in addition to four root cavities of one or two missing anterior teeth. The upper dental formula of this sirenian has been interpreted to be: Pm², Pm³, Pm⁴, M¹, M², M³ (Depéret and Roman, 1920, p. 33).

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

An indentation on the lingual and buccal sides of the well-worn crown of M¹ marks the location of the transverse valley. It is obvious then that the anterior portion of the crown (pl. 34, fig. 2) is slightly larger than the posterior, and that the latter is narrower. An incompletely closed enamel ridge marks the location of the buccal paracone. A

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

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

The length (28.5 mm.) exceeds the maximum width (18.5 mm.) of M³ anteriorly. The protocone (pl. 34, fig. 2) is the largest cusp and projects beyond the level of the apices of the protoconule and paracone. At the apex the protoconule and paracone are almost equal in size. An anterior crest connects the protocone, the antero-internal cusp, with the anterior cingulum. A low parastyle on the anterior cingulum is separated from the paracone by a shallow cleft. Between these elevations on the anterior cingulum and the transverse row, the protocone, protoconule and paracone, is a deep lake. From a posterior view, both the paracone and the protoconule are seen to be inclined obliquely toward the protocone, and are separated by a deep unobstructed transverse valley from the cusps on the posterior half of the crown.

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

This Calvert M³ does not resemble very closely the corresponding molar of the Helvetian *Metaxytherium cuvierii* [= *M. medium*] from Chazé-Henry, France (Flot, 1886, p. 502, pl. 27, fig. 2). The illustration of the three molars published by Flot seems to have been reversed by the engraver. Measurements (in mm.) given for these three molars (Flot, 1886) are:

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

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

Simpson (1932a, p. 449) and Gregory (1941, p. 36) have both commented on the excessive wear of the M¹ on a skull of *Felsinothierium ossivallense* before the M³ had fully erupted. A similar condition exists on this Calvert skull. It will be observed (pl. 34, fig. 2) that this incompletely erupted third upper molar is implanted in an alveolus at the posterior end of the maxillary, and that space for a more posteriorly situated alveolus can not be developed in this portion of the maxillary in view of its sutural contact with the descending process of the pterygoid.

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

Reentrant angles in the encircling enamel rim on the buccal side of the well worn isolated left M³ (USNM 23281) are interpreted as indicative of the boundaries of original cusps. The upper reentrant angle (pl. 35, fig. 3) on the buccal side separated the paracone and the small anterior parastyle. Between this reentrant angle and the median wider one the enamel rim follows the outer contour of the paracone. The wider median reentrant angle is the

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

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

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

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

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

Between the hypoconid and the entoconid, the posteromedian cuspule is situated centrally across the original trans-

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

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

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

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

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

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

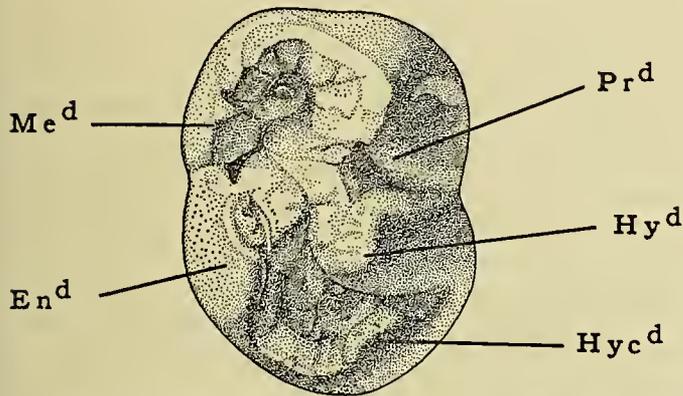


FIGURE 36.—Posteriormost lower cheek tooth, right mandible, USNM 16630, of *Metaxytherium calvertense*. Abbrs.: En^d, entoconid; Hy^d, hypoconid; Hyc^d, hypoconulid; Me^d, metaconid; Pr^d, protoconid.

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

No plausible explanation has been advanced to support the contention of Lepsius (1882, p. 106) that sirenian cheek teeth increase in size during advancing age. It is generally accepted that once the enamel crown is fully formed any size increase of cheek teeth is terminated. Thomas and

Lydekker (1897) have described and figured the continuous succession of cheek teeth in the Recent manatee (*Trichechus*). They have shown that as regards the mandibles of *Trichechus senegalensis* the anterior eroded cheek teeth are thrown off during growth, with the consequent increase in the length of the upper and lower jaws, and that the replacement teeth developing in the jaw at the posterior end of the row will be erupted sequentially (see also Heuvelmans, 1941). This method of replacement of worn off and shed cheek teeth may suggest at least one explanation of the diminutive size of the teeth of the young Calvert sirenian, which are so much smaller than those in the immature skull or isolated teeth of adults.

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

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

As an alternative interpretation, the suggestion is here made that the total number of cheek teeth that erupted during the life of this Calvert dugongid exceeded the

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

Scapula

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

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

The basal end of the right scapula of an adult individual (USNM 23213) is complete. Between the spinal crest and the glenoid cavity the neck (width, 42 mm.) is narrowed and a little compressed (28 mm.) exterointernally. The glenoid cavity is deeply concave and measures 55 mm. anteroposteriorly and 40 mm. exterointernally. The stout

coracoid process is rather short and bent inward, but is narrower and more strongly exterointernally compressed than the enlarged and blunt-nosed process of the right-scapula of the immature individual (USNM 16757).

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

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

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

Humerus

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

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

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

The olecranon fossa (pl. 41, fig. 4) on the posterior face at the distal end of the right humerus is deep and rather

broad. The bicipital groove on the proximal end between the greater and lesser tuberosities is relatively broad and deep. The detached cap or head is relatively small, as on other sirenian humeri.

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

Radius and Ulna

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

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

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

Pelvis

A right innominate bone (USNM 16757) was associated with the skull and other skeletal elements. A left innominate bone (USNM 23213) that lacks the anterior end of the ilium as well as much of the ischium behind the ace-

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

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

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

Sternum

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

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

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

Vertebrae

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

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

Axis: The configuration of the axis (USNM 16757) is quite similar to that of *Metaxytherium cuvierii* (Cottreau, 1928, pl. 2, fig. 1) and its preservation is somewhat better than the other cervicals. The blunt nipple-like odontoid process projects forward at least 25 mm. beyond the flat anterior articular facets for the atlas, which are subcircular in outline and slope obliquely backward from internal to external margins. The neural canal (pl. 39, fig. 5) is

higher (41 mm.) than wide (35 mm.) and rather flat at the base. The pedicles of the neural arch are almost triangular in cross section and give origin posteriorly to the postzygapophysial facets for articulation with the third cervical. The roof of the neural arch is thick, bluntly truncated dorsally and notched posteriorly, but no vestige persists of a neural spine. The posterior articular face of the centrum is concave or depressed and is wider (50 mm.) than high (28 mm.). Other measurements are: maximum height, 90 mm.; maximum width, 81 mm.; distance between outer margins of postzygapophysial facets, 71 mm.; and maximum width of neural canal, 35 mm.

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

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

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

prezygapophysial facet. The width of the neural canal is 51 mm.; and height 43 mm. The distance between the external angles of the transverse processes is 139 mm.

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

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

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

The first nine dorsal vertebrae of *Metaxytherium medium* (*cuvierii*) possess anterior and posterior demifacets for articulation with the heads of ribs according to Cottreau (1928, p. 13) and the posterior demifacet disappears after the

tenth dorsal. The posterior demifacet was well developed on the tenth dorsal (pl. 39, fig. 1) of the Calvert sirenian, but was not present on the twelfth dorsal, the eleventh being represented solely by the neural arch and neural spine.

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

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

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

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

On the first seven dorsals, the prezygapophysial facet is more or less horizontal although it curves upward on its external borders. On the eighth dorsal to the sixteenth dorsal of this series this articular facet definitely slopes obliquely downward from external to internal margin, and the anteroposterior ridge or crest delimiting its outer margin increases in prominence. This shift in the inclination of the facet culminated on the eighth dorsal with the in-

ipient development of the metapophysis which progressively increases in size and height toward the posterior end of the dorsal series and projects forward beyond the level of the anterior face of the centrum. The width of the gap between the prezygapophysial facets decreases from the first to the sixteenth dorsal and presumably to the end of this series. On the fourth (pl. 38, fig. 4) to and including the sixteenth dorsal a deep groove extending backward to the base of the neural spine bounds the prezygapophysial facet internally.

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

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

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

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

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

SACRAL VERTEBRA.—The sacrum is reduced to one ver-

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

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

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

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

Ribs

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

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

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

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

While dissecting a male dugong carcass, Owen (1838,

p. 41) found that the first four pair of ribs had a cartilaginous attachment to the sternum; the remainder of the ribs terminated freely in the mass of abdominal muscles.

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

The first pair are the shortest of the ribs in the thorax, the anteroposteriorly compressed vertebral end is abruptly bent inward, and the transversely flattened distal or sternal end of the shaft is twisted almost at right angles to the vertebral end. There are three processes or facets on the vertebral end of the first rib (fig. 37), the knoblike upper one, the tuberculum, is attached to the end of the diapophysis; the second, the capitulum, is at the end of a slender neck; and a third ventral knoblike process may have been connected by ligament with a cervical rib. The first rib of a skeleton of the dugong (USNM 20861) mounted for display in the Museum of Natural History has a short piece of a dried ligament still attached to this lower process. This liga-

ment may have formed a ligamentary connection with the very rudimentary cervical rib which is loosely articulated with the seventh cervical on this mounted skeleton. This cervical rib is bifurcated or at least has two heads; the upper head articulates with the diapophysis of the seventh cervical, the lower head articulates with the centrum of the sixth cervical. As regards the occurrence of rudimentary ribs in certain whalebone whales, Turner (1871, p. 360) states that the cervical rib possesses neither capitulum nor neck, nor does it take the place of the ventral transverse process of the seventh cervical, and it is articulated with the upper transverse process of this cervical. This lower process is not developed on the vertebral end of the first rib of the American manatee (*Trichechus manatus latirostris*). The absence of this process on the first rib of the manatee may bear some relationship to the reduction of the cervicals to six vertebrae. Depéret and Roman (1920, p. 16, pl. 4, fig. 6) illustrated the first rib of *Felsinotherium serresii* and mentioned the third ventral process below the capitular facet, but offer no suggestion of its functional significance.

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

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

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

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

of the proximal third of the shaft. The maximum width of the shaft is 47 mm. The lengths of the right and left ribs, respectively, are 308 and 307 mm.

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

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

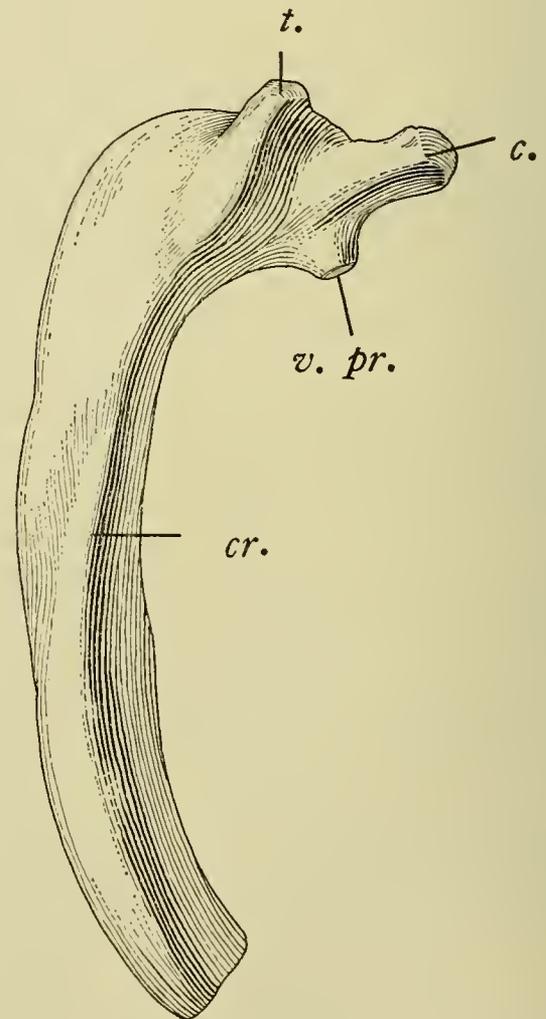


FIGURE 37.—First left rib, USNM 16757, of *Metaxytherium calvertense*. Abbrs.: c., capitulum; cr., crest of shaft; t., tuberculum; v.pr., ventral process.

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

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

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

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

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

the tubercular facet to 24 mm. across the capitular facet. The elongated depression external to the low tuberculum is rather deep.

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

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

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

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

inward more abruptly at the vertebral end than deflected backward at the sternal end. It is as uniformly curved from end to end as the eleventh rib.

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

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

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

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

Except for the shortening of the shaft the general configuration of the seventeenth rib is almost a replica of the sixteenth rib, the right and left ribs measuring, respectively, 405 and 408 mm. in length. The distal two-thirds of the

curved shaft tapers to the small oval end. A similar backward deflection of the distal portion of the shaft exists and the neck is slightly bent forward. The subtriangular neck is short but less dorsoventrally compressed and the distance from the articular face of the capitulum to the posterior edge of the low knoblike tuberculum is 40 mm. The groove which is present behind the tuberculum on the preceding rib has been replaced by a small shallow depression.

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

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

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

THE SOUTH CAROLINA MIOCENE DUGONG

DIOPLOTherium MANIGAULTI Cope

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

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

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

Associated in the phosphate derived collections with these small specimens, here referred to *Felsinotherium alleni*, are portions of skulls of a somewhat larger sirenian. At the request of Gabriel Manigault, the then director of the Charleston Museum, Cope (1883, pp. 52-54) described the anterior symphyseal end of a sirenian right premaxillary containing a large tusk lodged in the alveolus which he named *Dioplotherium manigaulti*. Cope mistakenly asserted that a second tusk was lodged in the premaxillary external to the first tusk and that the presence of a second tusk distinguished this form from all other sirenians. A critical examination

of the type specimen from the phosphate beds of the Wando River northeast of Charleston, S.C., failed to corroborate this assumption. The overall length of this portion of the premaxillary (Cope, 1890, pl. 25) is 168 mm., and the bent downward anterior end is quite broad, the maximum anteroposterior diameter being 105 mm. Other measurements are: vertical diameter from dorsal face of premaxillary near posterior end of symphysis to ventral alveolar border, 128 mm.; length of symphysis, 126+ mm.; length of tusk, 176 mm. (present condition, 153 mm.); anteroposterior diameter near base, 50 mm.; transverse diameter, 27 mm. The longitudinal fluting of the tusk is most pronounced on the internal face.

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

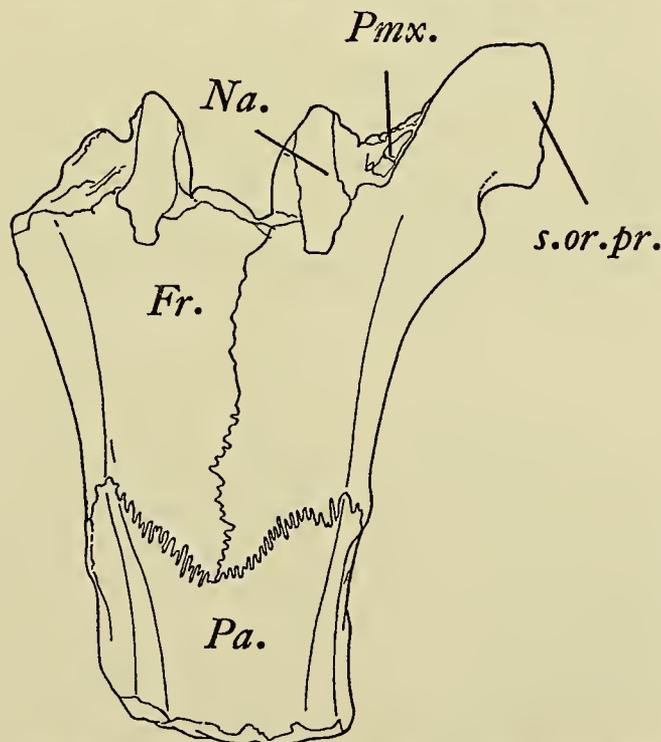


FIGURE 38.—Cranial roof, USNM 23394, of *Felsinotherium alleni*. Abbrs.: Fr., frontal; Na., nasal; Pa., parietal; Pmx., premaxillary; s.or.pr., supraorbital process of frontal.

donated by the Nérac Museum in 1866, measured 260.4 mm. in length and 77.5 mm. in greatest width. The skull described and figured by Delfortrie was excavated in the lower Miocene "marnes sableuse" at Saint-Morillon, Labrède Canton, Dépt. Gironde, France. According to the measurements published by Delfortrie (1880, p. 143), the length of the tusk is 300 mm., and the width, 56 mm. No cheek teeth have as yet been identified as belonging to *D. manigaulti*. The length of the roof of the braincase of *R. capgrandi* was about the same as that of *Metaxytherium jordani* (Kellogg, 1925, p. 66). The premaxillaries of *R. capgrandi* were, however, greatly elongated, measuring 450 mm., and the length of the premaxillary symphysis was 240 mm. The zygomatic width of the skull of *R. capgrandi* was 300 mm., and the width across the supraorbital processes of the frontals, 240 mm., as contrasted with the corresponding measurements of 317 and 192 mm., respectively, of *M. jordani*. Four cheek teeth (Delfortrie, 1880, pl. 8, fig. 3) are in place in each maxillary, the molariform series in the right maxillary being noticeably abraded and those in the left maxillary strongly abraded on the lingual side and relatively little worn on the buccal side. These four cheek teeth are regarded as Pm⁴, M¹, M², and M³; the length of the molariform series is 95 mm., and the length of M³ is 30 mm., and width, 25 mm. The crown pattern of the *Rytiodus* cheek teeth does not correspond very closely with teeth of *Metaxytherium*.

A left premaxillary (YPM 21334) in the Scanlon collection of the Peabody Museum of Yale University, which is broken off about 75 mm. in front of the anterior end of the mesorostral fossa, also has a large tusk lodged in the alveolus. The measurements of this rostral fragment are as follows: overall length, 220 mm.; maximum diameter of premaxillary about 50 mm., in front of posterior end of symphysis, 95+ mm.; transverse diameter of premaxillary near middle of mesorostral fossa, 32 mm.; maximum

diameter of tusk in cross section (presumably about 50 mm. from base), 51 x 25 mm. Near its commencement the maximum dorsoventral diameter of the symphyseal sutural contact is 56 mm. on both the type of *D. manigaulti* and the Peabody Museum specimen. Both of these premaxillaries have the ventral surface strongly striated or ridged for reception of the palatal extension of the corresponding maxillary. The bent downward anterior end of the maxillary, which overlapped the exteroventral surface of the premaxillary, terminated about 20 mm. in front of the anterior end of the mesorostral fossa. The estimated maximum width of the mesorostral fossa is 80 mm. and its length 150 mm.

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

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

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

THE COLOMBIA TERTIARY DUGONG

As a gift from the Instituto de la Salle, Bogotá, Colombia, a number of Cretaceous invertebrates and a fragment of a fossil sirenian skull were presented to Dr. John B. Reeside, Jr., United States Geological Survey, by Brother Ariste Joseph in 1923. The mandible of a fossil manatee (*Potamosiren magdalensis*) discovered farther south in the present Magdalena valley in the Miocene La Venta fauna of the El Libano sands and clays near Villavieja, Departamento del Huila, has been described by Reinhart (1951). These two occurrences demonstrate that during the interval when the Central American isthmus was submerged pelagic dispersal enabled representatives of the Dugongidae and Trichechidae to reach the American region now designated

as Colombia, South America. The occurrence of fossil vertebrates in the upper Tertiary of the municipality of Ortega, Dept. Tolima, without an indication of either the precise locality or the species, has been recorded in the literature (Botero, 1936, p. 44; Royo y Gomez, 1946, p. 499).

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

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

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

METAXYTHERIUM ORTEGENSE, *new species*

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

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

Dentition

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

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

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

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

M^3 is the largest and longest of the three maxillary cheek teeth. Measurements of the enamel crown are as follows: width across protocone, 25 mm.; width across hypocone, 21 mm.; length, 29.5 mm.; length-width ratio, 1.18. The paracone is slightly smaller than the protocone; its apex, however, is elevated above the centrally placed protoconule and the protocone. The dimensions of the anterobuccal parastyle are comparable to those of this cusp on M^2 and this style is likewise separated from the rather broad anterior cingulum by a thin cleft. On the lingual side the cingulum has an enlargement whose

dimensions are the same if not larger than those of the parastyle. The quadrangular anterior lake is larger than that of M^2 .

The deep transverse valley is deflected slightly forward centrally by the more forward placement of the rather large median posterior cusp (metaconule). The unworn apices of the metacone and hypocone are not elevated above the metaconule; the hypocone is, however, pressed

more closely against the metaconule than is the metacone. In contrast to M^2 there are three distinct cusps on the posterior cingulum; the apices of the buccal and lingual cusps are, however, elevated above the smaller medial cusp. The buccal and lingual cusps are also separated from the metacone and hypocone respectively by a thin cleft. The lake in front of the posterior cingulum is smaller than that of M^2 .

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4. A New Odontocete From the Calvert Miocene of Maryland

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

HADRODELPHIS, *new genus*

Type species: *Hadrodelphis calvertense*, new species.

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

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

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

Teeth

The incomplete right mandible (length, 388 mm.) has five teeth (pl. 44, fig. 1) with crowns in situ, 1 root only and 7 empty alveoli. The shorter portion (length, 233 mm.) of the left mandible has two teeth with worn crowns in situ and 4 empty alveoli. In the symphysis of these

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

The fourth tooth (pl. 45, fig. 2) in front of the broken posterior end of the right mandible (tenth tooth behind broken anterior end) was removed from its alveolus for examination and illustration. No appreciable variation in the configuration of the enamel crown of the five posterior teeth in the right mandible is noticeable. The apex of the subconical crown curves inward, overhanging the broad internal basal shelf. The black enamel on the crown of these posterior teeth is lightly roughened with irregular and anastomosing fine striae which are almost imperceptible except under magnification. No cingulum is developed. There is no distinct neck below the enamel crown, although the rounded ventral rim is pinched-in or turned inward. The internal basal shelf is progressively diminished toward the anterior end of the tooth row and is barely visible on the posteriormost of the two teeth retained in the left mandible. The conical apices of these two teeth are worn down transversely. The basal margin of the enamel crown seems to extend ventrally farther on the internal face than on the external face, although the distance from the conical apex to the ventral rim is approximately the same on both faces. None of the teeth possess any vestige of

accessory cusps or tubercles nor an anterior or posterior cutting edge (carina). The teeth preserved in the two mandibles show no evidence of lateral occlusal wear.

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

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

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

Mandibles

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

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

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

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

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

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

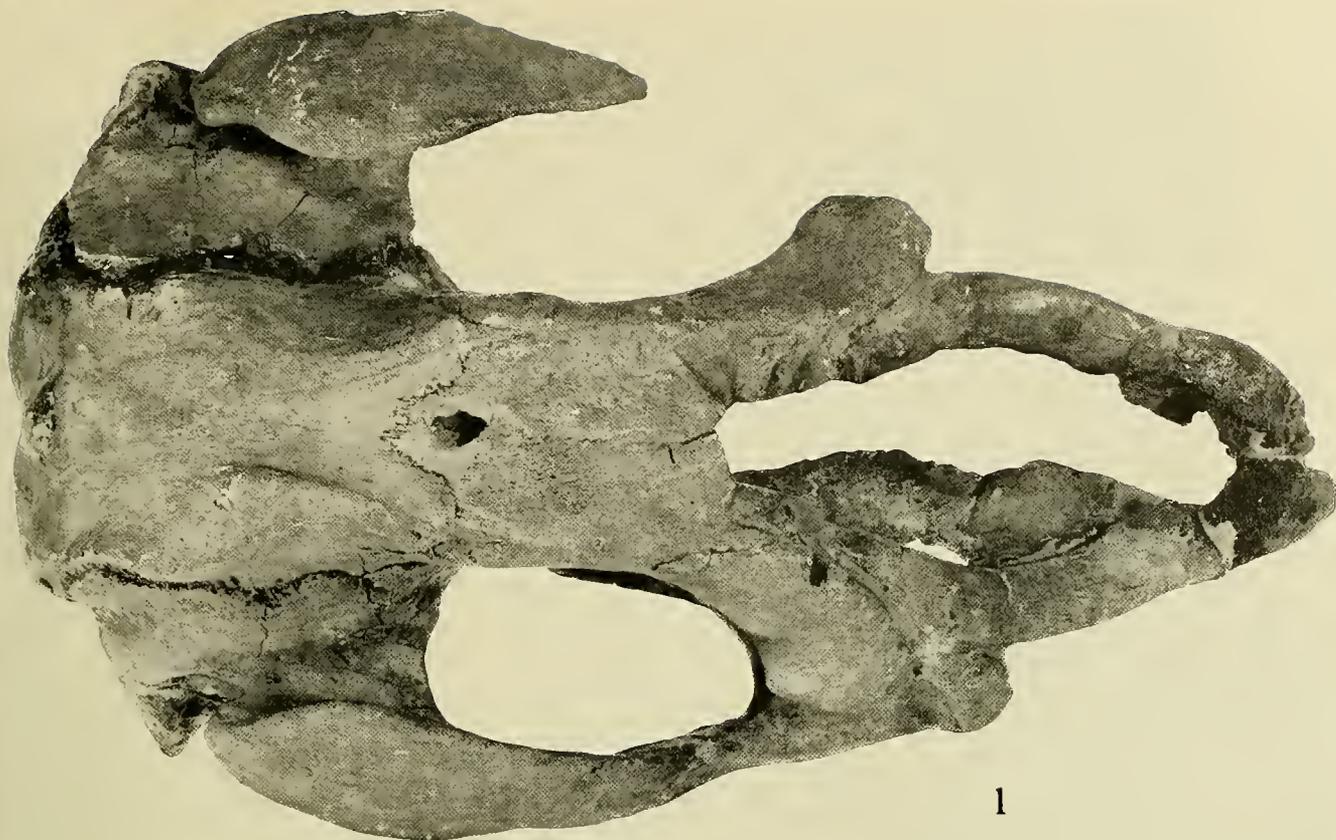
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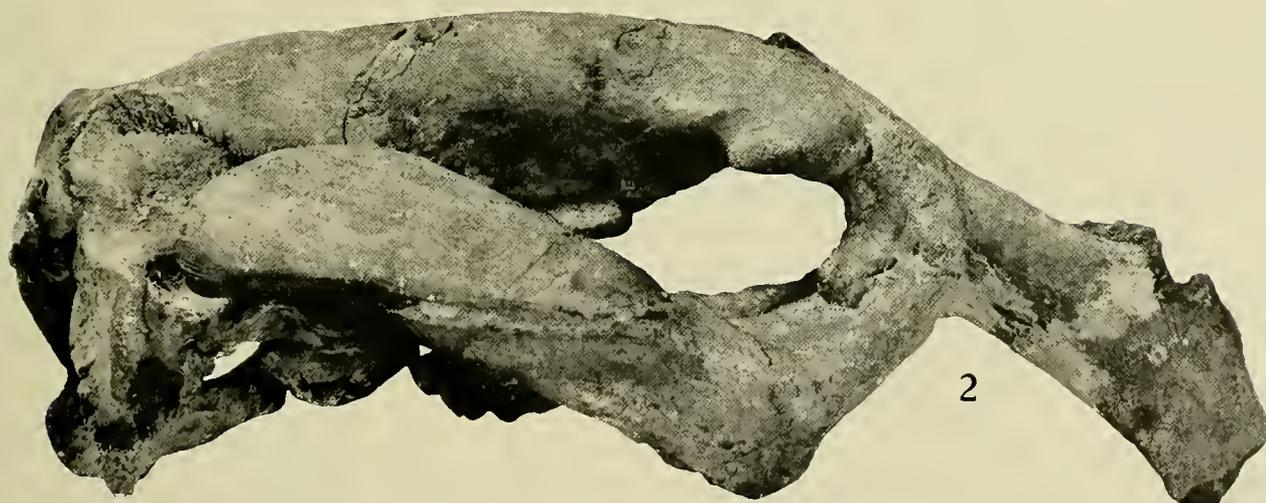
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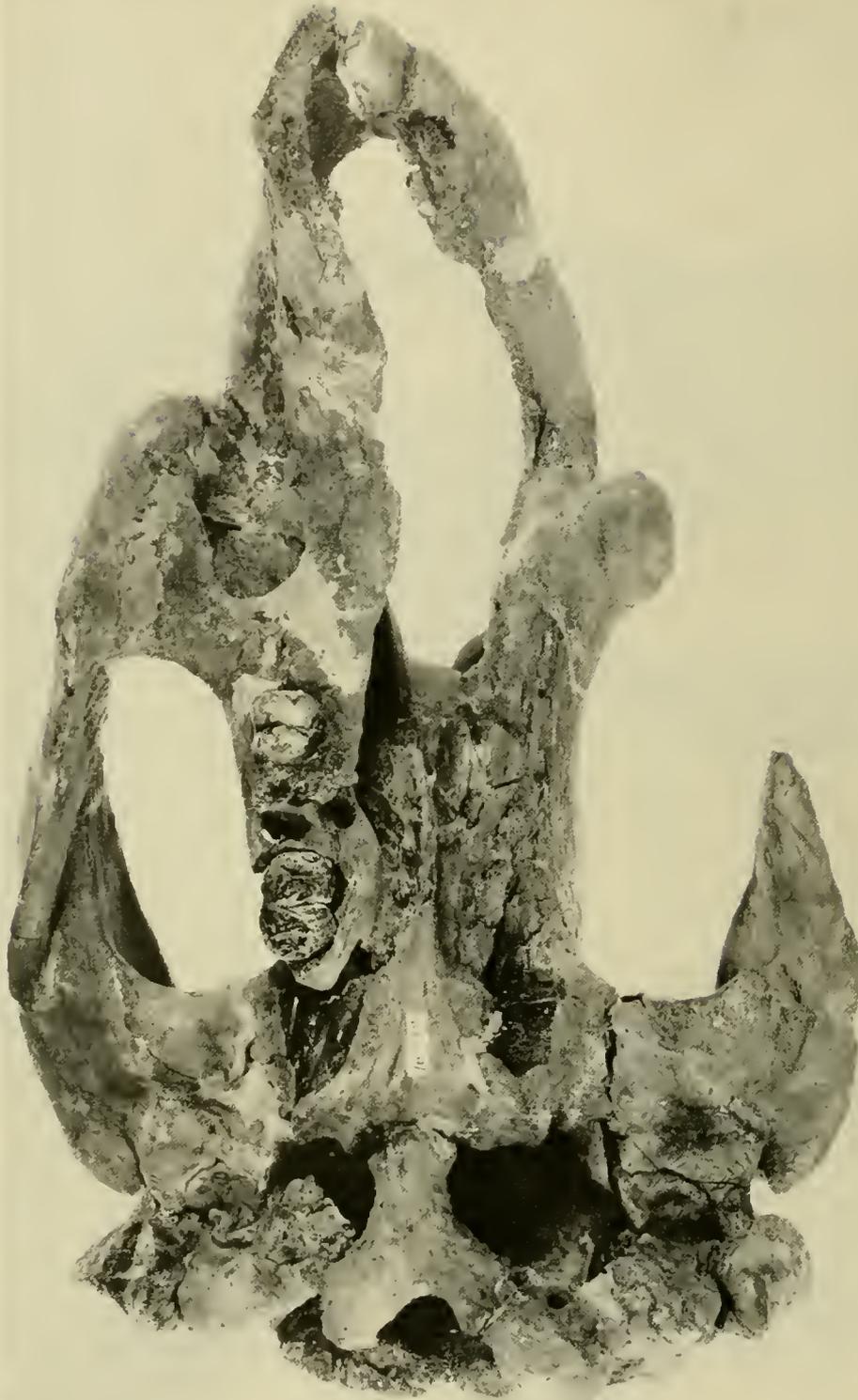
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SKULL, USNM 16757, *METAXYTHERIUM CALVERTENSE*

1, Dorsal view; 2, lateral view.



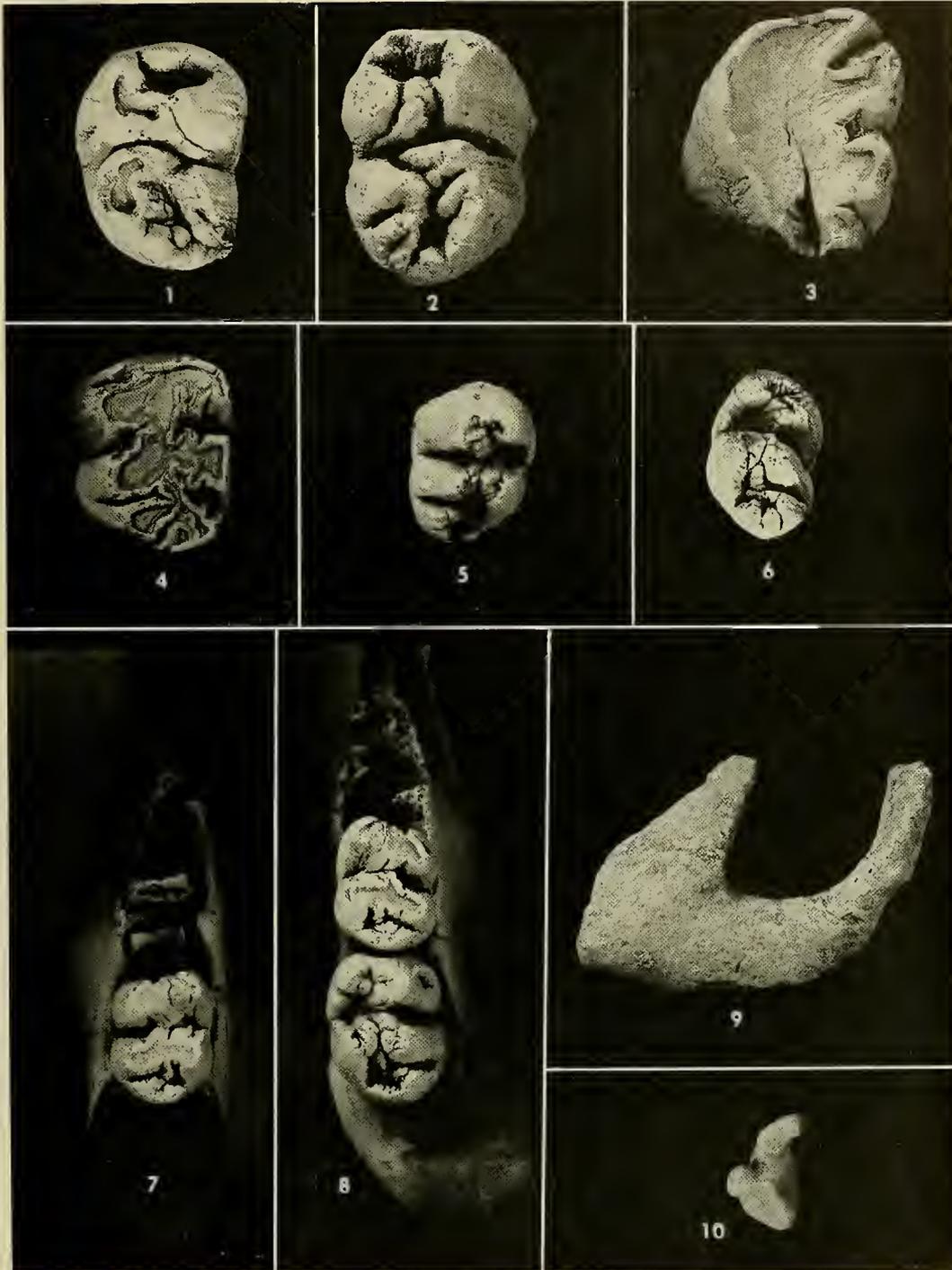
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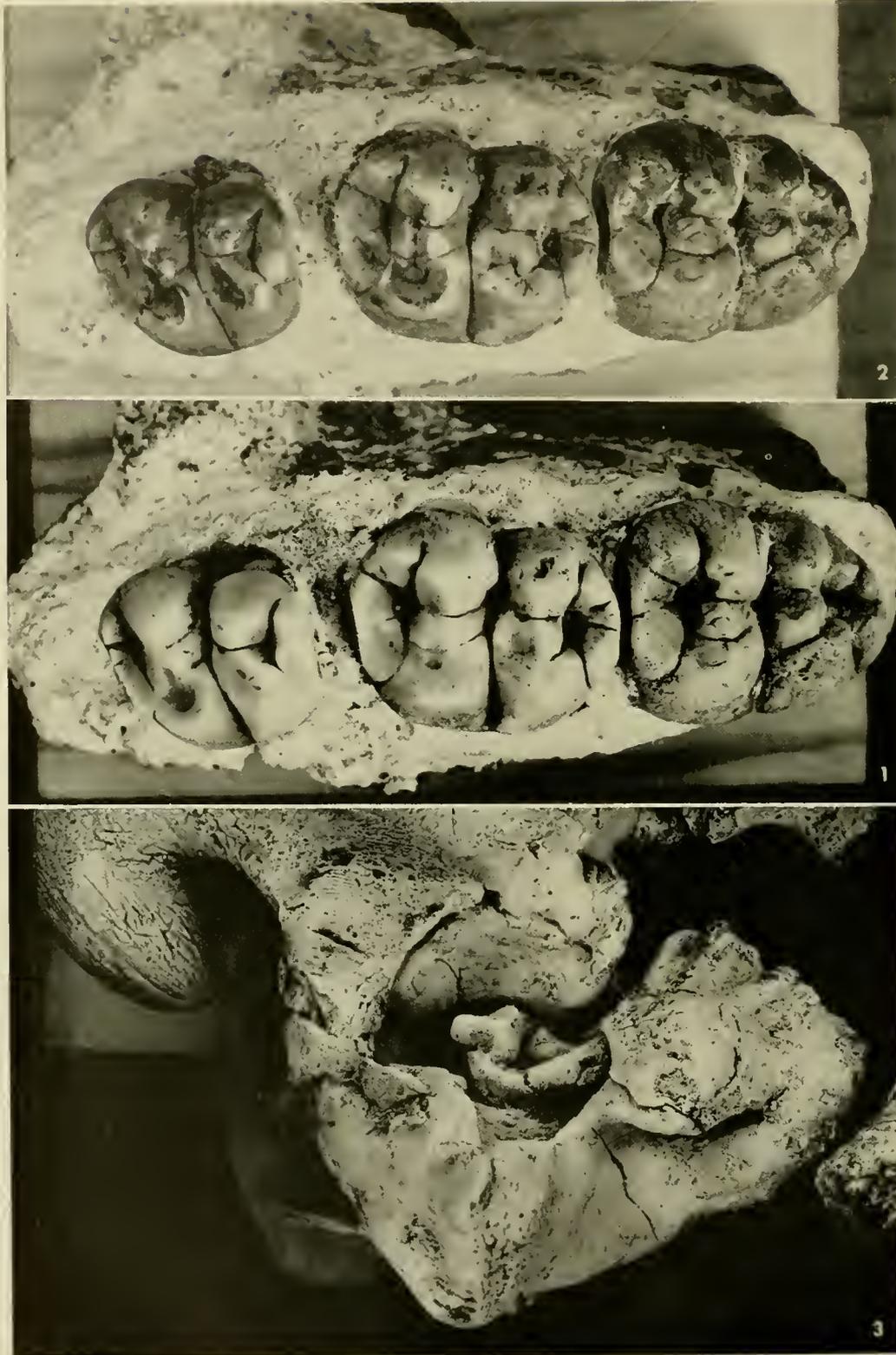
SKULL, USNM 16757, *METAXYTHERIUM CALVERTENSE*

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



METAXYTHERIUM CALVERTENSE

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



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



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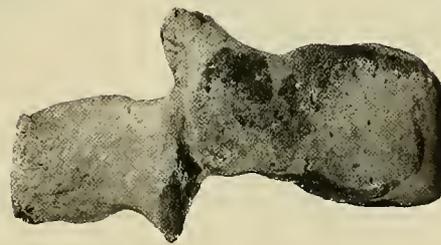
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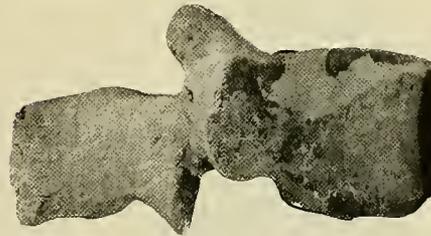
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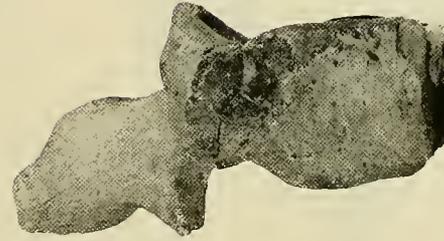
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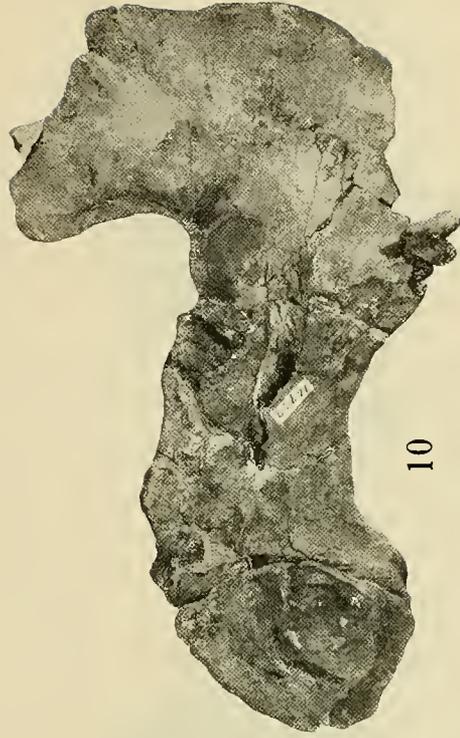
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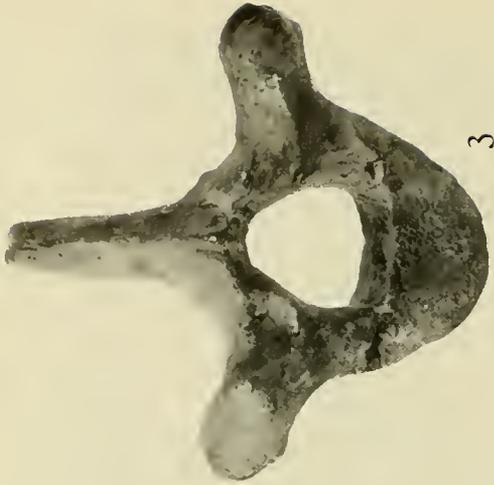
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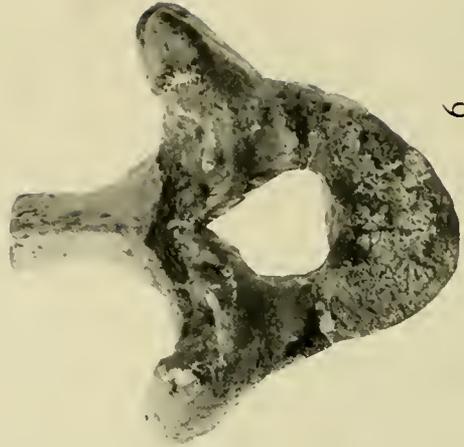
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USNM 16757, METAXYATHERIUM CALVERTENSE

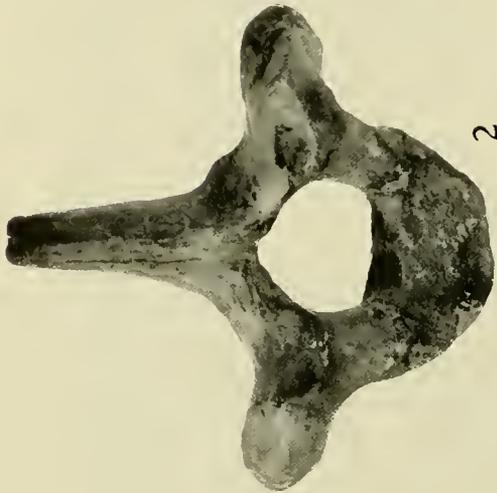
Dorsal vertebrae, lateral views: 1, first dorsal; 2, second dorsal; 3, third dorsal; 4, fourth dorsal; 5, fifth dorsal; 6, sixth dorsal; 7, thirteenth dorsal; 8, fifteenth dorsal; 9, sixteenth dorsal. Right mandible: 10, internal view, showing capsule for molar.



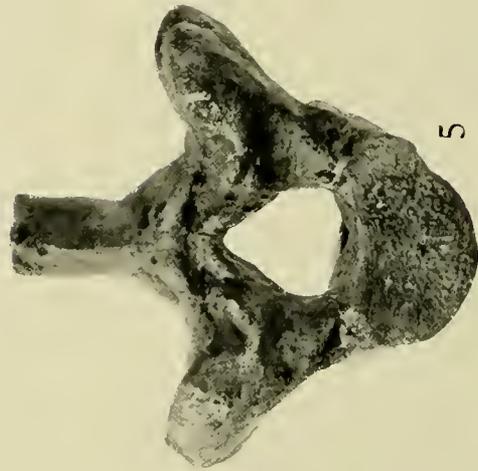
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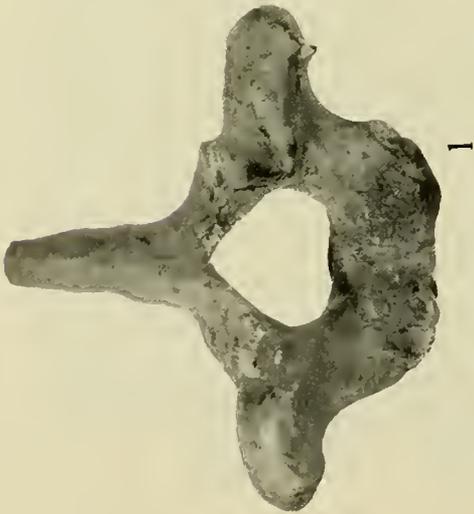
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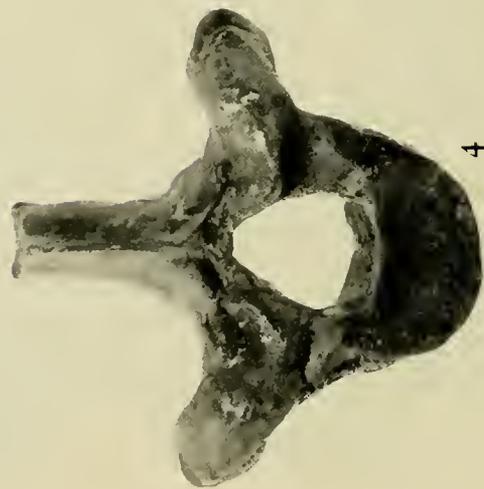
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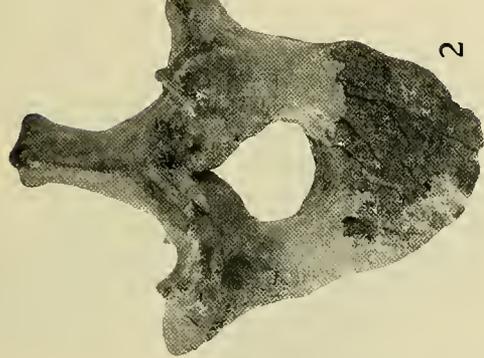
4

DORSAL VERTEBRAE, USNM 16757. METAXYTHERIUM CALVERTENSE

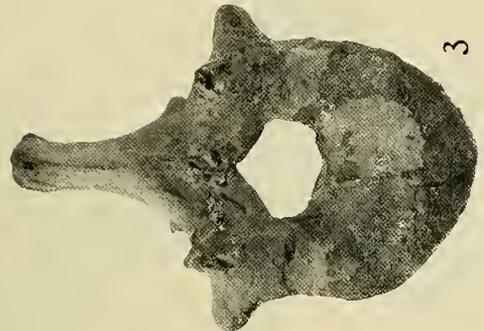
Anterior views: 1, first dorsal; 2, second dorsal; 3, third dorsal; 4, fourth dorsal; 5, fifth dorsal; 6, sixth dorsal.



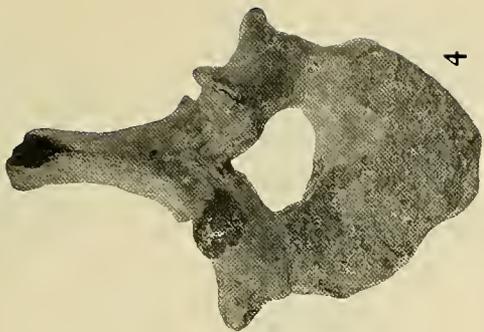
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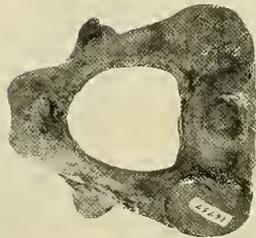
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4



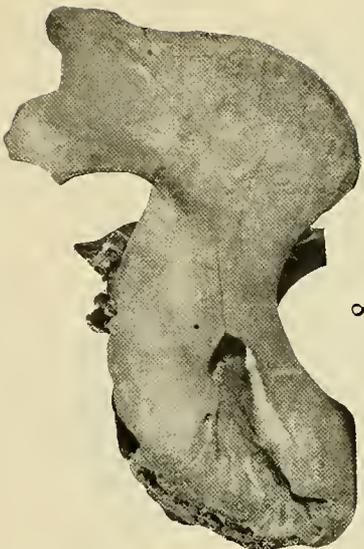
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6



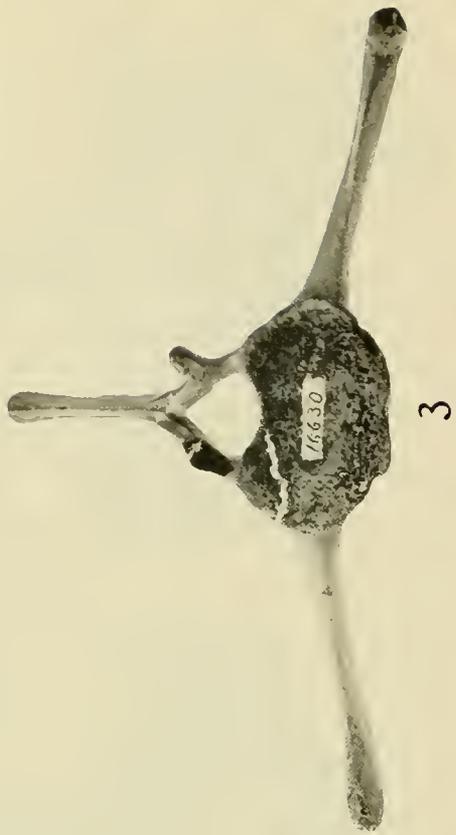
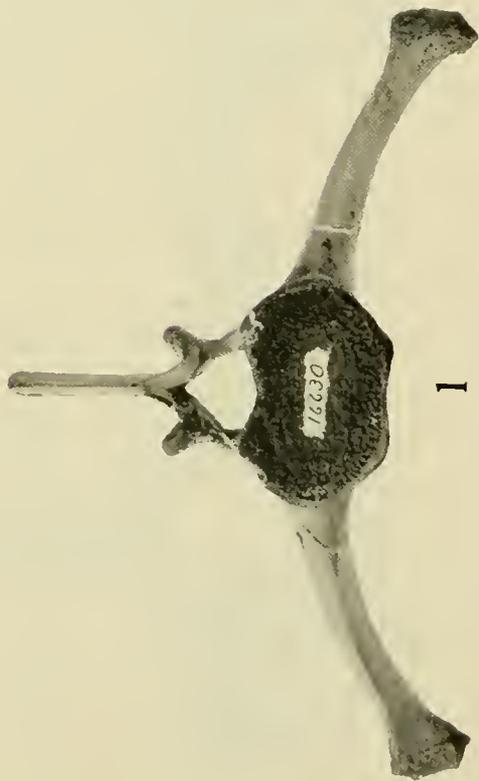
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8

DORSAL AND CERVICAL VERTEBRAE, USNM 16757, METAXYATHERIUM CALVERTENSE

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



LUMBAR AND SACRAL VERTEBRAE, USNM 16630, METAXYTHERIUM CALVERTENSE
1, Sacral vertebra, anterior view; 2, sacral vertebra, dorsal view; 3, lumbar vertebra, anterior view; 4, lumbar vertebra, dorsal view.



1



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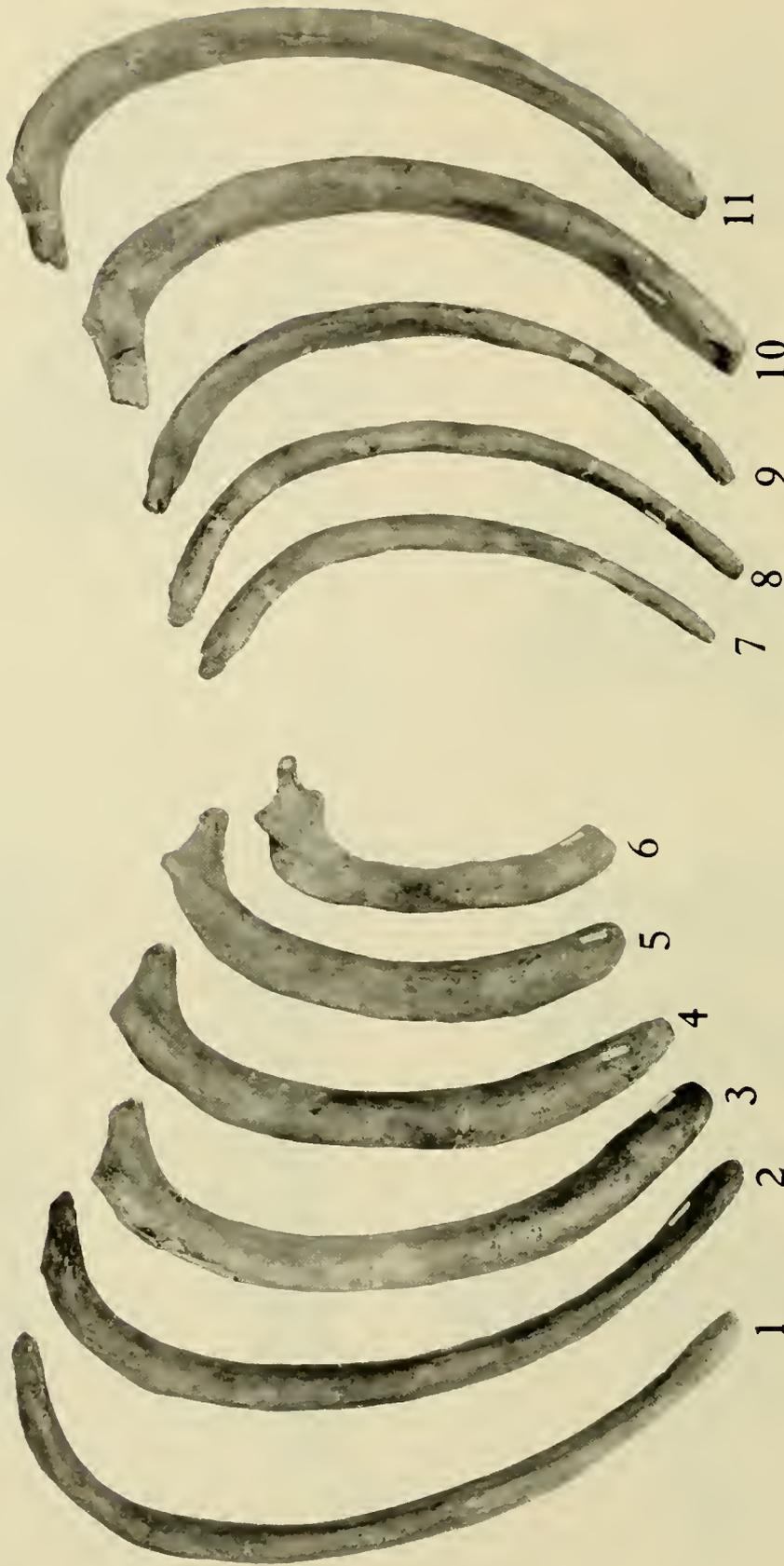
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7

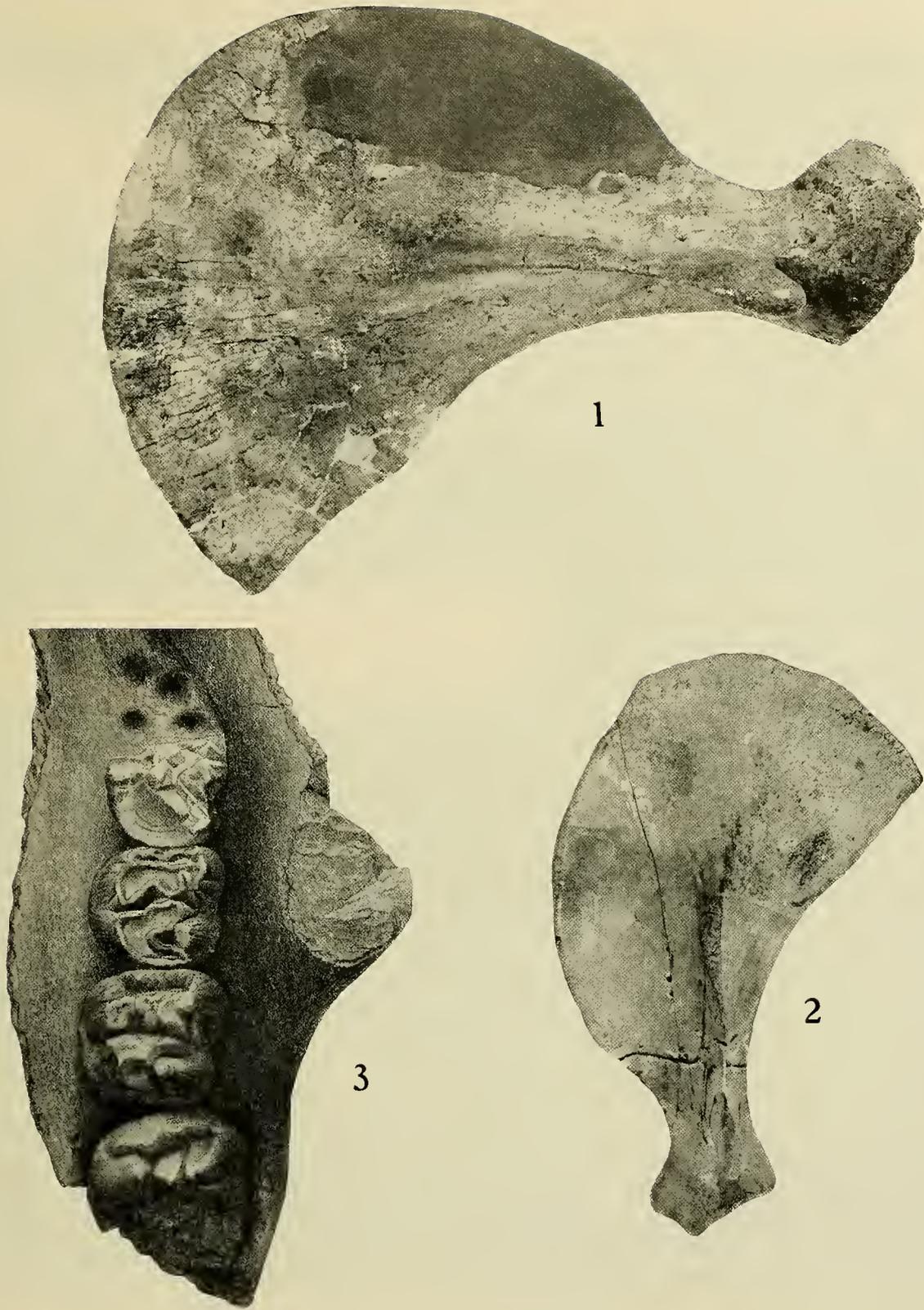
LIMB BONES, PELVIS AND STERNUM, METAXYTHERIUM CALVERTENSE

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



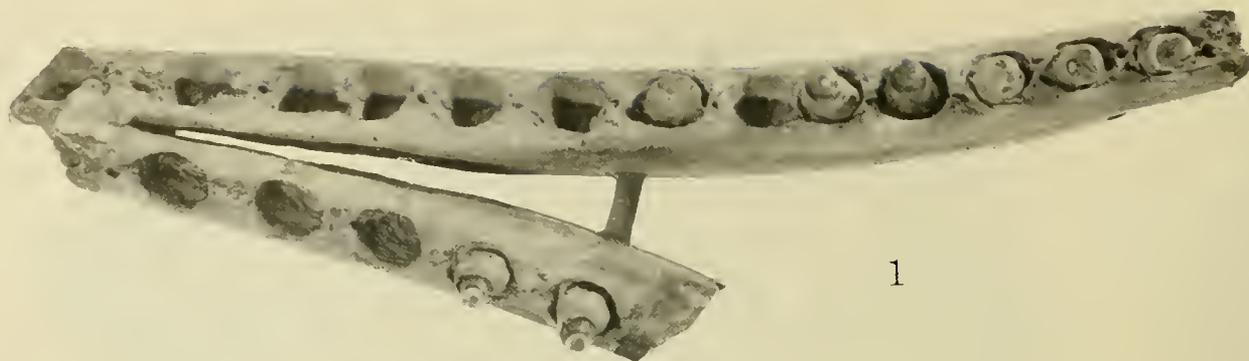
RIBS. USNM 16757. METAXYTHERIUM CALVERTENSE

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



SCAPULAE AND CHEEK TEETH

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



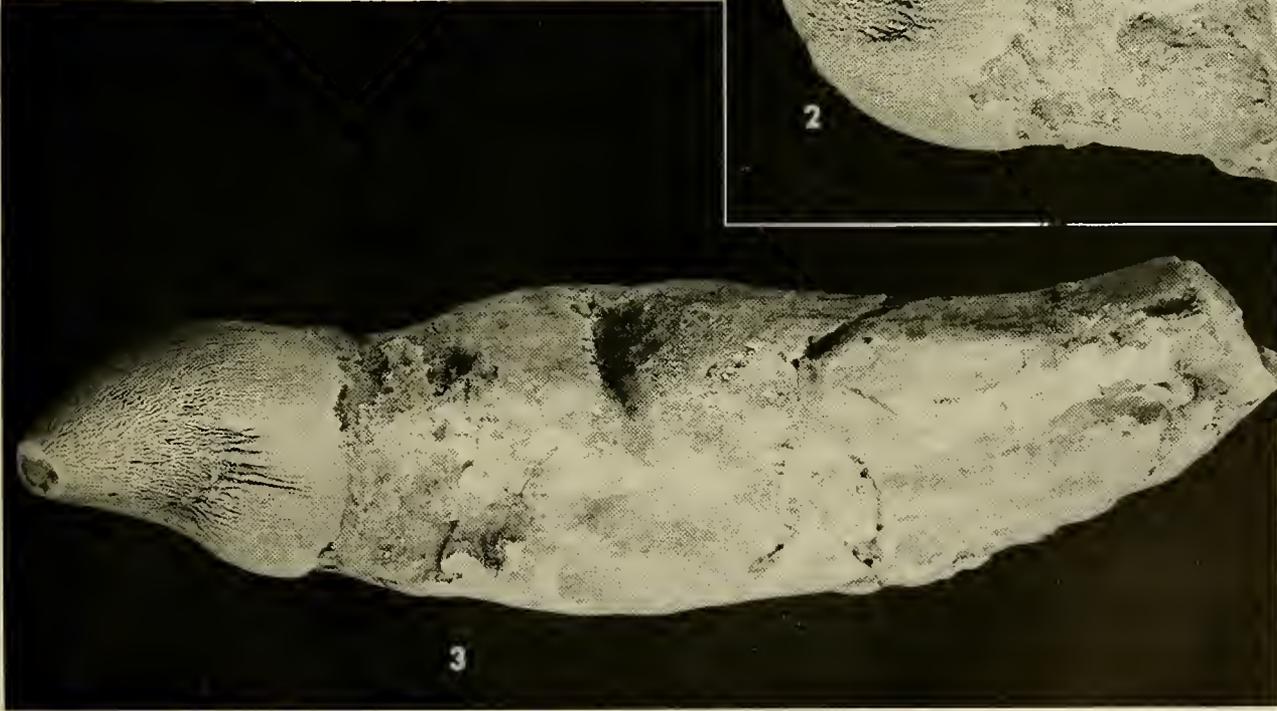
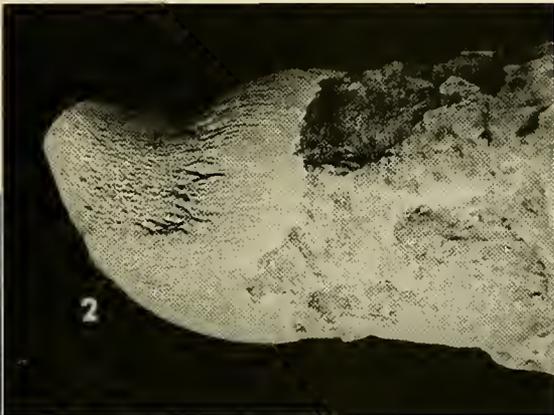
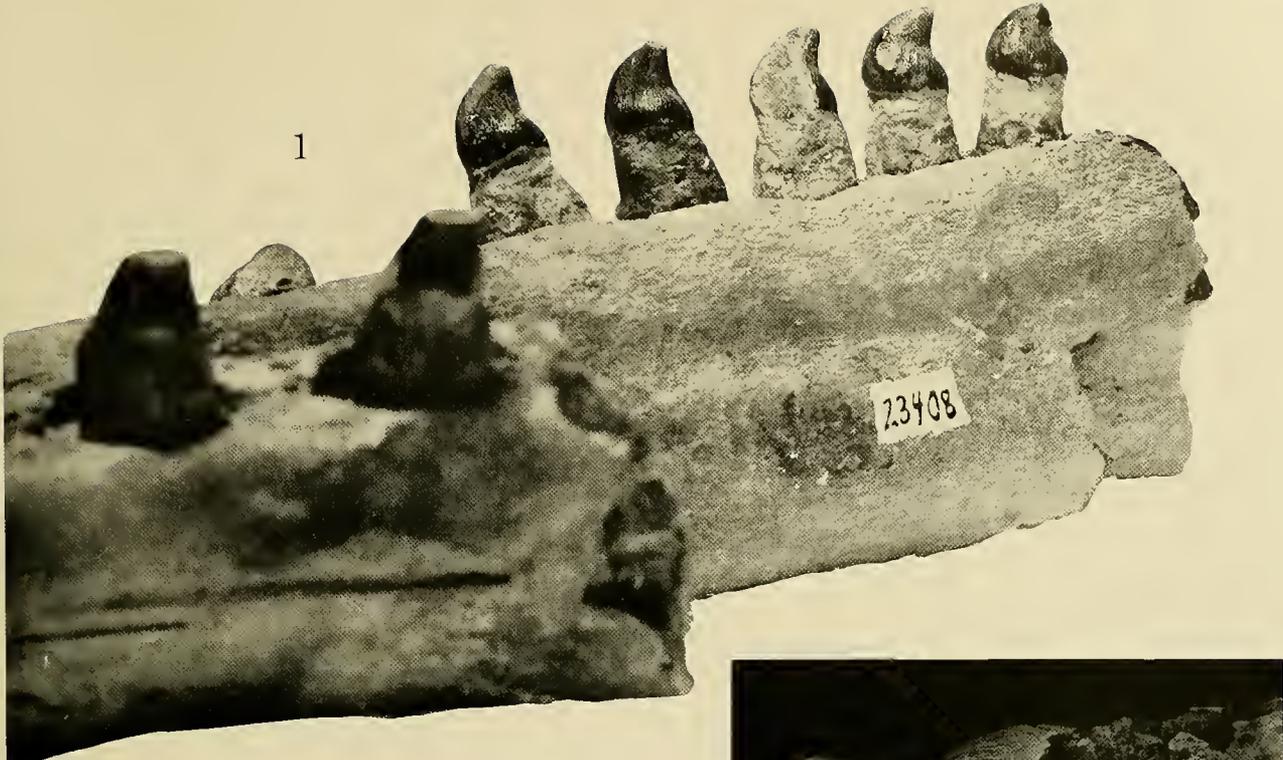
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2

MANDIBLES, USNM 23408, HADRODELPHIS CALVERTENSE

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



POSTERIOR MANDIBULAR TEETH, USNM 23408, HADRODELPHIS CALVERTENSE

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