A CONTRIBUTION TO THE KNOWLEDGE OF THE EXTINCT SIRENIAN DESMOSTYLUS HESPERUS MARSH.

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The genus *Desmostylus* has been the subject of a number of papers and its position among the mammals a matter of some dispute. The genus was described by Marsh in 1888.[1] Exactly what parts of the animal Marsh had at his disposal the writer does not know. There were some teeth or parts of them; and a lumbar vertebra is mentioned as being one of the best preserved specimens. His figures are views of a part of one tooth. The materials had been found in Alameda County, California; and, according to Marsh's knowledge, had been associated with a morotherium, a mastodon, a camel, and one or more extinct species of horses. All these were regarded by Marsh as indicating the Pliocene age of the animal. He referred the genus *Desmostylus* to the Sirenia.

In 1891 Flower and Lydekker[2] mentioned the genus and referred it to the Halicoridæ. The next discussion of the genus appears to have been that of Prof. H. F. Osborn,[3] in 1902. Osborn's remarks were occasioned by a paper published by Yoshiwara and Iwasaki.[4] This last mentioned paper will be frequently referred to in the present article. In Osborn's communication there was incorporated a note sent him by Prof. John C. Merriam, of the University of California, in which the latter discussed the geographical range of the genus. He informs us that besides the specimens of teeth in Marsh's hands there were others known to him. One of these had been found in "Canores Cañon, in the foothills of the west side of the lower end of the San Joaquin Valley." Another tooth, in the museum of the California Academy of Science, was of unknown origin. A third was in the hands of the late Professor Condon of the University of Oregon and had been picked up on the beach of Yaquina Bay, Oregon. Merriam stated that the Californian specimen appeared to have come

[1] Amer. Journ. Sci., ser. 3, vol. 35, pp. 94-96, figs. 1-3.
[2] Mammals, living and extinct, p. 223.
[3] Science, n. s., vol. 16, pp. 713, 714.
[4] Journ. College Science, Imp. Univ. Tokyo, vol. 16, art. 6, pp. 1-13, pls. 1-3, 4 text figs.

from fresh-water beds of late Tertiary or Quaternary age. None of these materials threw any additional light on the nature of the animal which was going under the name of *Desmostylus*.

Yoshiwara and Iwasaki, in the paper cited, described a part of a skull of an animal whose relationships were not definitely determined by them and to which they gave no generic or specific name. However, they concluded that the animal was a proboscidean, but they also recognized its sirenian relationships. The specimen presented the front end of the skull from the snout to the rear of the upper maxillae and the lower jaw from the front to a point below the orbit. The length of the specimen was 550 mm., about 21.6 inches. It presented a number of teeth; and these, in the paper published, were beautifully figured. On the publication of this paper both Osborn and Merriam recognized that the animal belonged to Marsh's genus *Desmostylus;* and this recognition led to the communication made by Osborn to Science in which Merriam's note is contained.

In 1906 Merriam [1] published a paper on the subject, in which he noted two additional finds of teeth of *Desmostylus*. One specimen had been obtained at La Panza, San Luis Obispo County, California; the second lot, near Santa Ana, Orange County, in the same State. Both lots occurred in marine shales of Miocene age. Thus the animal had been found in three cases in marine deposits of Miocene times, once at Yaquina Bay, Oregon, and in two places in the southern half of California. This sufficed to prove that there was some error in Marsh's statement that the *Desmostylus* teeth had been found associated with extinct horses, camels, and edentates. The error may have arisen on the part of the collector of Marsh's materials.

In 1911 Merriam published additional notes on *Desmostylus*.[2] In this paper he showed that Marsh's type had not been found in Alameda County, but in Contra Costa. Merriam regards the genus as belonging to the lower Miocene.

In April of the present year I received from Mrs. Ellen Condon McCornack, of Eugene, Oregon, a letter in which she informed me that Mr. J. G. Crawford, of Albany, Oregon, had in his possession a skull which she believed to belong to some sirenian. Mrs. McCornack enclosed photographs of this specimen and likewise a sketch of a tooth which is in the University of Oregon. This is quite certainly the tooth which is mentioned by Merriam as having been in the possession of Professor Condon. Mrs. McCornack is the daughter of Professor Condon and takes great interest in the subjects which occupied the attention of her father.

As a result of negotiations with Mr. Crawford the skull, together with a tooth of probably another individual and two cetacean ver-

[1] Science, vol. 24, pp. 151-152.

[2] Bull. Dept. Geol. Univ. Calif., vol. 6, pp. 403-412, figs. 1-11.

tebrae, was purchased for the United States National Museum. It has the catalogue number 8181.

This skull, according to information furnished by Mr. Crawford, was found in Miocene shales at the mouth of Spencer Creek, which flows into Yaquina Bay. From Mrs. McCornack I learn that it was about eight miles farther south that was found the fossil seal, *Desmatophoca oregonensis,* which was described by Professor Condon [1] in 1906. Mr. Crawford found the skull yet enclosed in the rock on the beach, with the palatal surface upward and washed by the waves; and he chiseled it out with some of the matrix adhering. This matrix is exceedingly hard and it adhered closely to the bone; and with difficulty it has been removed since the skull was brought to the United States National Museum. The skull was found in the year 1907.

The skull has suffered some injuries. The lower jaw is gone. The snout is missing nearly as far back as the rear of the external nares; and just behind this opening some bone is missing as a result of a transverse fracture. A part of the occipital crest is missing on one side. The crowns of all the teeth which had been in use are broken off. Other slight injuries occur here and there. It is evident that the skull belonged to Marsh's species *Desmostylus hesperus* and that the Japanese skull already mentioned belonged to a closely related species. The two skulls in many ways supplement each other. The Japanese skull was nearly twice as large as the Oregon specimen.

The following measurements have been determined:

Measurements of skull of Desmostylus hesperus, in millimeters.

Extreme length of skull, as preserved	310
Basilar length, about	360
From front of foramen magnum to rear of hard palate	110
From front of foramen magnum to palato-maxillary suture	175
From front of foramen magnum to front of basisphenoid	55
From outside to outside of occipital condyles	109
Foramen magnum, width from side to side	42
Foramen magnum, height of	27
Width of skull from outside to outside of mastoids	190
Width of skull on zygomatic arch, just over ear cavity	194
Width of supraoccipital bone	128
Width of brain case at center of squamosals	123
Length of parietal bone on midline	55
Greatest length of parietal	140
Width of parietal at hinder end	132
Distance between anterior processes of parietal	76
Length of suture between the frontals	106
From rear of frontals to line joining their front ends	150
Length of suture between the nasals, about	100
From outside to outside of nasals	30
Distance across skull at supraorbital processes	111
Width of skull at constriction behind orbits	80

[1] Condon, Univ. Oregon Bull., vol. 3, No. 3; Wortman, Science, vol. 24, p. 89.

Width of skull across zygomatic arches, at front of the glenoid fossæ	210
Width of skull at front of zygomatic processes of the temporal bone	190
From front of one orbit to front of the other	93
Width of snout at the rear of the nasal opening	77
Width of hinder nares	54
Width of palate between second molars	65
Width of palate between front premolars	68

It seems best, first of all, to compare briefly *Desmostylus* with other sirenians. From all existing forms it differs in having the snout little bent down on the axis of the cranium (pl. 58; fig. 1). Yoshiwara and Iwasaki state that in their specimen the jaws showed no trace of a downward curvature, but one has only to view their plate 2 to see that there is a downward flexure of the face about halfway between the tip of the snout and the orbit. However, in Owen's *Prorastomus*, from the Eocene of Jamaica, the jaws appear not to have been bent at all downward. In *Desmostylus* the flexure so commonly found in sirenians is just beginning to manifest itself. It appears to be somewhat more strongly developed in *D. hesperus* than in the Japanese form. Another feature of *Desmostylus* which distinguishes it from most of its kindred is the small size and the anterior position of the external narial opening. This is about the size of the orbit, and has its anterior border a short distance behind the front of the jaw and far in advance of the orbits. In a specimen of manatee from Demarara River it begins quite as far in front, but it extends far behind the orbit and is equal to nearly one-half of the length of the skull. In *Prorastomus* the nostril is about the size of the orbit, but its rear comes nearly to the front of the latter. In the Eocene sirenians of Egypt, *Eotherium* and *Eosiren*, as described and figured by Andrews,[1] the external nasal opening is rather large and extends back to or beyond the front of the orbit.

In *Desmostylus* the nasals are less reduced than in other known sirenians (pl. 56). The brain case is less compressed than in most sirenians and there are very feebly developed temporal ridges. Something like this condition seems to be found in *Eotherium*.[1] The teeth of *Desmostylus* differ greatly from those of other Sirenia. In the lower jaw there are two pairs of tusks.[2] The molars consist of a varying number of closely appressed columns which spring from the base of the crown.

In all the ways mentioned in which this skull differs from that of other described sirenians, except the teeth, it is more primitive than the hitherto described forms, except probably *Prorastomus*. Evidently the animal will enter none of the families hitherto proposed. A separate family must be constituted for it, and naturally it must take the name

[1] Andrews, Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt, p. 206.

[2] Yoshiwara and Iwasaki, Journ. College Scien., Imp. Univ. Tokyo, vol. 16, p. 5.

DESMOSTYLIDAE, new family.

Diagnosis of family.—Snout and lower jaw elongate and only slightly bent downward. Nasal opening small and far in advance of the orbits. Brain case more inflated behind and not compressed in front, and the temporal ridges feebly developed. Upper jaw with one pair of possibly latent tusks; lower jaw with two pairs of horizontal protruding tusks. Molars high crowned, composed of two longitudinal rows of appressed columns, with sometimes one or more intercalated columns.

The only genus at present known to belong to the family is *Desmostylus*, the diagnosis of which must be the same as that of the family, as above given. To this genus belongs the type *Desmostylus hesperus* Marsh, here to be described, and the Japanese species to be named below.

As will be seen from the illustrations (pls. 56–58), the skull is elongate, the snout rather narrow and prolonged, but truncated in front. The undulating surface of the occiput makes slightly less than a right angle with the axis of the skull. Along the midline, beginning behind, the surface is convex over the brain case, concave behind the orbits, then again convex to the descending snout. Viewed from above there appears in front of the orbits no such sudden contraction in width as is seen in *Trichechus* and *Halicore*. On the left side the contraction seems to be more abrupt because of the lack of some bone. According to Andrews' figures, the contraction in the width is abrupt and considerable in *Eosiren;* while in *Eotherium*, although the reduction in width is less sudden, it continues nearly to the front of the snout. Apparently the center of the orbit in *Desmostylus* is very nearly halfway from the occipital crest to the front of the snout. This was the position of the orbit in *Prorastomus* and apparently also in *Eotherium*, both belonging to the Eocene.

The supraoccipital (pl. 58, fig. 2) joins the exoccipitals below and the parietal above. Its outer angles barely come into contact with the squamosal. In the lower half of the midline of the supraoccipital there is a shallow groove; in the upper half a slight ridge, which upwardly expands into the occipital crest. This crest is formed principally by the supraoccipital as far as the latter extends. On each side of the ascending ridge the bone is slightly excavated. It does not enter into the boundary of the foramen magnum.

The exoccipitals and the basisphenoid form a single mass. The suture in front of the latter is yet open. The exoccipitals meet above the foramen magnum a distance of 12 mm. The occipital condyles are sessile. The foramen is wider than high and is notched neither above nor below. Laterally, the exoccipital comes into contact with the upper hinder angle of the squamosal for a distance of 28 mm.; below this it joins the mastoid portion of the petrosal bone apparently to the lower end of the paroccipital process. These processes probably extended down to the level of the lower surface of the occipital condyles; but the latter are slightly eroded, the former considerably. From the paroccipital process a strong ridge extends forward and joins the petrosal ridge; while higher up, in front of the mastoid, the base of the paroccipital process joins for a short distance the squamosal. In front of each of the condyles is a large condylar foramen. From the mesial border of one of these to that of the other, across the basioccipital, is a distance of 60 mm. The width of the anterior end of this bone is 47 mm. The bone is nearly flat on its lower surface. In each upper outer angle of the exoccipital is a deep depression, quite certainly a foramen; but the matrix has not been removed entirely. The height of the rear of the skull from the upper lip of the foramen magnum is 100 mm.; from the lower lip, 122 mm.

The parietal (pls. 56, 58) is a large bone which has many of the characteristics of that of *Trichechus*, but it is more extended fore and aft. Along the midline there are on the surface many fine twisted lines and grooves which suggest that a median suture had only recently closed.

Weber[1] in speaking of the sirenians states that the parietals are united in a sagittal suture, but in a skull of *Trichechus* and one of *Halicore* at hand there are seen no traces of this suture. It is present in skulls of *Hydrodamalis* (*Rhytina*). On each side, the parietal sends forward a narrow process which reaches nearly to the rear of the orbit. In the wide notch between these is received the hinder ends of the frontals. In both *Trichechus* and *Halicore* the parietal sends down a process which joins the alisphenoid. These bones join likewise in *Eotherium*. In *Desmostylus* the two bones are well separated by a process of the frontal, which extends backward and joins the squamosal. On each side of the parietal, about 20 mm. from the midline, is a low temporal ridge. From side to side the parietal is arched, although slightly flattened between the ridges just mentioned.

Each squamosal is a large bone which contributes to the formation of the side walls of the brain-case, partly incloses the auditory organ, forms a surface for the articulation of the lower jaw, and sends a great process forward to assist in forming the zygomatic arch. The suture formed with the parietal is 100 mm. long. The lower hinder angle forms a rough post-tympanic process, which joins the mastoid portion of the otic. The zygomatic process extends forward to a point 160 mm. in front of the rear of the squamosal, where it joins the malar. Unlike that of *Trichechus* and *Halicore*,

[1] Die Säugetiere, p. 792.

this process extends backward on its upper edge to the outer end of the occipital ridge. The lower border of the process extends backward and inward to the bulla-like tympanic ridge. Between these two borders, or roots, of the zygomatic process is a large tympanic cavity. At the front of this cavity the process is 33 mm. high; at the rear of the malar bone, two-thirds of the length from the rear, it is 53 mm. high and 14 mm. thick. The glenoid fossa is quite different from that of either *Trichechus* or *Halicore*. In these genera the articular surface for the lower jaw is elevated (as seen with the palatal surface held upward) above the surrounding bone. In *Trichechus*, especially, there is a deep transverse groove behind this surface, and behind the groove is a ridge. In *Desmostylus* the articulatory surface is flat and on a level with the rest of the bone. It measures 39 mm. from side to side; 22 mm. from front to rear.

The auditory organ is very different from that seen in *Trichechus* and *Halicore*. In the former there is an oval opening 74 mm. wide and 53 mm. long between the exoccipital and the alisphenoid, and this is occupied mostly by the otic bones. It is smaller in *Halicore*, but still large. In *Desmostylus* what corresponds to the same opening extends obliquely forward and inward a distance of about 60 mm. and fore and aft about 20 mm. Included in this opening is, outwardly, what is probably the stylomastoid foramen; mesially, the foramen lacerum posterius. In front of these openings, running obliquely forward and inward, is a ridge 50 mm. long, about 12 mm. high, and 7 mm. thick at the base. It is wedged in between the glenoid fossa and a part of the alisphenoid in front and the exoccipital behind. It evidently corresponds to the tympanic bulla of the ox. In the deep tympanic cavity the tympanic ring is probably not ankylosed to the surrounding bones, but the sutures can not be distinguished.

In *Trichechus* and *Halicore* there is a cleft between the exoccipital and the squamosal which is partly filled up by the mastoid portion of the petrous bone. In *Desmostylus* the mastoid portion is relatively much larger and forms a prominent portion of the hinder lower angle of the skull. Seen from behind it forms a strip of bone 60 mm. or more high and 28 mm. wide, tightly wedged in between the paroccipital and post-tympanic processes. Seen from below it passes between the processes nearly to the stylomastoid foramen. In a young musk-ox I find a very similarly disposed mastoid, but it is only 55 mm. high and 11 mm. wide.

As already stated the alisphenoid does not come into contact with the parietal. The pterygoid processes are feeble in comparison with those of *Trichechus*. They are thin—about 8 mm. or 10 mm. thick, and they descend from the level of the basisphenoid only about 20 mm. In a skull of *Trichechus* they descend a distance of about 44 mm. and are 18 mm. thick. Near the hinder border of the bone is seen the foramen ovale. Just behind this the alisphenoid sends backward a splint of bone against the front of the bulla-like ridge, much as is seen in the skull of a cow at hand. Anteriorly the alisphenoid joins the frontal above and the maxilla and the palatine below. The suture with the maxilla appears to be hidden in a deep fold behind the capsule of the hindermost tooth; and in this fold, too, are concealed the optic and other foramina.

The palatines are more extensively developed than in *Trichechus* and *Halicore*. They resemble the same bones in *Eotherium*. They extend forward to a line joining the front ends of the penultimate molars. Here, taken together, they have a width of 30 mm. Posteriorly the bones widen, so that at the front of the hinder nares they are 60 mm. wide, while at the middle of the mesopterygoid fossa the distance between their outer borders is 70 mm. As seen when the skull is turned with the palate upward, the hinder branches of the palatines overlap and conceal the edges of the pterygoid processes of the alisphenoid, extending backward nearly to the rear of the basisphenoid. The suture between the palatines and the maxillae are smooth and straight laterally, but in front they are very jagged.

On account of the advanced position of the external nares, the frontal bones are more normally developed than in probably any other sirenian. From their rear to a line joining their anterior ends is a distance of 148 mm. Posteriorly they fit into a broad notch between the parietals; in front they form a notch for the rear ends of the nasals. Their greatest breadth is at the supraorbital process, and here it is 110 mm. At this place they overlap the lachrymals. The hinder ends of the processes which join the squamosals are 97 mm. apart. These processes are 21 mm. wide and extend backward from their divergence from the body of the bone a distance of 37 mm. The lower border of each process joins the alisphenoid of its side, and the suture can be followed forward until it disappears in the fold between the capsule of the last molar and the body of the frontal. The anterior end of each frontal is truncated.

The nasals have the anterior end injured, but there is no reason to suppose that they terminate in front in any way different from that seen in Yoshiwara and Iwasaki's specimen. Quite certainly they ended in front in a sharp point a few millimeters behind the nasal opening. The length of each was close to 100 mm., the greatest width of the two combined is 30 mm. Posteriorly they are enclosed in a notch between the frontals; laterally they unite with the maxillae for a distance of 16 mm.; and for the rest of their length with the premaxillae. The relations of these bones are not greatly different from those of an ox, except that they do not come into contact with the lachrymals.

The lachrymal (pls. 56, 58, 7) is a very considerable bone in *Desmostylus*. It does not appear on the face, as in the Ungulata, but it forms the inner wall and the roof of the orbit. The position is as in the elephant, but the bone is far more developed than in the elephant. The sutures bounding its hinder half are not as distinct as desirable, but the length from the front to the rear is at least 50 mm. Over the orbit it forms the supraorbital process, but it is here covered over by the frontal. In the specimen described the frontal on the right side has been split off from the process so as to expose the part belonging to the lachrymal. This bone does not come into contact with the suborbital process of the malar, as it does in *Halicore*, but there intervenes between them a narrow strip of the maxilla. The lachrymal is imperforate.

The maxillae have lost a part of their anterior ends. In Yoshiwara and Iwasaki's figures these bones are represented as coming forward as far as the front of the nasal opening; hence in our specimen probably about 50 mm. of each bone is missing at the side of the snout. On the palatal surface, near the midline, is seen a fragment of the premaxilla and the premaxillo-maxillary suture. From this suture to the hinder end of the maxilla is a distance of 180 mm. In front of the orbit it rises to join the nasal for a distance of about 18 mm. Anteriorly this nasal process joins the premaxilla; posteriorly the frontal and lachrymal. At the front of the orbit the maxilla passes beneath the anterior process of the malar. Just how it ends at the anterior end of the zygomatic arch is not clear, inasmuch as the bone is injured here on both sides. On the underside of the arch, below the rear of the orbit, there appears to have been a downwardly directed process, similar to that which is seen in *Halicore* and *Trichechus*, descending from the lower border of the malar. The dimensions of this process can not be determined exactly, except that here the bone is about 5.5 mm. thick.

Beneath the shelf of bone under the orbit, formed by the malar and the maxilla, the bone is conspicuously excavated. Vertically the excavation reaches from the side of the snout to the alveolar border of the jaw; fore and aft, from the side of the snout to below the rear of the orbit. In the bottom of this excavation opens the infraorbital foramen. Seen from below, the maxillae meet in the midline by a straight suture along a low ridge; and they extend backward to join the palatines, as has been described. The palate along these bones is concave longitudinally as well as transversely. At the rear, at some distance in front of the palatine suture, is a pair of openings, the post-palatine foramina. The alveolar border on each side is narrow in front, but about half way back to the palatine border it begins to widen, to accommodate the teeth. At the rear this border is bounded inwardly by a strong ridge which articulates with the palatine.

The rear of the maxilla on each side forms a great capsule, in which is enclosed the developing hindermost molar. This protrudes upwardly into the front of the temporal fossa and almost into the rear of the orbit. It has a length of nearly 80 mm., a height of 53 mm., and a width of 48 mm.

The premaxillae are seen on the upper surface of the skull as a pair of lance-like processes, one at each side of the nasal opening, passing backward to become wedged in between the nasal and the ascending process of the maxilla. At the rear of the nasal opening each had a width of 30 mm. For our knowledge of the front part of these bones we must depend on the Japanese authors who have been already referred to. In their specimen the premaxillae formed the tip of the snout and extended back in each side of the nasal opening. From the front of the snout to the front of the nasal opening was a distance of 70 mm., from which fact we may conclude that the distance was about 35 mm. in *Desmostylus hesperus*. The amount missing in our specimen must be close to 75 mm. From the front to the rear of each premaxilla was then about 145 mm.

It is evident from Yoshiwara and Iwasaki's figures that the premaxillae, while retaining their width, thinned out in front to a transverse edge. They could hardly have been armed in front with teeth of any considerable size.

In the Oregon specimen the premaxillo-maxillary suture appears to be preserved on the palatal surface. Near the midline it turns back a distance of 20 mm. and ends at the midline. As the bone is injured at the midline, nothing can be determined regarding the anterior palatine foramina.

As already stated, Marsh based the genus *Demostylus* on teeth. He described them as being composed of a number of vertical columns closely pressed together, and in adult animals firmly united at their bases. He stated that in immature teeth the columns are nearly round and loosely united, but as they increase in size they press together and become more or less polygonal in cross section. These statements appear to be wholly correct. He says further that before being worn they have their summits smooth and convex, but after some use the center of each column presents a rounded elevation, such as is shown in his figure. This appears to be an error. The hindermost tooth of the Oregon specimen had only just come through the bone and had certainly not come into use; but the summits of the columns have exactly the structure described by Marsh (pl. 57, *23*). The three columns which he figured are certainly those of an unworn tooth.

As to the number of columns in each tooth Marsh was uncertain; but he thought that there were indications of at least twelve or fifteen. From what is at present known this conclusion is erroneous.

In none of the teeth figured by Yoshiwara and Iwasaka are there more than ten pillars, and not so many appear in any tooth of the specimen at hand.

As to the number of teeth of each kind we are not yet wholly certain. The Japanese authors were fortunate in having the anterior half of both rami of the lower jaw. On each side of this they found two straight, forwardly directed, tusk-like teeth, which they interpreted as the first and second incisors. The length was believed to be about 200 mm., and the diameter about 31.5 mm. Inasmuch as the lower jaw is missing in the Oregon specimen no comparisons can be made.

In the front part of the upper jaw the Japanese specimen presented, within the somewhat injured maxilla of the left side, a tooth resembling the tusk-like teeth of the lower jaw and, like them, directed forward; but it had not been extruded. The describers concluded that it was an incisor. However, this tooth appears to be inclosed principally in the maxilla, near the premaxillo-maxillary suture, and it is more probable that it was a canine. In *Prorastomus* there were well-developed canines above and below. In the upper jaw of *Eosiren* [1] there was a small canine and apparently small second and third incisors. There was, on each side, in the genus just mentioned, a large first incisor, as there is in *Halicore;* but it was at the end of the snout. In *Halicore* this tooth is wholly in the premaxillary. It seems most probable that the large upper tusk-like tooth of *Desmostylus* is a canine and that in the Japanese specimen it was destined to remain in the jaw, as the great first incisor of the female *Halicore* does. In the upper jaw of our specimen of *Desmostylus*, on the right side, there is present what seems to be the base of the upper tooth supposed to be a canine. All that is present lies behind the suture between the premaxilla and the maxilla, and it is badly eroded. In case the upper tusk-like tooth is a canine, it is probable that the hinder of the lower ones is also a canine. The other one is probably a third incisor, inasmuch as it is far removed from the midline of the front of the jaw.

Yoshiwara and Iwasaki found in the upper jaw, far behind the tusk, a tooth composed of four cylindrical pillars, varying in diameter. This tooth, about 22 mm. long and 24 mm. wide, was regarded by them as the second premolar; and there were reasons for believing that there was another front of it, pm^1?. Inasmuch as these teeth are immediately in front of a molar and there is a great space in front of them which might, in some ancestor at least, have been occupied by premolars, there seems to be little reason for not regarding them as pm^3 and pm^4; unless, indeed, as may have been the

[1] Andrews, Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt, p. 203, pl. 20, fig. 1.

case in *Eotherium*[1] they are pm^4 and pm^5, or pm^5 and pm^6. Since *Desmostylus* is so primitive in other respects, the writer prefers to regard them as pm^3 and pm^4.

In the skull from Oregon there is present the base of a tooth which belongs to the hinder premolar (pl. 57, *21*). It is nearly circular in section, with a transverse diameter of 17 mm. and a longitudinal diameter slightly less. There appears to be no reason for supposing that it had more than a single root, except that the Japanese writers say that the teeth in their specimen were two-rooted in all cases. How many columns there were in this tooth it is impossible to say with certainty; but the appearances are that there were a large one on the inner side, a second large one in front and nearer the outer side, and two smaller ones on the outer side and toward the rear. This could not be greatly different from the tooth regarded by the Japanese authors as pm^2.

With the skull here described there was sent a tooth which probably belonged to another individual (pl. 58, figs. 5, 6). It is composed of four columns of equal size and these had undergone considerable wear. The diameter of the tooth is 20 mm. This tooth has a worn surface on a side of one of its columns where it had been in contact with another tooth. This was certainly on the hinder face of the tooth; and from the form of the tooth I conclude that it belonged on the left side, in case it was an upper tooth. It was probably the hindermost premolar.

Immediately in front of the hinder premolar is a socket for another premolar; as I suppose, for pm^3. This socket is 14 mm. long and 9 mm. wide. There is a corresponding one on the left side. Yoshiwara and Iwasaki found evidence in the wear of a lower tooth that there was a premolar in front of the upper one which they described. Just in front of the socket mentioned there is a little pit, about 3.5 mm. in diameter, from which a small tooth may have fallen before the death of this animal. Between this pit and the object which is supposed to be a canine there is no evidence of the presence of other teeth. For a distance of about 12 mm. in front of the pit mentioned the narrow alveolar border is uninjured, but the remainder has the border broken off.

Behind the supposed pm^4 there is the first molar (pl. 57, *22*). On the left side of the skull this is broken off close to the bone and even this is eroded; on the right side all the columns are broken off not far from their common base. As preserved, the length of the crown is 40 mm. and the width 28 mm.; but by measuring nearer the bone the length is only 35 mm.; the width 25 mm. The length and the width of the complete tooth must have exceeded these figures some-

[1] Andrews, Catalogue of the Tertiary Vertebrata of the Fayûm, Egypt, p. 208.

what. There appear to have been present only five columns, two large ones in front, then two smaller ones in a transverse row, then behind and between these another. It is, however, possible that there was a column in front of and between the two first mentioned. No tooth of those described and figured by Yoshiwara and Iwasaki has the structure of this tooth. The corresponding one of their specimen had three columns in the first transverse row, two columns in each of two succeeding transverse rows, and in the rear a single column. This tooth had a length of 64 mm. and a width of 40 mm. Measured where longest the tooth, according to the authors' figure, had a length of 70 mm.

In the figure of the Japanese specimen there is represented, in the rear of a large bony capsule, portions of three columns of an imperfectly developed tooth which the authors regarded as the second molar. It is evident that this corresponds to the tooth just at the point of eruption in the Oregon skull.

In the latter there were seen originally only the summits of four columns; in front a transverse row of two columns, a second row of two columns, and a single column behind all. Thinking that other columns might be concealed within the jaw, the writer proceeded to dig away a part of the base of the first molar, some bone, and the hard matrix within the cavity. As a result, three more columns were discovered in a transverse anterior row, making in all eight (pl. 57. *23*). Therefore this second molar agrees in structure with the first upper molar of the Japanese specimen. In the skull before me the summits of the median and inner of the three columns lean rather strongly backward. The outer column is considerably shorter than the others. These anterior columns are lodged partly above the rear of the crown of the first molar. The column which is extruded the farthest is the inner one of the second row. It has a diameter of 13 mm. a short distance above its summit. The unworn summits of all the columns show a thick ring of enamel and in the center of the pit a little elevation.

Whether or not a third molar might at a later time have been developed behind the one just appearing it is impossible to speak with certainty. Naturally, our specimen throws no light on the lower teeth. In the lower jaw of the Japanese specimen Yoshiwara and Iwasaki found two premolars and a molar. The premolars they, as in the upper jaw, called the first and second; but there are the same reasons for giving these a higher number that we have found in the case of the premolars of the upper jaw. The crown of the tooth which they called the first lower premolar had a length of 32 mm., a width of 20 mm., and a height of about 27 mm. It was composed of seven columns rather irregularly arranged. The second premolars had a crown whose length was 47 mm., width 32 mm., and height 25 mm. It was composed of seven columns. The front and middle transverse rows had two each; the hinder row three, of which one is small. It will be observed that the length of the crowns of these two premolars taken together amounts to 79 mm. Opposed to these in the upper jaw the Japanese investigators found but one premolar, having only four columns and a grinding surface about 23 mm. long. Because of the state of wear on the hinder lower premolar they assumed the presence of another upper premolar; and their conclusion may be said to be confirmed by the Oregon specimen. Nevertheless, this would not probably have more than doubled the length of the grinding surface of the upper premolars, making it about 46 mm., just enough to cover the hindermost lower premolar. So far as appears there was nothing to oppose the anterior lower premolar. Another rather remarkable thing is that the hindermost upper premolar was so small in comparison with the last lower one.

It occurred to me that possibly the tooth in the Japanese specimen which is regarded as the last lower premolar was really the first molar. The lengths of the grinding faces of the two teeth are not greatly different; and on that supposition the anterior premolar would be opposed by the two upper premolars. This view would involve the removal of the lower jaw backward a distance of 47 mm. The Japanese authors had already concluded that the tip of the upper jaw protruded beyond the lower about 40 mm. The two sums together would amount to 87 mm. As the distance from the front of the upper jaw to the front of the nasal opening is given as 70 mm., we would have the tip of the lower jaw about 17 mm. behind this opening. This does not seem probable. Moreover, the crown of the upper first molar has a height of 60 mm., while that of the lower tooth which we are assuming to work against it has the crown worn down to a height of 25 mm. This is not likely to have been true. I am at present unable to solve the problem presented.

The tooth regarded, and probably properly so, by Yoshiwara and Iwasaki as the first lower molar had a crown whose length is given as 64 mm., width as 40 mm., and height as 39 mm. It consists of three transverse rows each with two columns. It has the dimensions of the first upper molar and was therefore a worthy antagonist of it.

From Yoshiwara and Iwasaki's paper we learn that in their specimen the first upper molar had three columns in the front transverse row, while the corresponding lower molar had only two columns in each row. On the other hand, the last lower premolar had three columns in the hinder row, two each of the other two rows.

Through the kind offices of Mrs. McCornack, I have received for examination from Prof. Warren D. Smith, head of the geological department of the University of Oregon, the tooth which has been already mentioned as having been found at Yaquina Bay by Pro- essor Condon. Two views of this tooth are here presented (pl. 58, figs. 3, 4). The tooth is considerably worn and all but the base of the root is missing. The crown consists of eight columns, three in a transverse row at one end, a single column at the other end, and between these two rows of two columns each. I interpret this tooth as the second upper molar of the right side. It has quite exactly the size and the arrangement of the columns seen in the uncut second molar of the skull here described, except that the oblique line joining the centers of the columns of each row is directed differently. Excepting in size, the tooth resembles closely the upper first molar of the Japanese specimen. The front end of the tooth is concave from side to side and the polished surfaces on the free faces of the columns show that another tooth of considerable size abutted against it. But there is likewise a surface of wear near the base of the single column which is supposed to be at the rear of the tooth. If, therefore, I am right in identifying this tooth as the upper second molar, it must be concluded that a third molar was coming up at the rear of it.

The length of the tooth here described, taken at the middle of the width, is 51 mm.; the greatest width, 33 mm.; the height of the columns, 27 mm. The largest columns have a diameter of 16 mm. Those of the anterior row are pretty strongly curved, with the concavity toward the contiguous columns. In the valley between the various columns is seen a small quantity of cement. It is not unlikely that this supporting material was more abundant during life.

In his paper published in 1911, already referred to, Merriam figured a tooth which had been found near Coalingua, Fresno County. This tooth is nearly identical in form with the one just described, but it is slightly larger. The length is 56 mm.; the width, 40 mm. A considerable part of the root is retained. There is a single fang in front and a larger one (possibly subdivided) at the rear. The grinding surface is worn concave from front to rear and from side to side. Judging from the teeth of the Proboscidea, we might be led to regard this tooth as one of the lower jaw.

It seems to me that there are, between the Japanese specimen and that from Oregon, differences of specific importance. The most striking of these is found in the sizes of the two animals. The Japanese skull was about twice as long as the American. Here follows a table which shows certain common dimensions and their ratios, those of the Japanese specimen being taken as 100. The dimensions of the latter specimen have been taken mostly from Yoshiwara and Iwasaki's statements, but partly from their illustrations.

Measurements.

Dimensions taken.	Japanese.	Oregon.	Ratios.
	mm.	*mm.*	
Width across the snout at nasal opening	130	75	58
Height of skull behind orbits	160	105	66
From rear of nostril to rear of nasal bones	240	115	48
From rear of nostril to front of orbit	200	95	48
Distance between inner borders of first molars	110	65	59

While these measurements show a great difference in the sizes of the two specimens, the ratios indicate considerable differences of proportions. The variations observed can not be due to differences of age; for, as shown by the more advanced condition of the hindermost molar, the Oregon specimen was the older.

If now we take the distance from the rear of the nostril to the rear of the nasal bones as a measure and give it the value 100 we shall have the following table:

Ratios of measurements.

Dimensions compared.	Japanese skull.	Oregon skull.
Ratio of distance between rear of nostril and rear of nasals to itself	100	100
Ratio of width across snout to distance between nostril and rear of nasals	54	65
Ratio of height of skull to distance between nostril and rear of nasals	67	91
Ratio of distance between rear of nostril and front of orbit to distance between nostril and rear of nasals	83	83
Ratio of distance between first molars to distance between nostril and rear of nasals	57	46

From these estimates it appears that relatively to the distance from the nostril to the rear of the nasals, *D. hesperus* has a wider snout, a higher skull, and a narrower palate between the last molars than the Japanese specimen had.

Quite as important as regards the relationships of the two animals is the structure of the first molar. There seems to have been in the Oregon specimen only two columns in the anterior row, although it is possible that a median one sprouted off from the base between the two recognized; but behind this row is only one transverse row of two columns; whereas, in the Japanese specimen, there were two transverse rows of two columns each.

The Oregon animal can hardly belong to anything else than the species called by Marsh *Desmostylus hesperus*. Under the circumstances it is the Japanese species which must receive a name. Hence, in honor of my friend Shozaburo Watase, Professor of Zoology in the Imperial University of Tokio, I call it *Desmostylus watasei*.

The following diagnoses may be proposed:

DESMOSTYLUS Marsh.

A Miocene genus of the Sirenia, exhibiting in its skull many primitive characters. Snout little deflected, nasal opening small and far in advance of the orbits. Nasal bone long and narrow. Brain case broad and rounded above; the temporal ridges feebly developed. Upper jaw with a pair of tusklike teeth, probably canines. Lower jaw with two pairs of tusks. Molars and some of the premolars composed each of high, closely appressed columns, varying in number.

Species of Desmostylus.

1. A species of moderate size, apparently with somewhat broader snout, higher skull, and narrower palate posteriorly. First upper molar apparently with five columns. American...*hesperus*.
2. A large species, with a snout apparently narrower, a frontal region lower, palate posteriorly wider, and the first upper molar with eight columns. Japanese. *watasei*.

EXPLANATION OF PLATES.

Explanation of numerals: 1, supraoccipital; 2, parietal; 3, frontal; 4, nasal; 5, premaxillary; 6, maxillary; 7, lachrymal; 8, squamosal; 9, zygoma; 10, jugal; 11, capsule for second molar; 12, nasal opening; 13, exoccipital condyle; 14, basioccipital; 15, basisphenoid; 16, adventitious bone; 17, mastoid; 18, palatine; 19, tympanic bulla; 20, supposed third premolar; 21, fourth premolar; 22, first molar; 23, second molar; 24, foramen lacerum posterius; 25, condylar foramen; 26, stylomastoid foramen; 27, tympanic cavity; 28, infraorbital foramen; 29, exoccipital; 30, paroccipital process.

PLATE 56.

Desmostylus hesperus Marsh. Skull seen from above. $\times \frac{2}{5}$.

PLATE 57.

Desmostylus hesperus Marsh. Skull seen from below. $\times \frac{2}{5}$.

PLATE 58.

Desmostylus hesperus Marsh.

Figs. 1, 2. Skull. $\times \frac{2}{5}$.

1. Seen from the left side.
2. Seen from behind.

Figs. 3, 4. Supposed upper right second molar. $\times$ 1.

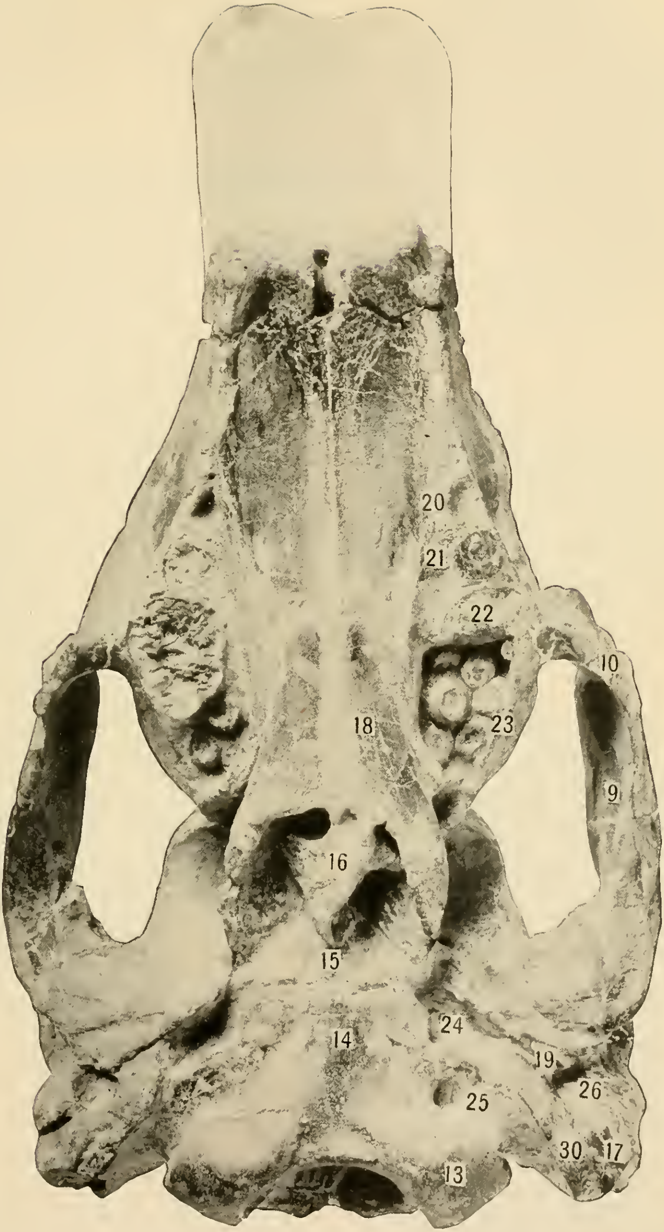
3. Showing grinding surfaces. Anterior end directed upward.
4. Seen from the left side. Anterior end directed to the left.

Figs. 5, 6. Supposed upper fourth premolar. $\times$ 1.

5. View of grinding surface.
6. View of tooth from the rear.

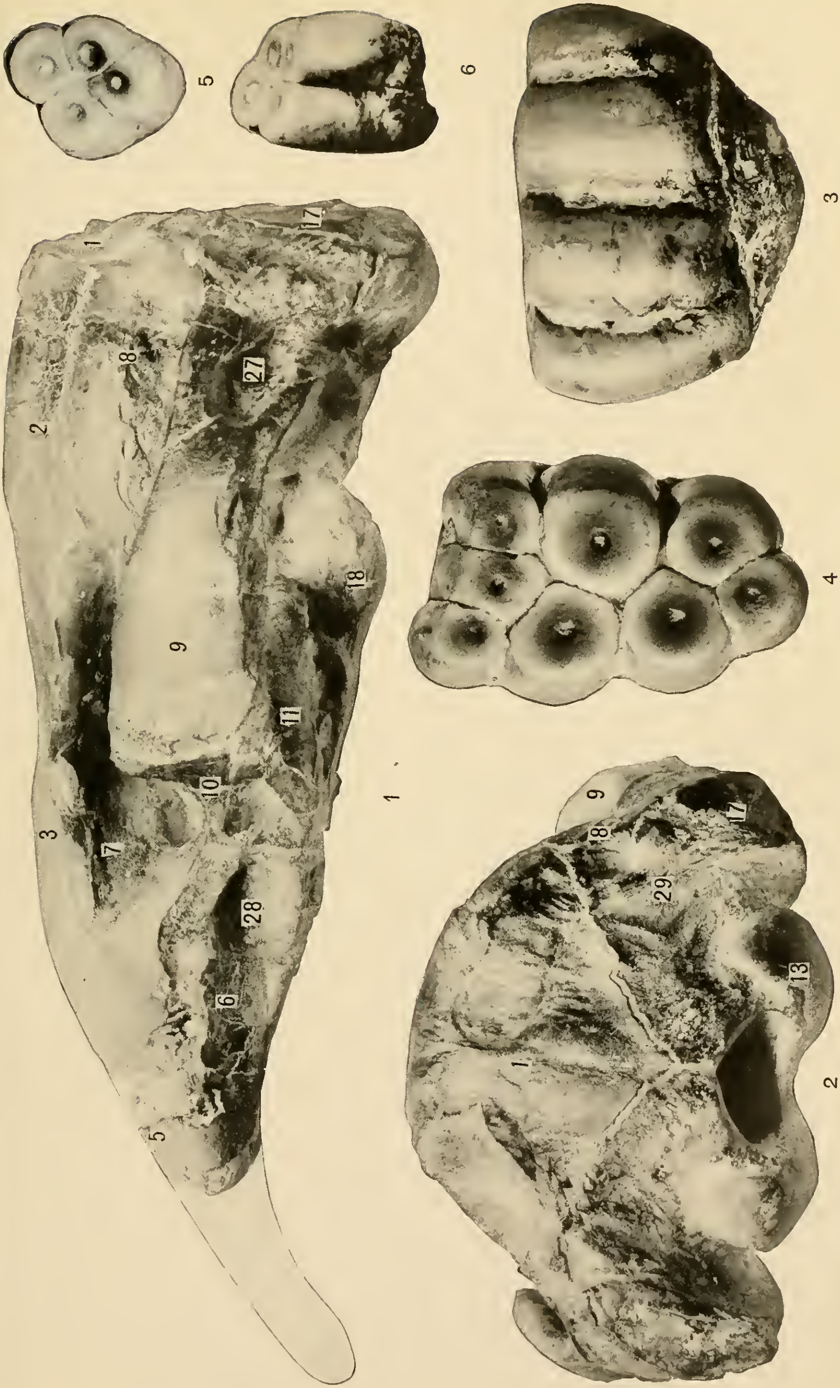
SKULL OF DESMOSTYLUS HESPERUS MARSH.

FOR EXPLANATION OF PLATE SEE PAGE 397.



SKULL OF DESMOSTYLUS HESPERUS MARSH.

FOR EXPLANATION OF PLATE SEE PAGE 397.



SKULL AND TEETH OF DESMOSTYLUS HESPERUS MARSH.

FOR EXPLANATION OF PLATE SEE PAGE 397.