QL
737
C4T354
Rel.

Case Shelf

REMINGTON KELLOGG
LIBRARY OF
MARINE MAMMALOGY
SMITHSONIAN INSTITUTION

QL
737
C4T95+
Case shelf 17
7K

(*Provisional Title*)

REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF

CAPTAIN GEORGE S. NARES, R.N., F.R.S.

AND

CAPTAIN FRANK TURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH
DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD

LIBRARY, U.S. NATIONAL MUSEUM
MAY 29 1911
SMITHSONIAN

ZOOLOGY—VOL. I.

PART IV.—REPORT ON THE BONES OF CETACEA

William Turner

Published by Order of Her Majesty's Government

PRINTED FOR HER MAJESTY'S STATIONERY OFFICE
AND SOLD BY
LONDON:—LONGMANS & CO.; JOHN MURRAY; MACMILLAN & CO.; SIMPKIN, MARSHALL, & CO.
TRÜBNER & CO.; E. STANFORD; J. D. POTTER; AND C. KEGAN, PAUL, & CO.
EDINBURGH:—ADAM & CHARLES BLACK AND DOUGLAS & FOULIS
DUBLIN:—A. THOM & CO. AND HODGES, FOSTER, & FIGGIS

1880

Price Two Shillings

NOTE.

PROFESSOR TURNER, F.R.S., has kindly undertaken the description of the Cetacea, the Seals, and the human remains procured by the Expedition. The present paper deals with the Whales only. Unfortunately only a few Cetacean bones were found; Professor Turner has, however, been able to make some most interesting observations, particularly on the structure and development of the teeth in *Mesoplodon*.

The trawl brought up from the greatest depths of the Pacific a few bones of the skeleton, and especially a considerable number of ear-bones of whales and porpoises. The determination of the species to which these remains belonged was a matter of great interest, but one of extreme difficulty, on account of their fragmentary nature. They were always mixed, as Professor Turner mentions, with the teeth of known Tertiary sharks, and with nodules of oxides of iron and manganese; and their occurrence under the conditions under which they were discovered, is among the most curious and interesting results of the Expedition.

This paper was received on the 2d of August 1879.

C. WYVILLE THOMSON.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the BONES OF CETACEA collected during the Voyage of H.M.S. Challenger in the years 1873-1876. By WILLIAM TURNER, M.B. (Lond.), F.R.SS. L. and E., Professor of Anatomy in the University of Edinburgh.

PROFESSOR SIR C. WYVILLE THOMSON having entrusted to me for purposes of description the bones of the CETACEA collected during the voyage of H.M.S. Challenger, I have to report as follows :—

The specimens which were placed in my hands for examination were—

A. The skull, without the lower jaw, of an adult *Mesoplodon layardi*. This specimen is now in the Oxford Museum, and I am indebted to Professor Rolleston for the opportunity of examining it.

B. The end of the rostrum, with the corresponding part of the lower jaw, and the two mandibular teeth of *Mesoplodon layardi*, also in the Oxford Museum.

C. The skull and a large part of the skeleton of an immature Cetacean, evidently a young *Mesoplodon layardi*.

D. A skull with lower jaw from the Colonial Museum, Wellington, New Zealand, marked *Epiodon chathamiensis*, but which I regard as a specimen of *Ziphius cavirostris*.

E. Atlas, axis, and 3d and 4th cervical vertebræ of Humpback whale of New Zealand, from the Colonial Museum, Wellington.

F. Cervical vertebræ of Right whale of New Zealand, from the Colonial Museum, Wellington.

G. Numerous ear-bones and some fragments of other bones brought up by the dredge from the floor of the ocean.

Mesoplodon layardi (Gray), (Pls. I.–III.).

Specimens *A* and *B* were collected in November 1873 at the Cape of Good Hope by Mr H. N. Moseley, F.R.S., one of the naturalists of the Expedition, and specimen *C* was obtained by the same gentleman at the Falkland Islands in 1875. Mr Moseley has with great courtesy placed at my disposal his notes on these specimens.

Specimen A.—"The skull of *Mesoplodon layardi* was obtained from John M'Kellar, Esq., of Cape Point. The animal came ashore at that place about 1865. Mr M'Kellar reports that it was about 18 feet long, black on the back, white on the belly, and with a conspicuous line of demarcation on the side between the black and white colours. The animal yielded a large quantity of oil, which was of a very superior quality, selling for more than twice the price of ordinary whale oil. It had long tusks in the lower jaw, and Mr M'Kellar thinks that he gave this bone with the teeth to Mr Layard, so that it is probable that this is the specimen to which Mr Layard's tooth belongs. The skull had lain exposed for eight years on the beach, and was found with the beak stuck in the sand, the skull having been put up as a target for rifle practice.[1] The fused cervical vertebræ, and one or two dorsal vertebræ, were lying with the skull, but the remainder of the skeleton was not to be found."

Specimen B.—The animal to which the rostrum and lower jaw with teeth belonged "was captured by the men in the employ of Mr Alexander Michael Black of Simon's Town, Cape Colony, who presented the specimens to the Oxford Museum. The animal came ashore at Walwick Bay in 1869. It was from 16 to 18 feet in length, and yielded 80 gallons of oil.[2] The entire head was brought to Simon's Bay as a curiosity, but it smelt so badly that the snout was sawn off with difficulty, owing to the density of the bone, and the head was pitched overboard."

Specimen C, which I have recognised to be a young example of *Mesoplodon layardi*, "was obtained at the head of Port Sussex, on the west coast of East Falkland Island. The animal ran ashore late in 1875. It was measured by Mr John Bonner, and found to be exactly 14 feet in length. It had a greyish-white colour below, but was black above. The oil was especially clear and good. The paddles were cut off, along with masses of blubber, and dragged to a distance. Mr Bonner gave me the head, which he had separated from the trunk as a curiosity." Mr Moseley carried the head and bones of the trunk on a pack horse from Port Sussex to Stanley,[3] where the Challenger was lying, but the paddles were not recovered. A similar whale was said by Mr Bonner to have come ashore at the peninsula known as Lafonia in 1866.

[1] See also Notes by a Naturalist on the Challenger. By H. N. Moseley, F.R.S., London, 1879. In these Notes, obviously by a misprint, the animal is said to be only "about 10 feet in length."

[2] See also Moseley's Notes above cited, p. 158.

[3] See Notes, p. 559.

The specimens already put on record which have been referred to the *Mesoplodon layardi* are as follows :—

1. A skull, with lower jaw, from the Cape of Good Hope, presented by Mr E. L. Layard to the British Museum. The skull was described and figured by Dr Gray,[1] and more fully described and with better figures by Professor Owen.[2]

2. A single tooth from another specimen in the possession of Mr E. L. Layard.[3] It is possible that this is the tooth already referred to as obtained from the skull of specimen *A* collected by Mr Moseley.

3. A lower jaw, with teeth, from the Chatham Islands, in the Colonial Museum, Wellington, New Zealand, described and figured by Dr Hector as *Dolichodon layardii*.[4]

4. A skeleton in the Sydney Museum, obtained at Little Bay, near Sydney, and named by Mr Krefft successively *Mesoplodon longirostris* and *güntheri*, and by Dr J. E. Gray *Callidon güntheri*.[5]

5. Skeleton from Saltwater Creek, now in the Canterbury Museum, New Zealand, described by Dr von Haast as *Mesoplodon floweri*.[6] From a comparison of a photograph of its skull with the skull of the *Mesoplodon layardi* in the British Museum, neither Professor Flower[7] nor M. van Beneden could recognise any specific differences between the crania, so that they regard them as of the same species.

The geographical range, therefore, of Layard's *Mesoplodon* is very extensive. From the Cape of Good Hope, where it was first discovered, at least three crania, including those collected by the Challenger, have been procured. Other specimens have been obtained, far to the eastward, from the Chatham Islands, New Zealand, and Australia, whilst the discovery of the skeleton of a specimen at the Falkland Islands has extended its habitat considerably to the west. All the localities in which it has been obtained are in the Southern hemisphere, either in the South Atlantic or South Pacific, and there is no knowledge of this Cetacean ever having been seen to the north of the equator.

The Skull.—That the adult skull *A*, and the lower jaw, beak, and teeth *B*, from the Cape of Good Hope were specimens of *Mesoplodon layardi* was unquestionable, as they agreed in characters with specimens of this animal already described and figured. The skull of the

[1] Proc. Zool. Soc., 1865, p. 358; and Catalogue of Seals and Whales, p. 353, where it is named *Ziphius layardii* (*Dolichodon*).

[2] Memoirs of the Palæontographical Society, 1870, in Monograph on the British Fossil Cetacea from the Red Crag. Owen's figures have been reproduced, though reversed in the copying, in pl. xxvii. figs. 1–3, *a*, of Van Beneden and Gervais' Ostéographie des Cétacés.

[3] Referred to by Professor Flower in his Memoir on the Recent Ziphioid Whales, Trans. Zool. Soc., vol. viii. p. 211.

[4] Trans. New Zealand Institute, vol. v. p. 166, pl. iii. Dr Gray in vol. vi. of these Transactions proposes to call this specimen *Dolichodon traversii*.

[5] Annals and Magazine Natural History, 1871, vol. vii. p. 368. Dr Gray had only a photograph and sketch of the tooth for examination.

[6] Notes on *Mesoplodon floweri*, Proc. Zool. Soc. London, June 6, 1876; and Trans. New Zealand Institute, vol. ix. p. 442, 1877.

[7] Remarks by Prof. Flower upon Dr von Haast's Communication on *Mesoplodon floweri*, Proc. Zool. Soc. London, June 6, 1876.

younger animal *C*, from the Falkland Islands, was also, after a careful comparison with the adult skull, regarded as an immature example of the same *Mesoplodon*, and not as a new species. For although it differed from the adult in some important characters, such as the absence of a mesorostral bone, and of a maxillary buttress, whilst the teeth were embedded in their sockets, yet these are differences which are perfectly explicable on the ground of the immaturity of the specimen, which may have been, perhaps, also of the female sex. That the specimen was immature, was satisfactorily shown by the open condition of the cranial sutures, the lightness, porosity, and indeed fragility of the cranial bones, and the non-ossification with the vertebral bodies of their plate-like epiphyses. I may also mention that my friend Professor Flower, who has also examined the skull, coincided in the opinion that it was an immature *Mesoplodon layardi*.

As the characters of the skull of the adult *Mesoplodon layardi* have been described with more or less fulness of detail by one or other of the naturalists already referred to, it seems unnecessary that I should give a detailed description of specimen *A*. But as no account has yet appeared of so immature a skull as that from the Falkland Islands, it is advisable that it should be described, and the most satisfactory way of recording its characters will be to write a comparative account of the younger and adult crania. In the course of this description I shall pursue almost the same order as that observed in the account which I gave a few years ago of the skull of *Mesoplodon sowerbyi*,[1] so that a ready comparison between the crania of Layard's and Sowerby's whales may be instituted.

In the first place I append a table of the dimensions, expressed in inches, of the crania of these specimens, and along with them I include the measurements of the skull of *Ziphius cavirostris*. The dimensions are taken between the points adopted by Professor Flower in his Memoir on the genus *Mesoplodon*,[2] so that a comparison may be made between these crania and the species *Mesoplodon australis*, *grayi*, and *hectori*, described by him.

	Adult *Mesoplodon layardi*.	Young *Mesoplodon layardi*.	*Mesoplodon sowerbyi*.	Shetland *Ziphius cavirostris*.	New Zealand *Ziphius cavirostris*.
Extreme length of cranium, ...	$40\frac{1}{2}$	25	$29\frac{1}{2}$	$36\frac{1}{2}$	...
Length of rostrum from apex of præmaxilla to middle of line drawn between antorbital notches, . .	$27\frac{1}{2}$	$14\frac{1}{2}$	$19\frac{1}{4}$	$21\frac{1}{4}$	$22\frac{3}{4}$
From middle of hinder edge of palate, formed by pterygoids, to apex of rostrum, ...	33	19	$22\frac{1}{2}$	$27\frac{1}{2}$	...
Greatest height of cranium from vertex to pterygoids, .	15	$10\frac{7}{8}$	$9\frac{1}{2}$	18	...
Breadth of cranium across middle of superior margin of orbits, ...	$16\frac{1}{8}$	$10\frac{1}{4}$	$11\frac{1}{4}$	20	...

[1] Trans. Roy. Soc. Edin., May 20, 1872, vol. xxvi.

[2] Trans. Zool. Soc. 1877, vol. x.

	Adult *Mesoplodon layardi.*	Young *Mesoplodon layardi.*	*Mesoplodon sowerbyi.*	Shetland *Ziphius cavirostris.*	New Zealand *Ziphius cavirostris.*
Breadth of cranium between zygomatic processes of squamosals,	$17\frac{1}{8}$	$11\frac{1}{8}$	$11\frac{1}{2}$	21	...
Breadth between antorbital notches,	9	$6\frac{3}{4}$	$7\frac{3}{4}$	$15\frac{1}{2}$	...
Breadth of middle of rostrum,	$2\frac{7}{8}$	$1\frac{3}{4}$	2	5	$5\frac{1}{4}$
Breadth of occipital condyles,	$5\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{1}{4}$	$6\frac{7}{8}$	...
Præmaxillæ, greatest width behind anterior nares	$6\frac{3}{4}$	5	5	...	...
Præmaxillæ, least width opposite anterior nares,	$5\frac{1}{8}$	$3\frac{1}{2}$	$4\frac{1}{4}$	...	...
Præmaxillæ, greatest width in front of anterior nares,	5	$3\frac{1}{8}$	4	...	...
Width of anterior nares,	$2\frac{5}{8}$	2	$1\frac{3}{4}$	$4\frac{1}{4}$	$5\frac{3}{8}$
Length of tympanic bone,	...	$1\frac{8}{10}$	...	$2\frac{4}{10}$	...
Greatest breadth of tympanic bone,	...	$1\frac{4}{10}$	...	$1\frac{7}{10}$	...
Mandible, length of ramus,	...	$17\frac{3}{8}$	$18\frac{1}{2}$	$25\frac{1}{2}$	27
,, length of symphysis,	$11\frac{3}{4}$	$4\frac{5}{8}$	$9\frac{1}{2}$	7	$7\frac{3}{4}$
,, greatest vertical height of ramus,	...	...	$4\frac{1}{2}$	$6\frac{1}{2}$	...

The length of the entire cranium of the younger specimen was $2\frac{1}{2}$ inches less than that of the beak of the adult. The crest at the vertex in both was formed of the nasals, frontal, supra-occipital, and the upper ends of the præmaxillæ and superior maxillæ, but in the younger specimen a thin lamina of each parietal could be traced upwards to the vertex, where the laminæ from opposite sides became fused together (Pl. I. figs. 1, 2).

The beak was about twice as long in the adult as in the young. Its apex in the latter was formed entirely of the two præmaxillæ, but in the adult the anterior end of the mesorostral bone seemed to be fused with the tips of the præmaxillaries, though the absence of sutures prevented the exact determination of their place of union. In the adult, the interval between the præmaxillaries was filled up as far as the base of the beak by the solid mesorostral bone, which, as in Professor Owen's description, "rises as a smooth, dense convex ridge, $1\frac{1}{4}$ inches across at its broadest part, gradually contracting to a breadth of half an inch, when it has traversed one-third of the length of the rostrum." In the younger skull this bone was absent, and an elongated mesorostral furrow, empty in the macerated skull, was seen. This furrow was occupied in the unmacerated state by a bar of cartilage, and the conversion of this cartilage into the dense mesorostral bone is accompanied by the remarkable elongation of the beak, which constitutes one of the most noticeable features of difference in the dimensions of the younger and adult crania. As the beak of specimen *B* had been sawn through $20\frac{1}{2}$ inches from the tip, the extremely dense porcellaneous character of the mesorostral bone, and its intimate fusion with the vomer, the superior and præmaxillary bones were seen on the surface of section. Whilst the vomer and præmaxillæ partook of the same porcellaneous character as the mesorostral bone, the superior maxillæ again possessed a much more spongy character. The surface of section through the beak approximated in shape to a heraldic lozenge, the inferior angle of which was rounded (Pl. I. fig. 6). In specimen *B* the mesorostral bone terminated $6\frac{1}{2}$ inches from the tip of the beak, and anterior to it the beak was hollowed into a deep furrow covered over by a dense, fibrous membrane.

In the younger skull, the inner borders of the præmaxillæ were parallel and close together in the anterior half of the beak, but diverged somewhat posteriorly. In both crania these bones ascended behind the base of the beak to form the sides of the anterior nostrils, and to terminate at the vertex in a roughened overhanging ridge. The anterior surface of the ascending part of each bone was concave from above downwards, and the outer and inner borders were concave in the same direction; the concavity of the inner border added to the width of the nostrils, the greatest transverse diameter of which in the younger skull was $2\frac{1}{8}$ inches, in the adult $2\frac{7}{8}$ inches. The præmaxillæ were a-symmetrical at their nasal ends, the right being not only wider, but higher than the left, so that the nasal openings were directed to the left. The a-symmetry was slightly more marked in the adult than in the younger skull. On the anterior surface of each præmaxilla a large foramen was situated a little behind the antorbital notch.

The nasal bones were laterally compressed and placed vertically between the two præmaxillæ. The upper border of the right was, in both crania, broader and more projecting than the left. The mesethmoid nasal septum was inclined obliquely to the left; in the adult its free border was sharp in the greater part of its extent, but below it was prolonged into the mesorostral bone. A deep depression was, however, situated at their place of junction, which indicates, I think, that the mesethmoid and mesorostral bones had originated from separate centres of ossification. In the young skull it was from $\frac{1}{4}$ to $\frac{1}{2}$ inch broad, and had the roughened surface characteristic of a bone to which ossifying cartilage had been attached.

The spout-like vomer formed in the young skull the floor and in part the sides of the mesorostral furrow to within $3\frac{1}{2}$ inches of the tip of the beak, where it terminated in a pointed end; posteriorly, in both crania, it articulated with the sides of the mesethmoid, and, expanding laterally, was jointed with the under surface of the body of the sphenoid. The vomer appeared in the hard palate of the younger skull, as a mesial fusiform bar of bone, nearly 5 inches long, situated between the superior maxilla and præmaxilla of opposite sides. In the adult, the rostral part of the vomer was concealed by the mesorostral bone, except on the palatal surface, where it appeared as a mesial fusiform bar, about 11 inches long. In both crania, the vomer also appeared on the surface as a slender mesial bar between the two pterygoid bones; in the adult, $3\frac{1}{2}$ inches were seen, extending backwards between these bones; but in the young skull, scarcely an inch in length of the vomer appeared, where the pterygoids diverged from each other anteriorly.

Each superior maxilla in the young skull extended to $2\frac{1}{2}$ inches from the tip of the beak where it terminated as a slender bar of bone. In both crania it expanded posteriorly, and, overlapping the frontal bone, ascended to the vertex behind the præmaxilla. The anterior surface of its cranial expansion was concave, and the hollow was somewhat deeper in the adult than in the young specimen. In the young a large single foramen was in the right bone almost on a line with the præmaxillary foramina, but in the left bone were two foramina. In the adult four foramina, one of which was partially subdivided, were in the right bone, but only two in the left. In both skulls a large foramen, directed outwards, opened in the expanded cranial portion, on a line with the middle of the anterior nares. An ectomaxillary ridge was present in both crania, but in neither so prominent as in *Mesoplodon sowerbyi*. In the adult the ectomaxillary groove, and the buttress-like projection of the pterygoid and superior maxilla, closely resembled Owen's description of the original skull in the British Museum. In the younger skull, whilst this groove was marked at the base of the rostrum, it disappeared in the anterior two-thirds, whilst neither the pterygoid nor superior maxilla swelled out to form a "buttress," so that instead of the massive piece of bone seen in the adult swelling out laterally beyond the margin of the ectomaxillary ridge, in the young, but a faint elevation occurred, and the ectomaxillary ridge formed the most prominent feature in the outline of this part of the beak. In both crania, as well as in *Mesoplodon sowerbyi*, the antorbital notch was separated from the base of the ectomaxillary ridge by an intermediate maxillary tubercle.

The palatal surface of the beak flattened anteriorly in the adult, but slightly concave in the younger skull was formed by the præmaxillæ, which passed backwards between the anterior ends of the superior maxillæ, to articulate with the mesial palatal part of the vomer. In the adult, the middle and posterior parts of this surface were much more convex than in the young skull, and the sutures were almost entirely obliterated. In the younger skull, the palatine plates of the two palate bones appeared as narrow triangles between the diverging anterior ends of the two pterygoids, and separated them from the superior maxillæ; but these plates did not articulate with each other mesially as in *Mesoplodon sowerbyi;* for the superior maxillæ were prolonged backwards between them in order to articulate with the interpterygoid part of the vomer which appeared on the surface in this locality. In the adult, the palate plate of the palate bone was absent, so that the pterygoid articulated directly with the superior maxilla. Both in the adult and younger crania the palate bone passed backwards and outwards on the side of the beak, between the pterygoid and superior maxilla, so as to come into proximity with the malar bone.

Each pterygoid was a triangular plate of bone, concave externally, and with its lower border everted so as to constitute the lower boundary of a pterygoid fossa; a deep notch directed upwards and forwards was situated in the base of each plate. The two pterygoids articulated with each other mesially for 4 inches from the base of each plate in the adult skull, but then diverged, and allowed first the vomer, and then the two superior maxillaries to appear between them. In the younger skull, the mesial articulation between the two pterygoids was more complete, for the vomer intervened only at the anterior part.

The posterior nares and the basis cranii had a similar shape and arrangement of bones to what I have elsewhere described in *Mesoplodon sowerbyi*. The occipital surface of the skull also had a similar form, and the jugal process of the ex-occipitals was separated by a cleft from the lateral elevation of the basi-occipital; there was little difference in the configuration of these parts in the young and adult crania. In both an extensively ossified falx was situated in the mesial plane of the cranial cavity.

The general shape of the squamoso-zygomatic part of the temporal resembled that bone in *Mesoplodon sowerbyi*, but the fossa in front of the petro-tympanic bone was not so smooth, and had an irregularly ridged and furrowed surface in both the adult and younger crania. A curved spur-like process descended in the younger skull from the squamous temporal in front of the petro-tympanic and aided in retaining it in place. In the adult skull this process was absent (probably broken off), the tympanic bullæ had been removed and only the left petrous bone was in place. In the younger specimen the mastoid, tympanic, and petrous portions of the temporal were distinctly differentiated: the petrous part was a separate element, but the mastoid and tympanic were fused together. The mastoid articulated behind with both the jugal process of the occipital and the posterior prolongation of the squamosal, by a broad roughened surface, whilst anteriorly it was continued into the the tympanic by a constricted neck. I have carefully compared the tympanic and petrous bones of *Mesoplodon layardi* with the corresponding bones of the *Ziphius cavirostris* from Shetland which I described some years ago.[1] In *Mesoplodon* the inferior surface of the tympanic was one inch in breadth at its posterior end, where it was divided into an outer and an inner lobe by a groove extending forwards from its posterior end, the outer of these lobes was more boss-like and smoother than the inner (Pl. II. fig. 7). In *Ziphius* this surface was not bilobed and possessed a ridge extending in the antero-posterior direction (Pl. II. fig. 9). The outer surface of the tympanic was deeper in *Ziphius* than in *Mesoplodon*, and the groove on this surface was more vertical and elongated in the latter than in the former. The inner surface in *Ziphius*, where it turned into the bulla, was more deeply denticulated that in *Mesoplodon*. The tympanic in *Ziphius* was somewhat larger than in *Mesoplodon*, and the same also was the case with the petrous bones. The longest diameter of the petrous bone in *Ziphius cavirostris* was $2\frac{4}{10}$ inches, of the adult *Mesoplodon layardi* $1\frac{8}{10}$, of the younger specimen the same: the greatest breadth in *Ziphius cavirostris* was $1\frac{4}{10}$, in the adult *Mesoplodon layardi* $1\frac{2}{10}$, and in the younger specimen $1\frac{3}{10}$ inch. The

[1] Trans. Roy. Soc. Edinburgh, 1872, vol. xxvi.

internal meatus of the petrous bone was a single canal in the young *Mesoplodon*, but was divided into two in the adult *Mesoplodon* and in *Ziphius*. The surface anterior to the meatus was roughened and slightly convex in *Mesoplodon*, but was elevated into a prominent tubercle in *Ziphius*. In both, the stapes formed a solid column of bone ankylosed to the inner wall of the tympanum (Pl. I. fig. 5). The most important difference between the petro-tympanic bones in the two animals was the bilobed character of the under surface of the tympanic in *Mesoplodon* and not in *Ziphius*, a character which *Mesoplodon layardi* shares with the other species of *Mesoplodon* described by Professor Flower in his recent memoir on this genus,[1] which is possessed by the true *Dolphins* and, as he points out, also by *Berardius*. Thus, by its tympanic bone, *Ziphius* may be distinguished from *Mesoplodon* as readily as by the differences in the naso-premaxillary region, the value of which I dwelt on in my former memoir on these genera.[2]

In *Mesoplodon layardi* the sphenoid took but a very small part in the formation of the temporal fossa. The parietal formed the larger part of its floor, and in the younger skull could be followed as a distinct bone situated between the supra-occipital and the frontal to the vertex, where it was united by synostosis to its fellow. In the adult, though the outline of the parietal in the temporal fossa could be readily seen, no part could be traced beyond the fossa to the vertex, for it was overlapped by the growth of the supra-occipital, so that only the thin edge of the frontal bone appeared in the interval between the supra-occipital and superior maxillary. The vertex part of the frontal articulated anteriorly, as in *Mesoplodon sowerbyi*, with the superior maxillæ, præmaxillæ, and nasals. The frontal formed the roof of the orbit and possessed a strong postorbital, but a feeble preorbital process. The malar bone consisted anteriorly of a flattened plate, which articulated with both the superior maxilla and the lachrymal: from this plate a long slender zygomatic bar passed backwards below the orbit to articulate with the zygomatic part of the temporal. The lachrymal closely resembled in shape the corresponding bone in *Mesoplodon sowerbyi*; in these skulls it articulated anteriorly and externally with the preorbital process of the frontal, the malar, and the superior maxilla.

The mandible was absent in specimen *A*, only its anterior part was preserved in *B*, whilst in *C*, though both halves were present, the condyloid ends were much broken. In *C* the right and left halves were not ankylosed at the symphysis, which part of the bone was 4½ inches long. In *B* the union between the two halves was complete, and the symphysis was 11½ inches long.

During the time that the Challenger was in the harbour of Wellington, New Zealand, Mr Moseley visited the Wellington Museum, and made a careful comparison between the lower jaw and teeth of specimen *B*, and the jaw and teeth from the Chatham Islands preserved in that Museum, which have been described and figured by Dr Hector.

[1] Trans. Zool. Soc., vol. x., 1878.
[2] Trans. Roy. Soc. Edin., vol. xxvi., 1872.

He has most courteously placed his notes at my disposal, and in this place I shall quote what he says respecting the lower jaw.

"The peculiar upward curve of the inferior edges of the rami of the mandible immediately behind the termination of the symphysis is alike in both specimens. The upper surface of the symphysial portion is in the New Zealand specimen broader than in the one from the Cape; the whole beak-like mass constituting this symphysial portion being less attenuated and not presenting such sharp projecting alveolar ridges. In the New Zealand specimen the symphysial line appears superiorly as a deeply-sunken groove, to the suture at the bottom of which the bone curves evenly downwards on each side, whereas in the Cape specimen a slightly raised ridge in each bone runs parallel and close to the suture.

"In the New Zealand specimen the under surface of the symphysial beak is evenly rounded, except at its very hindermost part, where two very slight ridges are to be made out, situated one on each side of the symphysial line, and passing off into the inferior edges of the two rami. In the Cape specimen the symphysial beak shows a lateral groove towards the tip, situated below the alveolar border, and instead of being rounded on its under surface, is compressed and sharply keeled along the middle line. The mental foramen in the outer surface of the jaw below the position of the tusk is a small and simple aperture in the New Zealand jaw, but in the one from the Cape it is large, and leads to a canal in the bone. The swelling caused by the large alveoli of the tusks is alike in both specimens. The portion of the symphysial beak in front of the spot where the anterior margin of the tooth emerges from the alveolus is about 1 inch longer in the Cape specimen than in that from New Zealand. In the New Zealand specimen the alveolar margin of the rami behind the teeth is very much compressed and sharp, and the alveolar groove can only be traced for about 2 inches backward: it then becomes obliterated when the margin of the jaw is knife-edged. In the Cape specimen the alveolar margin is much broader, and the groove visible up to the cut end of the rami."

In the younger specimen *C* the alveolar groove extended from the anterior end of the mandible to 7¼ inches behind the socket for the tooth. It was a narrow groove in its entire extent except in the region of the tooth, where it expanded into an appropriate socket. A well-marked mental foramen communicated with the inferior dental canal below the position of the alveolus.

The Teeth.—I shall now proceed to describe the form and structure of the very remarkable teeth of *Mesoplodon layardi*, and as the study of the tooth in the younger animal has thrown great light not only on the structure but on the peculiarities of form of the adult teeth, I shall in the first instance describe it.

The teeth of the young *Mesoplodon layardi* were imbedded in their sockets, one in each half of the lower jaw. Each tooth consisted of a small triangular denticle, which represented the crown of the tooth, and of a larger part, which for descriptive purposes may be termed the fang. The denticle projected outwards and slightly upwards from about the middle of the upper border of the fang. It was 7-10ths of an inch in its basal diameter, and 4-10ths from apex to base. The fang was homologous with the strap-shaped shaft in the adult tooth, but instead of being vertically elongated and strap-shaped, its longer diameter of 2 inches was in the antero-posterior direction, whilst its greatest vertical diameter to the base of the denticle was only 8-10ths of an inch. Along its deeper border it possessed a cleft 2-10ths of an inch wide, which led into the pulp-cavity. On making a vertical section through the middle of the entire tooth, this cavity was seen to be prolonged almost as far as the apex of the denticle (Pl. II. figs. 15, 16).

The free surface of the denticle was completely invested by a glistening white enamel. A thin vertical section was then taken out of the middle of the tooth and polished for microscopic examination.[1] The cap of enamel was then seen to be of almost uniform thickness over the entire denticle, at the base of which it was somewhat overlapped by an up-growth of cement from the fang. When highly magnified the surface of section was seen to be marked by delicate bands, extending almost perpendicularly to the surface of the denticle, which indicated the rods of which the enamel was composed.

Subjacent to the enamel was a well-defined mass of dentine, which constituted the chief substance of the denticle. It was traversed by undulating branched tubes, which radiated outwards from the pulp-cavity, and were arranged with as much regularity as one sees in the crown of a human tooth. Where the branched terminations of the dentine tubes came into relation with the deep surface of the enamel, a layer of irregular, but somewhat stellate, spaces occupied the dentine matrix. These spaces corresponded in appearance with the so-called granular layer situated in human teeth more especially in the fang, between the dentine and cement, and may be termed interglobular spaces (fig. 18).

The dentine was prolonged downwards into the fang, and with a simple lens could be traced almost as far as the edge of the cleft at its root, but it formed so thin a lamina in the greater part of its extent, as to appear merely as a line in the unmagnified section. When highly magnified, the dentine in the fang, immediately continuous with that in the denticle, was seen to contain the tubes arranged in a regular manner, but as the dentine was followed further into the fang, the tubes began to break up into irregular groups, then to be sparsely scattered through the matrix, and at last to disappear, so that in the lower part of the fang the dentine was represented by a translucent matrix, having indefinitely-shaped granules irregularly scattered through it.

The fang of the tooth was invested by a yellowish-brown substance, which was smooth on its surface in proximity to the denticle, but in the region of the cleft was pitted with shallow grooves and small foramina, so as to have a porous aspect. In the section this substance was seen to vary in thickness, its maximum being 1-10th of an inch, and becoming thinner both towards the denticle and the cleft. To the naked eye it was

[1] This and succeeding sections were kindly made for me in the Challenger Laboratory by my friend Mr John Murray.

divided into a superficial and a deep layer by a well-defined line. The superficial layer consisted of cement, in which the lacunæ and branching canaliculi were large and distinct. The deeper layer was more opaque, and required a very thin section to determine its structure. It consisted of a granulated matrix traversed by numerous canals, which were for the most part arranged perpendicularly to the surface of the fang, so as to extend from the dentine to the cement. To some extent they branched, and adjacent canals communicated with each other (Pl. III. fig. 18).

The pulp-cavity was lined in the greater part of its extent by a well-defined layer, having a maximum thickness of nearly 1-10th of an inch. This lining could be seen with the naked eye to extend into the crown of the tooth, reaching on one wall of the cavity to within 1-10th of an inch of its apex, on the other to about 2-10ths of an inch. It had a brown colour, and the surface next the pulp-cavity was marked by numerous shallow grooves and small foramina. Examined microscopically this lining had essentially the same structure as the deeper layer of the outer covering of the fang. The canals were, however, of greater calibre in the inner lining, and passed obliquely from the surface next the pulp-cavity to that next the thin layer of dentine (fig. 18). The minute foramina on the free surface of this lining were the openings of these canals. Although, to the naked eye, the dentine, which formed the apex of the pulp-cavity, did not appear to have any of this substance in contact with it, yet, when examined microscopically, the part next the cavity was observed to be discoloured brown, and with its proper dentine tubes often indistinct, whilst some tubes of a larger calibre were seen in it.

The cement, as capable of recognition by the presence of lacunæ and canaliculi, terminated about 2-10ths of an inch from the edge of the cleft-like opening of the pulp-cavity, and previous to its termination it became very thin. The structure which formed the wall of the cleft was directly continuous with the deeper layer of the outer investment of the fang, and with the substance lining the pulp-cavity. It had a similar microscopic appearance, but the part next the cavity had in addition to the obliquely-divided canals, many canals divided transversely. There can, I think, be no doubt, that in the living tooth these canals had contained blood-vessels. In size they approximated to the Haversian canals in bone.

The question now arises, What is the nature of this very vascular substance, which formed the lining of the pulp-cavity, and the deeper layer of the external investment of the fang? If one could have traced its development, one would have had no difficulty in answering this question, as the several tissues of a tooth arise from definite structures. Thus the enamel proceeds from the enamel organ, the cement from the alveolo-dental periosteum, and the dentine, with its modifications termed vaso-dentine and osteo-dentine, from the pulp. The absence, however, of both dentine tubes and lacunæ and canaliculi in its matrix, and the presence of vascular canals, leave doubts, from a structural point of view, whether this substance ought to be regarded as a modified cement or a modified vaso-dentine. This difficulty would have been increased if the layer situated in the fang between the cement and dentine had been the only one present, as from its position it might have belonged either to the cement or to the dentine. But as a layer of similar structure also existed next the pulp-cavity, there can, I think, be little doubt that it had arisen from the pulp, and notwithstanding the absence of dentine tubes, may be regarded as a modified vaso-dentine, to which substance also the deeper layer of the covering of the fang may be referred. This conclusion is supported also by what is known of the structure of the teeth of some fish in which the dentine consists of a substance destitute of dentine tubes, but possessing a finely-granulated matrix in which vascular canals ramify.[1]

When I received from Mr Moseley the lower jaw of the adult *Mesoplodon layardi*, only the left tooth was in its socket, the right had previously been extracted. The socket was situated at the junction of the symphysis with the body of the lower jaw, but more of the tooth was implanted in the body than in the symphysis. The length of the extracted tooth was 14 inches, 6½ inches of which had been included in the alveolus, or surrounded by the gum. The breadth of the tooth, where it emerged from the alveolus, was 3½ inches. Each tooth consisted of a denticle proper and a strap-shaped shaft. The shaft was laterally compressed, and as it emerged from the socket, it curved obliquely backwards, upwards, and inwards, so that its inner concave surface had been in relation to the side and dorsum of the beak. As the summit of each tooth passed to the opposite side of the middle line, the two teeth crossed each other on the dorsum of the beak, and from the smooth appearance of the anterior border and inner surface of each shaft it is evident that they must have rubbed against each other, or against the beak, during the movements of the lower jaw in the act of opening the mouth. The shaft represents, though on a much enlarged scale, that part of the young tooth which I have named the fang.

The denticle proper projected almost directly upwards from the outer edge of the upper end of the strap-shaped shaft, where it became continuous with the anterior border. It was triangular in shape, its base being half an inch, whilst its diameter from apex to base was 3-10ths of an inch (Pl. II. fig. 17). The base sprang abruptly from the shaft, and some irregular patches of a glistening white enamel formed its outer surface, but the enamel was not continued upwards to the apex of the tooth, which was formed of dentine. In Professor Owen's figure of the denticle of the tooth of the original specimen, whilst the enamel is apparently worn off the tip of the denticle, the base is represented as enveloped by a more complete layer than in this animal. It is also stated that the matrix, by which is obviously meant what I have called the shaft of the tooth, is calcified without enamel.

In the extracted tooth the alveolar end was seen to be closed, and to terminate, as in Professor Owen's description of the original specimen, in a solid jagged border. The surfaces of the imbedded part of the shaft were grooved with irregular longitudinal

[1] Owen, Odontography, 1840–1845. C. S. Tomes, Manual of Dental Anatomy, p. 79, 1876.

furrows, and of a brownish colour. The surfaces of the protruded part again were comparatively smooth, and of a yellow colour. A longitudinal section was then made through the shaft from the alveolar border to the upper end close to the base of the denticle. The shaft was then seen to be solid throughout, except for a minute mesial chink 1-10th of an inch long, and admitting only the point of a fine needle, which was situated 7-10ths of an inch from the upper end of the shaft.

To the naked eye the shaft consisted in the greater part of its length of an external cortical part investing a central band. The cortical part was of a dull yellow colour; at the alveolar end it formed a thin lamina on each surface of the tooth, but at and near the line of emergence from the gum it was 2-10ths of an inch thick, and on the extruded part of the shaft it averged about 1-10th of an inch in thickness. The cortical layer consisted of cement containing well-marked lacunæ and canaliculi. In the centre of many of the lacunæ a minute solid particle was situated, apparently the dried and shrivelled mass of nucleated protoplasm which occupies the lacuna in a living tooth.[1]

Sections through Haversian canals were occasionally seen in the cement, more especially in its deeper part. The surface of the section through the cement was marked by numerous lines placed parallel to each other, and to the surface of the tooth, which gave it a laminated appearance.

In the alveolar part of the tooth, and in the larger portion of the protruded part of the shaft, the cortical layer was in apposition with the central band, which had an opaque white appearance, and varied in breadth from 2-10ths to 4-10ths of an inch. This band was traversed by canals, some of which were continuous with those of the cement, though others were divided transversely and obliquely. The matrix between these canals had a granulated appearance. The opaque central band had, therefore, the structural characters of the modified vaso-dentine described in the young tooth.

The upper end of the shaft, in proximity to the base of the denticle, was complex in structure, and consisted of several layers (fig. 19); *a*, the most superficial, consisted of cement, in which, however, no Haversian canals were seen. Immediately subjacent to *a* was the layer *b*, thicker than the cement, and of an opaque white appearance: it had the same general structure as the central band of the shaft, and the chief vascular canals were directed perpendicularly to the surface of the tooth. The next layer, *c*, was from $\frac{1}{3}$d to $\frac{1}{4}$th the thickness of *b*, and was even more opaque; some vascular canals were seen to pass at intervals from it into the layer *b*. Subjacent to *c* was the layer *d*, which was about equal to it in thickness: it was very translucent, and contained undulating and branched dentine tubes, which ran outwards to the layer *c*. In one or two places *c* was less opaque than usual, and could be seen to contain closely aggregated tubes, not unlike dentine tubes, in addition to the vascular canals already referred to; *c* may, therefore, be regarded as vaso-dentine, whilst *d* is pure dentine. As these two layers were traced from the

[1] See fig. 207, p. 756, of my Introduction to Human Anatomy, for an illustration of the contents of the lacunæ of a tooth.

summit to the sides of the shaft they were seen to blend with each other: *c* lost its great opacity, the tubes of the dentine disappeared, and vascular canals occurred only at considerable intervals. About an inch from the summit of the tooth these layers ceased to be recognisable. Subjacent to the dentine layer, in the summit of the shaft, was the layer *e*, which formed the central portion of this part of the tooth. It had essentially the same structure as the layer *b*, but the main stems of the vascular canals ascended almost vertically, so as to be divided longitudinally in the vertical section through the shaft. Many shorter canals, which had, doubtless, connected the vertical canals with each other, were, however, divided obliquely or transversely. Along the surface of apposition of this layer with the dentine *d*, sections through a canal were seen, into which some of the vertical canals were traced. Below, where the dentine terminated, the layers *b* and *e* became blended with each other, and together formed the white opaque band in the centre of the shaft of the tooth, so that they, like it, had the structural character of the modified vaso-dentine. The minute mesial chink in the shaft already referred to was a space in the layer *e*, and represented all that was left of the pulp-cavity.

We may now proceed to inquire by what process the unprotruded tooth of the young *Mesoplodon layardi* assumes the remarkable form and structure exhibited by the tooth in the adult animal. It must be observed that no change takes place in the shape of the denticle or crown proper; in its size, however, there is a slight diminution in the adult. This is doubtless due to the friction to which the denticle would be subjected soon after it had projected beyond the gum. For when the growth of the tooth had proceeded until it projected beyond the mouth of the animal, the denticle could have suffered but little from the effects of friction, as it is set at such an angle to the shaft as to be directed away from the animal's snout, and towards the water in which it swims. That the surface of the denticle does undergo some slight loss of substance after it is protruded beyond the gum is evident, however, from the disappearance, to a large extent, from its surface of the cap of enamel. We are to look, therefore, for an explanation of the mode of production of the peculiar form of the adult tooth, to changes in the fang, by means of which it is converted into the strap-shaped shaft. These changes are due to an enormous growth of two of the tissues of the fang, viz., the cement and the modified vaso-dentine.

As has already been stated, both these structures are present, though in proportionally small amount, in the fang of the young tooth, whilst they make up almost the entire mass of the strap-shaped shaft of the adult. By their growth the pulp-cavity is obliterated, except the merest rudiment near the upper end of the shaft. Similarly, the dentine which exists as a very definite layer in the fang of the young tooth is reduced in the shaft of the adult tooth to a layer situated only at its summit. By the growth of the cement and modified vaso-dentine, not only does the tooth protrude from its socket and the gum, but from the mouth, so as to curve around the side of the snout in the manner already described, and which would necessarily limit the power of opening the mouth.

The cement undoubtedly owes its origin to the alveolo-dental periosteum, which will serve as a centre of formation of new cement so long as the growth of the shaft continues. It is not possible to speak so positively of the origin of the tissue which constitutes the opaque central band of the shaft. If it be, as I have surmised, a modified vaso-dentine, then one would have to look to the pulp for its seat of production, but if it be a modified cement, then it would arise from the alveolo-dental periosteum. In the latter case, therefore, almost the entire shaft would be of periosteal origin. The tooth differs most materially from the tusks of the elephant or the narwhal, in which the pulp-cavity is persistent, and the continuous growth of the tusk is due to the conversion of the pulp occupying that cavity into dentine.

In the original specimen from the Cape, described and figured by Dr Gray and by Professor Owen, the teeth were not so large as in this animal, in which, indeed, the teeth have attained a size greater than in any previously recorded specimen. Dr Gray states that the length of the anterior edge of the exposed part of the tooth of his specimen was $9\frac{1}{2}$ inches, whilst in this one the same border was 10 inches to the base of the denticle, and nearly an inch more to the highest part of the shaft. Nothing is said by either of these authors of the teeth crossing each other on the dorsum of the beak, and in the front view of the teeth in the jaw given by Dr Gray (fig. 72, *c*) the summits of the shafts are represented as touching, but not crossing.

From Dr Hector's short account of the teeth in his specimen, which was caught at the Chatham Islands, and from his published figures (Pl. III. figs. 1–5), it is obvious that his animal was younger than the specimen *B*. The teeth in the New Zealand jaw are only 6 inches long and 3 inches wide, so that they could have projected only at the side of the beak and not reached its dorsum. From the notes taken by Mr Moseley, on his visit to the Wellington Museum, I extract the following more complete account of these teeth, and a comparison of their characters with those of the Cape specimen :—

"When the anterior margins of the teeth in the two specimens, at the spots where they emerged from the alveoli, are placed accurately side by side at the same level, the posterior margins of the teeth in the New Zealand jaw reach back and correspond in sweep of curve exactly to the vacant alveolar spaces which are conspicuous immediately behind the teeth in the Cape jaw. The teeth in the New Zealand specimen are thus inclined at a less angle than they are in the Cape one, and it appears that the teeth as they increase in age and length, become tilted up towards the vertical, leaving vacant alveolar spaces behind them. Possibly they are dragged up by attempts to open the jaw after they have overlapped. In the New Zealand specimen the dentinal caps (my denticles) are about twice as large as in the Cape one, and proportionately thick and stout. In both, these caps are, when the teeth are *in situ*, almost vertical in direction, having thus, curiously enough, the original direction which they had when within the young alveolus, notwithstanding the curving of the hypertrophied fangs. In the New

Zealand specimen, the fangs being little curved, the caps are thus almost parallel to the fangs, or only slightly inclined outwards from them, whereas in the Cape specimen the caps are directed at right angles to the fangs, which, towards their tips, are so bent as to be almost horizontal. The alveolar regions of the fangs present in both specimens a similar series of ridges terminating in denticulations. The tips of all the denticulations are closed in the New Zealand specimen, and there is no trace of a pulp-cavity, notwithstanding that the animal may be assumed to be young and with its teeth yet to grow, which it would do by a continuous addition from without by a periosteum which acts the part of a persistent pulp.

"The New Zealand teeth are much less curved than those from the Cape. If the dentinal caps are placed in apposition and parallel to one another, the younger New Zealand teeth are seen to be nearly two and a half times as broad as the older teeth from the Cape at the place of attachment of the caps of dentine. In each case the cap is placed on the anterior corner of the somewhat square-ended tooth, hence a large portion lies behind the cap in the New Zealand specimen, and but a small portion in the one from the Cape. On the anterior margin of the New Zealand teeth are semilunar excavations, cutting into their substance, and evidently caused by wear. The inner more spongy substance of the tooth being exposed it has decayed somewhat, leaving a harder external layer a little prominent. This decay is probably a *post-mortem* occurrence. In the Cape specimen there is no trace of this wear, or a very slight depression may possibly mark it.

"The dentinal cap of the tooth in the New Zealand specimen is marked by grooves passing in an inclined direction from apex to base. Similar grooves are to be seen in the tooth of the young specimen of *Mesoplodon hectori* in the Wellington Museum, the tooth being divided by them into three lobes, a central and two lateral, on the inner face. The adult New Zealand specimen shows the same form in its dentinal caps, the lobes being on the inner face, and a pair of teeth of the same species from the Chatham Island, preserved in the Museum, show the same form also. In the teeth of the young *Mesoplodon hectori*, the pulp-cavity is still open as a slit-like cavity, showing internally numerous fine ridges, which are apparently the commencement of the denticulations of the adult tooth."

In the skull described by Dr von Haast, the length of the anterior edge of the exposed part of the tooth was 8·74 inches, and the anterior edge was not worn away; but both in it and the Chatham Island specimen, described by Dr Hector, a sufficient space existed between the upper ends of the pair of teeth to allow of the beak to pass, when the animal opened its mouth. Dr von Haast states that the animal was a full-grown male, and from the ossification of the epiphyses, he judges it to be of mature age.

The tooth of a ziphioid cetacean, from Little Bay, Sydney, figured by Dr Gray, which he regarded as a new genus, *Callidon*, but which Mr Krefft, who obtained the specimen, named *Mesoplodon güntheri*, closely approximates, in the relation of the denticle to the fang, to the tooth of the young *Mesoplodon layardi* described in this communication. It differs, however, slightly in the shape of the fang, which in the Little Bay specimen is more elongated than in my specimen, so that the tooth is a little larger. There is nothing, however, in this character to found specific, still less generic, distinction on, so that I am prepared to support Professor Flower's opinion that the Little Bay cetacean is an example of *Mesoplodon layardi*.

The Little Bay animal is said to have been 18 feet in length, which is also stated to have been about the length of the specimen described by Dr von Haast. The animal from which the adult teeth described in this communication were procured was said to have been from 16 to 18 feet long, and both in it and in von Haast's specimen the teeth had protruded, so as to form large tusks, whilst in the Little Bay example, and the one from the Falkland Islands, which was certainly under 14 feet long, the teeth are rudimentary in size. Now, as the Little Bay and von Haast's animals were of about equal length, and as von Haast's specimen, with well-developed teeth, was determined to be of the male sex, it is not unlikely that the little Bay and Falkland Island specimens were females, so that the presence of well-developed tusks in the skull of *Mesoplodon layardi*, and it may be in the other ziphioid cetacea also, is probably a character of the male sex.

As I have had the opportunity of examining the structure of a tooth in a young *Mesoplodon sowerbyi*, and as no account of the unprotruded tooth of this species has yet been put on record, it may not be out of place to include a description of it in this Report.[1] The tooth was from the mandible of the skull, the characters of which I described some years ago in the Transactions of the Royal Society of Edinburgh.[2] In many of its characters this tooth differed from that in the skull of the adult male in the Oxford Museum, described by Professor E. Ray Lankester,[3] which is probably due to the difference in the age of the two specimens, and it may be to a difference in sex.

The two teeth of the young *Mesoplodon sowerbyi* were imbedded in their sockets, in the lower jaw, out of which only the apex projected. Each tooth was laterally compressed, and triangular in form. Its vertical diameter, from base to apex, was 2 inches, its antero-posterior diameter, along the base, $2\frac{1}{10}$th inches. The anterior border was longer and more oblique than the posterior, so that the apex of the tooth was directed upwards and backwards. There was no sharp demarcation into crown and fang; although

[1] I gave an account of this tooth, and that of *Mesoplodon layardi*, to the Royal Society of Edinburgh on June 2, 1879, and printed it in the Journal of Anatomy and Physiology, July 1879.

[2] Vol. xxvi. 1872.

[3] Transactions of the Royal Microscopical Society, printed in Quarterly Journal of Microscopical Science, vol. vii. 1867.

a sinuous slightly raised line, half an inch from the apex, seemed to mark off the crown from the fang, and probably indicated where the gum had embraced the tooth. The outer surface of the tooth was smooth, except near the base, which was marked longitudinally with shallow furrows; it was of a dull whitish-yellow colour.

About the middle of the elongated base was a narrow chink, which had evidently at one time extended along its whole length, but in course of time had become almost entirely occluded. When a vertical section was made through the middle of the tooth, this chink was seen to communicate with a pulp-cavity, which extended to 4-10ths of an inch from the apex of the tooth. Near the base of the tooth the cavity was so contracted that the opposite walls were almost in contact, but in the middle of the tooth it dilated into a well-marked cavity (Pl. III. fig. 20).

A thin vertical section was then cut out of the tooth from base to apex, and prepared for microscopic examination. Under a low power the tooth was seen to consist in its greater part of dentine, which formed the wall of the whole of the pulp-cavity, except at the basal end of its contracted portion. In the upper third of the tooth the dentine tubes radiated in a very regular manner from the pulp-cavity outwards, but in the lower two-thirds, they were broken up into clusters and tufts, and sometimes irregularly scattered throughout the dentine matrix. The surface of the section through the dentine was marked by contour lines parallel to its surface, which expressed the primary curvatures of the dentine tubes (fig. 20). But, in addition, a line of interglobular spaces lay in the substance of the dentine, parallel to these contour lines, and about midway between the most external of them and the exterior of the dentine. This line of interglobular spaces did not pass in one direction much beyond the apex of the pulp-cavity, but in the other it extended some distance into the fang.

The dentine in the crown was invested by a thin layer of substance, which had the position and relations of a layer of enamel to the dentine. It extended as far down the tooth as opposite the apex of the pulp-cavity, where it was overlapped by the cement, but at the very tip of the tooth it was absent, having apparently been worn off. The characteristic enamel structure was not so definite in it as in the corresponding layer on the crown of the young tooth of *Mesoplodon layardi*, but in thin sections it was seen to be traversed by fine lines extending perpendicularly to the surface of the tooth, which obviously indicated the direction of the rods of enamel. But the exterior of the crown did not have the brilliant white appearance so characteristic generally of the enamel.

The free surface of the fang was invested by a thin but definite layer of cement. Where the dentine was covered by the cement, a change in the structure of the dentine occurred. Vascular canals were seen to lie in it perpendicular to the free surface of the tooth, and forming loop-like curves immediately subjacent to the cement. This portion of the dentine was, therefore, a vaso-dentine. As the cement and vaso-dentine were traced lower down in the fang, other modifications became apparent. The vaso-dentine acquired greater opacity from the increase and general distribution through it of minute interglobular spaces, with which the line of interglobular spaces already described in the upper part of the tooth became continuous. But there also appeared between the dentine and cement a definite layer, at first thinner than the cement, but increasing in thickness as it extended down the fang, in the lower part of which it equalled in thickness the cement and dentine together (fig. 22). This layer was readily recognisable to the naked eye from its opaque white appearance. It contained numerous branching and anastomosing canals, the chief of which lay perpendicularly to the surface of the tooth. The matrix between the canals was granulated. This layer corresponded, therefore, in structure to the modified vaso-dentine described in the teeth of *Mesoplodon layardi*.

To the naked eye the wall of the pulp-cavity had numerous hemispherical bodies projecting from its free surface. When examined microscopically they were seen to be continuous with the dentine, for the dentine tubes were prolonged into them. The dentine formed, therefore, the wall of the pulp-cavity in the greater part of its extent; but the wall of the constricted part of the cavity in proximity to the end of the fang, and at the sides of the chink-like opening in it, was not dentine, but consisted of the substance which I have named modified vaso-dentine. It was not, however, so regularly constructed as the layer between the dentine and cement, for the canals were few in number in proportion to the matrix, and had no definite arrangement.

I shall now make some observations on the leading differences between the tooth of this young *Mesoplodon sowerbyi*, and that of the adult animal described by Professor Lankester. In the first place, the crown of the tooth of the adult projected (as I have ascertained from a measurement of a cast of the jaw presented by Dr Acland to the Anatomical Museum of the University of Edinburgh) $1\frac{2}{10}$ths beyond the edge of the alveolus, whilst only the tip of the tooth in the young animal projected out of the socket. The outer surface of the young tooth was almost uniformly smooth, and not rough and knotted as in the adult. The pulp-cavity, instead of being almost equal to the entire length of the tooth, was restricted in the adult to a small space in the crown, the rest of the tooth being solid. In this respect the tooth of *Mesoplodon sowerbyi* approximates to what I have described in the shaft of the tooth of the adult *Mesoplodon layardi*. The early stage of the closing up of the pulp-cavity is to be seen even in the young *Mesoplodon sowerbyi*, in which almost the whole of the cleft at the root of the fang is closed up, and the walls of the adjacent part of the pulp-cavity are closely approximated to each other. The enamel had evidently been worn off the crown of the adult, for Mr Lankester makes no reference to it. The dentine in the adult was confined to a small conical cap at the apex of the crown, and to a very thin layer extending about half-way down the tooth, instead of, as in the younger tooth, forming the larger proportion of its substance. The great bulk of the adult tooth was made up of cement, osteo-dentine, and of a substance which Mr Lankester calls globular matter. The cement was evidently considerably thicker in the adult than in my specimen, and the osteo-dentine and globular matter together formed a large proportion of the adult tooth. In the younger tooth, well-marked vaso-dentine was present, as already described, but I could not say that I recognised any definite osteo-dentine. The material which I have named modified vaso-dentine was also present in considerable quantity, and in its opacity it corresponded with the globular matter of Prof. Lankester. In its structure, however, it appears to differ, for he describes the globular matter as having "no structure excepting an indistinct botryoidal character visible with a low magnifying power." "The amorphous matter at length shades off into the dentine, numerous distinct, minute, 'interglobular spaces' becoming more and more distinct as one recedes from the opaque stratum, and their number diminishes." It is probable that this globular matter may represent in the adult the modified vaso-dentine of the younger tooth, for the numerous vascular canals which the latter contains may become obliterated through an extension of the process of calcification, so as to give it the more solid character present in the fully-formed tooth. In the granulated matrix of the younger tooth, an appearance was not unfrequently seen, which might have been described as interglobular spaces.

From Professor Flower's description of the structure of the teeth of *Berardius arnouxii*,[1] it would appear that in that ziphioid the teeth are very similar to those of the adult *Mesoplodon sowerbyi* described by Prof. Ray Lankester.

The observations which I have now recorded on the non-erupted teeth, both of *Mesoplodon layardi* and *Mesoplodon sowerbyi*, prove, that in the earlier stages their structure does not differ materially from the ordinary type of tooth one meets with, say in the human or carnivorous jaw, the crown being covered by enamel, the fang by cement, whilst the great body of the tooth consists of dentine, in which is a well-marked pulp-cavity, communicating with the exterior by a slit-like aperture at the root of the fang. The exceptional character which these teeth exhibit in the erupted condition is due to the disappearance of the enamel from the crown, to the cessation in the development of the ordinary dentine, to the excessive formation of osteo-dentine, of modified vaso-dentine, and of cement, by means of which the pulp-cavity becomes almost obliterated, and the fang assumes dimensions which, in the case of *Mesoplodon layardi*, lead to the production of a tooth having the very remarkable form and relation to the beak which I have described.[2]

I shall next describe the other bones of the axial skeleton of the younger *Mesoplodon layardi* (specimen *C*), which consisted of the spinal column, ribs, sternum, and a portion of the hyoid bone.

Spinal column.—The length of the column in the macerated spine was, with the

[1] Trans. Zool. Soc., vol. viii. p. 223.

[2] I have not thought it necessary to figure the skull of the adult *Mesoplodon layardi*, as the illustrations given by Professor Owen in his Monograph on the British Fossil Cetacea in the Memoirs of the Palæontographical Society, 1878, express so well the characters of the adult skull. As the petrous bone, however, of the adult has not been figured, and as so immature a skull as that described in the text has not previously been examined, I have had them drawn in Plate I.

epiphysial plates not in position, 88½ inches. If 16 inches be allowed for the thickness of these plates, and another 16 inches for the thickness of the intervertebral discs, the total length of the spine would have been in the fresh state 120½ inches—say 10 feet. The length of the skull proper was 25 inches, but as the lower jaw projected an inch beyond the upper, the entire skull was 2 feet 2 inches in length. The length of the skull being added to that of the spine makes the length of the axial skeleton 12 feet 2 inches, which is considerably below the length of 14 feet, stated by Mr Bonner, the captor, to have been that of the animal. Even if we suppose that, in the macerated condition, one or even two of the terminal caudal vertebræ were absent, and make ample allowance also for the thickness of the integument at the tail and beak, one cannot see that the animal could have been so long as stated by Mr Bonner. The vertebral formula was—

$$C_7,\ D_9,\ L_{10},\ Cd_{18} = 44\ .$$

It is possible that one or even two of the terminal caudal vertebræ may not have been ossified, as not merely were the plate-like epiphyses not ankylosed to the vertebral bodies generally, but the bones in their general aspect had all the characters of immaturity. In Dr von Haast's specimen already referred to, the vertebral formula was C_7, D_{10}, L_{10}, $Cd_{19} = 46$. In *Mesoplodon sowerbyi* the formula is also 46, made up as follows:—C_7, D_{10}, L_{10}, Cd_{19}, or, according to Malm,[1] C_7, D_{10}, L_9, Cd_{20}. In *Mesoplodon grayi* it is, as Professor Flower has shown,[2] 48—viz., C_7, D_{10}, L_{11}, Cd_{20}; and in *Mesoplodon australis*, 47—viz., C_7, D_9, L_{11}, Cd_{20}, though in both it is probable that one minute terminal vertebra is wanting.

The *cervical vertebræ* had in their total length an antero-posterior diameter of 3½ inches. The atlas, axis, and third vertebra were united into a single bone. The fusion between the bodies and spines of the atlas and axis was very complete, but the pedicles and transverse processes were distinct. The body of the third was ankylosed to the second vertebra, but it was differentiated by a deep furrow at the place of fusion. The transverse processes, pedicles, and laminæ were quite distinct, but the laminæ were not united mesially, and there was, consequently, no spine. The breadth of the atlas was 6 inches, its vertical diameter was 5¼ inches. The remaining cervical vertebræ were separate bones, with loose epiphysial plates. Their bodies were thin plates of bones, and each possessed an inferior mesial tubercle. Their neural arches were incomplete mesially, except in the seventh, where the laminæ were united, and a spine an inch long was produced. The transverse processes not only in these posterior cervical vertebræ, but in the second and third also, were divided into a superior, projecting from the neural arch, and an inferior, from the side of the body, but these processes were not joined externally to form a "verte-

[1] Hvaldjur i Sveriges Museer år 1869 in Konig. Svenska Vetenskaps, Akad. Handlingar, Band 9, No. 2, Stockholm, 1871.

[2] On the Genus *Mesoplodon*, Trans. Zool. Soc., vol. x. p. 428, 1878.

brarterial foramen." The inferior transverse processes of the more anterior vertebræ were almost horizontal, but the more posterior had this process sloping downwards and outwards, and but slightly projecting; in the seventh it was reduced to a mere tubercle. On each side of the body of the seventh vertebra was a distinct articular surface for the head of the first rib (Pl. I. fig. 3).

In the union of the anterior three vertebræ into a single bone, this specimen agrees with the *Mesoplodon layardi* described by Dr von Haast, and it differs from *Mesoplodon grayi* and *Mesoplodon australis* described by Professor Flower, and from *Mesoplodon sowerbyi*, in all of which only the atlas and axis are fused together. It may be taken, therefore, as a piece of evidence, which is of value as far as it goes, in favour of the opinion expressed in this Report, that Dr von Haast's specimen from Saltwater Creek is of the same species as this one from the Falkland Islands.

In the *dorsal vertebræ* the bodies increased in size from before backwards. The first had a pair of slight tubercles projecting from its inferior surface in series with, but smaller than, the inferior transverse processes of the seventh cervical vertebra. A mesial ridge appeared on the inferior surface of the body of the sixth dorsal, which was more strongly marked in the hinder members of the series. In all, the laminæ and spines were complete, and became more massive from before backwards. The spine of the first, comparatively slender, was directed slightly forwards, that of the second was almost vertical, whilst those situated behind the second inclined a little backwards. Articular surfaces for the heads of the second, third, fourth, fifth, and sixth ribs were very distinct on the posterior border of the side of the bodies of the anterior five dorsal vertebræ, situated close to the place of origin of the pedicle. In the second, third, fourth, and fifth vertebræ a larger proportion of this articular surface was on the pedicle than on the body as compared with the first and sixth dorsal vertebræ. The articular surface for the head of the seventh rib was partly on the posterior border of the side of the body of the sixth, and partly on the anterior border of the seventh vertebra, its articulation with the seventh being better marked on the right than on the left side. The articular surface on the anterior part of the side of the body of the seventh vertebra was on a slightly projecting process, which was in series and obviously homologous with the much more strongly projecting processes from the side of the bodies of the eighth and ninth dorsal vertebræ. The anterior seven dorsal vertebræ had each a pair of broad transverse processes springing from the pedicles, close to the anterior articular processes, for articulation with the tubercles of the anterior seven pairs of ribs. These transverse processes projected forwards and somewhat downwards in the more anterior dorsal vertebræ, but in the sixth and seventh outwards and downwards. The long axis of the articular surface for the tubercle of the rib also changed in its direction, for on the transverse processes of the first and second it was almost vertical, further back it became oblique, but on the seventh dorsal it was horizontal and antero-posterior. The long axis of these articular surfaces corresponded to the direction of the surfaces of their transverse processes, which surfaces were flattened and not rounded. The eighth and ninth dorsal vertebræ had no transverse process projecting from the side of the neural arch, but instead a massive process was directed horizontally outwards from the side of the body nearer the anterior than the posterior surface. This process was nearly three times as big in the ninth as in the eighth vertebra, and in both it had a large articular surface at its outer end for the head of the corresponding rib. Zygapophyses were present as far back as the anterior pair of the sixth dorsal vertebra, but behind that they had disappeared, and a pair of well-developed metapophyses projected forwards, from the laminæ of the seventh, eighth, and ninth dorsal, to overlap and articulate with the laminæ of the vertebra immediately in front.

Compared with Dr von Haast's specimen this animal has one vertebra less in the dorsal series. This does not invalidate the opinion that they are of the same species, as it is well known that in the Cetacea variations to the extent of a vertebra and a pair of ribs may take place in the thoracic region. In *Mesoplodon grayi* and *Mesoplodon sowerbyi* there are also ten dorsal vertebræ, whilst in *Mesoplodon australis* the number is only nine. The transverse processes in my specimen were not rounded as in Dr von Haast's animal, and the articular surfaces for the heads of the ribs did not appear to rise quite so far above the base of the neural arch as he describes.

The *lumbar vertebræ* were almost uniform in shape, but increased in size from before backwards. The bodies were keeled on their inferior surface. At the anterior and posterior ends of the series the longitudinal and transverse diameters of the body were almost equal, but in the intermediate vertebræ the longitudinal was greater than the transverse. The transverse processes were not so long as the width of the body except in the anterior vertebræ. The base of the process sprang from the anterior half of the side of the body in series with the transverse processes of the eighth and ninth dorsal vertebræ —the processes projected forwards and outwards, and the free end was convex. The spines were long, laterally compressed, and sloped slightly backwards: the length of the eighth lumbar spine was 6 inches. A pair of broad lamelliform metapophyses projected forwards from the anterior border of the laminæ close to the root of the spine, but did not articulate with the vertebra in front, from the posterior edge of the laminæ of which a pair of much smaller processes projected backwards. As in Dr von Haast's specimen, the neural arches sprang from the centre of the bodies.

The *caudal vertebræ* diminished in size from before backwards. The first was $9\frac{1}{2}$ inches high and 7 inches between the tips of its transverse processes. The last was 9-10ths of an inch in greatest breadth, and 7-10ths of an inch in height. In the anterior four vertebræ the spines were massive, and these processes were present as far back as the tenth caudal, in which the neural arch and spine formed a slight ridge, and the spinal canal was diminished to the diameter of a goose-quill. The transverse processes were strong in the anterior four caudals, and had the same shape and direction as in the lumbar vertebræ; they rapidly diminished in size in the fifth and sixth, and in the seventh were reduced to a faint ridge projecting from the anterior half of the side of the body. Metapophyses, which were non-articular, projected forwards from the anterior edge of the laminæ of the anterior seven vertebræ, and a shorter pair of processes projected backwards from the posterior edge of the laminæ of the anterior four vertebræ. The posterior eight caudals were merely the bodies of vertebræ. The inferior surface of the body of each of the anterior fifteen caudal vertebræ was grooved antero-posteriorly, and on this surface in the anterior nine vertebræ were articular facets for eight chevron bones. Only five of these bones were present in this skeleton, viz., the larger and most anterior; it is not unlikely that the more posterior chevrons had not been ossified.

In von Haast's specimen, as in this, the spinous processes disappeared behind the tenth, and the transverse processes behind the seventh caudal vertebra; but there were nine instead of eight chevron bones. In both *Mesoplodon grayi* and *Mesoplodon australis*, again, Professor Flower found that the neural arch and spine were present on the eleventh caudal, and that the last trace of the transverse process did not disappear until the ninth caudal.

The Ribs.—There were nine pair of ribs, corresponding in number to the dorsal vertebræ. The first was the broadest and shortest, from which they increased in length, but diminished in breadth, to the fourth, when they again diminished in length to the ninth. The anterior seven each articulated both with a vertebral body and with a transverse process. From the second to the seventh inclusive, each rib possessed a distinct head and tubercle separated by an intermediate neck; but the first had an elongated articular surface at its vertebral end without any definite demarcation into head and tubercle. Each of these ribs was jointed by its head to the body of the vertebra in front of that to the transverse process of which it was articulated by its tubercle, but the head of the seventh rib was articulated with the bodies of both the sixth and seventh dorsal vertebræ, whilst its tubercle articulated with the transverse process of the seventh dorsal. The eighth and ninth ribs had each only a single articular surface at its vertebral end, which was jointed with the transverse process projecting from the side of the body of the corresponding dorsal vertebra. The greatest breadth of the first rib was $2\frac{1}{2}$ inches, its length along its posterior border was $11\frac{1}{4}$ inches. The greatest breadth of the fourth rib was in the region of the tubercle, viz., $1\frac{3}{4}$ths of an inch, and its length along the posterior border was 2 feet. The length of the last rib cannot be given, as it was broken.

In von Haast's specimen, where ten ribs were on each side, the eighth, ninth, and tenth had each only a single articular surface at its vertebral end for articulation with its corresponding vertebra. In *Mesoplodon grayi*, also with ten pairs of ribs, only the ninth and tenth had a single articular surface at their vertebral ends for articulation respectively, with the transverse processes from the side of the bodies of the ninth and tenth vertebræ, whilst the eighth rib was attached to the articular surfaces on the contiguous sides of the body of the seventh and eighth dorsal vertebræ, but not to any transverse process. In *Mesoplodon sowerbyi*[1] the anterior seven ribs were articulated by both heads and tubercles to their appropriate vertebræ, whilst the eighth, ninth, and tenth ribs had each only a single articulation with the transverse process from the side of the body of the corresponding dorsal vertebra. In *Mesoplodon australis*, again, the anterior six ribs were articulated by head and tubercle to body and transverse process ; the eighth and ninth only to the transverse process from the side of the body of the corresponding vertebræ ; whilst the seventh left rib was attached by the former method and the seventh right by the latter only.[2] In my specimen of *Mesoplodon layardi*, as in *Mesoplodon australis*, the seventh dorsal vertebra with its pair of ribs was the vertebra of transition.

Sternum.—The sternum consisted of three bony segments articulated together by intermediate bands of cartilage. A band of unossified cartilage about 1 inch deep was attached to the anterior border of the manubrial segment. Between the manubrial and second segment was a mesial foramen about $1\frac{1}{2}$ inch long and $\frac{3}{4}$ths of an inch wide, and a similar hole was between the second and third segments. The manubrium was 5 inches long by $4\frac{3}{4}$ inches in its greatest transverse diameter ; its inferior surface had a faint mesial ridge, its superior surface was concave. Its inferior border had a mesial notch. The second segment was $3\frac{3}{4}$ inches long and notched both at its anterior and posterior borders, where it contributed to form the boundaries of the mesial sternal foramina. The third segment was $2\frac{1}{2}$ inches long and notched only at its upper border. The sternum articulated with four pairs of ribs. The first with the cartilaginous band at the anterior border of the first segment ; the second with the plate of cartilage between the first and second segments ; the third with the corresponding band between the second and third segments ; the fourth with the sides of the posterior border of the third segment (Pl. I. fig. 4).

In von Haast's specimen the sternum consisted of four segments, of which the fourth was divided into a right and left portion. It also articulated with five pairs of ribs. In *Mesoplodon australis* four segments articulating with five pairs of ribs were also present, and in the immature sternum of *Mesoplodon grayi* four segments were recognised by Professor Flower. In *Mesoplodon sowerbyi* five segments are figured by MM. Van Beneden and Gervais,[3] the last being divided into two lateral halves. It is very probable, that in the immature skeleton of *Mesoplodon layardi* I am now describing, the fourth segment had not been ossified.

Hyoid bone.—The only representatives of the hyoid apparatus consisted of the pair of stylo-hyals, each of which was broken, but the articular surface apparently at the cranial end was preserved.

[1] Van Beneden and Gervais, Ostéographie des Cétacés, pl. xxii. fig. 1.

[2] See Flower in Trans. Zool. Soc., 1878, p. 431.

[3] Ostéographie des Cétacés, pl. xxii. fig. 2.

Ziphius cavirostris, Cuvier.

In November 1872 Dr Hector read before the Philosophical Society of Wellington, New Zealand, a memoir On the Whales and Dolphins of the New Zealand Seas.[1] In it he described and figured by the name of *Epiodon chathamiensis*, or goosebeak whale, a skull collected by Mr H. Travers at the Chatham Islands. He expresses the opinion that it is possible this animal may be identical with *Epiodon australis* from Buenos Ayres described by Burmeister, and states that except in the upward curve of the beak and the less development of the vomerine callosity, the skull resembles the *Petrorhynchus capensis* of Gray. He further mentions that the rostrum of an individual of this species, and having a less upward curve, found at Lyall Bay, near Wellington, is in the Colonial Museum.

In a memoir which I had previously read before the Royal Society of Edinburgh in May 1872,[2] I advanced facts and arguments to prove that the Cetacea which had been described by the several generic names of *Epiodon* and *Petrorhynchus* should be referred to the Cuvierian genus *Ziphius*, of which *Ziphius cavirostris* was the type species, and I further expressed the opinion that the exotic specimens which had been named *Ziphius indicus*, Van Beneden, *Petrorhynchus capensis*, Gray, and *Epiodon australe*, Burmeister, should be ranked, along with the several European specimens named in that memoir, as examples of the *Ziphius cavirostris*.

When a box arrived from the Challenger in 1875 containing a skull and lower jaw marked *Epiodon chathamiensis*, Hector,[3] which had been presented to the collection by the Colonial Museum, Wellington, I examined it with great interest, and compared it with the cranium of the *Ziphius cavirostris* from the Shetland Islands in the Anatomical Museum of the University of Edinburgh. The skull was, unfortunately, not perfect, as the occipital and sphenoid bones, in the region of the basis cranii and foramen magnum, the pterygoid bones and temporals were broken away, but the beak, the great prænasal fossa, the anterior nares and the summit of the cranium, which are the most distinctive parts of the skull, were preserved. There is no need for me to give a detailed description of this cranium, but it will be sufficient for my present purpose if I compare what there is of it with the skull of the Shetland specimen, described at length in my memoir, and point out wherein they correspond or disagree.

The skull, like the Shetland specimen, was evidently from an old animal, as the cranial sutures were to a large extent obliterated, the bones were massive and weighty, and the teeth were shed from the mandible, their sockets, as in the Shetland specimen, being occupied by a growth of bone. Owing to the occipital end of the skull having been so much injured, I am unable to give the entire length of the cranium, but several other measurements showed that it was on a somewhat larger scale than the Shetland skull.

[1] Trans. New Zealand Institute, vol. v.

[2] On the Occurrence of *Ziphius cavirostris* in the Shetland Seas, and a comparison of its Skull with that of Sowerby's Whale (*Mesoplodon sowerbyi*), Trans. Roy. Soc. Edin., vol. xxvi.

[3] Dr Hector writes to me that this specimen was got near Wellington. He has now had a good many specimens through his hands. This Cetacean, he says, is common in the New Zealand seas, though rarely captured or cast ashore.

In their general form the two crania closely resembled each other. The summit of each skull was formed of the same bones similarly arranged, but in the New Zealand skull the nasal bones were an inch longer, and somewhat more than an inch wider at the base than in the one from Shetland. In both the great prænasal fossæ and anterior nares were similarly shaped, and the bones forming their walls were similarly arranged; the only appreciable difference being that in the New Zealand specimen the transverse diameter of the fossa was about an inch wider, the præmaxillæ forming the sides of the fossæ were more massive, and from the inner surface of the left præmaxilla a stronger ridge projected than in the Shetland cranium. In the New Zealand specimen the greatest width between the two præmaxillæ was 10 inches, whilst that of the Shetland cranium was $8\frac{7}{8}$ inches. The beak was similarly constructed in both specimens. The mesorostral bones were almost identical in shape, but in the New Zealand skull it was $1\frac{1}{4}$ inch longer than in the one from Shetland—$14\frac{3}{4}$ inches as against $13\frac{1}{2}$ inches. In the New Zealand specimen a narrow longitudinal groove between 3 and 4 inches long was situated at the posterior truncated end of this bone, no similar groove existed in the Shetland animal. Both possessed an ecto-maxillary ridge and furrow; in the Shetland specimen the furrow was narrower and deeper than in the New Zealand, but in the latter the superior maxilla in the middle third of the beak had its sides more uniformly rounded, and projecting somewhat more laterally, than in the Shetland animal. In both, the under surface of the beak had a similar construction, and the palate bones articulated with each other mesially between the anterior ends of the two pterygoids, and separated the latter from the superior maxillæ. The mandibles resembled each other in shape and in projecting beyond the tip of the beak, but in the New Zealand specimen the bone was somewhat more massive and $2\frac{1}{4}$ inches longer than in the one from Shetland—$34\frac{3}{4}$ inches to $32\frac{1}{2}$ inches.

The evidence which I have obtained from a personal comparison of these two crania, belonging to animals dwelling in such widely separated seas as those of the Shetland Isles and New Zealand, is not such as to justify me in classifying them as distinct species. In all the essential features of form and construction they are practically alike. The differences which I have noted between them are merely such as are due to a difference in size, and to the New Zealand cranium having, along with its greater size, a somewhat more extended condition of ossification than the Shetland specimen, so that, so far as the cranial characters afford a basis for observation, I could come to no other conclusion than that the New Zealand animal is *Ziphius cavirostris*.

Since the skull from the Wellington Museum arrived in Edinburgh, the New Zealand naturalists have published additional information on this genus of Ziphioids.

In May 1876 a paper by Dr von Haast was contributed to the Philosophical Institute of Canterbury, New Zealand,[1] and also to the Zoological Society of London,[2] in which was described the skeleton of an aged female whale that had been stranded, in July 1872, in Lyttleton Harbour, Bank's Peninsula. This is apparently the same animal

[1] Trans. New Zealand Institute, vol. ix. p. 430, 1877. [2] Proc. Zool. Soc. Lond., June 6, 1876, vol. xliv. p. 466.

as is referred to by Dr Hector in his paper, read in November 1872, as having been captured in Port Cooper, and the skeleton of which was being prepared for the Canterbury Museum. Dr von Haast named the animal *Epiodon* (*Ziphius*) *novæ-zealandiæ*. In an appendix to his paper he applied the same name to another skull, also of an adult female stranded in July 1873 in Akaroa Harbour. Von Haast considers that these animals are closely allied, if not belonging, to the same species as *Epiodon chathamiensis*, but as there are some minor differences between them, of which he more especially refers to the form of the teeth, he prefers to apply a different specific name to these animals.

Professor Flower, at the same meeting of the Zoological Society,[1] in commenting on Dr von Haast's paper, stated that he saw no good grounds for distinction between *Ziphius novæ-zealandiæ* and *Ziphius chathamiensis*, and that, indeed, von Haast's two animals differed more from each other than either of them did from *Ziphius chathamiensis*. Further, that the photographs sent by Dr von Haast, when compared with the skull at the British Museum which Dr Gray had named *Petrorhynchus capensis*, did not show any greater differences than are consistent with the range of individual variation, and that no proof had yet been given that any clearly defined specific difference existed between *Petrorhynchus capensis*, *Ziphius australis*, and *Ziphius cavirostris*.

Dr Hector, in a second memoir in the Transactions of the New Zealand Institute (vol. x. p. 342, 1878), states that the specific distinction made by von Haast between the Chatham Island and New Zealand specimens is founded on little more than the form of the teeth, which in the specimen in the Canterbury Museum had become absorbed, only the fangs being left, whilst in the specimen from the Chatham Islands the teeth were still large and serviceable. He does not recognise, therefore, any specific difference between the animal he had originally described and those named by von Haast *Ziphius novæ-zealandiæ*. But Dr Hector goes still further, and, influenced evidently by the facts and arguments advanced in my memoir on *Ziphius cavirostris*, to which he makes special reference in his paper, now regards his *Epiodon* (*Ziphius*) *chathamiensis* as the same species as the *Ziphius cavirostris* of Cuvier; a conclusion which coincides entirely with that which I had arrived at from a comparison of the skulls of these animals. M. Van Beneden in a recent paper On the Geographical Distribution of the Cetodonts[2] reviews the whole of the evidence up to that time advanced on this subject. He now regards not only his *Ziphius indicus* but the specimens from the Cape, and that described by Dr Burmeister from near Buenos Ayres, as the same as the *Ziphius cavirostris*, so that he supports the opinion I had expressed in my original memoir, that the exotic as well as the European crania, which have up to this time been described, are all examples of one species— the *Ziphius cavirostris* of Cuvier. The present state of our knowledge of this cetacean strengthens, therefore, the statement which I had made in that memoir that the geographical range of the *Ziphius cavirostris* equals that possessed by the spermaceti whale.

[1] Proceedings, 1876, vol. xliv. p. 477. [2] Bulletin de l'Academie royale de Belgique, April 1878, vol. xlv. No. 4.

Megaptera lalandi (Fischer).

The vertebræ of the humpbacked whale (*Megaptera lalandi*) belonging to the collection consisted of the atlas, axis, and third and fourth cervical vertebræ. They were from an animal captured in the New Zealand seas, probably in Queen Charlotte Sound.

The atlas was a distinct bone, but the axis and third and fourth vertebræ were ankylosed into one block. The bones had evidently been exposed on the beach for some time, as they were rubbed and weathered, and had many small pebbles in their grooves and foramina. The transverse diameter of the atlas was 26 inches, its supero-inferior $14\frac{1}{2}$ inches. The spine was stunted. The transverse processes were massive and undivided. The groove for the sub-occipital nerve was converted into a foramen by a bridge of bone. The occipital articular surface was divided into two facets by a mesial notch and furrow. The axis had a transverse diameter of $32\frac{1}{2}$ inches, a supero-inferior of $13\frac{1}{2}$ inches. The spine was massive, and both it and the right lamina were fused with the corresponding parts of the third cervical. The transverse processes each possessed a superior and inferior division continued into each other externally by a broad plate of bone, so that the "vertebrarterial" foramen was completely bounded by bone. A broad stunted process, representing a rudimentary odontoid projected from the anterior surface of the bone, and was received into a corresponding hollow on the posterior surface of the atlas. The superior transverse process of the third vertebra was a slender plate of bone 4 inches long; the inferior transverse process was much stronger, and 7 inches in length. The superior transverse process of the fourth vertebra was $8\frac{1}{4}$ inches long, but the inferior was only 5 inches, both were strong bars of bones. Neither in the third nor fourth vertebræ did the superior and inferior transverse processes meet externally so as to complete the boundary of a foramen. The body of the axis was $15\frac{1}{2}$ inches in its greatest transverse diameter by 9 inches in its greatest supero-inferior. The body of the fourth cervical was 10 inches by $7\frac{3}{4}$, and as it was not so rounded at the sides as in *Balænoptera*, its shape approached the quadrangular. The fusion between the bodies of the second, third, and fourth vertebræ was not complete, but restricted to the sides of their anterior and posterior surfaces, so that intervertebral discs had obviously been present in the recent state between the greater part of the surfaces of the bodies. The left laminæ of the third and fourth vertebræ were fused with each other, but not those of the right side.

The presence of a large Rorqual in the seas of the Southern Hemisphere was determined by Cuvier, from a skeleton brought to Paris by Delalande from the Cape of Good Hope, and was named by him *Rorqual du Cap*. Fischer subsequently called it *Balæna lalandii*, but it was recognised by Schlegel that it possessed affinities to the long-finned Rorqual of the Northern Hemisphere, *Megaptera longimana*. Dr J. E. Gray considered that it formed a genus distinct from *Megaptera*, and named the animal *Pœscopia lalandii.* Its generic difference is not, however, accepted by zoologists generally, and MM. Van Beneden and Gervais associate it with the genus *Megaptera* as species *lalandii*;[1] at the same time they point out that the differences between its skeleton and that of *Megaptera longimana* are not of a strongly-marked character.

In 1864 Dr J. E. Gray received from New Zealand some ear-bones, which though very like those of *Megaptera longimana*, yet had the tympanics shorter and more swollen. He accordingly proposed to distinguish the animal from which they had been obtained as a new species by the name of *Megaptera novæ-zealandiæ.*[2]

MM. Van Beneden and Gervais hesitate to accept the New Zealand *Megaptera* as a distinct species from that of the Cape, and Dr Hector, who at first adopted Dr Gray's nomenclature, has in his latest memoir On the New Zealand Cetacea[3] regarded it as *Megaptera lalandii.* He states that the humpback is the most common whale around the coasts of New Zealand.

The cervical vertebræ in this specimen do not, however, entirely correspond with the vertebræ of *Megaptera lalandi* described by MM. Van Beneden and Gervais. In their specimen it is stated that all the cervical vertebræ were free, but that Cuvier had described the second and third as united by the upper part of the body, and that in the British Museum was a specimen in which the second was united to the third on one side only. In fig. 2, Pl. IX., the junction of the second and third with each other is represented by them, and in the same figure it can be seen that not only are the superior and inferior transverse processes of the cervical vertebræ behind the second not united together externally, but that those of the axis also are free at their outer ends. From this circumstance, as well as from the union of only two vertebræ with each other in the specimens above referred to, there can, I think, be little doubt that the specimen now described was of more mature age than those previously recorded.

In October 1870 a cargo of whales' bones was imported into Leith from the Cape of Good Hope. Messrs J. & J. Cunningham, the importers, kindly allowed me to examine them, and select some specimens for the Anatomical Museum of the University. The collection contained numerous bones of the Cape Humpback, and I had no difficulty in picking out several specimens of the atlas-vertebra of this animal. I have compared the atlas of the New Zealand animal with one of those from the Cape, and except that the furrow between two anterior articular surfaces for the occipital bone is somewhat broader and deeper in the Cape specimen, there is no appreciable difference between them. It should be stated that the atlas from the Cape is a somewhat larger bone than that from New Zealand.

[1] Ostéographie des Cétacés, p. 130.
[2] Proc. Zool. Soc., 1864, p. 208, and Catalogue of Seals and Whales, p. 128.
[3] Trans. New Zealand Institute, vol. x. p. 335, 1878.

Balæna australis, Desmoulins.

The block of vertebræ, marked "Right Whale of New Zealand," consisted of the seven cervical and first dorsal vertebræ ankylosed into one mass. They were from an animal captured at the peninsula of Kaipara.

The bones were broken in places and generally friable, with the roots of plants in the intervertebral foramina, presenting the appearance of having long been exposed to the weather. The fusion of the cervical vertebræ with each other was very complete, for not only were the bodies ankylosed into a solid mass, but also the spines and laminæ. The fusion of the first dorsal by its spine and laminæ with the corresponding parts of the seventh cervical was also complete, so that the spines and laminæ formed a massive crest of bone which sloped upwards and backwards.

The body of the first dorsal was, however, connected, through an irregular band of ossification by only its inferior border, with the corresponding part of the seventh cervical; for the bodies generally of these two vertebræ had evidently been separated in the usual way by an intervertebral disc. The left transverse process of the atlas was broken, but when entire the vertebra must have had a transverse diameter of at least 29 inches. Its width across the anterior articular surfaces was 14 inches, and these surfaces were separated from each other by a non-articular depression, varying in width from 2 to 3 inches. The length of the cervical part of the block, along the line of the spines, was 14 inches, along the inferior surface of the bodies, $11\frac{1}{2}$ inches, when the body of the first dorsal was included the length was 15 inches.

The superior transverse processes were present in all the cervicals. Those of the first and second vertebræ were massive, and projected outwards for several inches; the remainder were much more slender, and in the case of the third to the sixth comparatively short, whilst that of the seventh was again longer, and curved outwards and forwards. In the case of the anterior six cervicals, these processes were fused into a continuous bar of bone at their outer ends, whilst the superior transverse process of the seventh was not ankylosed on the right side, but on the left it was united to the transverse process of the first dorsal vertebra. The inferior transverse processes of the second and third vertebræ were massive and partially ankylosed, that of the fourth was much more slender, and fused with that of the third. They were absent in the fifth, sixth, and seventh. In no instance did the superior and inferior transverse processes unite externally so as to bound a "vertebrarterial" foramen.

The transverse process of the first dorsal vertebra was in series with the superior transverse processes of the cervicals, and like them projected from the side of the neural arch. It was 11 inches long, and curved forwards and outwards external to the superior transverse processes of the more posterior cervicals, so that its free end was close to the transverse process of the atlas. A faint tubercle projecting from the side of the body of this vertebra probably represented a rudimentary, inferior transverse process.

These bones are evidently a portion of the skeleton of the *Balæna* or *Eubalæna australis.* In their form and appearance they closely correspond to the block of cervical vertebræ, figured by Van Beneden and Gervais, in Plates I. and II. fig. 19, as the cervical vertebræ of that animal. M. Van Beneden states that in *Balæna australis* there is no trace of inferior transverse processes in the last four cervical vertebræ, and that this constitutes a noticeable point of difference between this species and the *Balæna antipodarum,* in which all the cervical vertebræ, except the seventh, have an inferior transverse process. In the Challenger specimen, the inferior transverse process was absent in the seventh, sixth, and fifth cervical vertebræ, but present in the fourth, third, and second, so that in the presence of this process in the fourth vertebra, it differed from the specimen described and figured by M. Van Beneden. I am inclined to think from the appearance of his figure, that his specimen must have been from a younger animal, as the lines of demarcation between the spines and laminæ of the vertebræ are more distinct than in the Challenger specimen, and the first dorsal vertebra is not ankylosed to the seventh cervical. The absence, therefore, of an inferior transverse process in the fourth vertebra in M. Van Beneden's animal, may, perhaps, be due to the ossification not having advanced to a stage so far as was the case in the Challenger specimen.

Cetacean Bones dredged from the Bed of the Ocean (Pl. II.).

The dredge brought up in various localities, from a great depth, numerous tympanic and petrous bones of Cetacea, together with fragments of other bones of the skeleton. They have been all carefully picked out by Mr John Murray from the other contents of the dredge, and arranged according to their locality, and the depth at which they were obtained. The conditions under which they were found will be described by Mr Murray in his Report on the deep-sea deposits. At his request, and that of Sir Wyville Thomson, I undertook to determine, as far as possible, the generic and specific characters of these bones, and have compared them with the collection in the Anatomical Museum of the University of Edinburgh. In 1876 and 1879 I took a number of selected specimens to the Museum of the Royal College of Surgeons of England, and, along with Professor Flower, compared them with specimens in that magnificent collection.

The bones were almost without exception coated with a brown material consisting of a mixture of the peroxides of manganese and iron, along with earthy matters; sometimes only with a thin layer, but at other times imbedded in masses of these minerals,[1] which frequently assumed a nodulated or botryoidal arrangement, and the manganese had also penetrated into their substance. In attempting to peel this material, which for the sake of brevity will be spoken of as manganese, off the exterior of the bones, they

[1] See Mr Murray's paper in Proc. Roy. Soc. Edin., December 18, 1876, p. 257.

not unfrequently broke up into fragments, for their texture and cohesiveness were often greatly injured; but at times Mr Murray had succeeded in removing the whole of the manganese from the exterior of the bone, so as to enable one to study its form.

In the catalogue of the dredgings which has been compiled for the use of the naturalists engaged in describing the animals collected during the voyage of the Challenger, the stations at which the dredge was put down are all designated numerically, and the latitude and longitude are recorded, so that the locality can be determined on the map; the date when the dredging took place, and the depth of the ocean at the spot are also given. I have extracted from this catalogue these important facts in connection with the description of the cetacean bones obtained at each station.

The stations are numerically arranged according to the dates when the dredgings were done, but instead of taking the first at which cetacean bones were observed, it will be more convenient to start with the description of the station where the largest number and the greatest variety of the bones of these animals were brought to the surface. I shall commence, therefore, with a description of the bones found at Station 286.

Station 286, lat. 33° 29′ S., long. 133° 22′ W., October 16, 1875, 2335 fathoms. This station was remarkably rich in cetacean remains. About ninety tympanic bullæ were recognised, and, in addition, there were various fragments coated and imbedded in peroxide of manganese, many of which appeared to be portions of tympanic bones. In the first place I made a rough classification of these bones according to their size, and found that they could be arranged into five groups.

The *first* group was represented by a single specimen nearly 6 inches long, and by a fragment of another, which had apparently been of the same magnitude. They were impregnated with manganese, and much corroded on the surface. The more perfect specimen had been cut in two, and one half sent for chemical analysis before I saw it; but from the half that remained I judged it to have been about the same size as the tympanic bone of the great Northern Rorqual (*Balænoptera sibbaldi*), stranded at Longniddry, which I described some years ago.[1] A section through this bone is figured by Mr Murray in his Report on deep-sea deposits (Pl. VII. fig. 2). On comparing it with the corresponding tympanic bone of this animal, they were seen to have a somewhat similar general configuration, but the corrosion of the surface of the deep-sea specimen prevented a close comparison being instituted. From the magnitude of the specimen, it is probable that it is the tympanic bulla of a great Southern Rorqual, perhaps the *Balænoptera antarctica*, or a closely-allied species.

The *second* group consisted of fifteen tympanic bullæ, varying in size from 3 inches to 4 inches, but these were divisible into two very distinct types.

In the one type, consisting of the somewhat larger specimens, were two admirably-preserved bones with the deposit of manganese so thin that the form of the bone was not

[1] Trans. Roy. Soc. Edin., Nov. 1870, vol. xxvi.

interfered with. The one bulla was 3·6 inches long, the other was 3·4 inches. They closely corresponded in size to the tympanic bones of the northern pike whale (*Balænoptera rostrata*). The larger specimen also resembled in its configuration the bulla of *Balænoptera rostrata*, it is figured by Mr Murray (Pl. VII. fig. 3); the smaller was also very like it on the external convex surface, but the internal surface, where it curved towards the tympano-periotic fissure, was much more convex in the deep-sea specimen than in the recent *Balænoptera rostrata*. There can, I think, be no doubt that both these specimens are from Cetacea of the genus *Balænoptera*, and from an animal closely allied to, if not identical with, the *Balænoptera rostrata* of the North Atlantic Ocean. It is possible that they may have belonged to the pike whale of the Southern Ocean, named by Dr Gray, *Balænoptera huttoni*, an animal which Dr Hector states,[1] "is hardly distinguishable from the northern *Balænoptera rostrata*."

Belonging to the same type of bullæ, but not more than 3 inches or 3·2 inches long, were several bullæ, all of which, with one exception, were thickly coated with manganese, and the hollow of the bulla was almost filled with it. They were not only shorter than the bulla of *Balænoptera rostrata*, but not so swollen out (Pl. II. fig. 11). I am not aware of any existing *Balænoptera* in which the bullæ have such small dimensions; but in the series of fossil ear-bones from the Red Crag of Suffolk, in the Museum of the Royal College of Surgeons of England, collected by Professor Flower, is a specimen marked 1452*x*, which he is disposed to regard as a small *Balænoptera*, that agrees in size with these specimens, and has a general resemblance in form, although differences in the smaller features of detail can be recognised. These bullæ may have belonged to a species of *Balænoptera* no longer extant.

The other type of bulla belonging to the second group consisted of two bones 3 inches in length. They were much more compressed laterally than was the case with the bullæ of the *Balænopteridæ*, and were concave on the outer surface, but the inner surface was almost entirely broken away, so as to expose the interior of the bulla. In both specimens (obviously a pair) the outer surface was scored with elongated, somewhat curved furrows, as is represented in Plate VII. fig. 5 of Mr Murray's plates on the deep-sea deposits. The general direction of these furrows corresponded with that of the long axis of the tympanic bone; but, though generally alike, they were not quite symmetrical in the two bullæ. In one specimen the grooved surface was completely coated with a very thin layer of manganese, in the other only partially so. The fact, however, that the manganese lined the grooves shows that they must have been imprinted on the bones before the deposition of manganese began at the bottom of the ocean. Whether they are natural marks, or artificially produced by the teeth of a fish or other marine animal, it is difficult to say. These bones seem to belong rather to the type of the *Balænidæ* than the *Balænopteridæ*, though they are very much smaller than the

[1] Trans. New Zealand Institute, vol. x. p. 337.

tympanics of any of the *Balænidæ* that have come under my observation—not more indeed than about one-third the size of the corresponding bones of the *Balæna australis*. The British Museum, the Museums of the Royal College of Surgeons, and the University of Edinburgh, do not contain any specimens similar in size and form, or marked with similar furrows. Whether they belong to existing species or to some extinct cetacean must for the present be left undetermined, though, from their scanty coating of manganese as compared with the thick covering possessed by others of the bones, obtained from the same station, it is not likely that they were so ancient as the more thickly coated forms.

The *third* group consisted of eight bullæ, from 2½ to 3 inches in length. Only one specimen, which was unfortunately not entire, could be freed from manganese, so as to enable one to see its form. It was 2·6 inches long. It had a certain similarity in form with the tympanic bone of the *Ziphius cavirostris* referred to in a former part of this report as having been obtained from Shetland. It differed from it, however, in several particulars. It was not only longer, but generally more massive, and did not possess the somewhat unciform lobe at the posterior end of the under surface seen in *Ziphius cavirostris* (Pl. II. fig. 12); on the outer surface a faint concavity extended in the longitudinal direction instead of being slightly convex, as in *cavirostris*. The inferior surface, again, was more rounded, and not raised into a feeble roughened ridge as in the Shetland specimen (Pl. II. fig. 9). For the present this bone must be left undetermined.

The *fourth* group consisted of about forty specimens, generally from 1·6 to 2 inches long, although one was 2·3 inches, and another 2·2 inches. In all, the posterior end of the under surface had the bilobed character of the bulla. The two largest specimens (Pl. VIII. figs. 1, 2, Mr Murray's Report) were compared both with Professor Flower's figures of the petro-tympanic bones of *Berardius arnouxii*[1] and with the bones themselves, to which they approximated somewhat in size. They differed, however, from the tympanic bullæ in that animal in having the external posterior lobe more boss-like, and in possessing a much wider furrow between that lobe and the internal posterior lobe; moreover, the inferior surface in them was not so irregularly roughened as in *Berardius*. In appearance they corresponded closely with the tympanic bullæ of *Mesoplodon layardi*, described in an earlier part of this report, but they were on a larger scale, for not only was the larger of the two bullæ half an inch longer; but its greatest width was 1·5 inch, whilst that of *Mesoplodon layardi* was 1·3 inch. They should, I believe, be referred to the genus *Mesoplodon*, though probably to a larger species than *layardi*, for although my specimen of *Mesoplodon layardi* was from an immature animal, yet the petro-tympanic bones in the Cetacea assume their full dimensions at a comparatively early period of life. In both these specimens the petrous bone was united with the tympanic. It closely resembled in shape that of *layardi*, but was somewhat bigger, for its length was 2·2 inches, whilst that of *layardi* was 1·9 inch.

[1] Trans. Zool. Soc., vol. viii.

Of the remaining specimens of this group the larger number closely corresponded in size to the bullæ of *Mesoplodon layardi*, and were almost identical with them in the configuration of the lobes, in the broad, roughened, inferior surface, and in the curvatures of the inner and outer surfaces, so that I think they should be referred to that animal. I have figured a characteristic one in Plate II. fig. 8. A few specimens in this group were a little smaller than *Mesoplodon layardi*, but possessed the same general characters of shape, and two specimens were somewhat broader, and more flattened on the inferior surface, than in the immature Falkland Isle *layardi*.

The *fifth* group consisted of at least twenty-four specimens, which varied in length from 1 inch to 1·7 inch. They were all bilobed, and had the general configuration of the tympanic bulla of the *Delphinidæ*. The longest possessed a transverse diameter of 1·1 inch, and in its general form resembled the bulla of a *Globiocephalus*. It is figured in Pl. VIII. fig. 6, by Mr Murray. Others were from animals of the genus *Delphinus*, whilst the smallest had the size, and almost exactly the shape, of the common porpoise. A specimen figured in my Plate II. fig. 13, and from another aspect in Mr Murray's Plate VIII. fig. 7, was 1·3 inch long, and ·7 inch wide. It was obviously not one of the Dolphins, for it was not bi-lobed posteriorly, whilst its small size precluded it from belonging to the Baleen whales. Professor Flower, to whom I showed the specimen, thought from its resemblance in form to the tympanic bulla of the sperm whale (*Physeter macrocephalus*), though of course very much smaller, that it might be the bulla of the short-headed sperm whale of the southern seas (*Kogia*, Gray). There was no tympanic of this whale in the Museum of the College of Surgeons with which to compare it, but in the stores of the British Museum I fortunately met with a specimen marked *Kogia macleayii*, which was from a young animal, and had unquestionably a considerable resemblance to the deep-sea specimen. The latter was slightly larger, but they were almost identical in shape ; only, the deep-sea specimen was somewhat more roughened on the inferior surface, the anterior or Eustachian orifice was somewhat wider and the internal surface deeper. There can, I think, be little doubt that this bone should be referred to a species of *Kogia*. Two other specimens also occurred in this series which at the first sight seemed to have some resemblance to the bulla of *Kogia*, but on further examination were found to differ in several respects from it. The best preserved was 1·1 inch long, and is figured in Plate II. fig. 14. It was divided posteriorly into two lobes, but the intermediate depression was very shallow, and was not prolonged as a sharply differentiated groove along the inferior surface. The external posterior lobe was relatively large and boss-like, whilst the internal posterior was much smaller, and almost pointed. It cannot be regarded as one of the Dolphins, but was probably from an animal allied to *Kogia*, though generically distinct from it.

In this station forty-two detached petrous bones were also obtained. The longest was 2 inches, which is 0·1 inch less than the one already referred to in the fourth group as still attached to the bulla of the big *Mesoplodon*. Several were 1·8 and 1·9 inch long, and in their configuration resembled the petrous bone of *Mesoplodon*, and, without doubt, belonged to the bullæ of this animal already referred to as found in the same station. Others were of the same magnitude as the petrosal in the genus *Delphinus*, and very similar in form, whilst two specimens were smaller than those of the common porpoise. In all, the manganese had been deposited in the canals and foramina in the bones, and had given a coating more or less thick, in different instances, to the entire bone. Mr Murray has figured three specimens in Plate VIII. figs. 8, 9, 9*a*, 14 and 14*a*.

Fourteen specimens also occurred which consisted not only of the petrous, but of a portion of the elongated "mastoid" element continuous with it. These varied considerably in size, the largest being 3·6 inches long, and the smallest 2·5 inches, and the latter is figured by Mr Murray in Pl. VIII. fig. 3. They were all deeply impregnated with manganese, which had filled up the hollows and foramina, and coated the entire bone, so that it was difficult to obtain an exact idea of its form. It is not unlikely that these may have been the petro-mastoid elements belonging to the tympanic bullæ of some of the Baleen whales already stated to have been found in this station.

In addition to these ear-bones, numerous fragments of other bones were also present, all, with one exception, being deeply impregnated with manganese. The most noticeable of these was an elongated bar of bone 8·1 inches in length, which Professor Flower and I concurred in regarding as the beak of a Ziphioid whale. Sections of the beak were made by Mr Murray which confirmed the accuracy of this opinion. The beak and sections through it are figured by Mr Murray (Pl. X. fig. 1, *a*, *b*). Three other, but much smaller, fragments of bone, which also seemed to be portions of the beaks of Ziphioids were also present.

A number of fragments of flat bones, most of which were portions of the brain case, though one or two might have been bits of the shaft of a rib, occurred. The largest, figured by Mr Murray (Pl. X. fig. 2, *a*), was marked on its inner surface by a groove for a venous blood sinus.

An irregular mass of spongy bone, 4 inches by 8, by 3, consisting apparently of a portion of the expanded wing of a superior maxilla, was present. It was noticeable, not only from its size, but from the paucity of manganese deposit as compared with the other bones. Another smaller portion of similar spongy texture was surrounded with nodulated masses of manganese; this is figured by Mr Murray (Pl. X. fig. 3). A third mass, 5 inches by 5, having its surfaces concavo-convex, was covered by, and deeply impregnated with, manganese and iron deposition, so that it had quite a mineral appearance. It was also apparently a part of the expanded wing of the superior maxilla. Further, there were between one and two hundred smaller fragments, looking on the exterior like nodules of manganese, which, when broken through, exhibited evidence of bone structure. In one the fracture had displayed the helicoidal turn of the cochlea.

If we were to suppose that the eighty-nine tympanic bullæ obtained in this station had been exact pairs, and that the numerous petrous bones all belonged to the same animals as the tympanic bullæ, it would follow that the remains of at least forty-five whales were brought from the bottom of the ocean in this single station by one haul of the dredge; but as the bones were not in pairs, the remains of a much larger number of whales were obtained in this station. It may further be noted that a recognisable proportion of these animals were Ziphioids, and many of them belonged to the genus *Mesoplodon*, so that the central part of the South Pacific Ocean is obviously a favourite habitat of this family of cetaceans.

Station 131, lat. 29° 35′ S., long. 28° 9′ W., October 6, 1873, 2275 fathoms. A tympanic bulla $2\frac{1}{2}$ inches long, very slightly discoloured with manganese. This bulla closely corresponds with that of the *Ziphius cavirostris* from Shetland, so that I have no hesitation in associating it with that genus, and most probably with that species. I have figured it in Plate II. fig. 10, alongside of the Shetland *Ziphius*, so that the two may be compared with each other. The South Atlantic Ocean is, therefore, a habitat for this cetacean, a fact which is of interest in its bearings on the determination of the zoological position of the *Epiodon australe*, Burmeister, from Buenos Ayres, and of the *Petrorhynchus capensis*, Gray, from the Cape of Good Hope, both of which I have referred (p. 27) to *Ziphius cavirostris*.

Station 143, lat 36° 48′ S., long. 190° 24′ E., December 19, 1873, 1900 fathoms. A small fragment of bone was brought up by the dredge, about the size of a boy's playing marble. It consisted of cancellated tissue, and was coated and impregnated with manganese, and had foraminifera attached to it. It was too small a piece for one to say what bone it had formed a portion of, but it was probably from a cetacean.

Station 160, lat. 42° 42′ S., long. 134° 10′ E., March 13, 1874, 2600 fathoms. Several tympanic bullæ were found. One is figured by Mr Murray in transverse section, and surrounded by manganese (Pl. VIII. fig. 11). It possessed the bilobed form, but the lobes were more nearly equal in size than in *Mesoplodon*, so that one could not definitely pronounce it to belong to that genus. Two others had the *Mesoplodon* characters, but the one had the internal posterior lobe more massive and the outer surface more concave in its posterior half than the other. In one the furrow between the two lobes was somewhat narrower than in *Mesoplodon layardi*. Another tympanic bone was *Delphinus*. A petrous bone was apparently that of a *Globiocephalus* (Mr Murray's Pl. VIII. fig. 10). A nodulated mass of bone, not so big as a cricket ball, was covered by botryoidal deposits of peroxide of manganese, and penetrated by deposits of manganese and iron, so that it was dense and of stony hardness. There were also three small fragments of bone, one a flat bone.

Station 274, lat. 7° 25′ S., long. 152° 15′ W., September 11, 1875, 2750 fathoms. A tympano-periotic bone from a *Globiocephalus*, figured by Mr Murray (Pl. VIII, figs. 4, 5); another from one of the *Delphinidæ* (Mr Murray's, Pl. VIII. figs. 12, 13).

One in size and configuration like a *Mesoplodon.* Six separate petrous bones and four separate tympanic bullæ, either broken or so encrusted with manganese that it was difficult to determine them precisely, but they were all from the smaller species of Cetacea. There were several manganese nodules, one of which had for its nucleus a fragment of bone the size of a thick wafer.

Station 276, lat. 13° 28′ S., long. 149° 30′ W., September 16, 1875, 2350 fathoms. Two tympano-periotic bones of *Mesoplodon* closely resembling *Mesoplodon layardi*, figured by Mr Murray (Pl. VII. figs. 6, 7). In addition there were eight separate petrous bones and six tympanic bullæ. One of these bullæ was a *Globiocephalus;* another had the same form as the two specimens described at the end of the fifth group of Station 286, one of which is figured in Plate II. fig. 14; the remainder belonged apparently to the genus *Delphinus.*

Station 281, lat. 22° 21′ S., long. 150° 17′ W., October 6, 1875, 2385 fathoms. Six tympanic bones and three petrous bones. The largest tympanic was $1\frac{1}{4}$ inch long, the smallest 1 inch. They all belonged to the family of dolphins.

Station 285, lat. 32° 36′ S., long. 137° 43′ W., October 14, 1875, 2375 fathoms. This station gave one tympanic bone, 4·7 inches long, from a large species of *Balænoptera* (Mr Murray's, Pl. VII. fig. 1); one 3·2 inches long, and two others about 2·7 inches long, from smaller species of *Balænoptera,* such as are referred to in the second group of Station 286. A tympanic bone, $3\frac{1}{2}$ inches long, was not swollen out as in *Balænoptera,* but was much smaller than the bulla of either *Megaptera lalandi* or *Balæna australis.* This bone was imperfect, as the part of the outer aspect which turns over into the hollow of the bulla was broken off. Upwards of twenty-five smaller sized, separated tympanic bones, which may be referred to the genera *Mesoplodon, Delphinus,* and *Globiocephalus.* At least eighteen petrous bones recognisable as belonging to the above genera of toothed whales. A petro-mastoid bone, 4 inches long, probably belonging to one of the Baleen whales, but with its form obscured by manganese incrustations. Numerous small fragments of bone thickly coated with manganese.

Station 289, lat. 39° 41′ S., long. 131° 23′ W., October 23, 1875, 2550 fathoms. Three large tympanic bones were obtained here; one 4 inches long, another $3\frac{1}{4}$ inches, the third about 3 inches long. They were all thickly covered with nodulated manganese. Sufficient of this deposit was removed to show that they were all apparently the bullæ of whales of the genus *Balænoptera.* Two nodules containing bony nuclei were also present.

Station 293, lat. 39° 4′ S., long. 105° 5′ W., November 1, 1875, 2025 fathoms. In this station only one small fragment of bone, the form of which was quite lost through impregnation with manganese, was found.

Station 299, lat. 33° 31′ S., long. 74° 43′ W., December 14, 1875, 2160 fathoms. This station contained one bilobed tympanic bulla, with the petrous bone attached, apparently a *Globiocephalus.*

It is important to observe that no ear-bones or fragments of other cetacean bones were obtained from the dredgings north of the Equator. The stations south of the Equator, where the bones of Cetacea were found, may be arranged in two groups, the one in comparatively close proximity to continental land, the other in mid-ocean. In the first of these groups the number of ear-bones found in any single station was small, apparently, because, from their proximity to land, and to the influence of the solids suspended in the currents of great rivers, they would become covered over, and imbedded in detritus falling to the bottom of the ocean. Thus only one bone, and that the tympanic bulla of a *Ziphius*, resembling *Ziphius cavirostris*, was obtained in the South Atlantic at Station 131, off the east coast of South America. One station (160) south of the Australian continent yielded only a few ear-bones. A station (299) off the west coast of South America yielded only the tympano-periotic bone of a single species, one of the Delphinidæ. Stations 143 and 293 gave only fragments of bone, which could not definitely be pronounced to be cetacean. All the other stations, viz., 274, 276, 281, 285, 286, 289, belonged to the second group, and were in the central southern portion of the Pacific Ocean, *i.e.*, in localities the farthest removed from continental land. These, as Mr Murray has pointed out in his Report, are areas of exceedingly slowly accumulating deposits, and consequently in them the bones dredged up at each station were, as a rule, much more numerous than at the stations nearer to the great continents, for they were not imbedded in thick strata of substances which had fallen to the bottom.

In all the localities, except 299, 293, and 143, where merely a single ear-bone or a small fragment of bone was found, the deposit at the bottom of the ocean was, as Mr Murray informs me, a red or chocolate-coloured clay, containing, besides the ear-bones, many hundreds of sharks' teeth and nodules of manganese. The preservation of the ear-bones and of the fragments of the beaks of ziphioid whales is accounted for by the extreme density of these portions of the skeleton. Some of the bones were in a much better state of preservation than others. In some the manganese coating was extremely thin, and but little had entered into the Haversian canals and lacunæ, so that a fractured surface was greyish-white (Mr Murray's Pl. X. figs. 1*a*, 1*b*, 2*a*, 4*a*). Others again were not only thickly encrusted with the mineral, but the Haversian canals and lacunæ were infiltrated with it, so that a fractured surface was dark brown or black, and the bones were extremely brittle. The chemical composition of these bones was thus entirely altered, and this was more especially the case with the fragments of the flat bones, and others of a more porous texture which formed the nuclei of so many of the manganese and iron nodules. It is worthy of note that no bone was identified as belonging to the great sperm whale (*Physeter macrocephalus*), although the track of the Challenger, at the stations where such large hauls of cetacean bones were dredged up, was through the seas frequented by this huge cetacean; but the tympanic of the short-headed sperm whale (*Kogia*) was obtained at one station (286). Further, it is to be noted that the bones obtained did not present any evidence of having been rolled or rubbed. They had evidently rested quietly in the spots where they had been deposited, and in many cases the tympanic and petrous bones were still attached to each other, although they could be separated by the exercise of but little force.

The sharks' teeth belonged to the genera *Carcharodon*, *Oxyrhina*, and *Lamna*, and are to be referred to no species, so far as we know, now living. They are identical with the sharks found in the Tertiary deposits. The question, therefore, naturally arises, Are the cetacean remains associated with them on the floor of the ocean the bones of existing or extinct forms? Of the resemblance of the greater number of these bones, more especially the tympanic bullæ, to existing genera, I have given a number of examples, and have occasionally had to point out how closely some of them correspond with existing species, so that they may be referred to them. But whilst these may be the bones of species still extant, there are others which present greater difficulties in the identification, so that, like the sharks, they may have belonged to animals which had lived in a previous geological epoch.

This observation will more especially apply to the undetermined bones found at the various stations in the central southern portion of the South Pacific Ocean. In none of these stations was the depth less than 14,000 feet, and in one (274) it reached 16,500 feet. From the position of these stations in mid-ocean, its floor in them is subjected, as Mr Murray has shown, to a minimum amount of deposition from above, so that but little change can have taken place in the ocean bed in these localities during a great period of time. The occurrence of the teeth of sharks, identical with known Tertiary species, lying so loosely on the ocean floor that they can be scraped up by the dredge, may show either that the sea bottom in these regions has remained unchanged, and with scarcely any appreciable gain from deposition since Tertiary times, or that some species of shark have continued to haunt these waters from the Tertiary down to the present period. In the former case, which other data render not improbable, the remains preserved may represent organisms existing during the Tertiary epoch, as well as animals which have lived and died in the ocean from that time to the present. From the peculiar circumstances of the case, therefore, animal remains, belonging to periods of time widely remote from each other, may be lying side by side in the same place on the sea bed, so that the association together of their remains may not necessarily imply that they were co-temporaneous. But if there has been, as seems not improbable in these very deep localities in mid-ocean, no appreciable geographical change since the Tertiary epoch, and if the food supply and the climatic conditions as regards ocean temperature have remained uniform, one sees no good reason why animals which lived in these seas during those remote times should not also be found there at the present day, if our knowledge of the oceanic fauna were complete. It may be precipitate, therefore, to pronounce the ear-bones, which we have not been able to refer to living species, to be those of extinct cetaceans, for a more complete examination of the fauna of the South Pacific Ocean may perhaps supply us with their existing representatives. For this reason, as well as from the fact that a complete collection of the ear-bones of known cetacea does not exist in the museums to which I have had access, so that our acquaintance with the configuration of these bones in already recognised species is still imperfect, I have thought it advisable not to erect those, which I was unable to determine, into new species, but merely to point out their characters, and to defer an expression of opinion on their systematic classification until the possession of more ample means of comparison places at our disposal the data which may be requisite.

EXPLANATION OF THE PLATES.

The drawings in these plates are all from nature. Those of the bones and of the form of the teeth have been executed by Mr J. Dunlop Dunlop, whilst the microsocpic sections in illustration of the structure of the teeth have been made by Alfred H. Young, M.B.

Fig. 1. A profile view of the skull of the immature *Mesoplodon layardi* from the Falkland Islands. (Specimen *C.*) Reduced one-fourth.

2. A front view of the same skull. Reduced one-fourth.
3. Profile view of the series of cervical vertebræ of the same animal. Reduced one-third.
4. Front view of the sternum of the same animal. Reduced one-fifth.
5. Petrous bone of an adult *Mesoplodon layardi* from the Cape of Good Hope. (Specimen *A.*) Natural size.
6. Transverse section through the beak of an adult *Mesoplodon layardi* from the Cape of Good Hope. (Specimen *B.*) Reduced one-half.
7. Inferior surface of the right tympano-periotic bone of the immature *Mesoplodon layardi* from the Falkland Islands. Natural size.
8. Inferior surface of the right tympanic bone of a *Mesoplodon*, probably *Mesoplodon layardi*, dredged at Station 286. Page 37. Natural size.
9. Inferior surface of the right tympanic bone of the *Ziphius cavirostris* from Shetland. Natural size.
10. Inferior surface of the right tympanic bone of a *Ziphius*, resembling *Ziphius cavirostris*, dredged at Station 131. Page 39. Natural size.
11. Outer surface of tympanic bone of a *Balænoptera*, dredged at Station 286. Page 35. Natural size.
12. Inferior surface of tympanic bone of a cetacean, dredged at Station 286. Page 36. Natural size.
13. Inferior surface of left tympanic bone of a *Kogia*, dredged at Station 286. Page 37. Natural size.
14. Inferior surface of a right tympanic bone, dredged at Station 286. Page 37. Natural size.
15. Tooth of young *Mesoplodon layardi*. Natural size.

Fig. 16. Vertical transverse section through the same tooth to show the pulp cavity. Natural size.

17. Vertical transverse section through the upper part of the shaft of the tooth of the adult *Mesoplodon layardi*. The right shaded portion is the outer surface of the tooth, from the upper end of which the denticle projects. Natural size.

18. A magnified vertical transverse section through the tooth of the young *Mesoplodon layardi*. *P*, pulp cavity; *e*, enamel; *d*, dentine; *c*, cement; *v*, modified vaso-dentine on exterior of dentine; *v′*, modified vaso-dentine lining the pulp cavity; *i*, the interglobular spaces. Page 11.

19. A magnified vertical transverse section through the summit of the shaft of the tooth of the adult *Mesoplodon layardi*. *a*, Cement; *b*, the subjacent modified vaso-dentine; *c*, a layer of more opaque modified vaso-dentine; *d*, dentine; *e*, modified vaso-dentine of centre of shaft. The peripheral canal on the surface of this layer between it and the dentine is shown. As this drawing was not made until some months after the description was written, during which time the balsam used in mounting the section had contributed to make it more translucent, Mr Young was enabled to recognise and figure a faint lamellation about the canals of the central layers, as well as to see the passage of an occasional canal from the layer *b* into the dentine, through which they probably extended obliquely into the layer *e*. Where *b* and *e* blended with each other, the passage of canals directly from one to the other was seen. Page 14.

20. Vertical transverse section through the tooth of *Mesoplodon sowerbyi*. Natural size.

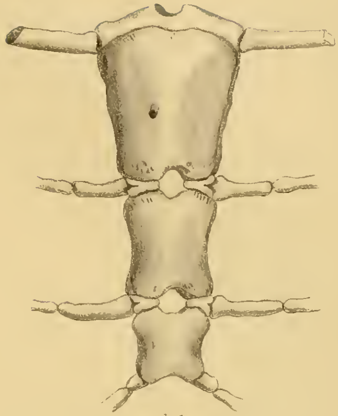
21. A magnified vertical transverse section through the upper half of the same tooth. *e*, Layer of ill-defined enamel; *d*, dentine; *c*, cement; *v*, vaso-dentine; *mv*, modified vaso-dentine. *P*, pulp-cavity. Page 19.

22. A similar magnified section through the lower half of the same tooth. *P*, pulp-cavity; *d*, dentine; *mv*, modified vaso-dentine; *c*, cement. Page 20.

Fig. 2.

$\frac{1}{4}$th

Fig. 4.



$\frac{1}{5}$th

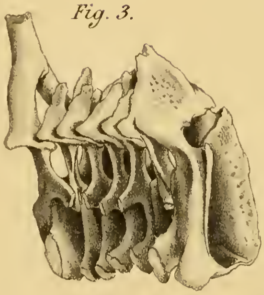
Fig. 5.

n s.

Fig. 6.

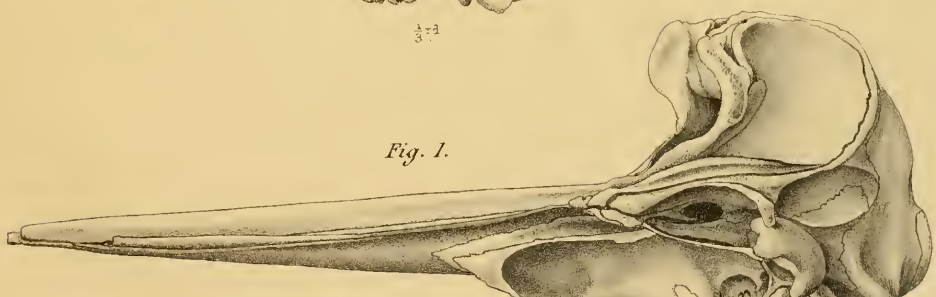
$\frac{1}{2}$

Fig. 3.



$\frac{1}{3}$rd

Fig. 1.

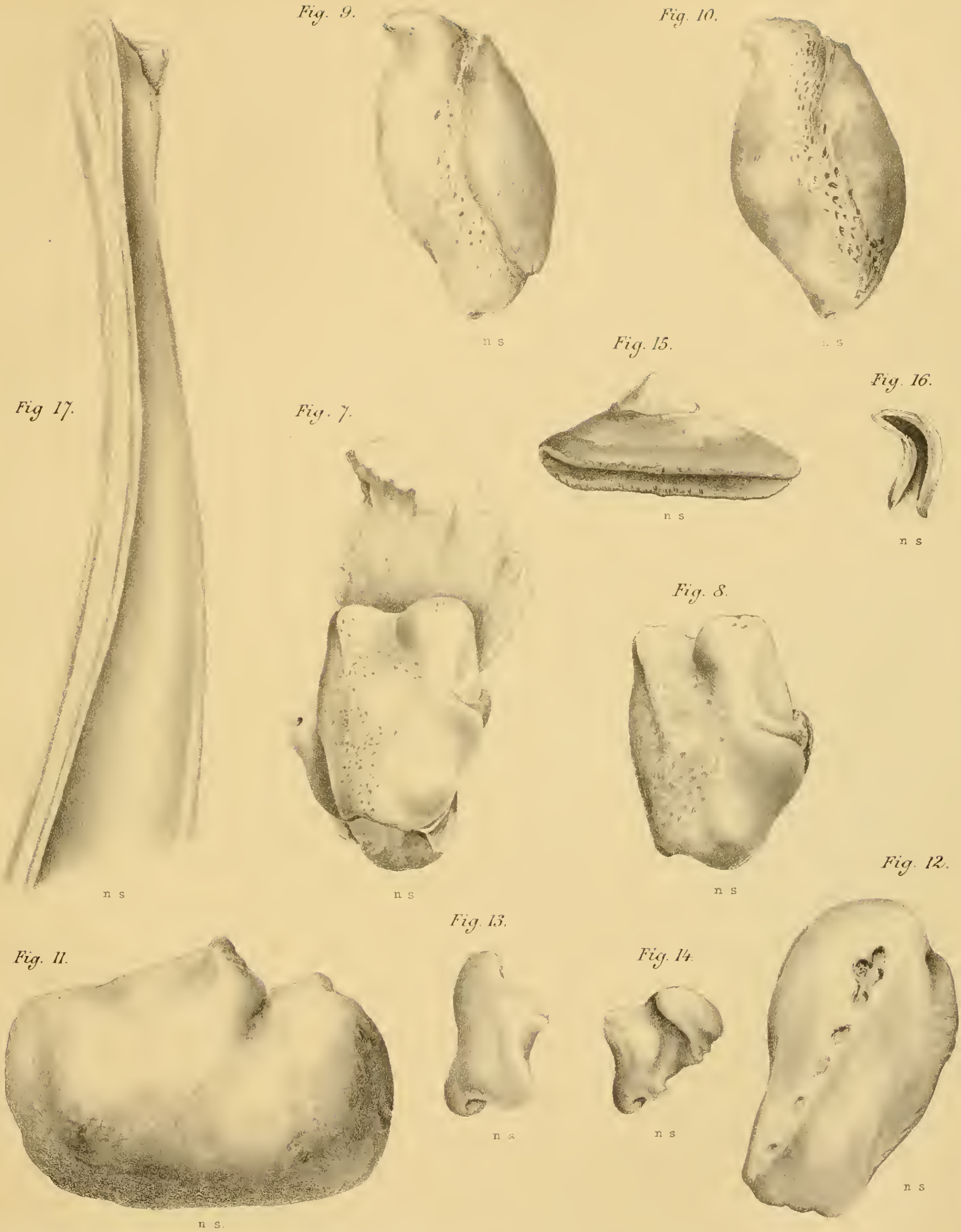


$\frac{1}{4}$th

J. Dunlop Dunlop, del

F Huth, Lith^r Edin^r.

MESOPLODON LAYARDI.



J Dunlop Dunlop, del

F Huth Lith^r Edin^r

EAR BONES AND TEETH OF ZIPHIOIDS, &C.

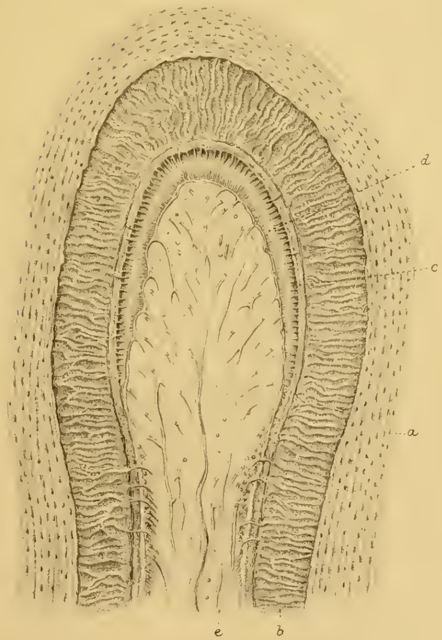
Fig. 18.

Fig. 20.

Fig. 22.

Fig. 21.

Fig. 19.



A. H. Young, del. ad nat.

F. Huth, Lith^r. Edin^r.

TEETH OF MESOPLODON.

The Zoology of the Voyage of H.M.S. Challenger

PART IV.

REPORT ON THE BONES OF CETACEA

BY PROFESSOR TURNER, M.B. (LOND.), F.R.SS. L. & E.

Price Two Shillings

SMITHSONIAN INSTITUTION LIBRARIES
3 9088 00265464 8
nhkell qQL737.C4T954
Report on the bones of Cetacea.