26. A CONTRIBUTION to the HISTORY of the CETACEA of the NORFOLK "FOREST-BED." By E. T. NEWTON, Esq., F.G.S. (Read April 7, 1886.)

[PLATE XI.]

WHEN the Geological Survey Memoirs on the geology and palæontology of the country around Cromer were published, it was hoped they would awaken an increased interest in the collecting of fossils, more especially from the "Forest-bed Series," and thus be the means of increasing our knowledge of the fauna and flora of these deposits. Since that time there has been a more energetic collecting of "Forest-bed" fossils, with the result that several new forms have now to be added to our lists. My colleague, Mr. Clement Reid, has discovered a number of new plants, an account of which will shortly be published. Regarding the vertebrate fauna, perhaps the most remarkable addition has been that of the *Ovibos moschatus*, from Trimmingham, made known to us by Prof. W. Boyd Dawkins, who has also recognized *Cervus tetraceros* from West Runton (Quart. Journ. Geol. Soc. vol. xxxix. p. 575, and vol. xli. p. 243) and has likewise discovered a new form of deer from Kessingland, to be called *Cervus Savini* (Proc. Roy. Soc. vol. xxxviii. p. 345), the description of which has yet to be published. *Hyæna crocuta* has been found at Corton Cliff (Geol. Mag. dec. ii. vol. x. p. 433), and Mr. Savin has fragments of this species from near Cromer. Several species which were not well authenticated have now been confirmed by additional examples: thus there is no longer any doubt as to the occurrence of *Cervus elaphus*, Mr. W. Davies, of the British Museum, having determined an antler in the collection of Mr. Backhouse, of York. The doubtful humerus of Wolf has now been supplemented by a part of a jaw from East Runton and a piece of tibia from Kessingland.

The latest acquisition has been made by Mr. Clement Reid, who, during a recent holiday on the Norfolk coast, purchased from a fisherman a tooth which had just been washed out of the "Forest-bed" at Sidestrand (Pl. XI. fig. 1); this he recognized as new to the deposits, and thinking that it was probably Sperm-Whale, kindly left it with me for determination. There is no doubt as to the horizon of this specimen; for although found on the shore just after a storm, as, indeed, is the case with most of the vertebrate fossils of this deposit, it has, cemented to it by iron pyrites, the peculiar white sandy matrix of the "Forest-bed." This tooth is in a very perfect condition, only the thin edges of the pulp-cavity being broken away, and this has evidently been done by rolling on the shore subsequent to removal from its resting-place. The summit has been rounded by wear during life, in a manner similar to that which is seen in the teeth of the recent Sperm-Whale; and the external surface, which is partly obscured by the incrusting sandy matrix, presents a number of irregular longitudinal grooves, especially noticeable towards the base. There is a slight, but distinct double curvature,

and the entire tooth is flattened from side to side, particularly in the region of the pulp-cavity, the flattening being natural and not due to post-mortem compression. The greatest thickness of the tooth is at a little more than a third from the apex, and from this region to the base it becomes rapidly compressed. The large size of the pulp-cavity and the entire absence of globular osteodentine show that the tooth was not fully developed. The proportion of dentine to cement is shown in the section (Pl. XI. fig. 2). At the middle of the tooth, where the larger diameter is 2·35 in., the dentinal core has a diameter of 1·7 in., and the cement is about 0·3 in. thick on each side.

Measurements.

	inch.
Greatest length of tooth	5·8
Greater diameter, one third from base	2·5
Lesser diameter, one third from base	1·6
Greater diameter, one third from apex	2·2
Lesser diameter, one third from apex	1·75
Greater diameter at base	2·6
Lesser diameter at base	1·3
Pulp-cavity extends from base	2·65

Thin sections examined with the microscope show the dentinal tubules passing obliquely upwards from the axis with slight undulations, and giving off at intervals fine anastomosing branches; just before reaching the cement layer the tubules become finer and terminate in the granular layer, a more opaque band in which the structure is obscure. Throughout the dentine, and especially towards the periphery, the globular calcigerous cells are more distinct than is usually the case in mammalian teeth; but this peculiarity seems to be shared by other forms of marine mammals.

The minute characters of the cementum are remarkable, and although repeated, in a less marked degree, in some recent forms, they do not seem to have been fully described. Polished sections of the cement, even when examined with a pocket lens, show series of laminae, and under the microscope thin sections show these to be composed of alternating, more or less transparent bands. In a transverse section, besides the lacunæ, which are arranged on the whole parallel to the laminae, there are numerous "Sharpey's fibres" which cross the bands. For the most part, these fibres are far larger than the tubules of the dentine, and much less regular in size and direction; passing from the inner side they undulate, crossing and recrossing one another so as to produce a complex plaited appearance. In a longitudinal section the undulations are seen to be much more deeply curved (fig. 3, *b* to *c*). The fibres do not remain of the same size throughout, but are enlarged at intervals, and becoming more opaque produce the appearance of spindle-shaped bodies. When these bodies are examined with a power of 200 diameters or more (fig. 4) they may be seen to contain one, two, or perhaps three rows of indistinct spherules, which are probably calcigerous cells. The

greater number of these spindles are aggregated in certain of the laminae and, indeed, seem to be the cause of the greater opacity of the darker bands.

The examination of some very thin sections of a recent Cachalot's tooth failed at first to reveal these spindle-shaped bodies; but a closer examination of more carefully prepared sections showed that the spindles were present, although not so obvious as in the fossil, and they seemed to contain but one or perhaps two rows of calci-gerous cells. Probably the condition of fossilization has much to do with the distinctness of these bodies, which I have detected in the thick cement of some other forms of mammals. With the exception of this variation in the structure of the cement, I see no difference worth mentioning between this "Forest-bed" fossil and the tooth of a recent Sperm-Whale. The presence of globular osteodentine in the basal portion of the Cachalot's tooth is no doubt characteristic; but its absence from the "Forest-bed" specimen does not militate against the latter belonging to the same species; for it is obvious that there must have been a time with every tooth when the osteodentine had not begun to be formed, and this fossil is doubtless a young tooth in that condition. The absence of globular osteodentine from the *Physeteroid* teeth of the Red Crag, which have been called by Sir R. Owen *Balenodon physaloides*, cannot be taken as evidence of their affinity with the "Forest-bed" specimen; for not only does it happen that osteodentine is sometimes present in the Crag teeth, but the outward form of these fossils is different, being more slender and cylindrical, and having always a proportionately smaller core of dentine and a larger development of cement, notwithstanding that there is much variation in the latter particular.

With the exception of the Cachalot's tooth noticed by Sir R. Owen (*Brit. Foss. Mamm.* p. 524), as from "the superficial deposits near the coast of Essex," which is of doubtful age*, I am not aware that the Sperm-Whale has ever been noticed as a fossil in this country. M. Gervais records several *Physeter* teeth from the Pliocene of Montpellier and of Gironde (Gervais and Van Beneden, 'Ostéographie des Cétacés,' 1880, p. 329, and *Zool. et Pal. Fr.* p. 285), but these, being of a different form, have been doubtfully referred to another species, *Physeter antiquus*.

At the present day the Sperm-Whale inhabits the tropical and warmer temperate latitudes, but wanders occasionally both northwards and southwards. Numerous instances are on record of its having been found on our own coasts; the last, according to Bell (*Brit. Quadrupeds*, 1874, p. 418), was stranded in Loch Seavaig, I. of Skye, in 1871. The species is not altogether unknown on the

* There can be little doubt that the figure of this tooth given in the 'British Fossil Mammals' at page 524 was drawn from the specimen in the Hunterian Museum, Roy. Coll. Surgeons, no. 2387, which in the catalogue is said to have been presented by Mr. Darwin, and to be from S. America. This could not have been the tooth to which Mr. Charlesworth referred in 1884 (*Quart. Journ. Geol. Soc.* vol. i. p. 40, 1845), which was doubtless one of the Red-Crag *Balenodon* teeth.

Norfolk coast; for Mr. T. Southwell ("Fauna of Norfolk," Trans. Norf. and Norwich Nat. Hist. Soc. vol. i. p. 71) refers to a record of a Sperm-Whale being washed on shore at Wells, and another at Hunstanton, early in the 17th century.

Another interesting example of a "Forest-bed" fossil Cetacean (Pl. XI. figs. 5, 7) is in the possession of Mr. Jas. Backhouse, of York, who has been good enough to allow me to make use of it for these notes. The specimen is a portion of the ankylosed cervical vertebræ of a large Whale, belonging to a genus not hitherto recognized in these Norfolk deposits. Before describing this fossil, it will be well to give some explanation of its condition and origin. The presence of oysters and polyzoa on the surface would lead one to suspect that it had been dredged, and that its age was therefore uncertain; such, however, is not the case. The fossil was obtained through Mr. A. Savin, of Cromer; and in a letter he tells me that this mass of vertebræ came from a low ledge of rocks ("Forest-bed") opposite Overstrand, near Cromer, which is only exposed at very low spring-tides; and as these rocks would be for a greater part of the time in deep water, the presence of oysters &c. adhering to the specimen is fully accounted for; moreover other examples of fossil bones covered with marine organisms have been obtained from the same spot. I am the more anxious to call attention to these facts because bones and teeth in a similar condition to this specimen are not uncommon in collections, and although many of them have doubtless been dredged, this is not always the case, and such specimens may be true "Forest-bed" fossils.

Mr. Backhouse's specimen is the right half of the seven cervical vertebræ of a Whale, so closely ankylosed that only the slightest trace of their original distinctness is now discernible. The centra have been broken through longitudinally and vertically, as nearly as may be, in the middle line, and all the neural arches and processes have been more or less broken away; but sufficient remains to enable one to trace the positions of the six intervertebral foramina and thus to show that seven vertebræ are combined to form the mass (fig. 5). Between these foramina, or grooves as they now are, may be seen the surfaces from which the neural arches have been broken away. Judging from these broken surfaces, the first neural arch and superior transverse process were far larger than any of the others. The second neural arch seems to have been next in point of size, and then the seventh and fifth. The third, fourth, and sixth are nearly of the same size and smaller than the others. The first and second superior transverse processes seem to have been closely united. The inferior transverse process of the second vertebra was large, as indicated by the broken base; those of the third and fourth vertebræ were slender, while the hinder three vertebræ have no trace whatever of inferior transverse processes. The double cup of the atlas for the reception of the condyles of the skull must, when perfect, have been at least 17 inches across (the one half being a little more than $8\frac{1}{2}$ inches). The outer edge of the cup is to some extent denuded.

The upper surfaces of the centra are nearly flat from side to side, except at the front, where the median region sinks down into the depression seen between the cups of the atlas. In a side view (fig. 5) the upper surface makes a regular sweep from the hinder part, and is continued upwards towards the top of the atlas. The hinder surface of the seventh centrum is concave and, in outline, flattened from above downwards; but as it is a little broken both at the top and bottom, the exact form is disguised. The width of this surface, when complete, was probably $10\frac{1}{2}$ or 11 inches.

Measurements.

	Forest-bed fossil.	<i>Balæna</i> <i>mysticetus</i> . Coll. Surg. 2744.	<i>Balæna</i> <i>biscayensis</i> ? Brit. Mus. 338, f.
Across both cups of atlas.....	in. 17	in. 15.5	in. 14
Fore and aft length of lower surface of centra	9	11.0	9

The cervical vertebræ of Cetacea vary much as to the extent to which they become ankylosed together, and these variations are very characteristic of the different genera. Among recent Whales the only forms large enough to render a comparison of them with this fossil desirable are *Balenoptera*, *Megaptera*, *Balæna*, and *Physeter*. In the first of these the cervical vertebræ, as a rule, remain separate; but in exceptional cases two or three may be united. *Megaptera* generally has two or three of the neck-vertebræ fixed together. *Balæna* has all seven cervical vertebræ soldered into one mass; but the divisions between the bodies are generally, if not always, distinctly seen. In *Physeter* the first vertebra (atlas) is always free, but the hinder six are more closely united than in any other form.

The "Forest-bed" fossil has the seven cervical vertebræ closely united, and it is obvious therefore that it comes nearer to *Balæna* than to any of the other genera mentioned. There are three examples of the united cervical vertebræ of *Balæna mysticetus* available for comparison in the Museum of the Royal College of Surgeons, which, by the courtesy of Prof. C. Stewart, I have been able to examine and measure. In most of their characters these specimens agree with Mr. Backhouse's fossil; but in none of them are the divisions between the vertebræ so completely obliterated. As regards the number of inferior transverse processes, there is much variation to be observed among them, and even the two sides of a specimen do not always agree. It is evident from this and other differences that a wide allowance must be made for individual variation. The point in which these specimens seem most to differ from the fossil is in the concavity of the upper surfaces of the centra.

This concavity is such that the intervertebral foramina are raised much above the level of the floor of the neural canal, and this is not the case in the fossil. Even in this particular, however, there is some difference among the recent examples; but in none of them is the upper surface so flat as it is in the fossil.

In the Cetacean Gallery of the British Museum, South Kensington, there is a specimen of the cervical vertebræ of a *Balæna*, labelled *B. biscayensis* (no. 338, f.), which has the upper surfaces of the vertebræ more flattened, and therefore agrees better with this fossil. There is one important point, however, in which this, as well as the *B. mysticetus*, differs from this fossil, and that is in the proportion between the width across the cups of the atlas and the length of the vertebral centra measured along their lower surfaces, as shown in the table of measurements on page 320.

The British-Museum specimen, which was dredged off Selsey, was referred by Dr. Gray at first to *Balæna biscayensis*, but afterwards to a new species, and subsequently to a new genus (Proc. Zool. Soc. 1873, p. 140). In the latest catalogue of the British-Museum Cetacea (by Prof. Flower, 1885) this specimen, in the absence of sufficient evidence for separation, is included provisionally under the name of *Balæna australis*.

By some authors *B. biscayensis*, *B. australis*, and *B. antipodarum* are regarded as distinct species; but their cervical vertebræ, as figured by Gervais and Van Beneden (Ostéographie des Cétacés, pls. i., iii., and x.), do not show differences which can be taken as definitely specific.

The fossil forms of *Balæna*, *Balænula*, and *Balænotus* described by Van Beneden ("Ossem. Foss. d'Anvers," Ann. Mus. Roy. Hist. Nat. Belg. tome iv. part 2, 1880) may have some resemblance to the "Forest-bed" fossil, but are less nearly allied to it than some of the recent forms.

Mr. Backhouse's specimen is certainly a *Balæna*, and possibly may represent a new species; but bearing in mind the uncertainty which exists as to the living species of the genus, it is better not to give a new name, but to refer the fossil provisionally to one of the recent species. It is generally agreed that in the northern hemisphere there are two true whalebone Whales—one the *Balæna mysticetus*, which is only found in high northern latitudes and always in the neighbourhood of ice; the other, which has been named *B. biscayensis*, is believed to be the form that, until quite modern times, was an inhabitant of our own seas. At present there is some doubt as to the southern species, *B. australis* and *B. antipodarum*, being distinct from *B. biscayensis*; but their identity has yet to be established. *Balæna mysticetus* may, like some other northern mammals, have found its way further south in later Pliocene times than it does at the present day, and it is just possible that this fossil might belong to that species; but the available evidence seems rather to favour its being referred provisionally to *B. biscayensis*.

In the Survey Memoir on the "Forest-bed" Vertebrata two large Cetacean vertebræ were noticed; but in the absence of sufficient

evidence they were not named, but provisionally left where one of them had already been doubtfully placed, that is, in the genus *Balænoptera*. As we now know of two other genera of Whales in the "Forest-bed," *Physeter* and *Balæna*, the question arises, may not these vertebræ belong to one of these forms? Let us take, in the first place, the vertebra from Cromer, belonging to Mr. W. Barker of Birmingham, to whom I am indebted for measurements and sketches which enable me to give the following particulars of this largest Whale vertebra with which I am acquainted. This specimen, which has lost all its processes, measures about 16 inches across the terminal face, and about $10\frac{1}{2}$ inches from front to back. There is a pair of surfaces below for the attachment of chevron bones, as well as evidence of the neural arches above, and at the side are the bases of the broken transverse processes. From this it is clear that we are dealing with a caudal vertebra which probably belonged to quite the anterior part of that region. The variations in the proportions of length to width in the vertebræ of the large Whales gives a clue to the genus to which they belong, and judged by this standard Mr. Barker's specimen agrees with the anterior caudal vertebræ of *Balæna*, as shown in the table of measurements (p. 323). It is quite possible that it belongs to the same species as the cervical vertebræ above described, with which it will for the present be associated.

The second large Cetacean vertebra is in Mr Gunn's collection in the Norwich Museum, and is from the "Forest-bed" of Bacton; it is almost as large as Mr. Barker's specimen, being nearly 15 inches in diameter. Mr. Gunn has most kindly supplied me with measurements and other information concerning this vertebra. The two surfaces from which the neural arch has been broken away are seen on the upper part, and at the sides are the bases of the transverse processes. In the middle of the lower surface there is an irregular thickened projection, which seems to be the characteristic ridge of the Whale's lumbar vertebræ. Neither in form nor in the proportion of length to breadth does this vertebra agree with the lumbar vertebræ of either *Physeter* or *Balæna*. Its measurements, however, agree fairly well with the lumbar vertebræ of *Balænoptera*; and, although the inferior ridge is stronger than in either of the recent skeletons I have been able to examine, it seems highly probable that it belonged to a species of that genus.

Other Cetacean vertebræ of smaller size have been found in the "Forest-bed;" but with the exception of the two forms already referred to *Delphinus* (Survey Memoir), their affinities have not been determined.

The following list includes all the Cetacea at present known to occur in the "Forest-bed":—

- Balænoptera*, sp., from Bacton.
- Balæna* *biscayensis*, from Overstrand.
- Physeter* *macrocephalus*, from Sidestrond.
- Monodon* *monoceros*, from Mundesley.
- Delphinus* *delphis*, from Overstrand.
- sp. (near to *D. tursio*), from Overstrand.

Table of Measurements.

		Transverse diameter.	Length.	Percentage of length to breadth.
		in.	in.	
Vertebra in Mr. Barker's collection ...		15.75	10.5	66.6
Vertebra in Mr. Gunn's collection		14.5	11.0	75.8
<i>Balanoptera</i> , sp., in the College of Surgeons Mu- seum, no. 2754	1st lumbar	11.5	9.5	82.6
	7th lumbar	11.5	10.0	86.9
	15th lumbar	12.5	11.25	90.0
	1st caudal	12.5	11.0	88.0
	5th caudal	12.5	11.0	88.0
<i>Balanoptera mus- culus</i> , in British Museum	1st lumbar	13.0	10.0	76.9
	5th lumbar	13.0	10.25	78.8
	1st caudal	14.0	12.5	89.2
	5th caudal	14.5	12.75	87.9
<i>Balanoptera Sib- baldi</i> , in British Museum	4th lumbar	12.5	8.25	66.0
	1st and 2nd caudal	13.5	10.25	75.9
	5th caudal	13.5	10.25	75.9
<i>Physeter macro- cephalus</i> , in British Mu- seum	1st lumbar	14.0	9.5	67.8
	5th lumbar	14.0	10.0	71.4
	1st caudal	14.0	12.0	85.7
	5th caudal	13.75	11.25	81.8
<i>Balæna</i> , sp., Col- lege of Surgeons, no. 2750	caudal	12.75	8.5	66.6
	caudal	13.0	8.5	65.3

EXPLANATION OF PLATE XI.

- Fig. 1. *Physeter macrocephalus*. Tooth from the "Forest-bed" of Sidestrand. Presented by Mr. Clement Reid to the Museum of Practical Geology. $\frac{1}{4}$ natural size.
2. Same specimen, cut through longitudinally, to show pulp-cavity and proportion of dentine and cement.
 3. Same specimen. Longitudinal section of portion of dentine and cement, enlarged 20 diameters, to show the interlacing of the spindle-shaped "Sharpey's fibres." *a* to *b*, dentine; *b* to *c*, cementum.
 4. Same specimen. A few of the "Sharpey's fibres," with a few lacunæ, from lamina *d* in fig. 3, enlarged 215 diameters.
 5. *Balæna biscayensis*. Side view of the right half of seven ankylosed cervical vertebrae, wanting the processes and neural arches, from the "Forest-bed" of Overstrand, near Cromer, in the collection of Mr. Jas. Backhouse, of York. $\frac{1}{2}$ natural size.
 6. Same specimen, with neural arches restored in outline. $\frac{1}{2}$ natural size.
 7. Same specimen, front view. $\frac{1}{2}$ natural size.
 8. Same specimen, front view, with the neural arch and processes restored in outline. $\frac{1}{2}$ natural size.

DISCUSSION.

Professor FLOWER said Mr. Newton's descriptions were very careful and exhaustive. Unfortunately, in the case of the larger

Cetacea, despite the large number of specimens recently added to our collections, there was still a want in this country of sufficient materials for comparison. *Balæna biscayensis* had almost died out without specimens being procured, but fortunately it seemed to have lately increased in numbers. Whales varied much individually, and one skeleton of each species was insufficient for comparison.

With the general conclusions of the Author the speaker agreed. He saw no reason for distinguishing the tooth on the table from that of the Common Sperm-Whale. He doubted whether *Balæna biscayensis* differed from *B. australis*; but perhaps it was safer to refer the specimen described to the first-named species. Mr. Newton's collection gave a fair epitome of the Cetaceans inhabiting British seas, as it contained examples of all the leading types.

Dr. WOODWARD inquired whether the remains might not be rather later in time than the true Forest-bed age, especially if the latter was a land period, and referable to the time when the Forest-bed was being again submerged.

Mr. CLEMENT REID thought the bones came from the Forest-bed, as they agreed with specimens from that deposit in the state of mineralization. He obtained the Sperm-Whale tooth himself from a fisherman who had just found it, and he described the circumstances. It was noteworthy that the large land-mammals of the Forest-bed were extinct, whilst the Cetaceans appeared to be of recent species.

The AUTHOR thanked Prof. Flower for his remarks, and acknowledged his indebtedness to Prof. Flower's writings in the working out of these fossils.