Anatomy of a Fœtus of Balænoptera borealis.

By H. von W. Schulte.

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MONOGRAPHS OF THE PACIFIC CETACEA.

II.—THE SEI WHALE (*BALÆNOPTERA BOREALIS* LESSON).

2. ANATOMY OF A FŒTUS OF BALÆNOPTERA BOREALIS. BY H. VON W. SCHULTE.

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Introduction.

The fœtus described in the following pages was taken by Mr. Roy C. Andrews at Aikawa, Rikuzen Province, Japan, on July 5, 1910. Together with several other fœtuses of other species of *Balænoptera* and of *Megaptera,* also collected by Mr. Andrews, it was entrusted by the American Museum of Natural History to the Department of Anatomy of Columbia University for purposes of anatomical study. At the time, the summer of 1914, the wish was expressed by the Museum authorities that the fœtus of *B. borealis* should form the subject of an anatomical report to the Museum, which might be published in conjunction with Mr. Andrews's monograph of the species. It is difficult to overestimate the importance of material of this sort from a diminishing species, of which I am not aware that a fœtus has previously been procured and preserved for laboratory examination. For this unusual opportunity and for many courtesies in the course of the work, I owe most grateful thanks to the officers of the American Museum, and in particular to Mr. Andrews for the great assistance, which his knowledge of the adult, most generously placed at my disposal, has rendered in the whole progress of the study. To Professor Huntington, under whose oversight I have prosecuted this investigation, I would express my deep appreciation of his interest and advice; his experience has been invaluable in securing a fuller utilization of the material, his judgment on occasions innumerable has cleared up difficulties both of fact and interpretation. The illustrations are the work of Mr. M. Petersen, Artist to the Department of Anatomy. Their production has been a labor of infinite care, most of them have been studied and drawn under a lense, and for their finished accuracy of detail I am under great obligations to the patience, skill and intelligence of the artist. Dr. John D. Kernan, Jr., of this department has undertaken the description of the nasal fossa and the ear.

The fœtus measured 375 mm. linear length from the tip of the rostrum to the notch in the flukes. Immediately upon being taken it was placed in a large receptacle of alcohol, the abdomen and thorax having been previously opened by a small incision in the linea alba. In a few places, the diaphragmatic surface of the liver and the dorsum of the ligamentum latum, the fluid seems to have penetrated slowly, for these surfaces are pitted by minute bubbles of gas. The cerebrum also has largely disintegrated, and the surface of the left lobe of the liver was friable and became damaged superficially during its removal. Otherwise the viscera were successfully hardened *in situ* and retained clear impressions of adjacent organs, so that an unusually favorable opportunity was afforded to study their syntopy. For transportation and storage the fœtus was placed in a cylindrical jar, in which it acquired a marked spiral twist to the right. This attained a maximum in the thorax and here the ribs of the right side were bent in lateral to their angles with consequent deformity of the right lung and disturbance of thoracic proportions. There was also considerable desquamation of the epidermis and several small areas of inconsiderable surface damage. On the whole the sum of the defects is very small for material obtained and transported with such difficulty, and its great merit consists in the admirable preservation of its muscles and viscera.

Accordingly, with a view to using it to the best advantage, attention was concentrated upon the myology and visceral anatomy, and in this latter field primarily upon the topography of the upper abdomen. Since Carte and MacAlister no general account of the muscles in a Mysticete has been given, and as their dissections were performed two weeks after the death of their specimen, and their description in many places is extremely brief, it seemed desirable to use this opportunity for reexamination of this topic. As to the abdomen, Weber in his important study of the position of the alimentary canal in the Cetacea, has not touched upon the conditions of the lesser sac, and the general literature affords but scanty information upon its arrangement. Outside of these two main inquiries, I have recorded briefly the results of dissection, but have refrained from detailed study of many anatomical structures, which in a fœtus of this size were inconveniently small for dissection, and rather large for serial sections and reconstruction.

It has been the purpose of this report to record as objectively as possible the organization of this fœtus of a little studied species, and I have confined myself rather strictly to my subject. In particular I have not attempted a collation or review of the literature, but have relied largely upon the more recent studies in this field for comparison and interpretation, limiting myself here again as far as possible to the works dealing particularly with the Balænopterinæ.

Measurements.

The dimensions of this fœtus are given in the accompanying table I and their percentage proportions in terms of the length from the tip of the rostrum to the notch in the flukes. While the fœtus, as has been said, was curved in an irregular spiral it was flexible enough to be straightened and the measurements given were taken in this position with callipers. In the case of a structure situated in the dorsal or ventral midline the measurement was taken to its transverse plane thus avoiding obliquity in line of measurement and increase of dimensions by following the curvature of the surface. The dimensions most dependent upon the mode of measuring are of course the distances between dorsal points and in particular the total length, owing to the curvature of the dorsum and the greater or less degree of flexion of the head. In this fœtus the linear length when the body is straight is 375 mm., but when the curvature of the dorsum is included it amounts to 450 mm.

Table I. Measurements of Andrews's fœtus of Balænoptera borealis.

	mm.	%
Total length, snout to notch of flukes	375	
Tip of snout to blow hole	45	12.0
Tip of snout to eye	65	17.3
Tip of snout to external auditory meatus L. 96 R. 88 Av.	92	24.5
Tip of snout to axilla	110	29.5
Tip of snout to umbilicus	185	49.3
Tip of snout to anus	257	68.5
Tip of snout to hump	233	62.1
Length of hump	16	4.3
Notch of flukes to umbilicus	180	48.0
Notch of flukes to anus	120	32.0
Notch of flukes to hump	126	33.6
Tip to tip of flukes	81	21.6
Anus to clitoris	8	2.2
Anus to umbilicus	63	16.8
Length of umbilicus	10	2.6

	mm.	%
Depth of pedicle just anterior to flukes	25	6.6
Depth of pedicle midway between flukes and anus	36	9.6
Depth of body at anus	42	11.2
Depth of body at umbilicus	63	16.8
Depth of body at shoulder	66	17.6
Length of flipper tip, to anterior insertion	48	12.8
Greatest breadth of flipper	14	3.7
Circumference at eye	220	58.6
Circumference at shoulder	200	53.3
Circumference at umbilicus	173	46.1
Circumference at anus	122	32.6

Guldberg [1] has given the dimensions of a larger fœtus of *Balænoptera borealis* taken in June at Sörvar which are here repeated.

	metres.
Total length	1.355
Length of the head (from the anterior extremity of the upper jaw to the meatus auditorius externus)	0.345
Distance from the anterior extremity of the lower jaw to the umbilicus	0.685
Distance from middle of umbilicus to the median groove in the caudal fin	0.660
Length of right anterior limb	0.185
Distance from anterior edge of the above to anterior extremity of lower jaw	0.415
Size of anterior limb	0.045
Dorsal fin, length at base	0.068
Dorsal fin, height	0.050
Distance from dorsal fin to caudal groove	0.417
Distance from dorsal fin to extremity of lower jaw	0.875
Breadth of caudal fin	0.332
Distance from the anus to the caudal aperture	0.405
Distance from the anus to the centre of the umbilicus	0.250
Distance from the anus to the extremity of the lower jaw	0.950

Collett [2] gives the measurements of four still larger fœtuses collected in the Varangerfjord in the month of July as follows:—

Table II. Collett's measurements of four fœtuses of B. borealis.

	16 July No. 1, ♀	18 July No. 2, ♂	19 July No. 3, ♂	18 July No. 4, ♂
	millim.	millim.	millim.	millim.
Total length	1550	1830	2410	2830
Snout to angle of mouth	250	320	410	460
Angle of mouth to flipper	220	250	350	360
Length of the flipper	240	250	370	410
Width of the flipper	50	54	—	—
Snout to the dorsal fin	1030	1180	1550	1810
Dorsal fin to end of the tail	520	650	860	1020
Snout to the navel	760	940	1230	1340
Greatest height of the body	240	300	330	390
Height at the beginning of the dorsal fin	170	230	310	320
Height at the middle of the tail	140	160	220	250
The least height of the tail	100	120	—	170
Length of each fluke	200	250	—	340

[1] Guldberg, G. A. 1885. On the existence of a fourth species of the genus Balænoptera. Jour. Anat. and Phys., Vol. XIX, p. 298.
[2] Collett, R. 1886. On the external characters of Rudolphi's rorqual (*Balænoptera borealis*). P. Z. S. London, Part II, p. 261.

For purposes of comparison the proportional dimensions of these fœtus are given in Table III.

Table III. Comparative measurements of six fœtuses of B. borealis.

Embryo, Sex	R. C. Andrews ♀	Gulberg ♀	Collett No. 1, ♀	Collett No. 2, ♂	Collett No. 3, ♂	Collett No. 4, ♂
Place	Aikawa, Japan	Sörvar, Norway	Varangersfjord, Norway			
Date	July 5	June	July 16	July 18	July 19	July 18
Length in millimeters	375	1355	1550	1830	2410	2830
	%	%	%	%	%	%
Snout to external auditory meatus	24.5	25.3	—	—	—	—
Snout to umbilicus	49.3	50.6	49.0	51.4	51.0	50.2
Snout to anus	68.5	70.0	—	—	—	—
Snout to hump	62.1	64.3	66.5	64.5	64.3	63.9
Notch of flukes to hump	33.6	30.8	—	—	—	—
Notch of flukes to anus	32.0	29.9	—	—	—	—
Anus to centre of umbilicus	18.1	19.2	—	—	—	—
Depth at anus	11.2	—	10.9	12.6	12.3	11.3
Depth at middle of pedicle	9.5	—	10.3	10.3	9.0	8.1
Breadth of flukes	21.6	24.5	25.8	27.3	—	24.1
Length of flipper	12.8	13.6	15.5	13.6	16.2	14.5
Breadth of flipper	3.7	3.3	3.2	2.9	—	—

While neither Guldberg nor Collett state their mode of measuring, the very general correspondence of percentages reckoned from their data with the linear proportions of this fœtus makes it highly probable that they too used linear measurements. The comparison of these six fœtuses shows no progressive change of proportion during the period represented save only in the breadth of the flipper, which progressively diminishes, being least in the fœtus of 1830 mm., the oldest in which this dimension is given, and here a more slender form is attained than is found in the adult, according to Collett's measurements,[1] the length bearing the ratio to the breadth of 1 : 4.7 while in the adult it is as 1 to 3.5 or 1 to 3.6 reckoned to the axilla. The distance from rostrum to hump is in all cases within the limits of adult variation as given by Collett, this dimension varying in five specimens between 61 and 68%.

The measurements of six fœtuses of *B. musculus* (= *physalus*) ranging in length from 4 ft. 11 in. to 9 ft. 3 in. given by Burfield [2] makes possible a comparison with this species, and I have added measurement of two fœtuses of *B. vellifera* and one of *B. sulphurea* collected by Mr. R. C. Andrews of the American Museum. I have quoted here only the percentage table of Burfield and have used his points of measurement to facilitate comparison.

This table indicates the relatively great fixity of the position of the anus in the several species at the beginning of the last third of the body; it is in advance of this in *B. vellifera* alone and there only to a very slight degree. Somewhat more variable, but still within narrow limits is the position of the umbilicus just behind the middle of the body, being farthest caudad in *B. physalus* and *B. vellifera*. *B. borealis* has the shortest rostrum, the longest pectoral limb

[1] *Loc. cit.*, p. 252.

[2] Burfield, S. T., Belmullet Whaling Station. Report of the Committee appointed to investigate Biological Problems incident to the Belmullet Whaling Station. Report of Bri. Ass. Adv. Sci., Dundee, 1912, p. 145.

Table IV. Percentage measurements of fœtuses of Balanoptera musculus (= physalus), borealis, vellifera and sulphurea.

Measurement	♂ *B. musculus* Burfield, No. 51	♀ *B. musculus* Burfield, No. 37	♂ *B. musculus* Burfield, No. 14	♀ *B. musculus* Burfield, No. 18	♀ *B. musculus* Burfield, No. 25	♀ *B. musculus* Burfield, No. 16	Average	♀ *B. borealis* Andrews	♀ *B. borealis* Guldberg	♀ *B. borealis* Collett	♂ *B. borealis* Collett	♂ *B. borealis* Collett	♂ *B. borealis* Collett	Average	♂ *B. vellifera* Andrews	♀ *B. vellifera* Andrews	Average	*B. sulphurea* Andrews
Total length	ft. in. 9 3 %	ft. in. 9 0 %	ft. in. 8 11 %	ft. in. 8 5 %	ft. in. 6 0 %	ft. in. 4 11 %		mm. 375 %	mm. 1355 %	mm. 1550 %	mm. 1830 %	mm. 2410 %	mm. 2830 %		mm. 450 %	mm. 425 %		mm. 427 %
Tip of Snout to centre of eye	18.0	19.0	19.6	18.8	20.1	18.6	(6) 19.0	17.9	....	....	....	....	....	(1) 17.9	19.3	19.9	19.6	19.4
Tip of Snout to centre of blow-hole	14.9	14.8	14.9	15.8	14.6	14.4	(6) 14.9	13.1	....	....	....	....	....	(1) 13.1	14.9	15.5	15.2	13.8
Tip of Snout to posterior insertion of pectoral fin	34.2	33.3	....	34.2	34.7	33.9	(5) 34.0	30.67	....	....	....	....	....	(1) 30.67	34.1	34.6	34.35	33.5
Tip of Snout to posterior insertion of dorsal fin	75.7	75.0	76.6	73.8	73.6	75.4	(6) 75.0	66.4	....	....	....	....	....	(1) 66.4	72.2	71.1	71.65	73.3
Eye to ear	6.3	5.6	8.9	5.9	?1.8	5.1	(5) 6.3	6.7	....	....	....	....	....	(1) 6.7	7.6	7.5	7.55	7.5
Notch of flukes to anus	30.6	28.7	30.8	29.7	29.9	30.5	(6) 30.0	32.0	29.9	....	....	....	....	(2) 30.95	32.9	34.7	33.8	31.6
Notch of flukes to umbilicus	46.0	41.7	48.6	45.1	45.1	48.3	(6) 45.8	48.0	49.1	....	....	....	....	(2) 48.55	49.8	48.3	49.05	44.5
Length of pectoral fin (tip to anterior insertion)	14.4	13.9	14.5	12.9	12.5	12.7	(6) 13.5	12.8	13.6	15.5	13.6	16.2	14.5	(6) 14.37	13.8	13.9	13.85	13.1
Length of pectoral fin (tip to posterior insertion)	9.9	11.1	11.2	9.4	8.7	9.3	(6) 9.9	....	....	....	....	....	....	....	11.1	11.8	11.45	12.9
Greatest breadth of pectoral fin	3.6	3.2	3.7	3.5	3.1	3.0	(6) 3.3	3.7	3.3	3.2	2.9	....	....	(4) 3.5	4.0	4.0	4.0	3.7
Vertical height of dorsal fin	3.1	3.2	3.3	3.9	2.8	2.1	(6) 3.0	2.1	2.4	....	....	....	....	(2) 2.25	1.8	2.0	1.9	....
Flukes (tip to tip)	18.0	13.0	17.7	....	....	19.5	(4) 17.0	21.6	24.5	25.8	27.3	....	24.1	(5) 24.66	19.1	20.3	19.7	20.1

and the hump of most rostral position, being distinctly in front of the anus. It has also the widest flukes. *B. physalus* has the hump farthest caudad and of greatest height in the series, and has also the narrowest flukes. In *B. vellifera* the flipper is broadest, the rostrum longest.

External Anatomy.

Coloration.— To some extent the epidermis has desquamated though the precise limits cannot now be determined accurately. As the pigment is epidermal this desquamation has reduced the colored area of the fœtus, and the following description therefore understates the pigmentation, which presumably was present over the greater part of the back. This, in the fœtus when received, together with the venter was a uniform light buff, except for the lips of the blow holes and the ridges lateral to them. A narrow dark streak is present upon the lips. On the upper lip it is sharply limited orally by the superior labial sulcus. It extends forward within a centimeter of the tip of the snout; at the angle of the mouth it turns inward beside the ridge formed by the temporal muscle, and broadening and becoming paler upon the palate can be followed to the orifice of the pharynx. A small extension on each side is directed rostrad beside the median ridge of the palate. In the lower lip the pigmentation also stops abruptly at the very minute inferior labial sulcus. The streak becomes paler and broader towards the angulus oris and fades out before reaching it. Rostrad it is prolonged upon the pointed extremity of the lips and passes over their margin to a slight degree upon their aboral surface. This pigmented area at the symphysis is divided by two pale lines continuing the direction of the inferior labial sulci into a median triangle on the oral aspect of the symphysis, and an outer V-shaped area formed by the union of the labial streaks. The dorsum of the flukes is pigmented. They are darkest near their caudal margin and become paler towards the median line and towards the rostral border, which itself is unpigmented as is also the ridge of the peduncle between the flukes. The posterior margin of the flipper and a narrow border zone of its inner surface are dark slate colored; the outer surface is more extensively colored along the posterior margin in the middle third of its length, and there is in addition a narrow axial streak extending nearly to the tip. In later fœtal stages this type of pigmentation evidently disappears, for Collett describes the coloration of his specimens, from five to nine feet in length, as being "homogeneous, a reddish-brown on the upper and under sides, without any appearance of white on the belly."

Hairs.— Eight very small papillæ were present, four on each side, in a row along the inferior margin of the lower jaw. The most posterior is placed vertically below the eye, the most anterior 14 mm. farther forward. The intervals between the papillæ increase in length from behind forward (3, 4 and 6 mm.). Collett found the hairs 'visible but quite short" in his youngest fœtus (155 cm.). He does not give their number or arrangement. In a fœtus of 241 cm. there were seventeen hairs on each side in the mandibular region arranged in three rows, three each in the upper and lower and eleven in the middle row. On the upper jaw there were seven hairs on each side in a single row, thus making a total of thirty-four hairs in this fœtus.

Outline of body.— The rostrum is moderately arched, pronouncedly decurvate at the tip. It is separated from the strongly projecting brain case by a shallow concavity in which are situated the blow holes. From the prominence of the cranium the dorsal contour is evenly and gently convex as far as the hump, beyond which it declines in a straight slope to the beginning

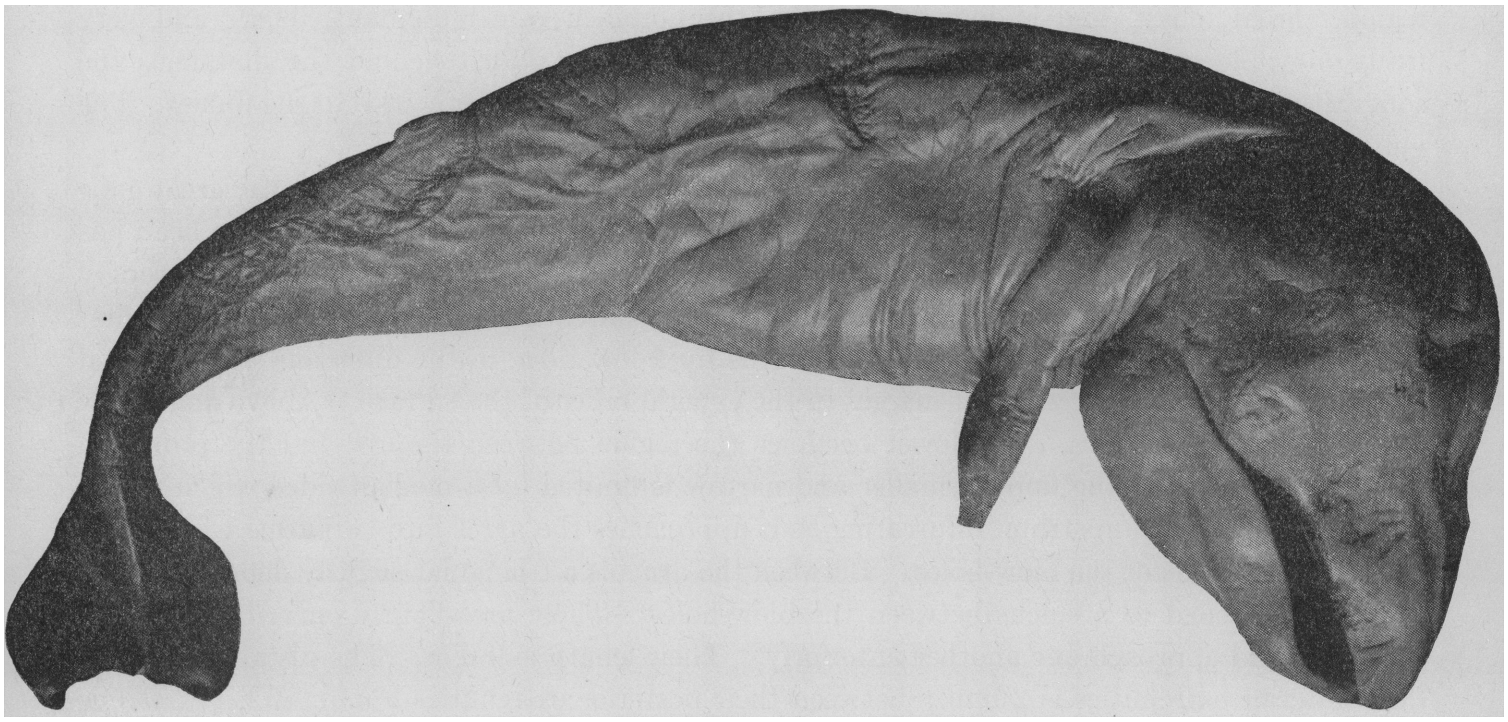

Fig. 1. Lateral view of fœtus.

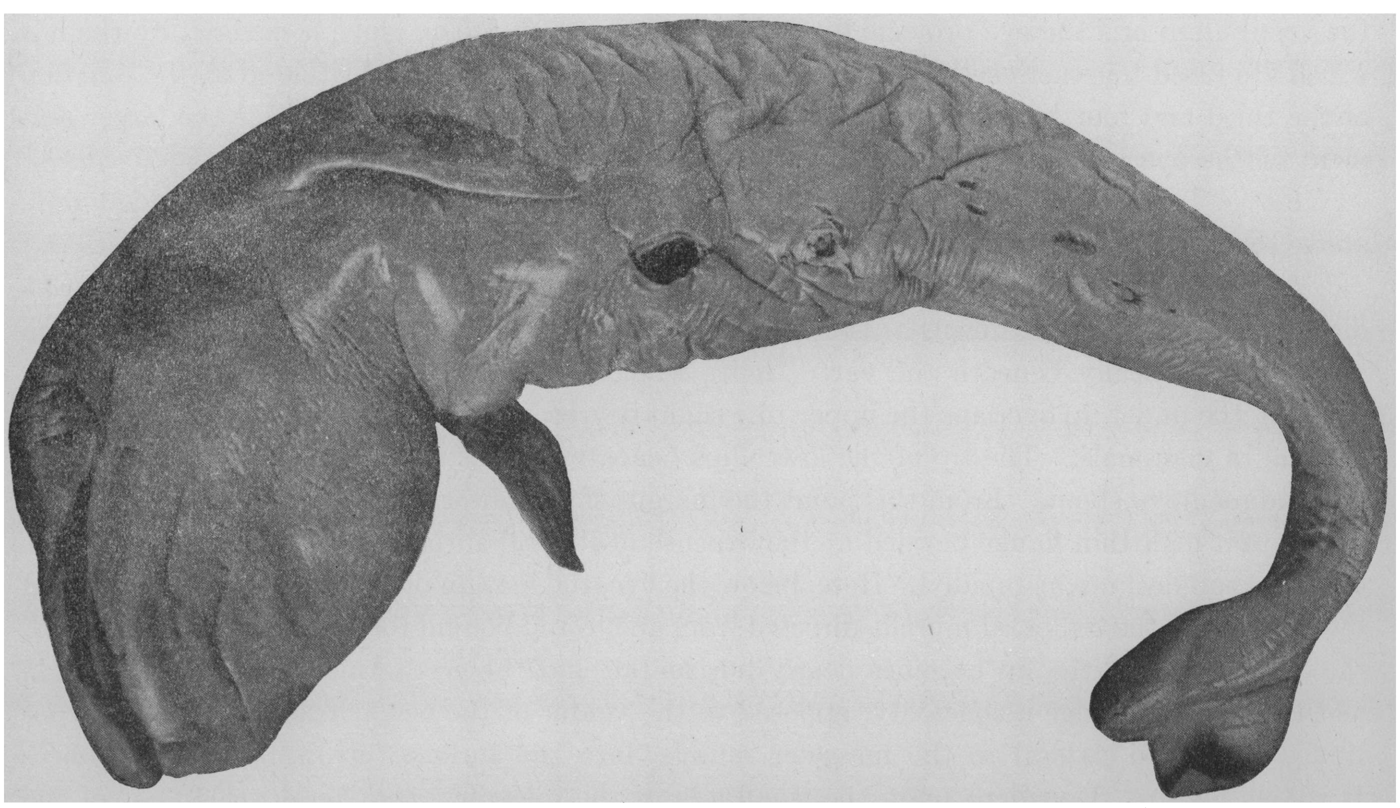

Fig. 2. Ventral view of fœtus.

of the flukes, where the inclination increases somewhat. In the whole length of the upper ridge of the peduncle are slight irregular undulations. The integuments of the intermandibular region, throat, chest, and abdomen nearly to the umbilicus are redundant, baggy and very freely movable on the deeper parts. There are no furrows. Just behind the umbilicus the convexity of the belly ends and the ventral contour takes a rectilinear course to the flukes. The vulva and anus occasion only a very slight protrusion.

Head.— In the convex rostrum with its downcurved tip, the prominent eye, the great gape of the mouth and its prolongation by a surface furrow below and beyond the eye, the head has a remote and specious resemblance to that of the sauropside embryo. The rostrum is strongly arched transversely and presents a slight protuberance on each side at the junction of its first and middle thirds. This is prolonged backwards by a low ridge in the direction of the frontal eminence before reaching which it merges in the general relief of the surface. Above and below this ridge are concavities. The lower occupies the region between the eye and the protuberance of the rostrum; the upper, smaller and narrow is limited by a median ridge which marks the caudal half of the rostrum, bifurcating as it approaches the nares into two arms which skirt the lateral margins of the blow-holes. Between the arms is a triangular slightly depressed area, which is deepened to a sulcus between the blow-holes. These are slightly curved with mesal concavity and approach one another anteriorly. Their length is 9 mm. The distance between their anterior extremities is 2 mm.; between their posterior extremities 9 mm. They are thus inclined to the median line at an angle of 68 degrees. About each blow-hole and in the median sulcus there is some pigmentation of the epidermis.

Eye.— The eye forms a large prominence above the surface prolongation of the oral cavity, which continues lateral to and beyond the temporal muscle. Into this caudal extension of the vestibulum oris the eye projects by its ventral convexity. The globe is covered by the lids which are fused together except for a small hiatus, 6 mm. in length and situated at the junction of the third and fourth vertical quarters of the ocular protuberance, so that far the larger segment of the eye is covered by the upper lid.

Ear.— The external auditory meatus has a punctate orifice 24 mm. behind and 9 mm. above the centre of the eye.

Lips.— The line of the mouth ascends with a moderate arch almost to the eye, where its direction changes curving downwards below the eye and running out into a surface furrow which terminates vertically beneath the ear. In its whole extent, save at the decurved tip of the rostrum, the under lip overlaps the upper to a slight degree, a condition the reverse of that which is usual in mammals. The tip of the lower lips beneath the rostrum, is everted and protrudes in a rudimentary spout. From this point the margin of the lower lip, beginning as a faint ridge rises into a high thin flange beveled at the expense of its oral surface, which upon reaching the ocular region declines as rapidly. Here, below the eye, the margin of the lower lip is approached by the ridge of the temporal muscle, directed from above and behind rostrad and slightly laterad; the oral surface of the lip becomes nearly horizontal, and there is formed between its margin and the temporal ridge a concavity, apposed to the venter of the ocular protuberance and continued backward, lateral to the masseter muscle, into the surface furrow before mentioned. It is this feature, dependent upon the small size of the masseter, the non-development of the cheek, and the consequent rudimentary condition of the vestibulum oris, together with the absence of a distinct mandibular ramus, which is largely responsible for the curiously sauropsid expression of the cetacean fœtus.

The lower lip is marked sagittally by a minute furrow. Beginning as an unpigmented line at the symphysis it runs in the intermediate region rather nearer the base than the margin of the lip, here forming the oral limit of the pigment-streak. On reaching the temporal ridge the furrow turns on its mesal surface, eventually ascending slightly to be lost in a depression which corresponds to the orbital triangle of other mammals. Obviously in the post-temporal segment the furrow has ceased to have the significance of a labial or dento-labial sulcus, and it is evident that here an independent element has become secondarily continuous with that furrow.

The labial sulci diverge for about three fourths of their length and then converge more rapidly. They thus describe curves of lateral convexity and are farthest apart immediately in front of the eyes. In the caudal segment of their course they sweep mesad to the ridge of the temporal muscle and end in a fossa of the roof of the mouth mesal to this muscle and ventral to the orbit (orbital triangle). Lateral to the dental sulci are the low ridges which form the upper lips. These broaden caudad and in the ocular region merge with the convexities which correspond to the under-surface of the eye, and form the roof or upper boundary of the subocular extension of the oral cavity.

Naso-vomerine organ.— At the tip of the rostrum, between the extremities of the dento-labial sulci is situated a small tripartite elevation. It is separated from the surface of the rostrum by the terminal portions of these sulci, and from the palate by a small transverse furrow continuous with the dento-labial. In the median line, the middle lobe of the elevation forms a bridge between the rostral surface and the palate interrupting the sulci, or at least reducing their depth. This portion is triangular with the base caudad. To its sides are attached the lateral lobes, which are reniform, with their concavities mesad. Lateral to them the dento-labial sulci are deepened to little blind pits. They thus are very similar to the structures described and figured by Weber,[1] and by him interpreted as the rudiments of Steno's ducts. In the slightly older fœtuses of *Balænoptera* and of *Megaptera*, which I have examined, the bounding sulci diminish, the lateral lobes merge into the general relief of the rostrum, and the little pits deepen somewhat, changes which seem to lead up to the conditions described by Lillie.[2]

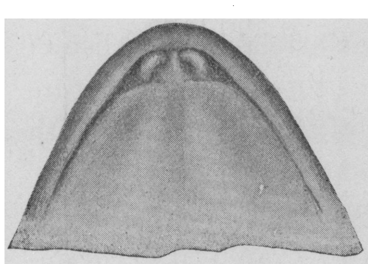

Fig. 3. Naso-vomerine organ.

The flipper.— The flipper attains its greatest thickness close to the preaxial border and maintains it for about two thirds of its breadth, the postaxial third being reduced to a thin plate. It is slightly narrowed at its emersion from the integumentary covering of the trunk, immediately distad of the olecranon. From this point it gradually expands for two thirds of its length and then more rapidly tapers to its pointed extremity chiefly at the expense of its postaxial portion. The preaxial border is not quite straight but has an anterior convexity in its third quarter, beyond which the outline has three slight projections corresponding to the interphalangeal joints of digit II. The postaxial border is convex caudad in its proximal two thirds. Its distal third is rectilinear save for a shallow concavity close to the extremity, which gives the tip of the flipper a faintly hooked contour.

[1] Weber, M. Studien über Säugethiere. Leipzig, 1885, page 145 and pl. iv, figs. 22–24. *Cf.* also Kückenthal, Denkschr Med.-Nat. Gesells. Jena, 1889.

[2] Lillie, D. G. Observations on the Anatomy and General Biology of some members of the larger Cetacea. P. Z. S., 1910, p. 784 and text fig. 75. See also Burfield, S. T. Belmullet Whaling Station. Rep. Bri. Ass. Adv. Sci., Dundee, 1912.

The hump.— The hump is triangular with rounded apex. Its longest side is attached, the intermediate is rostral, the shortest caudal. It is not falciform. Its caudal end is nearly opposite the vulva, distinctly in front of the anus. Guldberg states that the posterior extremity is opposite the anus, but his measurements (*vide ante*) indicate that it is somewhat in advance of the latter.

The flukes.— The flukes are strongly rolled on themselves ventrad. The ridges of the pedicle are prolonged between them to the notch, which is deep and narrow.

The vulva.— The vulva presents a prominent conical clitoris which overhangs the vestibule. This is bounded at the sides by low ridges, the labia majora. Caudad the vestibule rises gradually to the level of the perineum, here presenting three short furrows, a median sagittal, and two lateral diverging with slight mesal convexity. On either side are the slits of the mammary pockets each about 2 mm. in length. There was no asymmetry of the external genitalia.

The anus.— The anus is slightly elongated sagittally separated by a convexity from the vulva. The region about it is but slightly elevated above the general relief of the adjacent surface.

Myology.

(*Plates LXIII–LXVIII.*)

The chief source for the myology of the Mystacoceti is the study by Carte and MacAlister [1] of *Balænoptera rostrata* (= *acuto-rostrata*) published in 1869. Since that time the musculature of the suborder has not again been investigated as a whole, and the list of authors dealing with it at all is surprisingly small in comparison with those that have directed their attention to the toothed whales. No doubt the accessibility and the smaller size of many members of the latter suborder is largely accountable for this. As it is, Perrin [2] has partially reexamined *B. acuto-rostrata*, and has reported his findings briefly in the form of *addenda et corrigenda* to the work of Carte and MacAlister. Beauregard [3] has described in much detail the masseter and temporal muscle of *B. Sibaldii* (= *musculus*) and *B. musculus* (= *physalus*) and there are further the important studies of Weber [4] upon the ocular muscles and of Dubois [5] upon those of the larynx. The fine work of Struthers [6] upon the intrinsic muscles of the flipper, and upon those of the pelvis about exhausts the list. In these circumstances I have found it necessary to refer to the more abundant literature of the Odontoceti on many occasions, but it is needless to say I have attempted no general consideration of the comparative myology of the two suborders, nor do I conceive that this could profitably be undertaken on the basis of our present scanty knowledge of this subject in the Mystacoceti.

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[1] Carte, A., and MacAlister, A. On the anatomy of *Balænoptera rostrata*. Phil. Trans. Roy. Soc. London, Vol. 158, p. 201.

[2] Perrin, J. B. Notes on the anatomy of *Balænoptera rostrata*. P. Z. S., 1870, p. 805.

[3] Beauregard, H. Étude de l'articulation temporo-maxillaire chez les Balænoptéres. Jour. de l'Anat. et de la Phys., An. XVIII, 1882, p. 16.

[4] Weber, Max. Studien über Säugethiere, Jena, 1886, p. 119.

[5] Dubois, E. *Idem.*, p. 93.

[6] Struthers, J. On some points in the anatomy of a great finwhale (*Balænoptera musculus*). Jour. Anat. and Phys., Vol. VI, 1871, p. 107. Account of rudimentary finger muscles found in the Greenland right whale (*Balæna mysticetus*). Jour. Anat. and Phys., Vol. XII, 1878, p. 217. On the bones, articulations, and muscles of the rudimentary hind limb of the Greenland right whale (*Balæna mysticetus*). Jour. Anat. and Phys., Vol. XV, 1881, p. 141 and p. 301. Nature, Vol. IV, 1884, p. 342, contains in the proceedings of the Biol. Sect. A. A. A. a paragraph to the effect that rudimentary finger muscles are present in *Megaptera longimana*.

Panniculus carnosus.— The cutaneous musculature is highly developed, forming an uninterrupted layer upon the sides and venter of the trunk from the occiput to the beginning of the pedicle and being continued beyond this point by a firm aponeurosis which completely invests the tail. It adheres firmly to the derma, beneath which little or no fat has as yet formed, but is in general separated from underlying structures by a moderate quantity of loose areolar tissue. In the region of the ventral pouch however, it is intimately conjoined with the deeper layers by firm connective tissue, and the whole complex is separated from underlying structures by a great area of very loose tissue, the cavum ventrale.

As a whole the panniculus falls into two divisions, one dorsal and the other ventral, the two united by a lateral raphé as far cephalad as the flipper, in front of which they overlap, the fasciculi of the dorsal division passing superficially to those of the ventral. This raphé extends from the axilla to beyond the vent, inclining toward the mid ventral line as it passes caudad. Its axillary extremity is attached to the humerus in union with the insertions of the latissimus dorsi and pectoralis muscles, which insert also into the proximal portion of the raphé. At its beginning linear and permitting a slight degree of interdigitation on the part of the inserting fasciculi, it gradually widens into a broad band which merges behind the vent into the aponeurosis of the pedicle.

The dorsal division arises from a broad aponeurosis which covers the dorsal muscles and in the midline is connected to the spines of the vertebræ by a vertical lamella which intervenes between the muscle masses of the two sides. Its fasciculi are directed ventrad and cephalad, inserting into the lateral raphé, the dorsal aspect of the aponeurosis of the flipper, and in front of this passing as a thin sheet of scattered fasciculi ventrad across the side of the neck to the intermandibular region, where they sweep rostrad almost to the symphysis. Some of them reach the midline and there interdigitate with the bundles of their antimere; the majority do not extend so far but find scattered insertions into the derma along the side of the ventral pouch. The dorsal division extends sagittally from the occiput to near the middle of the pedicle; here it rapidly narrows, the bundles arising at an increasing distance from the dorsal midline but maintaining their regular arrangement and constituting a continuous sheet throughout.

The ventral division arises from the ventral midline, its fasciculi showing a tendency to interdigitate with those of the opposite side. To some extent they are separated by a line of fibrous tissue which blends with their deep epimysium but is not firmly connected with the linea alba. At the umbilicus the muscles of the two sides separate to give passage to the cord. Here there is a considerable increase in the quantity of connective tissue, both of the pannicular layer and more especially in the linea alba. The panniculus has a well defined edge and none of its fasciculi are prolonged upon the cord. Sagittally the ventral division extends from the symphysis mandibularum a short distance beyond the vent. Its fasciculi have a rostro-lateral or dorsal direction and form a continuous sheet. This is very thin in the intermandibular region and very firmly united with the overlying scattered fasciculi of the dorsal division and on its deep surface with the mylohyoid, from both of which it is distinguished by the direction of its bundles. These layers together with a deeper stratum of longitudinal direction constitute the muscular wall of the ventral pouch and form a well defined complex, which is only with great difficulty resolved by dissection into its component elements. The fasciculi of the ventral panniculus can be followed in part to the lips and some of them reach the mandible in front of the insertion of the masseter, but many of them terminate within the intermandibular region

PLATE XLIII.

PLATE XLIII.

Balænoptera borealis.

Fig. 1. Superficial dissection exposing panniculus carnosus. $\frac{3}{4}$ natural size.
Fig. 2. Musculature of ventral pouch. Ventral division of panniculus has been reflected. $\frac{3}{4}$ natural size.

1. Ventral division of panniculus.
2. Dorsal division of panniculus.
3. Lateral raphé.
4. M. mylohyoideus.
5. Longitudinal muscle of ventral pouch.
6. M. sternomandibularis.
7. M. pectoralis.

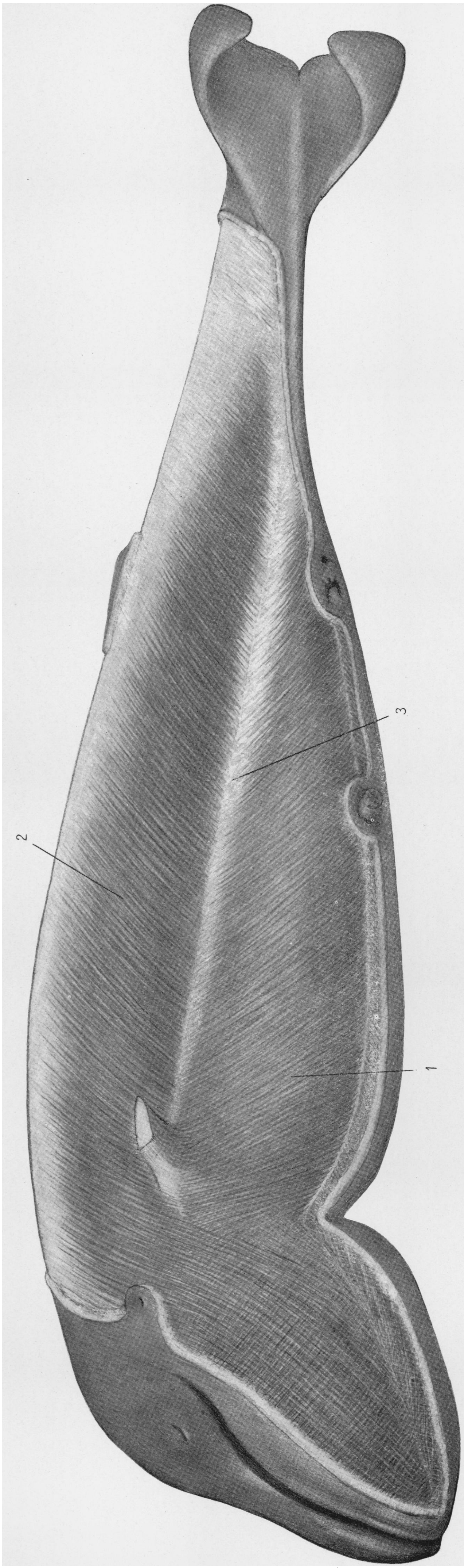

Fig. 1.

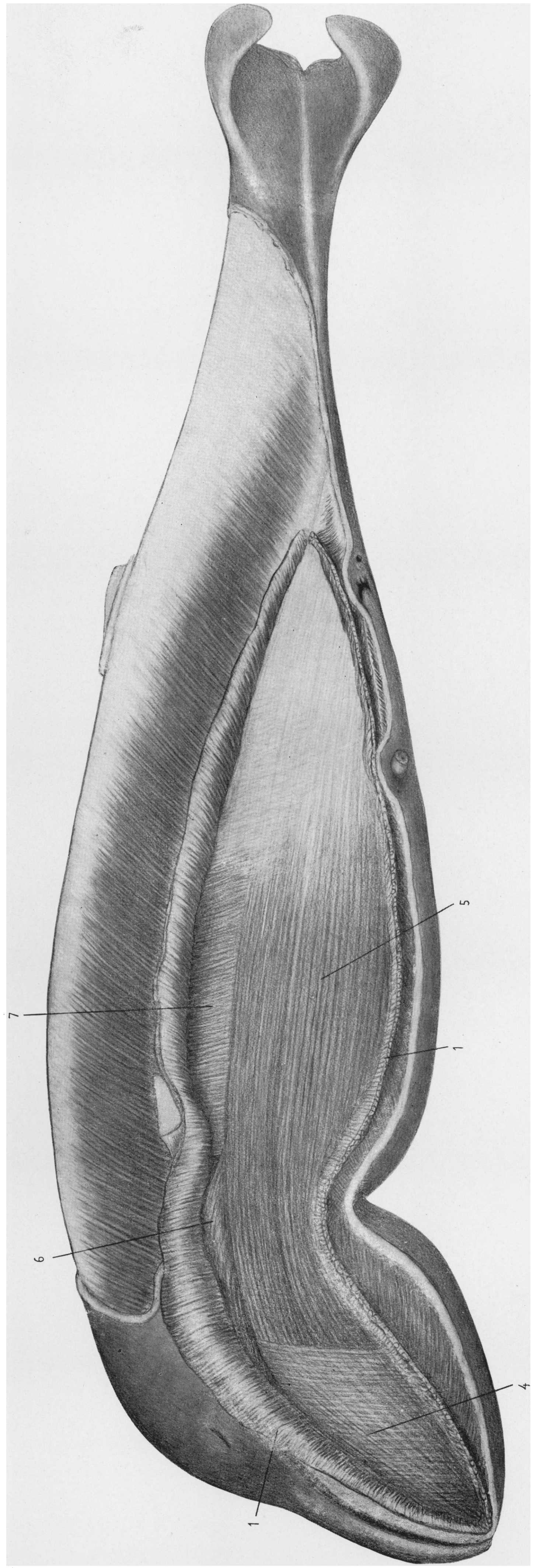

Fig. 2.

BALÆNOPTERA BOREALIS.

on the surface of the mylohyoid muscle, presumably by means of a fibrous inscription but the precise details of their insertion I could not determine in this fœtus. Carte and MacAlister describe a peculiar fibrous structure in connection with the mylohyoid and as their description is somewhat obscure to me I give it literally: "Occupying the inferior or superficial part of the interspace between the rami of the lower jaw in the anterior part of the middle line was a condensed fibrous expansion, which extended forwards as far as the symphysis, and was bifurcated posteriorly at the middle point of the lower jaw, giving attachment to the following muscle (mylohyoid)." In a fœtus of *Megaptera versabilis* of Mr. Andrews's collection which I dissected with a view of gaining a better understanding of the musculature of the ventral pouch, a fibrous structure somewhat resembling the foregoing was present. In the midline immediately behind the symphysis mandibularum a sagittal ridge projects from the surface of the skin with a length of something over 1.5 cm. This is caused by a local thickening of the derma. Caudad its surface relief ends abruptly, but on dissection it is found to be prolonged by two fibrous strands on the surface of the mylohyoid, parallel to and at a distance of about 1 cm. from the lower margins of the mandibles, extending for somewhat more than a third of the length of the jaw. The whole tendinous structure has then the shape of a Y, the stem at the symphysis and the arms stretching caudad roughly parallel to the mandibular rami. It thus would have a general resemblance to the structure described by Carte and MacAlister, if they could be understood as meaning that it terminates, not bifurcates, opposite the middle of the ramus. That this was their intention is, I think, probable from their description of the mylohyoid muscle, of which only the anterior portion is given as arising from the fibrous structure, the remainder having the usual origin from the mandible. It remains to question whether this fibrous structure actually replaces the mandible in part as the origin of the mylohyoid or serves some other purpose. In the fœtus of *B. borealis* I thought I could follow the mylohyoid to the jaw in its whole length. In that of *Megaptera* this was certainly the case, and the fibrous arcade received only fasciculi of the ventral panniculus, which were thus attached to the ectal surface of the mylohyoid by a tendinous inscription. The contraction of this part of the panniculus would therefore seem to serve to deepen the oral cavity by pulling down the floor of the alveolingual region. Not all of the fasciculi of the ventral panniculus had this insertion, however, for some were prolonged beyond the inscription and passing over the border of the mandible were lost in the substance of the lower lip.

Caudal to the intermandibular region the ventral panniculus ascends upon the sternomandibularis under cover of the overlying fasciculi of the dorsal panniculus. Its fasciculi are inserted into the caudal portion of the lower lip and into the derma of the subocular furrow that prolongs the vestible, and more caudally still reach the malar bone and the zygomatic process of the squamosal. In the pectoral region they cross the axilla to reach the ventral aponeurosis of the flipper, here joining the pectoralis, and caudal to the flipper they reach the lateral raphé which unites them to the dorsal division.

The innervation of the panniculus carnosus falls into two districts. Behind and at the shoulder it is supplied by a pannicular or lateral thoracic nerve, the lateral cutaneous of English authors,[1] which runs caudad beneath the lateral raphé distributing branches to both the dorsal

[1] Wilson, J. T. The innervation of axillary muscular arches in man, with remarks on their homology. Jour. Anat. and Phys., Vol. XXII, 1888. Further observations on the innervation of axillary muscles in man. Jour. Anat. and Phys., Vol. XXIV, 1889. Birmingham, A. Homology and innervation of the Achselbogen and Pectoralis quartus and the nature of the lateral cutaneous nerve of the thorax. Jour. Anat. and Phys., Vol. XXIII, 1889.

and ventral divisions. In the neck and intermandibular regions the nerve supply is derived from several branches of the facial which have a general ventro-rostral direction on the deep surface of the muscle. One of larger size emerging at the anterior border of the depressor mandibulæ crosses the masseter and is continued rostrad parallel to the lower margin of the mandible in a position which might lead to its confusion with the mylohyoid nerve.

This description of the panniculus differs materially from the observations of Carte and MacAlister upon a specimen of *Balænoptera acuto-rostrata*. They report a platysma myoides which "could be seen only in the median line," and found that the "portion of the neck external to the inner margin of the sternomastoid had no superficial muscular investment." On the other hand Stannius [1] describes in *Phocœna* a panniculus with dorsal and ventral divisions separated by a lateral raphé and except in the intermandibular region and in its more intimate relations to the pectoralis closely resembling the superficial musculature of this fœtus of *B. borealis*. A panniculus of the *Phocœna* type is also present in fœtuses of *Tursiops truncatus*, and Murie [2] has described one of extensive but modified development in *Globiocephalus*. The conclusion would therefore seem warranted that the panniculus is extensive and highly developed in the Cetacea (Leche),[3] and that *Balænoptera* is not an exception to the rule, but in correlation with its throat furrows possess this muscle in a highly developed form. The persistence of the subcutaneous musculature in these well-nigh hairless forms can not wholly be ascribed to its insertion upon the flipper, but would seem to stand in relation to the maintenance of pressure upon the contents of the abdominal and thoracic cavities as the animal rises to the surface; in accord with this view is the confinement of muscular fasciculi to the ventral and lateral regions of the trunk and their replacement by aponeurosis over the massive dorsal muscles and upon the pedicle.

Cavum ventrale.— This is an extensive area of very delicate areolar tissue which gives way almost without dissection. It reaches from the intermandibular region to within a short distance of the umbilicus. Ventrally it is closed by the muscle complex of the ventral pouch, which is reinforced on the side turned towards the cavum by a strong and moderately thick aponeurosis. At the sides its boundaries are formed by the sternomandibularis and their investing fascia. The dorsal limit is given by a dense and thick aponeurosis which covers the supra- and infrahyoid muscles and from its position corresponds to the usual deep fascia of the neck. Over the pectoralis and external oblique it becomes thinner, and as it approaches the umbilicus it fuses with the aponeurosis of the pouch muscles and so closes the cavum caudally. Rostrad the space does not extend quite to the symphysis and bodies of the mandibles, but is brought to an end inside their arch by the approximation of the pouch muscles to the genioglossus.

The musculature of the ventral pouch.— In addition to the panniculus this comprises the mylohyoid and a longitudinal stratum of cervico-hypoglossal innervation. The muscles are in the form of thin sheets very firmly united by connective tissue. Their general arrangement in cross section is shown in the accompanying photomicrograph (Text-fig. 4). Ectally are scattered bundles of the dorsal panniculus, obviously here equivalent to the platysma myoides. These are followed by the more abundant fasciculi of the ventral division, cut nearly at right angles. The mylohyoid forms the third layer and is very tenuous. Entally are the larger bundles of the longitudinal layer which is thicker than any of the others.

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[1] Beschreibung der Muskeln des Tümmlers (*Delphinus phocœna*). Müller's Arch., Jahrg. 1849.

[2] On the Organization of the Caaing Whale, *Globiocephalus melas*. Trans. Zool. Soc. London, Vol. VIII, 1874.

[3] Braun's Klassen und Ordungen des Thier-Reichs; Säugethiere, Bd. I, p. 669.

The mylohyoid arises in the usual manner from the oral surface of the mandible along a line which ascends somewhat on the bone in the direction of the ramus. Its fasciculi are directed to the median line with an inclination rostrad to unite with their antimere by means of a poorly developed raphé which permits of some interdigitation, the two halves of the muscle being distinguished more by the inclination of their bundles than by the amount of connective tissue interposed. The innervation is by the usual mylohyoid branches of the inferior maxillary nerve, which also supplies the anterior belly of the digastric and is placed upon the ectal surface of the muscle close to the mandible. There was no attachment either of the raphé or of the mylohyoid to the body of the hyoid, from which the muscle is separated by the longitudinal layer already referred to as the deepest stratum of the pouch. In the post mortem distension of the ventral pouch by gases, the caudal border of the mylohyoid produces a transverse furrow sometimes of considerable depth as is shown in Turner's illustration,[1] and particularly well in Andrews' photograph (unpublished).

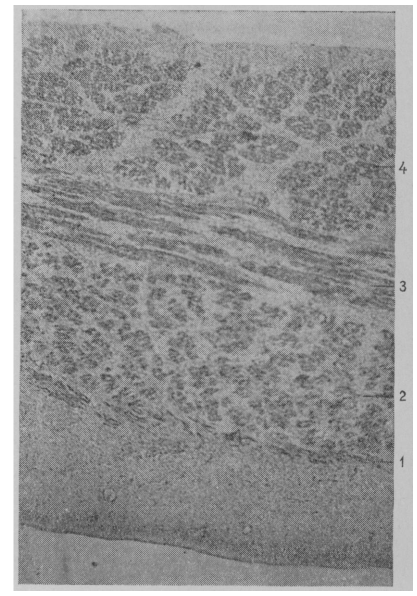

Fig. 4. Photomicrograph of coronal section of the muscles of the ventral pouch. 1, Dorsal division of panniculus carnosus (*cf.* Pl. XLIII, fig. 1). 2, Ventral division of same. 3, Mylohyoid. 4, Longitudinal stratum.

The longitudinal muscle of the pouch extends from its caudal limit in front of the umbilicus to the mandibular arch. It arises in successive sheets, so that as a whole it is of a laminated structure, from the deep surface of the intermuscular septum between it and the ventral panniculus. The layers of thoracic origin are superficial to those beginning farther caudad. On reaching the mylohyoid it passes upon its dorsal or oral surface and is attached to the mandibles immediately dorsal to the insertion of that muscle. As it approaches the jaw it becomes firmly united with the genioglossus to an extent approximately corresponding to the floor of the alveolingual region, in this detail differing from conditions observed in *Megaptera*, where it is easily separable from that muscle. The union in *Balænoptera* is by connective tissue only; I could find no exchange of fasciculi. As the longitudinal layer passes the sternomandibularis in the neck it receives in its lateral portion a contribution of bundles from that muscle, a condition which is more marked in *Megaptera*. The relation of the two muscles is further shown by their innervation from the hypoglossal after it has received the communication of the cervical nerves, the longitudinal muscle receiving a large branch which ramifies on its ental surface.

Carte and MacAlister describe a mylohyoid of loose structure, "composed of fine muscular fibres and areolar tissue permeated by numerous blood vessels"; the fibres in the midline interlace with those of its fellow; no mention is made of an origin from the body of the hyoid, which as their description is detailed, it may be taken that the muscle did not possess. In the matter of structure, the muscles of this region, though thin, were far more compact in this fœtus than in their specimen. As in the fœtus of *Megaptera* the fasciculi were less coherent and in their interstices delicate areolar tissue was more abundant, it would seem that an increasing invasion

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[1] Turner, Wm. An account of the Great Finner Whale (*Balænoptera Sibaldii*) stranded at Longniddry. Part I. The Soft Parts. Trans. Roy. Soc. Edinburgh, Vol. XXVI, 1872, plate v, fig. 1.

of the muscles by connective tissue takes place during fœtal life. Carte and MacAlister's description concludes as follows:

"The inferior or posterior fibres of this muscle ran downwards as far as the lower part of the pouch, and some of them were traceable backwards in the median line, forming a sort of subcutaneous muscular expansion on the anterior surface of the abdomen; this, however, did not expand laterally in the cervical region, and hence that part of the neck external to the inner margin of the sterno-mastoid muscle had no superficial muscular investment."

They would thus seem to have considered the longitudinal layer an extension of the mylohyoid, which is probably to be attributed to the "dartoid character" of the muscle in their specimen and its infiltration with fat making an exact discrimination impossible. The nerve supply would have cleared up the condition, but this they do not seem to have ascertained.

The redundancy of the musculo-cutaneous complex of the ventral pouch in reference to the deeper structures is a striking peculiarity of this fœtus as contrasted with those of the toothed whales. While as yet no furrows have appeared, we are evidently dealing with their antecedent developmental condition.

It is to be noted that the extent of the pouch far exceeds the limits of the intermandibular region and is patently in excess of the demands for space incident to the distensibility of the oral cavity, so that Kückenthal's reference of the throat furrows to this cause alone would not seem to afford an adequate explanation of their presence on the thorax and abdomen. Andrews [1] has suggested that originating in the intermandibular region their caudal extension has taken place in correlation with the increased expansion of the thorax incident to the large size of the lungs and the reduction of the sternal fixation of the ribs in the Balænopterinæ, an explanation which has the advantage of including a larger number of facts and which accords with the structure and extent of the integumentary complex. The difficulty that meets us here is to find grounds for attributing to the ribs under the action of the inspiratory muscles in life an excursion of such degree as to require and utilize a redundancy of the integuments. Müller [2] has thought that the increased freedom of the ribs in Mystacoceti stood in relation to a lessened degree of diaphragmatic respiration as contrasted with the Odontoceti. In favor of this he finds the greater size of the inspiratory muscles in the former and the diminishing development of the diaphragm in their older fœtuses, in one of which he found a centrum tendineum. But granted that such a distinction can be established between the two suborders, it is still to be shown that it can become quantitatively so great in the rorquals as to require an amplification of the integuments, and it is also a question whether in them the type of respiration is not still predominantly abdominal even though it be so in less degree than in the toothed whales. Hasse [3] has presented much evidence to show that the direction of the respiratory movements of the several parts of the thorax accords with the direction of the corresponding bronchi, and that the degree of the movement is proportional to the diameter of the bronchus. With this in mind the pattern of the bronchial tree of *B. musculus*, as given by Müller (cf. op. cit. Fig. 39) would seem by the inclination of its secondary branches to indicate an abdominal type of respira-

[1] Andrews, R. C. Monographs of the Pacific Cetacea, I. The California Gray Whale (*Rhachianectes glaucus* Cope). Mem. Am. Mus. Nat. Hist., N. S., Vol. I, Pt. V. New York, 1914.

[2] Müller, O. Untersuchungen über die Veränderungen, welche die Respirationsorgane der Säugetiere durch Anpassung an das Leben in Wasser erlitten haben. Jenaish. Zeitsch. f. Naturwiss., Bd. 32, 1898.

[3] Hasse, C. Die Formen des menschlichen Körpers und die Formänderungen desselben bei der Atmung. Jena, 1888–1890. Bemerkungen über den Bau der Lungen und über die Form des Bruskorbes bei dem Menschen und bei den Säugetieren. Arch. f. Anat. und Phys., 1893.

tion. Yet in strictness as this is a fœtal lung, this could be considered indicative only of the primitive type of breathing of the species and not absolutely of its adult condition which might be adaptively modified. What the adult condition is, both in respect to respiration and to bronchial type is unfortunately not known in such detailed exactitude as is required by this kind of a problem. In this connection a suggestion made by Dr. John C. Vaughan of this department is not without interest and with his permission I state it. When the animal has filled its lungs at the surface and then dives, its thorax and diaphragm are in the position of full inspiration. The position of the diaphragm during submergence is of course a matter of conjecture. But on the assumption that it does not maintain its contraction, it is evident that the pressure of the water upon the abdomen would force the relaxed muscle rostrad in the thorax, and that this would necessitate a redistribution of the air in the lungs entailing a passive movement of the ribs beyond their position in full inspiration. As with the exception of the first, the ribs are free of sternal connections it is conceivable that their ventral extremities might be displaced laterad to a marked degree, even so far as to take up the slack in the ventral pouch, which in this fœtus is by no means so baggy over the thorax and abdomen as in the intermandibular region. It would seem therefore that Andrews's association of the ventral furrows on thorax and abdomen with respiratory movements has much in its favor and that its plausibility is increased by Vaughan's suggestion of passive distention following a hypothetical relaxation of the diaphragm.

Sterno-mandibularis and associated muscles.— The side of the neck is occupied by a very large muscle mass of complex arrangement which extends from the thorax to the mandible and to the postglenoid region of the cranium, its fasciculi having an obliquely dorso-rostral direction. This muscle which for want of a better name may be called sterno-mandibularis, lies under cover of the panniculus carnosus; its dorsal margin is in apposition with the mastohumeralis and trapezius; mesad it enters into the boundary of the cavum ventrale and by its deep surface conceals the sterno-mastoid and farther rostrad overlies the caudal portion of the mylohoid near the origin of the latter muscle. From its mesal border fasciculi are added to the longitudinal stratum of the ventral pouch, in this as in its nerve supply revealing its provenience from the cervico-hypoglossal musculature. It is not however a modified and extended sternohyodeus, for that muscle is present with its usual attachments; it should rather be considered a cleavage product of the infrahyoid group, resulting in the formation of a superficial stratum which has attained enormous size and acquired extensive new origins and insertions. At its origin it is obscurely divided into two heads, partially separated by the rostral border of the pectoralis. The mesal fasciculi arise from the aponeurosis covering the pectoral muscle and on their deep surface receive additional bundles from a narrow strip of sternum between the origins of the pectoralis and sternomastoid. The lateral fasciculi arise from the rostral margin of the first rib near its sternal extremity, here being continuous with the deep origin of the mesal head, further from the fascia of the posterior triangle of the neck, from the sheath of the sternomastoid and mesal to this from the sheath of the sterno-hyoid. From this extensive origin the fasciculi are directed dorsad and rostrad, spreading out to form a thick fan shaped sheet which splits into two layers to give passage to the facial nerve. Of the superficial stratum the most mesal fasciculi are continuous with the longitudinal stratum of the ventral pouch. The next pass over the lower border of the mandible join the panniculus and are inserted into the lower lip, into the floor of the furrow which prolongs the vestibule below the eye, while the most dorsal gain an insertion into the postglenoid process of the squamosal and the fibrous structures adjacent to the temporo-maxillary articulation. The deeper stratum has interesting relations. Its dorsal fasciculi terminate in an intermuscular septum which attaches them to the posterior belly of the digastric in almost its whole length. Its ventral fasciculi which apparently are separated from the rest of the muscle by a tendinous inscription (this is clearly present in *Megaptera*) and are distinguished as well by a more longitudinal course are divided into two slips. The dorsal of small size, applied to the lateral surface of the posterior belly of the digastric and united to it by a common septum passes horizontally forward to be inserted into the body of the mandible below the attachment of the masseter. This slip thus arises from fibrous inscriptions, which unite it with both the sterno-mandibularis and the depressor mandibulæ (posterior belly of the digastric). It is of larger size and of better definition in a fœtus of *Megaptera longimana* and there I was able to demonstrate its innervation from the mylohyoid branch of the fifth. It is therefore to be interpreted as the anterior belly of the digastric. The remaining slip, of considerably larger size in *Balœnoptera,* is directed rostrad parallel to the foregoing and, in part overlapping it, is lost in the dense fibrous tissue between the mylohyoid and panniculus. This slip was small in *Megaptera.* In both fœtuses it was innervated by a branch of the seventh nerve. In both forms there was a general correspondence in the make up of this muscle complex, and I have relied upon the data obtained from the *Megaptera* fœtus for confirmation of the findings in the smaller and in this region less well preserved *Balœnoptera.* The chief differences in the arrangement in the two forms lies in the development of a muscle-free interval in *Megaptera* between the mandibular and postglenoid divisions of the muscle. Here a triangular aponeurosis is present and is continued superficial to the anterior belly of the digastric and the facialis slip. I am quite sure that muscle fasciculi were present in this position in *B. borealis,* though infiltrated with fat, the precise distribution of which I could not determine. It would seem therefore that the mandibular insertion in *Megaptera* defaults, the superficial stratum here being replaced by fascia. The muscle would seem therefore to consist essentially of fasciculi of thoracic and mesal origin directed to the mandible and the region adjacent to the temporo-maxillary articulation. This system of fasciculi is innervated by the hypoglossal after its communication with the cervical nerves, several small branches entering at the lateral border of the sterno-hyoid and others being derived from the large division of that nerve which runs over its ental surface. To this, on its deep surface, slips of quintal and facial innervation have gained attachment; the former attached also to the depressor mandibulæ constitutes the anterior belly of the digastric.

Muscles of mastication.— The masseter is composed of two layers which are completely separate, the superficial small, triangular and very oblique in position, the deep quadrilateral, of large size and intersecting the superficial portion, by which it is deeply grooved, almost at right angles. In recognizing but two layers I am in agreement with Carte and MacAlister; the middle division of Beauregard's[1] careful description of *B. musculus* seems here to form an intrinsic part of the deep stratum. The superficial portion arises by a small flattened tendon from the orbital aponeurosis, just mesal to the zygoma at the junction of its middle and caudal thirds. Here it is continuous with strong band-like thickenings of the aponeurosis, which collectively form a sagittal arch of tendinous structure and ventral convexity. Its caudal arm is

[1] Beauregard, H. Étude de l'Articulation temporo-maxillaire chez les Balænopteres. Jour. de l'Anat. et de la Phys., An. 18, 1882, p. 16.

PLATE XLIV.

PLATE XLIV.

Balænoptera borealis.

Fig. 1. Dissection of musculature of ventral pouch and the sterno-mandibularis. $\frac{3}{4}$ natural size.

Fig. 2. Superficial muscles of face, hyoid musculature, muscles of flipper, of neck and of intermandibular region. The panniculus carnosus and the muscles of the ventral pouch have been removed. $\frac{3}{4}$ natural size.

1. Ventral division of the panniculus reflected.
2. M. mylohyoideus reflected.
3. Longitudinal layer of ventral pouch partially reflected.
4. Cavum ventrale.
5. M. sternomandibularis.
6. M. pectoralis.
7. M. latissimus dorsi.
8. M. teres major.
9. M. infraspinatus.
10. M. deltoideus.
11. M. trapezius.
12. M. masto-humeralis.
13. M. sterno-mastoideus.
14. M. splenius.
15. M. trachelo-mastoideus.
16. M. occipito-frontalis.
17. M. orbicularis palpebrarum.
18. Superficial layer of transverse rostral muscle.
19. M. masseter.
20. M. depressor mandibulæ.
21. M. geniohyoglossus.
22. M. hyoglossus.
23. M. omohyoideus.
24. M. sternohyoideus.
25. M. rhomboideus.
26. M. triceps.
27. M. extensor communis digitorum.
28. M. flexor carpi ulnaris.
29. M. obliquus externus.

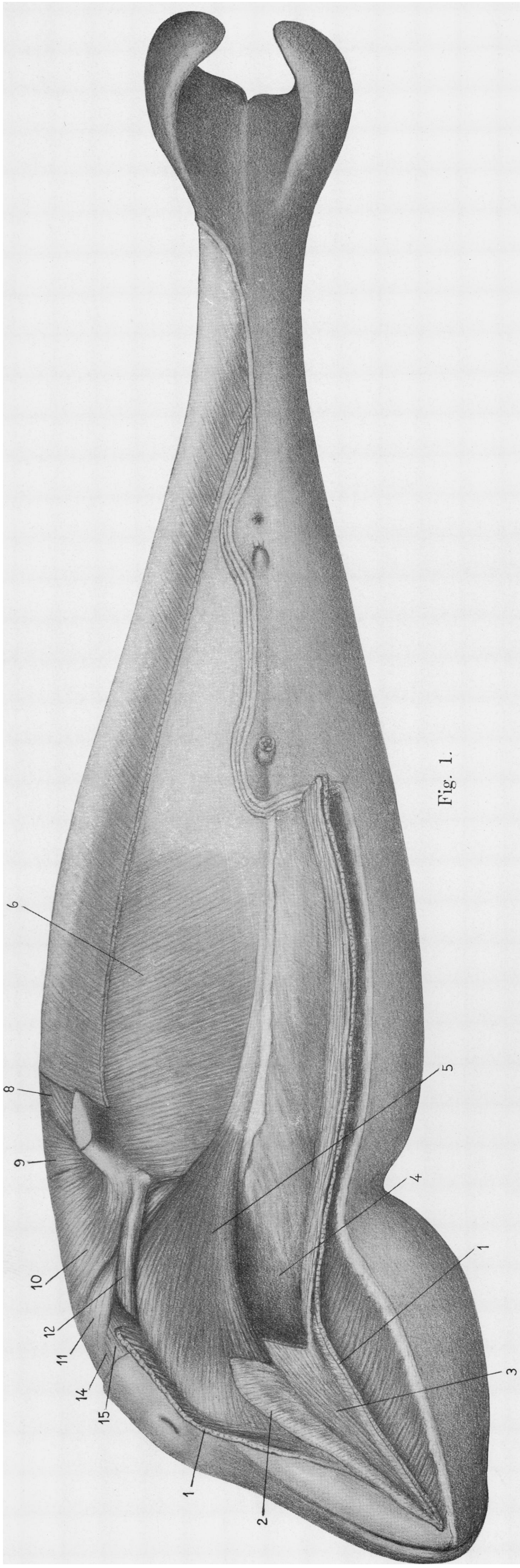

Fig. 1.

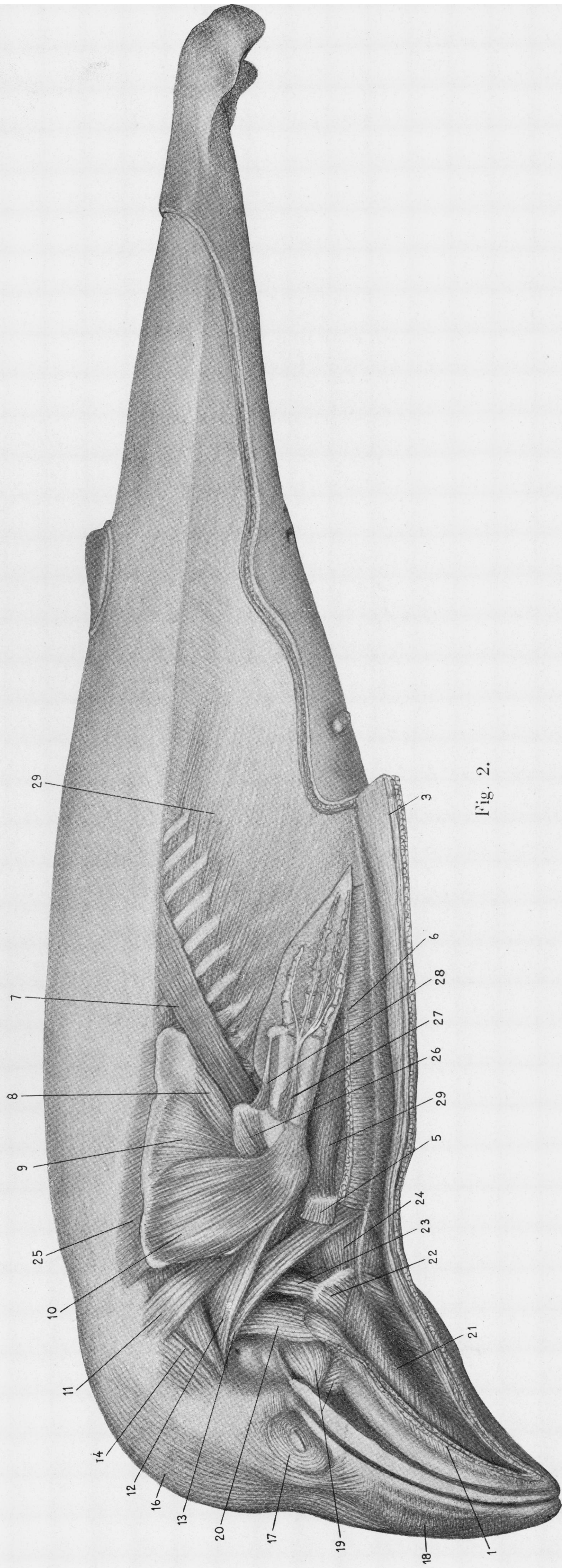

Fig. 2.

BALÆNOPTERA BOREALIS.

attached to the squamosal at its junction with the zygoma. Its rostral prolongation divides into three slightly diverging strands, of which the lateral reaches the zygoma in its rostral third, the middle is attached to the junction of the zygoma with the maxilla, and the mesal inserts upon the orbital border of the maxilla. Beauregard describes this tendinous complex as being placed ventral to the orbital aponeurosis, but in this specimen it seemed to be incorporated in it and capable of pulling it ventrad on the contraction of the muscle. From the tendon the muscular fasciculi diverge fan-wise, having a general ventro-caudal direction and forming a belly large in proportion to the tendon. They are inserted into the lateral surface of the mandible between the deep portion of the masseter and the depressor mandibulæ, the latter preventing them from extending to the border of the body or of the ramus except at the extreme caudal angle of this insertion. From its size and position this portion of the masseter would seem to find its chief function as a tensor of the orbital aponeurosis. The orbit on its ventral aspect bulges into the roof of the vestibulum oris, and the protection to its contents, attained by keeping the aponeurosis taut, may serve as compensation for the deficiency of its osseous encasement.

The deep portion of the masseter can be resolved into two parts. The rostral arises from the junction of zygoma and squamosal, from the postorbital process of the squamosal and from the tendon of the dorsal muscles which is there attached. Its fasciculi are directed ventrad and rostrad and are inserted into the lateral surface of the mandible, from the concavity at the side of the coronoid process to the border of the mandible rostral to the superficial portion of the masseter. The fasciculi of more rostral insertion correspond in position to the intermediate layer of Beauregard, but I could not follow them to a tendon or to an origin distinct from the remainder of the layer. The caudal portion of the deep layer arises from the tendon of the dorsal muscles and from the middle root of the zygomatic process of the squamosal, and is inserted into the margin of the sigmoid notch and adjacent lateral surface of the mandible. It has a triangular form with the base at the origin, and is in part under cover of the rostral portion of the deep layer, from which it can not be wholly separated, as the two portions exchange fasciculi to a considerable degree; these pass chiefly from the origin of the caudal to the belly of the rostral portion.

The temporal muscle is the largest of the quintal muscles but, as is usual in young animals, fails to fill the temporal fossa, occupying with its rather thin sheet of bundles only the lower and deeper portion of the fossa and being covered by a thick and compact layer of fat. The limit of its origin is an arched line coinciding rostrad with the anterior temporal ridge and then falling off obliquely to the mastoid region. The fasciculi converge upon a tendon, which appears at the rostral border of the muscle and is inserted into the summit and rostral border of the coronoid process. Many of the caudal fasciculi continue to the mandible and are inserted fleshy into both surfaces, chiefly the ental, and into the caudal margin of the process.

The internal pterygoid is of moderate size. It arises from the caudal margin of the palate and the adjacent surface of the internal pterygoid plate. It is directed as a flat band laterad and caudad towards the mandible; here assuming a more sagittal direction it passes between the mandible and the auditory bulla, to the fibrous covering of which it adheres firmly and from which it receives an increment to its bundles. It now broadens into a thin sheet and turning laterad it is inserted into the mesal surface of the mandible in a depression between Meckel's cartilage and the angular process, into the angular process itself and the caudal margin of the ramus, and behind this into the dense fibrous tissue surrounding the temporo-maxillary fibro-cartilage. From its caudal margin a fasciculus of considerable relative size diverges at an angle and becoming tendinous is inserted into the dense fibrous tissue which invests the auditory bulla, on its ventro-lateral aspect extending as far as the base of the styloid process.

The external pterygoid is placed at the lateral margin and partly under cover of the foregoing. It is a small cylindrical muscle arising from the junction of external and internal pterygoid plates, and is directed caudad, laterad and slightly ventrad to its insertion upon the front of the temporo-maxillary fibro-cartilage.

Carte and MacAlister describe a single pterygoid, which "was inserted into the lower jaw near its angle, sending some of its posterior fibers to be inserted into the interarticular fibrocartilage." This they regard as an external pterygoid. It is preferable, however, to regard such single pterygoids as having failed to differentiate into internal and external portions. Certainly the majority of the bundles in their description of *B. acuto-rostrata* have the insertion of the internus. Beauregard in *B. sibaldii* (=*B. musculus*) mentions, but does not describe, two pterygoids crossing the temporal tendon at an acute angle. In *Phocæna* (Rapp, Stannius) both pterygoids are present, and the internus extends upon the auditory bulla.

Facial Muscles.— The forehead is covered by a broad thin sheet of muscle which arises from the epicranial aponeurosis. The fasciculi have a longitudinal course and extend upon the rostrum. Here the deep fasciculi turn ventrad and are inserted into a rough area upon the maxilla which extends transversely across that bone and is bounded in front by a high sharp ridge. Of the superficial fasciculi the mesal are inserted into the lateral margin of the nostril in its whole length, a few reaching the midline of the rostrum just in front of it, while others taking a somewhat deeper course are attached to the back and mesal wall of the narial passage. The lateral superficial fasciculi spread out upon the transverse muscle of the rostrum, to some extent blending with its bundles but in the main lying superficial to them. Caudad the epicranial aponeurosis is attached to the margin of the supraoccipital. In this situation there seemed also to be muscular fasciculi but I was not able to determine their presence with certainty. This muscle is apparently better developed than in Carte and MacAlister's *Balænoptera* and far more so than in *Megaptera*, where it has no insertion upon the maxillary. In both it is the most superficial muscle of the region, though Carte and MacAlister assign it to their second or middle layer. Its function must be to draw the blow holes caudad, though from its general position it is most conveniently designated occipitofrontalis.

At the lateral margin of the frontalis and in part continuous with it is placed a second muscle of longitudinal course. This lies upon the supraorbital margin arising from it and from the adjacent temporal fascia. In front of the orbit its fasciculi turn ventrad, for the most part to be inserted into the transverse rough area and ridge upon the maxillary lateral to the frontalis. The more superficial bundles are continued upon the transverse muscle of the rostrum and inserted into the fibrous tissue of the lip. Owing to the mesal concavity of the supraorbital margin a portion of this muscle rests against the globe of the eye, ectal to its musculature and aponeuroses. Its contraction would seem to entail a depression of the eye ventrad. In *Megaptera* it is far smaller, arises only from fascia and is separated from the eye by the prominent margin of the orbit. Its function here would seem to be that of an elevator of the lip. Carte and MacAlister describe a muscle of their second plane arising from the anterior edge of the temporal fossa and from the maxilla and inserting upon the median raphé, the lateral lip of the naris and the upper edge of the maxillary bone. As I could find no fasciculi of the supraorbital muscle having this mesal course, and as there are such bundles in the next deeper layer, it would seem possible that here they had failed to separate the superimposed muscles satisfactorily.

The dorsum of the rostrum is covered by a muscle composed of fasciculi of transverse general direction but converging towards the blow-holes. This muscle is situated immediately below the blubber except at the base of the rostrum where it is overlapped for a short distance by the frontalis and the laterally placed supraorbital muscle. It may be resolved into two layers. The superficial one arises from the septal cartilage of the rostrum and the lateral margin of the blow-hole. It is inserted into the whole length of the lip and at the tip of the rostrum also by a few fasciculi into the extremity of the intermaxillary. The deeper layer has the same general direction. It arises from the intermaxillary in its whole length and at its lateral margin to a slight degree from the maxilla, except at the base of the rostrum where it gains a broad origin from this bone, arising from the front of the sharp transverse ridge for more than half its breadth laterad, and mesad extending to the elevation behind the nares in which the frontal process of the maxilla ends. The fasciculi arising in this last situation would seem to correspond in part to the retractores, in part to the compressores nasi of Carte and MacAlister. The fasciculi arising most caudally from the maxillary ridge are directed sagitally, those from its lateral portion mesad and rostrad; they thus converge fan-like towards the rostral extremity of the blow hole. From their direction it is clear that they dilate the nares, but the sagittal fasciculi would seem farther to assist the superficial frontalis in elevating the orifice and turning it caudad during respiration. The remainder of the layer inserts into the raphé its fasciculi having a generally transverse direction but converging towards the nares. *Megaptera* shows a close correspondence save that relatively its muscles are of smaller size.

In addition to the foregoing three smaller muscles act upon each blow-hole. The largest of these, the dilator naris of Carte and MacAlister's illustration arises from the premaxillary close to the median line and in the proximal half of its prenarial extent, and from the adjacent portion of the septal cartilage. It has a sagittal course and inserts into the rostral end and about half the lateral wall of the narial passage, including the front of its sloping diverticulum. Its main function must be to draw forward the blow-hole; dilation would seem to be abundantly provided by the transverse rostral muscle.

At the caudal extremity of the blow-hole is a small fan-shaped muscle superficial to the frontalis. It arises from the fibrous tissue of the median line and inserts into the extremity of the nostril and the adjacent portion of its median wall.

The third muscle is placed below and parallel to the oblique lateral sinus of the nasal passage, from the wall of which it arises and also from the adjacent margin of the premaxillary. It is directed dorsad and caudad and slightly mesad to the extremity of the blow-hole, where it inserts by a short tendon, close to the preceding muscle. Its action would be to draw the caudal end of the nostril ventrad and so perhaps assist in the elevation of its rostral extremity, the obliquity of its pull being perhaps corrected by the small fan-shaped muscle mesal to the blow hole. In *Megaptera* these three muscles have an identical arrangement.

The collective action of the narial muscles must be considered in connection with the changes in the blow holes during respiration. Their condition during this act is admirably shown in Andrews's[1] photograph. Here the blow-hole has a subcircular contour and looks directly

[1] Plate XXX, Fig. 4.

caudad, the plane of its orifice being practically vertical. The blow-hole is then not only dilated during respiration but its rostral extremity is elevated through an arc of 90°. To permit the latter movement it is necessary that its wall should be highly elastic or should present some sign of redundancy when closed, in the form of folds which might open out during elevation of the region. The Spritzsack, the oblique diverticulum of the lateral wall, would seem to supply the latter condition, for it is partially opened up by traction upwards on the rostral extremity of the blow-hole even with the limited degree of movement possible in the alcoholic specimen. The direction of the fasciculi of the two layers of the transverse rostral muscles justify the ascription to them of the dilatation of the nares, and in view of the almost total lack of muscular insertion into the mesal wall of the passage it seems clear that this act is accomplished almost entirely by the movement of the lateral parietes. As regards the elevation of the rostral extremity of the blow-hole, the initiation of the act is more difficult of explanation. Once started, and the front end of the nares slightly elevated, the sagittal fasciculi of the frontalis and caudal portion of the deep transverse muscle could well serve to complete their erection, but inasmuch as even in the fœtus their origin is but little above the plane of the blow-hole, they would act at great disadvantage if not absolutely at dead center. The difficulty is to account for the initial elevation. If some resiliency of the wall may be assumed, and this in view of Andrews's observation [1] seems warrantable, the action of the oblique muscle below the Spritzsack may supply the required moment. From its oblique position it must draw the caudal end of the blow-hole ventrad and laterad. If the narial wall possesses sufficient rigidity to allow this movement to tilt dorsad the rostral extremity, the preliminary elevation might in this way be secured. The small muscle extending between the midline and the caudal extremity of each blow-hole may correct the lateral component in the pull of the oblique muscle. The return of the nares to the horizontal position is provided by the sagittal premaxillary muscle, and with this fixing its rostral extremity the mesal fasciculi of the frontalis would serve to effect an approximation of the lateral to mesal wall of the narial passage, closure being further provided by the interlocking arrangement of the folds about the Spritzsack, which is such as to secure their tighter coaptation under the influence of external pressure.

The other facial muscles are poorly developed and of great delicacy in this fœtus so that little more than their presence could be ascertained. The orbicularis palpebrarum was thickest at the canthi, where it had attachments to the orbital margin. At the inner canthus a tendo oculi was present. There were no tarsal plates. At the outer canthus a small band of muscular fibres arising from the postorbital process joined the orbicularis. It seems to correspond to the malaris externus of Stannius. In the margin of the lips, mingled with fasciculi of the transverse rostral muscle in the case of the upper lip, of the panniculus in the lower, are longitudinal strands. In the floor of the subocular prolongation of the vestibule these unite to form a small sheet, which caudad can be traced to the deep surface of the panniculus. I could not follow it to pharynx. The system would therefore seem representative of the orbicularis oris, the buccinator being reduced in consequence of the failure to develop a cheek by the advance of the angulus oris.

Extrinsic muscles of the eye.— These conform so closely to Weber's [2] descriptions that they require but brief mention here. The four recti with the superior oblique arise from an annulus

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[1] *Vide* Pt. I, Spouting.

[2] Weber, M. Studien über Säugethiere, II, Jena, 1886.

tendineus at the apex of the orbit, which on its ental aspect is associated with the fibrous origin of the retractor. The four recti broadening towards their insertion, together with the superior oblique, form a complete muscular cone which is deficient only by a narrow gap between the oblique and the internal rectus. Elsewhere the border of one muscle is in contact with that of its neighbor and the whole is held in place by a thin but firm investment of fascia, through which the obliqui pass to their insertions upon the sclera. Of each of the recti a majority of the fasciculi pass on into the lids and there expanding find an insertion into the fibrous tissue on the deep surface of the orbicularis. These extensions to the eyelids, first found by Hunter, constitute collectively the musculus palpebralis of Weber.

Weber describes exchange of bundles between the recti which I take him to mean of their palpebral portions, for elsewhere in this fœtus the muscles were clearly defined from one another. The superior rectus was partially divided in both eyes by a longitudinal cleft, so that at first it appeared as though a discrete levator were present. This was not the case, for both portions sent bundles to eyelid as well as globe, and the cleft did not extend throughout the length of the muscle. The inferior oblique arises from the maxilla near its articulation with the zygoma. It is directed laterad and caudad to the border of the inferior rectus, where it turns on itself, passing between the deep and superficial fasciculi of the palpebral extension, by which it is maintained in position. Its belly then expands into a broad insertion upon the sclera, which begins ectal to the mesial half of the inferior rectus and continues obliquely to the level of the ventral border of the external rectus. All of the peculiarities of this muscle have been minutely described by Weber. From the deep surface of its sheath a few fibrous strands could be followed to the zygoma, which no doubt reinforced the muscular support afforded by the cleft in the palpebralis. The insertion beginning ectal to the inferior rectus occurs in other cetacea but is not confined to this order (Weber). In this fœtus it is broad and continuous as in *B. Sibbaldii* (= *B. musculus*) and not divided into two slips as in *B. rostrata* (= *acuto-rostrata*). The superior oblique, like the inferior, is fleshy to its insertion. The belly turns through the palpebral extension of the superior rectus and is maintained in position in a manner similar to the inferior. I could not find a fibrous trochlea, though it is present in adults of the genus (Weber).

The musculus retractor oculi (m. choanoides) arises from the ental contour of the annulus tendineus. Its fibrous tube is deficient on its nasal aspect to give passage to the optic nerve. From this tube a circular muscle arises, which distad divides into four slips, separated by triangular intervals. Throughout its length it is firmly adherent to the supportive tissue of the underlying vascular plexus. It is inserted into the sclera near the equator of the globe. It is innervated by the abducens (Weber).

Muscles of the tongue.— The genioglossus is a broad sheet-like muscle arising from the ental aspect of the ventral margin of the mandible from the symphysis for about one half of its length. Its mesal fasciculi pass sagittally caudad, those of more lateral origin obliquely mesad and caudad. On reaching the mesal margin of the hyoglossus all save the most caudal fasciculi turn dorsad to be inserted into the dorsum of the tongue. Here between the muscles of the two sides is a considerable oval interval filled with fat, to the increased development of which may be due the peculiarly flabby character of the tongue in the adults of this genus. The most caudal fasciculi unite in a raphé which broadens to a tendinous sheet towards the hyoid to which it is but loosely attached, the dorsal turn into the substance of the tongue being prevented at this point by the transverse lingualis bundles accumulated here in the immediate vicinity of the faucial orifice. Rostrad of the extremity of the fossa between the genioglossi, the ventral surfaces of these muscles are intimately united to the layers composing the wall of the ventral pouch; elsewhere they are in relation to the cavum ventrale. There are no separate geniohyoidei.

The hyoglossus is a long cylindrical muscle arising from the ectal surface of the greater cornu and lateral portion of the body of the hyoid, and continued forward to the tip of the tongue. Close to its origin it crosses the transverse fasciculi of the lingualis mentioned above. Immediately rostrad of these its insertion begins, which is into the dorsum of the tongue from this point to its tip. The hypoglossal nerve lies upon the ventral surface of this muscle at its origin, here giving off large branches, which are continued into the interval between the hyoglossus and genioglossus and are destined for their supply together with that of the lingualis. A small slip passes from the deep surface of the hyoglossus to the caudal border of the transverse lingualis band, well laterad at its junction with the palatoglossus. I failed to find the styloglossus. Carte and MacAlister describe it as of small size, fan-shaped and lateral to the other muscles, sending its fasciculi into the caudal third of the tongue.

The palatoglossus is of moderate size; arising from the caudal margin of the hard palate, it is directed ventrad towards the base of the tongue where it continues with the transverse lingualis. It lies immediately beneath the oral mucous membrane forming a thin transverse sheet, the most mesal fasciculi apparently inserting into the mucosa about the faucial aperture, the more lateral passing beside it reach the side of the depression between the base of the tongue and this aperture and blend with the lingualis, thus forming a sphincter of the fauces. It shows no tendency to radiate rostrad along the side of the tongue.

The lingualis is of course intimately blended with the other muscles of the tongue. Towards the base it shows a high degree of independence and can be separated from the other muscles as far rostrad as the insertion of the hyoglossus. It there presents itself as a transverse band forming a thick wall to the depression between the fauces and the paired elevations where the tongue begins to rise above the floor of the mouth. Mesad its more superficial fasciculi arise from the deep surface of the aponeurotic expansion of the raphé between the genio-hyoidei. Its caudal portion is continuous with the palatoglossus and is joined by the slip above mentioned from the deep surface of the hyoglossus. The remainder inserts into the mucous membrane of the side and dorsum of the tongue, the most rostral fasciculi inclining forwards beside the hyoglossus.

Infrahyoid muscles.— The sterno-hyoid muscle is a flat band of longitudinal fasciculi arising from the rostral border of the sternum under cover of the sterno-mastoid, and contracting slightly as it is inserted into the caudal border of the body of the hyoid close to the median line. Its mesal border is in contact with that of its antimere. The sterno-mandibularis overlies its latero-caudal portion where it emerges from beneath the sterno-mastoid and derives some fasciculi from its sheath. The sterno-thyroid, covered by the sterno-hyoid, arises from the margin and ental surface of the sternum, and diverging laterad is inserted into the ectal surface of the thyroid cartilage close to its caudal margin. The thyro-hyoid is a small muscle of obliquely transverse position. It arises from the thyroid near its rostral margin, and narrowing has a small insertion upon the caudal margin of the hyoid close to the midline under cover of the sterno-hyoid. The omo-hyoid has but a single belly. It arises from the rostral margin of the scapula near its middle and receives in addition a small slip from the angle, the two origins being connected by a sheet of fibrous tissue. Emerging in the interval between the deltoid and supraspinatus muscles, its belly crosses the neck obliquely and is inserted into the whole length of the greater cornu of the hyoid. These muscles all receive branches from the anser cervicalis.

Suprahyoid muscles.— Of these the geniohyoid is lacking and the mylohyoid has been described in connection with the ventral pouch. The depressor mandibulæ (posterior belly of the digastric) is a large muscle placed obliquely below the external auditory meatus and the broad extremity of the postglenoid process. It arises by mixed tendinous and fleshy fibres from the dense connective tissue covering the mastoid region of the periotic under cover of the sternomastoid. The belly expands in its course to the mandible where it is inserted into the angle, chiefly at its caudal and ventral borders, but extending upon the lateral surface also ectal to the attachment of the masseter. A large branch of the facial nerve emerges between its belly and the postglenoid process, crosses the condyle of the jaw and the masseter muscle and breaks up into branches for the panniculus. From this while in contact with its rostral surface the nerve of the depressor is derived. The relations of this muscle to the sternomandibularis and the anterior belly of the digastric have already been described.

The stylohyoid is a ribbon like muscle arising from the mastoid region of the periotic ventral and mesal to the depressor mandibulæ and caudal to the orifice of the facial canal. It is inserted into the body of the hyoid close to its junction with the anterior cornu and to the adjacent portion of that process. Throughout its course it is closely applied to the lateral and caudal aspect of the stylohyal cartilage. It is innervated by a branch of the facial nerve.

The trapezius complex.— These muscles derive their innervation from the spinal accessory reinforced by branches from the ventral divisions of the cervical nerves. The sterno-mastoid is a broad ribbon-shaped muscle, arising from the cephalic border of the sternum in its whole breadth, where it abutts upon the origin of the pectoralis. It crosses the neck obliquely, narrowing somewhat to its insertion by mixed tendinous and fleshy fibres into the squamosal and the dense fibrous tissue which covers the mastoid. Here it is covered by a muscle of similar but more superficial origin which directed caudad and ventrad towards the shoulder enters into relation with the trapezius. At the shoulder this muscle resolves itself into two portions, a deeper rounded belly which joins the trapezius and a superficial sheet which expanding is inserted into the fascia along the rostral margin of the pectoral in its lateral half, extending to the mesal border of the deltoid. The fascia of the posterior triangle of the neck is of considerable density and in its course ventrad splits to enclose the sterno-mastoid in the usual manner. Traced towards the thorax it becomes thickened along the cephalic margin of the pectoralis; adjacent to the median line it is firmly attached to the sternum and laterad at the shoulder blends with the dense sheath of the deltoid. Beyond this transverse line it continues upon the pectoralis but is somewhat less dense and aponeurotic. The fasciculi of fascial insertion are obviously representative of the cleido-mastoid, the slip joining the trapezius is the masto-humeralis. Of the trapezius proper or cephalo-humeralis only the cephalic portion is represented. This is a small fan shaped muscle arising from the dorsal aponeurosis of the cervical region without direct attachment to bone. Its fibres are directed ventrad and slightly caudad converging to a small rounded tendon, which after uniting with the larger masto-humeralis passes in front of the shoulder to be inserted into the radial tubercle of the humerus on its ventral aspect between the deltoid and the coraco-brachialis. Below this the tendon is continued by two very strong ligamentous bands; the larger is continued in the line of the tendon along the venter of the humerus to the capsule of the elbow joint and the proximal portion of the radius; the smaller takes a slightly oblique course to the ulnar aspect of the elbow passing laterad of the insertion of the coraco-brachialis, latissimus and teres. In these bands it is possible to see the rudiments of the long and short heads of the biceps. Carte and McAlister mention tendinous bands on the flexor surface of the humerus in *B. rostrata* (= *B. acuto-rostrata*), which they too take to be rudiments of the biceps. For the rest their account of the muscules of this group differs materially from the foregoing. They describe a masto-humeral with additional origins from the transverse processes of the anterior cervical vertebræ. This they found inserting into the anterior and internal part of the humerus. They do not mention a trapezius (cephalo-humeralis) nor a cleido-mastoid. Their sterno-mastoid has an additional head from the first and second costal cartilages. This last point of difference is probably due to their failure to distinguish the sterno-mandibularis which in *B. borealis* has a costal origin and immediately overlies the sterno-mastoid.

Ventro-appendicular musculature.— The pectoralis is an extensive sheet of muscle which covers the venter of the thorax and extends upon the abdomen to within 1.5 cm. of the umbilicus. It arises from the ventral surface of the sternum, from the whole width of the first rib by a narrow origin between the attachments of the rectus and of the external oblique, and extensively from the linea alba. Here while it approaches its fellow of the opposite side very closely, I was not able to detect an interdigitation of the fasciculi of the two muscules. The fasciculi are directed in the main transversely with a slight inclination cephalad to an extensive insertion into the lateral raphé and the aponeurosis which invests the humerus, only a minority of its fasciculi inserting into the preaxial border of that bone under cover of the deltoid. In the raphé the pectoralis is united with the ventral and dorsal divisions of the panniculus and with the latissimus dorsi, and retains this relation to the ventral panniculus in its insertion into the aponeurosis of the arm. Its pannicular affinities are further indicated by its innervation from branches of the long thoracic. Throughout the whole sheet the course of the fasciculi are parallel, there is no convergence towards the shoulder, and the thoracic portion of the muscle is distinguished from the abdominal by its greater thickness alone. There is no pectoralis minor.

The latissimus dorsi is a small thin muscle parallel to the caudal margin of the scapula. It arises from the aponeurosis covering the dorsal extensor muscles and on its deep surface it is reinforced by delicate slips from the 7th, 8th and 9th ribs. Its fasciculi converge somewhat to their insertion being directed rostro-ventrad to the lateral raphé where they meet those of the pectoralis, and to the flexor surface of the humerus where they are inserted ventral to the subscapularis and teres. With the tendon of the last the latissimus is intimately joined as it crosses its ventral surface to gain a proximal insertion upon the humerus. The nerve supply is by a slender branch of the long thoracic which lies upon the ental surface of the muscle and penetrates it near its middle.

The coraco-brachialis is placed on the ventro-mesial aspect of the shoulder. It arises from the tip of the coracoid process and crossing the tendon of the subscapularis is inserted into the humerus immediately below the head and just mesial to the ligamentous bands, which are probably representative of the biceps, with the postaxial one of which it is connected by a narrow slip as Perrin found.

PLATE XLV.

PLATE XLV.

Balænoptera borealis.

Fig. 1. Musculature of flipper, mesal view. $2\frac{2}{3} \times$ natural size.

Fig. 2. Skeleton of flipper, mesal view showing attachments of muscles. $2\frac{2}{3} \times$ natural size.

1. M. rhomboideus.
2. M. levator anguli scapulæ.
3. M. omohyoideus.
4. M. subscapularis.
5. M. teres major.
6. M. serratus anticus.
7. M. supraspinatus.
8. Processus coracoideus.
9. M. coraco-brachialis.
10. M. masto-humeralis.
11. M. deltoideus.
12. Mm. pectoralis and latissimus dorsi.
13. M. triceps.
14. Ligamentous bands representative of biceps.
15. M. flexor communis digitorum.
16. M. flexor radialis.
17. M. flexor ulnaris.

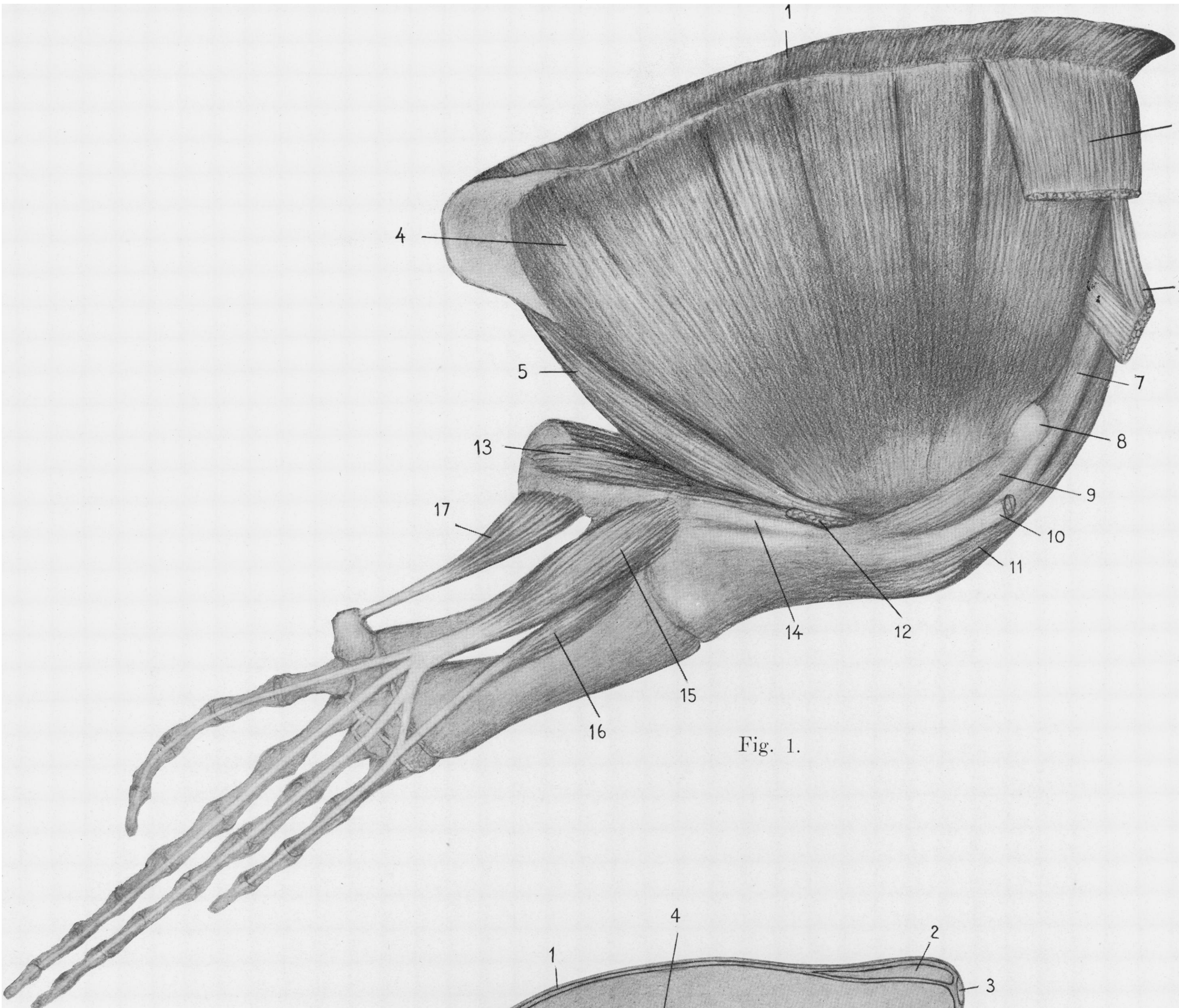


Fig. 1.

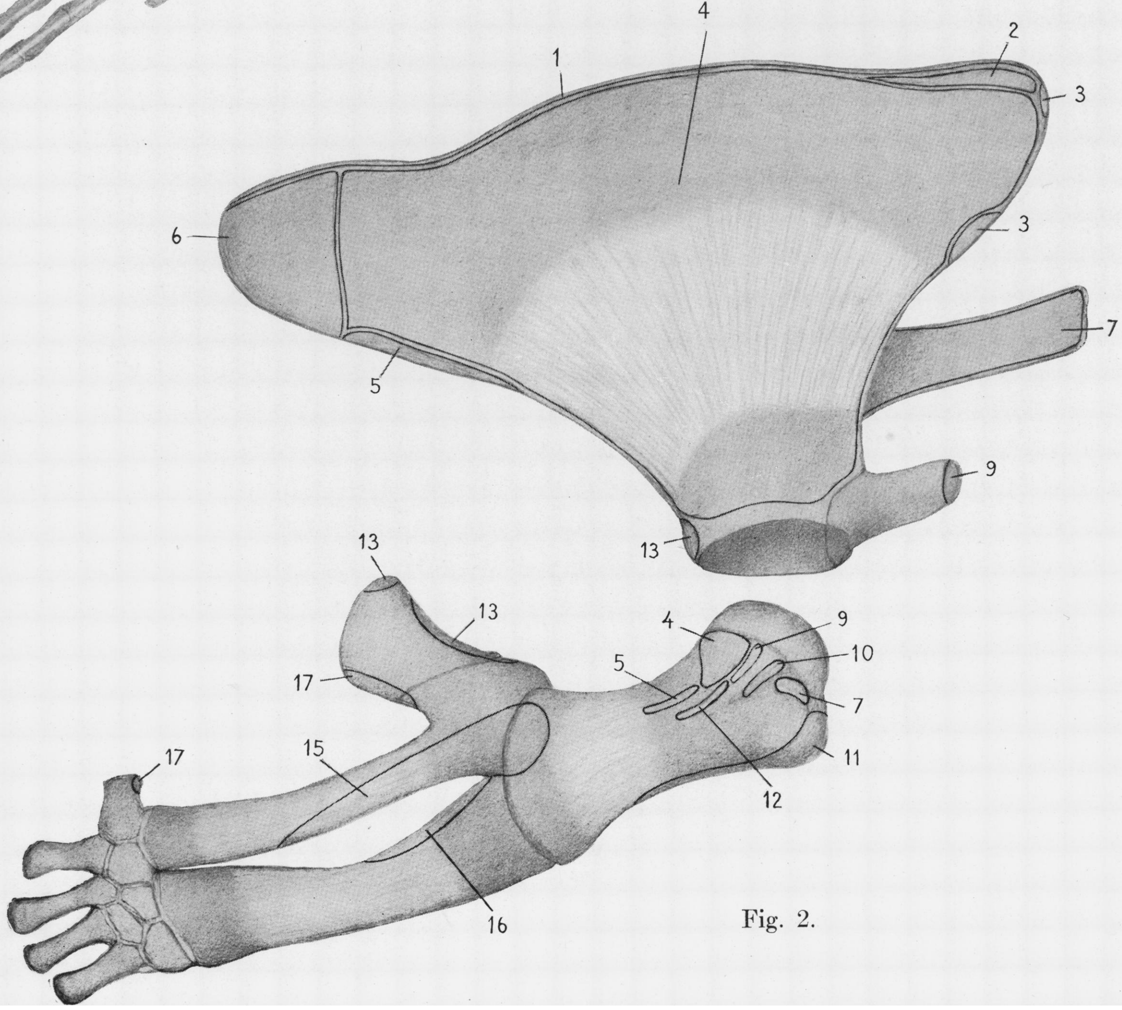


Fig. 2.

BALÆNOPTERA BOREALIS.

The long head of the triceps arises from the caudal extremity of the glenoid cavity, the glenoid ligament and capsule of the shoulder joint. The belly is broad and flat and markedly convex along its dorsal margin. It is inserted by a short tendon into the extremity of the long olecranon process. The external head, triangular in shape, arises from the postaxial border of the humerus in its distal half. Its fasciculi are inserted into the whole length of the cephalic border of the olecranon save for the area at the tip occupied by the long head. The third head I failed to find. Its presence is recorded in *B. rostrata* by Carte and McAlister. Perrin does not describe the triceps but his illustrations show only a long and an external head.

Trachelo-costo-scapular muscles.— The serratus anticus is best developed at the caudal angle of the scapula. Here strong slips from the 4th, 5th and 6th ribs converge to an insertion at the angle itself and the adjacent surface. Except in this region I failed to find fasciculi of this muscle. Carte and MacAlister found it arising from the eight caudal ribs with a slip from the second. Its nerve supply is from the long thoracic nerve.

The levator anguli scapulæ is a short thick muscle arising from the costal process of the second cervical vertebra. It passes between the scalenus and the trachelo-mastoid turning dorsad to be inserted into the ventral aspect of the cephalic angle of the scapula. It is supplied by ventral branches of adjacent cervical nerves.

Rhomboideus.— The rhomboideus is not cleft into major and minor, but forms a narrow continuous sheet along the whole length of the suprascapula. Its origin does not extend to the spines of the vertebræ, but takes place by muscular fasciculi from the dorsal aponeurosis over the longissimus dorsi.

Scapulo-humeral muscles.— The deltoid is the largest of this group. It arises from the rostral two fifths of the dorsum scapulæ as far caudad as the infraspinatus, which it overlaps by its caudal margin, further from the ectal surface and ventral border of the acromion process, and from the fibrous tissue, which bridges the angle between this process and the rostral border of the scapula, serving as an intermuscular septum between the deltoid and the supraspinatus. The muscle is coarsely fasciculated. Its bundles converging towards the head of the humerus are inserted upon a tendon, which appears first on the surface and caudal border of the muscle. Into this the fasciculi of acromial origin insert along its preaxial border as it approaches the humerus, so that here the muscle is fleshy to its insertion. Some of these fasciculi reach the radial tuberosity of the humerus inserting between the infraspinatus dorsad and the masto-humeral and supraspinatus ventrad. The tendon after crossing that of the infraspinatus, which separates it from the shoulder-joint, is inserted into dorsal surface of the humerus from the neck distad and into the whole preaxial border of that bone, blending distad with the capsule of the elbow and extending upon the radius, and above expanding into the deep fascia, of the flexor surface of the arm.

Perrin describes a strengthening band of the capsule of the shoulder passing from the glenoid margin and the base of the coracoid to the humerus. This is here represented by a small sub-deltoid muscle. It arises, as Perrin's ligament from the base of the coracoid and the margin of the glenoid cavity, but is much narrower. Its tendon rests upon the capsule of the shoulder joint which it crosses on its rostro-lateral aspect to be inserted into the tuberosity of the humerus under cover of the deltoid, between the infraspinatus and the fleshy insertion of the deltoid which separate it from the cephalo-humeralis and supraspinatus. Both of these muscles are supplied by the circumflex nerve.

The supraspinatus, covered by the deltoid, is a larger muscle and of more extensive origin than in the porpoise (Rapp, Stannius) and yet far from attaining half the size of the deltoid as found in *B. rostrata* (= *B. acuto-rostrata*) by Carte and MacAlister, with whose description it corresponds in general. It arises from the rostral border of the scapula as far ventrad as the acromion, from the ventral surface of the acromion, and from a fibrous layer, which closes the angle between scapula and acromion and gives origin by its ectal surface to the deltoid. The fasciculi converge to a tendon, which passing upon the rostral aspect of the shoulder-joint is inserted into the radial tuberosity of the humerus under cover of the tendon of the masto-humeral. It is supplied by the suprascapular nerve.

The infraspinatus arises from the vertebral margin of the scapula in its third and fourth fifths and from the corresponding portion of its dorsum as far as the neck. The muscle is triangular, abutting upon the origin of the teres by its caudal margin, overlapped by the deltoid along its rostral border. After crossing the long head of the triceps it passes into a flattened tendon, applied to the dorsum of the shoulder-joint, to which it is adherent, then expanding somewhat it is inserted into the radial tuberosity of the humerus on its extensor aspect. At its insertion it is embraced by the expansion of the deltoid. It is innervated by the suprascapular nerve.

The teres arises from two thirds of the caudal border of the scapula adjacent to the neck and from a firm intermuscular septum common to it and the subscapularis. Its tendon crosses that of the latissimus dorsi very obliquely being intimately united with its dorsal surface, and is then inserted into the shaft of the humerus distal to the subscapularis. Its nerve is derived from the long thoracic in its course through the axilla.

The subscapularis occupies the whole venter of the scapula. It is partially divided at its origin into eight fleshy slips. Its fasciculi converge to a narrow insertion upon the postaxial surface of the humerus immediately below the head, and by an aponeurotic expansion into the fascia of the flexor surface of the arm. It is supplied by small branches of the long thoracic. Its tendon is firmly united with the capsule of the shoulder, not perforating it as Carte and MacAlister describe, but can be separated leaving the joint intact, in this corresponding with the observations of Perrin.

Intrinsic muscles of the flipper.— The extensor communis digitorum arises from the capsule of the elbow-joint and from the adjacent surfaces of the ulna and radius together with their interosseus membrane. The ulnar origin is small being confined to 3 or 4 mm. of the proximal portion of the bone. On the radius the origin includes the proximal three fifths of the shaft. The tendon appears first at the ulnar border of the belly and before the carpus is reached has received all the fasciculi of the muscle. On the carpus the tendon expands and divides into four slips. The middle two follow the axial lines of the two middle digits. The postaxial slip follows the preaxial border of the ulnar digit; the preaxial slip the postaxial border of the radial digit. In their whole length these tendons are united by fibrous tissue to the perichondrium of the phalanges and the union is especially firm at the enlarged interphalangeal joints. I could not make out the definite lateral slips in the region of the joints, which Struthers [1] mentions in his beautiful description and illustration of this muscle in *B. musculus* (= *B. physalus*), and which Carte and MacAlister describe in *B. rostrata* (= *B. acuto-rostrata*). From the diminutive

[1] Struthers, 1871. *Op. cit.*, Jour. Anat. and Phys., Vol. VI, p. 107.

PLATE XLVI.

PLATE XLVI.

Balænoptera borealis.

Fig. 1. Skeleton of flipper, lateral view showing attachments of muscles. $2\frac{2}{3} \times$ natural size.
Fig. 2. Suprahyoid and infrahyoid muscles. Natural size.

1. M. deltoideus, origin.
2. M. supraspinatus, origin.
3. M. infraspinatus, origin.
4. M. teres major, origin.
5. M. subdeltoideus, origin.
6. M. coraco-brachialis, origin.
7. M. subdeltoideus, insertion.
8. M. infraspinatus, insertion.
9. M. deltoideus, insertion.
10. M. triceps, origin of long head.
11. M. triceps, insertion of long head.
12. M. triceps, origin of short head.
13. M. triceps, insertion of short head.
14. M. flexor ulnaris, origin.
15. M. flexor ulnaris, insertion.
16. M. extensor digitorum communis.
17. Longitudinal stratum of musculature of ventral pouch.
18. M. sternomandibularis.
19. N. hypoglossus.
20. N. lingualis.
21. M. genioglossus.
22. M. depressor mandibulæ.
23. M. hyoglossus.
24. Os hyoides.
25. M. omohyoideus.
26. M. sternohyoideus.
27. M. sternothyroideus.
28. M. thyrohyoideus.
29. M. sterno-mastoideus.
30. M. pectoralis.
31. M. scalenus.
32. M. obliquus externus.
33. M. rectus abdominis.
34. M. sternomandibularis, costal origin.

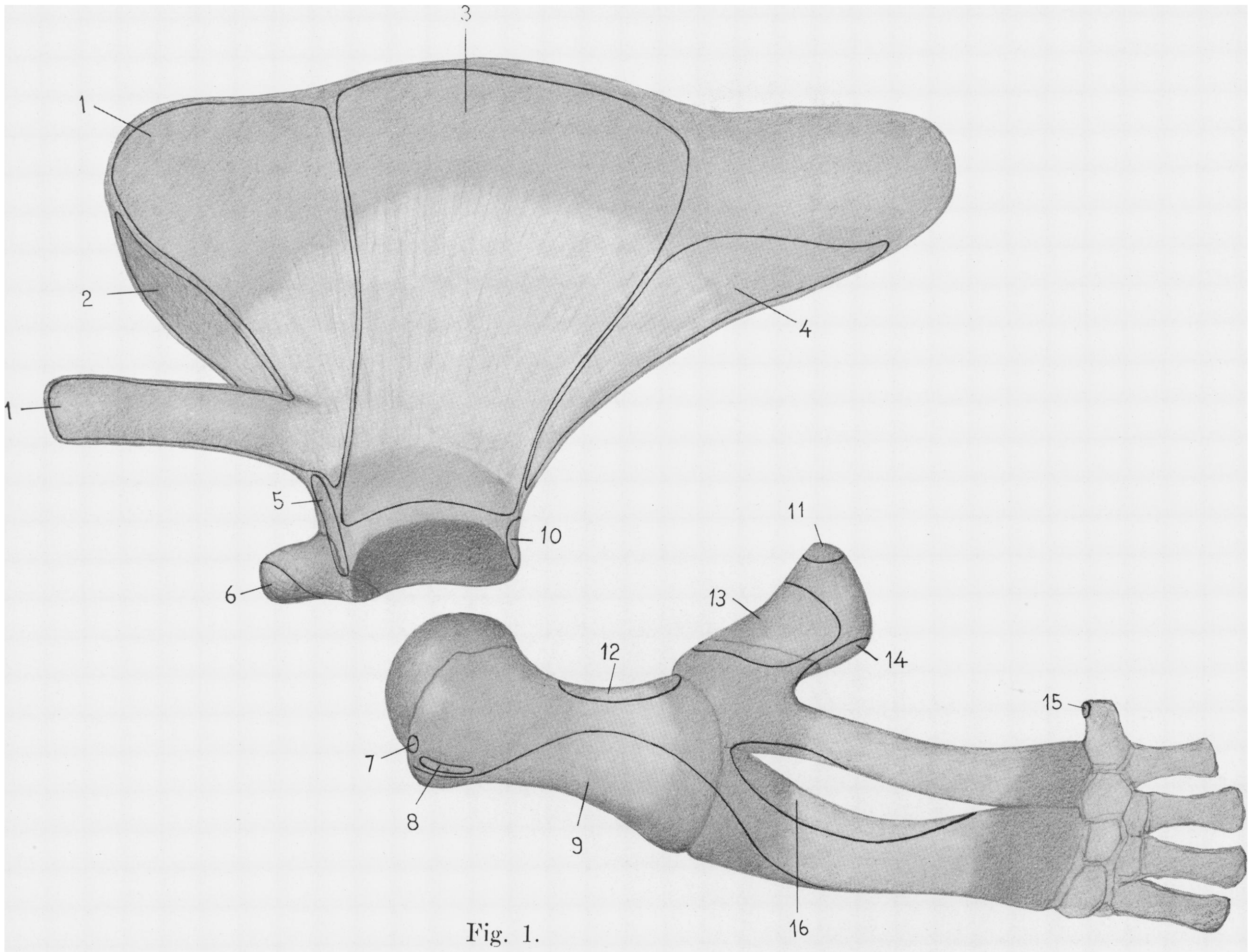


Fig. 1.

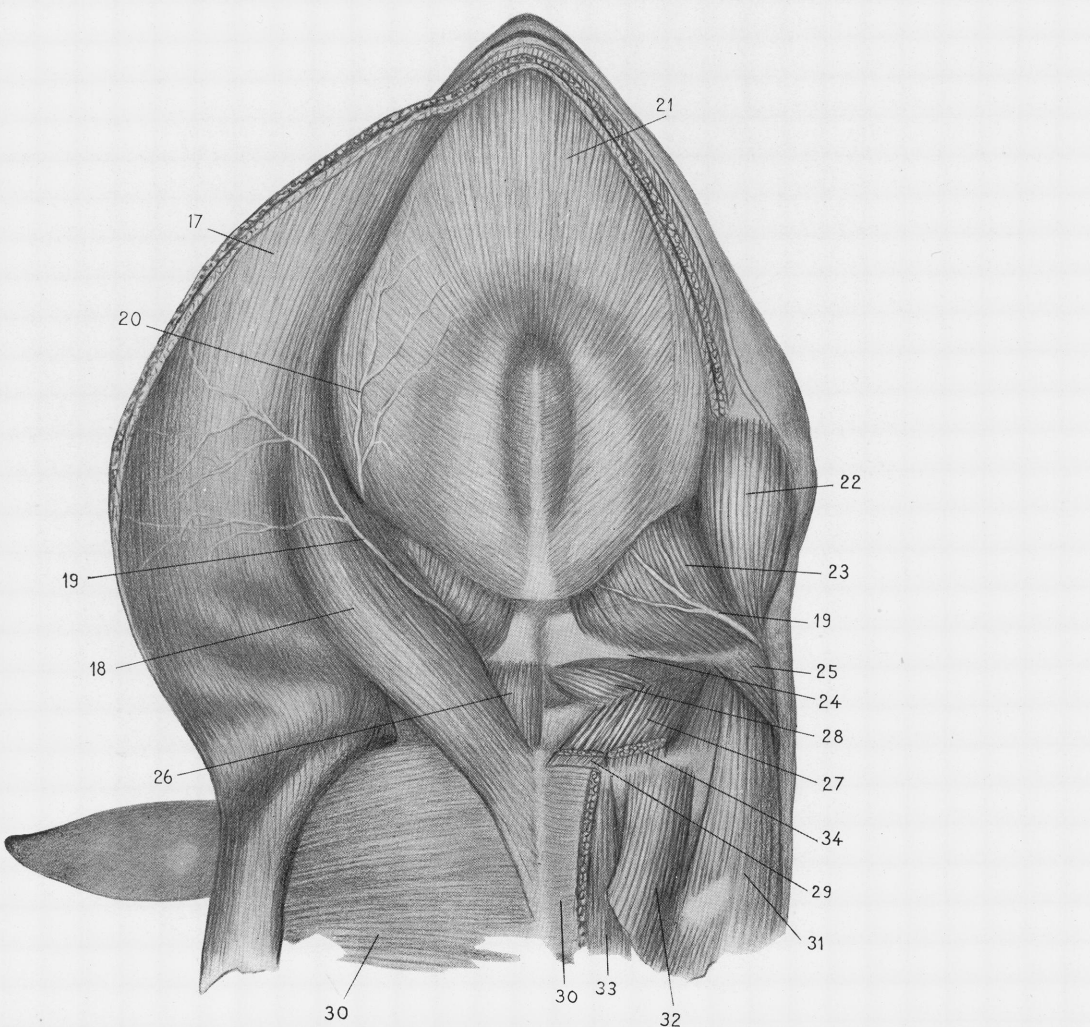


Fig. 2.

Balænoptera borealis.

proportions of these structures in this fœtus I doubt if they could be seen without recourse to sections. In Perrin's specimen the origin extended proximad upon the humerus, and the tendon of digit II gave off a slip to the metacarpus. This I could not find, nor does Struthers mention its presence as a distinct element in *B. musculus* (= *B. physalus*), but finds all the tendons united to the metacarpals in the same way as to the phalanges.

The flexor carpi ulnaris arises from the distal margin of the olecranon and from the adjacent shaft of the ulna to a slight extent. Its fasciculi converge to a long and slender tendon which is inserted into the pisiform. It is identically the same as in *B. musculus* (Struthers) but differs in its insertion from *B. rostrata* (= *B. acuto-rostrata*) where Carte and MacAlister found it inserting into the fourth metacarpal, Perrin into the ulna.

The flexor digitorum radialis is a slender muscle arising from the postaxial portion of the shaft of the radius as far distad as the middle of the bone, from the interosseous ligament, and from the septum between it and the flexor ulnaris. Its tendon runs distad and towards the radial digit where it joins the slip of the flexor ulnaris to that digit.

The flexor digitorum ulnaris arises from the internal epicondyle of the humerus, the capsule of the elbow joint, the shaft of the ulna in its proximal half, the interosseus membrane and the intermuscular septum common to it and the flexor radialis. Its fasciculi converge upon a slender tendon which upon reaching the carpus divides into four slips. These are continued upon the flexor surface of the phalanges to the last. In this course the tendons are firmly bound down to the phalanges and especially to the enlarged interphalangeal synchondroses, in the last position by expansions of the tendon which are attached to the sides of the articular cartilages. The slip to digit IV continues the line of the main tendon, that to digit V is the strongest of the four. The slip to digit II is of approximately the same size, certainly not larger than those to digits III and IV. I could find no trace of a palmaris longus described by Carte and MacAlister, nor of the flexor sublimis found by Perrin, in *B. rostrata* (= *B. acuto-rostrata*). In this as in other respects the intrinsic muscles of the flipper agree closely with the conditions in *B. musculus* (= *B. physalus*) as recorded by Struthers.

Abdominal muscles.— The rectus abdominis is a broad and massive muscle, forming the chief support of the abdominal wall and extending from the sternum to the pelvis as a continuous sheet uninterrupted by tendinous inscriptions. It arises from the ventral surface of the sternum and the whole breadth of its caudal margin, and from the ventral extremities of the first eight ribs and their cartilaginous prolongations. The costal slips diminish in size caudad. Those from the second and following ribs arise from their caudal borders and add themselves to the lateral border and deep surface of the muscle, which thus increases in breadth as well as thickness in its thoracic portion. It attains its maximum width a little rostrad of the umbilicus and thence contracts again caudad. As it approaches the pelvis the rectus divides into a medial and a lateral portion separated by a large neurovascular foramen, through which emerge the nerves and blood vessels for the genitalia and proximal portion of the pedicle. The median division of the muscle is narrow and inserts in large part upon the rostral border and ectal surface of the ilium. The remainder expands into an aponeurosis interposed between the ischio-caudalis and the hypaxial muscle, which inclining mesad joins with its antimere by its more rostral fibres, forming an arch to give passage to the rectum and vagina, while its more caudal fibres are attached to the proximal chevron bones in common with similar fibres from the opposite side. The lateral division of the aponeurosis expands beneath the obliquus internus and panniculus and can be followed to the lateral septum ventral to the transversarius, through which it gains attachment to the transverse processes of the caudal vertebræ. A muscular slip from the dorsal division passes at the lateral margin of the neuro-muscular foramen, intervening between it and a weak area in the dorsal aponeurosis, to be inserted upon the ventral tendinous expansion. Near this point of insertion, which is just caudal to the ischium, a small transverse muscle arises and passing mesad is inserted into the fibrous tissue of the midventral line, in common with its antimere, between the anus and the first chevron bone. It is possible to see in this the representative of the coccygeus.

The rectus is enclosed in a strong sheath derived from the aponeurosis of the obliqui and transversalis. It is weak in the thoracic region and here adheres to the venter and dorsum of the muscle so firmly as to be removed with difficulty. The aponeurosis of the external oblique forms the more ventral layer of the sheath; that of the internal oblique splits to enclose the rectus, and this cleft involves the muscular fasciculi as well as the aponeurotic lamellæ, while the aponeurosis of the transversalis forms the ental layer passing wholly upon the dorsum of the rectus. These several layers fuse in the midventral line to form the linea alba, which is narrow and weak in the thoracic region becoming firm and dense in the abdomen. At the umbilicus the dorsal and ventral layers of the sheath are continuous around the mesal margin of the rectus, and are separated from those of the opposite side by an interval which gives passage to the umbilical cord. Here the connective tissue structures are very much thickened.

The obliquus externus, except upon the front of the thorax, is an extremely thin sheet. It arises by a series of digitations from all the ribs and beyond these from the lumbar aponeurosis, but here only to a very small degree, so that a considerable portion of the internal oblique is left exposed. The slip from the first rib is massive and is attached to its ectal surface as well as its caudal border abutting upon the insertion of the scalenus anticus, from which however it is clearly separated. The remaining digitations are attached to the caudal margins of the ribs at successively greater distances from the median line. Those arising from the second, third and fourth ribs interdigitate with the scalenus medius, but I could not find that any fasciculi were continuous from one muscle to the other as Carte and MacAlister observed in *B. rostrata* (= *B. acuto-rostrata*). The slips from the fifth and sixth ribs interlock with slips of the serratus anticus. The fasciculi are directed very obliquely caudad and mesad. They are continued a short distance upon the venter of the rectus before becoming aponeurotic, except at the caudal end of the muscle where they terminate before reaching the rectus.

The obliquus internus is considerably thicker than the externus. It arises from the lumbar aponeurosis as far caudad as the transverse plane of the vulva. Its fasciculi are directed very obliquely rostrad and ventrad. At the margin of the rectus it divides into two lamellae. The superficial promptly becomes aponeurotic and is thus inserted into the linea alba. The more caudal of the fasciculi of the deep lamella behave in a similar manner upon the dorsum of the rectus muscle, the more rostral are inserted upon the caudal margins of the cartilages of the last seven ribs, close to the slips of origin of the rectus.

The transversalis, arising likewise from the lumbar aponeurosis and for about the same extent as the obliquus internus, is directed transversely towards the median line, its aponeurosis passing wholly dorsal to the rectus. The sheet is continued in the thoracic region by slips from the deep surface of the extremities of the last nine ribs, interdigitating with the origins of the diaphragm. Like the external oblique this layer is very thin.

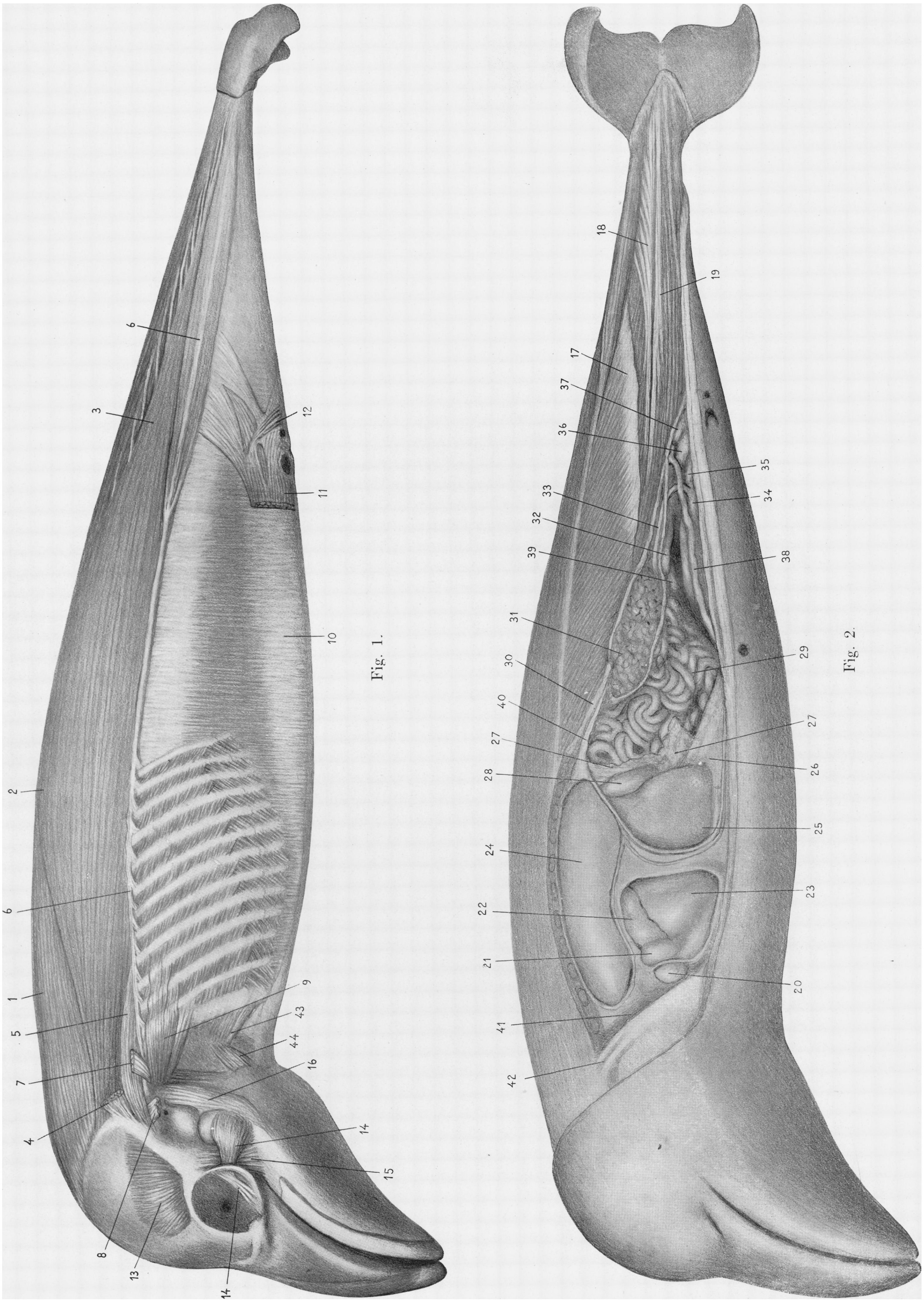
PLATE XLVII.

PLATE XLVII.

Balænoptera borealis.

Fig. 1. **Deep muscles of thorax and abdomen, dorsal musculature. $\frac{3}{4}\times$ natural size.**
Fig. 2. **Situs viscerum, and hypaxial muscle of pedicle. $\frac{3}{4}\times$ natural size.**

1. M. semispinalis capitis.
2. M. longissimus dorsi.
3. M. iliocostalis.
4. M. splenius.
5. M. trachelo-mastoideus.
6. M. transversarius.
7. M. levator anguli scapulæ.
8. M. sternomastoideus and mastohumeralis.
9. M. scalenus.
10. M. transversalis abdominis.
11. M. rectus.
12. M. coccygeus.
13. M. temporalis.
14. M. masseter, pars superficialis.
15. M. masseter, pars profunda.
16. M. depressor mandibulæ.
17. Hypaxial muscle of pedicle, superficial portion.
18. The same, lateral portion.
19. The same, mesal portion.
20. Thymus.
21. Pulmonary artery.
22. Left atrium.
23. Left ventricle.
24. Lung.
25. Liver.
26. Falciform ligament.
27. Omentum.
28. Stomach, second compartment.
29. Small intestines.
30. Rib XIII.
31. Kidney.
32. Ovary.
33. Ureter.
34. Bladder.
35. Urethra.
36. Vagina.
37. Rectum.
38. Umbilical artery.
39. Colon.
40. Diaphragm.
41. First thoracic rib.
42. Cervical rib fused with the foregoing.
43. M. sternothyroideus.
44. M. thyrohyoideus.



BALÆNOPTERA BOREALIS.

Pelvic musculature.— The ischio-caudalis arises from the ectal surface of the pelvis in its ischial portion by its mesal fasciculi, and far more extensively from the sheath of the rectus lateral to the pelvis. It is a thin sheet-like muscle of triangular form, united in the midline with its fellow of the opposite side by a narrow raphé. Its fasciculi are directed caudad and mesad and are inserted into the tips of the chevron bones. The muscle extends to the junction of the pedicle with the flukes, being the most superficial of the ventral muscles of the region and covered only by the aponeurosis which continues the panniculus. The muscles are united as far rostrad as the anus, where they diverge to give passage to the rectum. On its dorsum as in *Phocœna* (Stannius) they are united by a firm aponeurosis.

The levator ani arises from the ental surface of the pelvis and, caudal to the ischium, its origin is continued from the deep surface and mesal border of the ischio-caudalis to which it is united by a tendinous inscription. Its fasciculi pass to the midline almost transversely uniting in a raphé with those of their antimere; where passage is given to the vagina and rectum, the bundles of the levator are continued into their walls.

The ischio-cavernosus is a relatively large muscle, superficial to the levator. It arises from the mesal margin of the ischium and expanding slightly is inserted into the dorsum of the clitoris, uniting with its fellow in a raphé.

Intercostals.— These muscles, of which there are twelve pairs on each side, were strongly developed and characterized by the marked obliquity of their fasciculi. In other respects their arrangement was as usual. The interval between the two proximal segments of the bifurcated first rib was occupied by mucle continuous with and having the direction of the scalenus.

Diaphragm.— This is a strong and compactly built muscle, in its sterno-costal portion averaging somewhat more than 1 mm. in thickness. On its abdominal surface is a dense endabdominal fascia, upon which is a heavy layer of subperitoneal areolar tissue, the whole, diaphragm, fascia and areolar tissue measuring 2 mm. in thickness. The diaphragm in the ventral midline arises from the linea alba and the ental layer of the sheath of the rectus between the extremities of the ribs of the sixth pair. These fasciculi, the equivalent of the pars sternalis, have a sagittal course and overlap the bundles of the pars costalis on their abdominal surface so that there is no fibrous interval between these portions of the muscle. The pars costalis arises along an oblique line extending from the tip of the sixth to that of the thirteenth rib. Here it turns upon itself and the line of origin is continued in a dorso-rostral direction along the ental surface and upper border of the last rib for the distal third of its length. These fasciculi are directed rostrad and dorsad having nearly the same inclination as the ribs from which they arise, in this direction agreeing with the lateral bundles of the pars lumbalis with which they are perfectly continuous. The pars lumbalis is composed of a crus laterale, crus intermedium and crus mediale. The latter arises tendinous from the bodies of the first two lumbar vertebræ. The tendon of origin arches in front of the aorta immediately rostrad of the cœliac axis. From this in its whole length arise fasciculi of a general sagittal direction and, with reference to the crus intermedium, of superficial position. The bundles of the right crus are compacted into a ridge as they ascend and arch ventrad of the orificium œsophagi, forming a sharp muscular falx to the right and in front of the aperture. Those of the left crus continue as a flattened band upon the dorsum of the œsophagus and turning to the right reach the central tendon. The remainder of the diaphragm arises from the sheath of the great hypaxial muscle, which extends from the last rib throughout the lumbar region and the pedicle. The line of origin has here the shape of an inverted V with unequal arms. The longer lateral arm gives rise to the crus laterale, the mesal to the crus intermedium, but only in part for bundles of this portion arise also from the deep surface of the crus mediale. The lateral crus is continuous with the pars costalis and has the same orientation of its bundles. It is separated from the crus intermedium by a fibrous trigone, which cephalad has its apex prolonged into a strand, which receives on its lateral aspect the rostro-mesally directed bundles of the crus laterale, on its mesal side the fasciculi of the intermediate crus, which have a rostro-lateral inclination. On the right side the strand proceeding from the fibrous triangle joins the centrum tendineum, on the left it is possible to follow it beside the œsophageal orifice, where it turns towards the right as though to join the central tendon by arching between the orificium œsophagi and the foramen quadrangulare, but here its course is obscured by muscular bundles and it disappears from view.

The centrum tendineum is large, but is confined to the dorsal plane of the diaphragm. Its most ventral point is the caval aperture which it surrounds with a narrow zone of fibrous tissue, expanding caudad in a wide oval which exceeds on the right the limits of the hepatic adhesion and then tapering is continued by the fibrous strand already described to the trigone of the right side. On the left the margin of the tendon approaches the right mesal crus, but a narrow strip of the crus intermedium intervenes between them. Thus the right leaf of the central tendon is highly developed, the central leaflet is all but entirely replaced by muscle, and the right is represented by a slight expansion in the fibrous interval between the crus intermedium and crus laterale. By means of this structure on the right the central tendon is prolonged to the origin of the pars lumbalis. The structure of the muscle is peculiar chiefly as a consequence of the arrangement of its fibrous tissue. This as a whole may be schematized as an inverted U with its ends at the fibrous trigones and its arch, obscured it is true, ventral to the foramen œsophagi. Into the ectal contour of this U are inserted, converging from the costal arch, the bundles of the pars costalis and caudad also those of the crus laterale. More superficially and partly overlapping the most ventral fasciculi of the costal portion, the sagittally directed pars sternalis inserts upon the arch of the U. The crus laterale, the origin of which extends upon the tendinous arch of the crus mediale, inserts upon the sides of the ental contour of the U, while the crus mediale, itself superficially placed, is inserted into its arch, the right pillar passing ventrad, the left dorsad to the œsophagus and blending at their insertion. As a result of the approximation of the two superficial sets of bundles, the pars sternalis and the crura medialia, the tendinous insertion is concealed from view, and the arch of the U of our schema is buried in the substance of the muscle.

The phrenic nerves, derived chiefly from the fourth cervical, emerge from the scalenus near its mesal border and passing round this margin descend into the thorax along the venter of the precava. Here the nerve of the left side receives a considerable branch from the fifth cervical. After passing the hila of the lungs the nerves are concealed in the accumulation of subpleural fat about the pericardium. They enter the diaphragm after division into several branches. The inferior phrenic arteries are derived from the aorta caudad of the origin of the superior mesenteric. Before piercing the crus mediale each gives a branch to the adrenal. The phrenic veins empty into the renals.

The hypaxial musculature.— The muscles placed upon the ventral surface of the spine attain an extraordinary and highly specialized development in *Balænoptera*. They extend along the whole axis in this position, save for a thoracic interval from the VI to the XIII dorsal vertebra

PLATE XLVIII.

PLATE XLVIII.

Balænoptera borealis.

Fig. 1. Thoracic, abdominal and pelvic muscles. $\frac{3}{4}$ natural size.

Fig. 2. Suboccipital muscles. $\frac{3}{4}$ natural size.

Fig. 3. Scalenus, rectus capitis anticus and pterygoid muscles. $\frac{3}{4}$ natural size.

1. External auditory meatus.
2. Temporo-maxillary fibro-cartilage.
3. M. hyoglossus.
4. M. genioglossus.
5. M. depressor mandibulæ.
6. M. omohyoideus.
7. M. thyrohyoideus.
8. M. sternothyroideus.
9. M. sternohyoideus.
10. M. sternomastoideus.
11. M. splenius.
12. M. trachelomastoideus.
13. M. levator anguli scapulæ.
14. M. scalenus.
15. M. strenomandibularis.
16. M. serratus anticus.
17. M. serratus posticus inferior.
18. M. obliquus externus.
19. M. obliquus internus.
20. M. rectus abdominis.
21. M. ischio cavernosus.
22. M. levator ani.
23. M. ischio-caudalis.
24. Pelvis.
25. Mm. recti capitis postici.
26. M. trachelo-occipitalis.
27. M. obliquus superior.
28. M. rectus capitis lateralis.
29. Mm. intertransversales posteriores.
30. M. multifidus.
31. M. pterygoideus internus.
32. M. pterygoideus externus.
33. Meckel's cartilage.
34. Posterior nares.
35. Zygoma.
36. Zygomatic process of temporal bone.
37. Postglenoid process of temporal bone.
38. Internal maxillary artery.
39. M. sternomastoideus.
40. M. mastohumeralis.
41. M. depressor mandibulæ.
42. Auditory bulla.
43. External auditory meatus.
44. Facial nerve.
45. Base of styloid.
46. Jugular foramen.
47. M. rectus capitis anticus major.
48. M. longus colli.
49. First rib.
50. Dome of pleura.
51. Aorta.
52. Transverse process of axis.

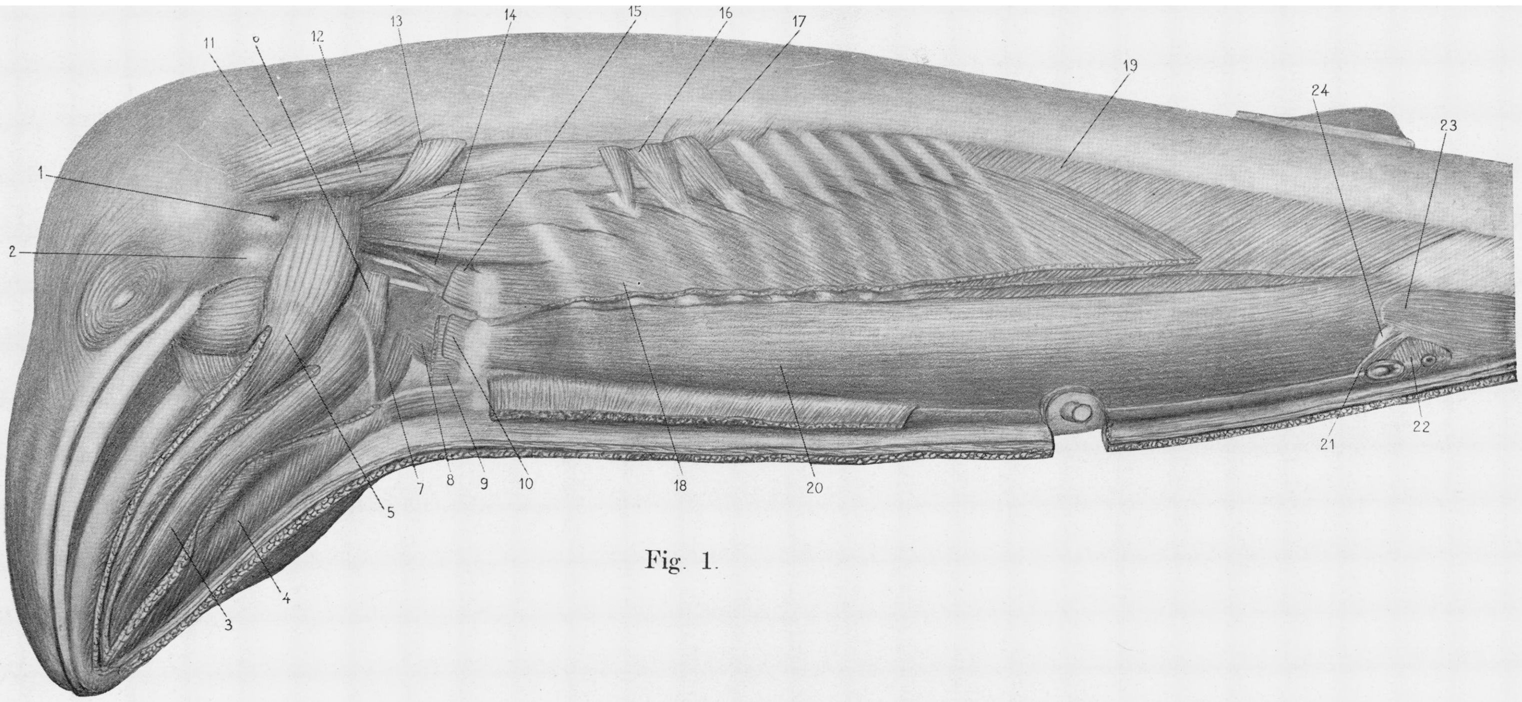


Fig. 1.

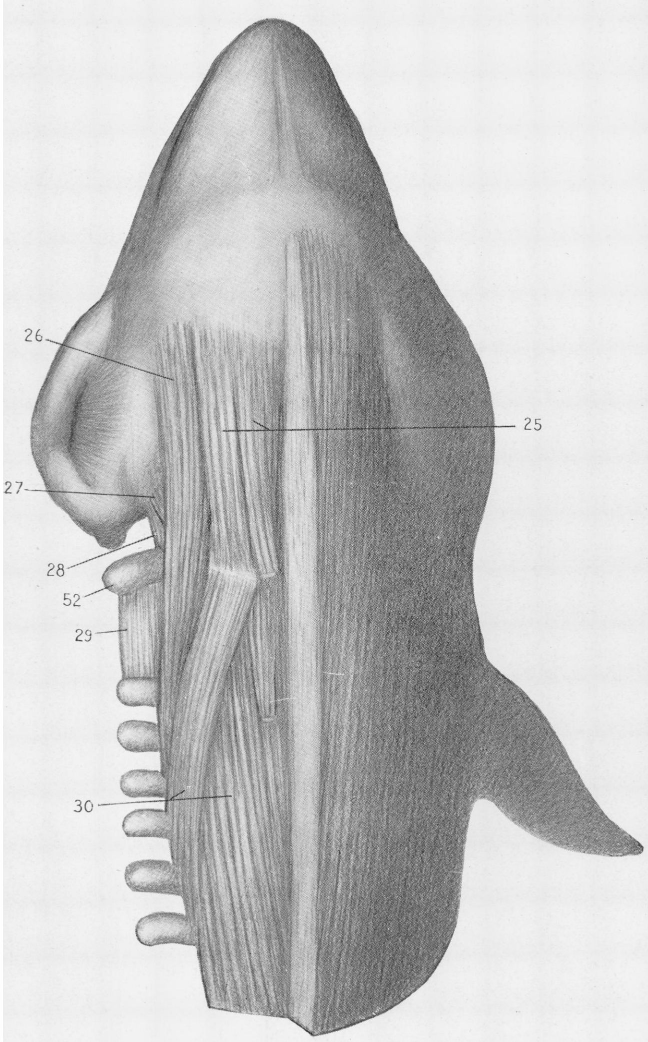


Fig. 2.

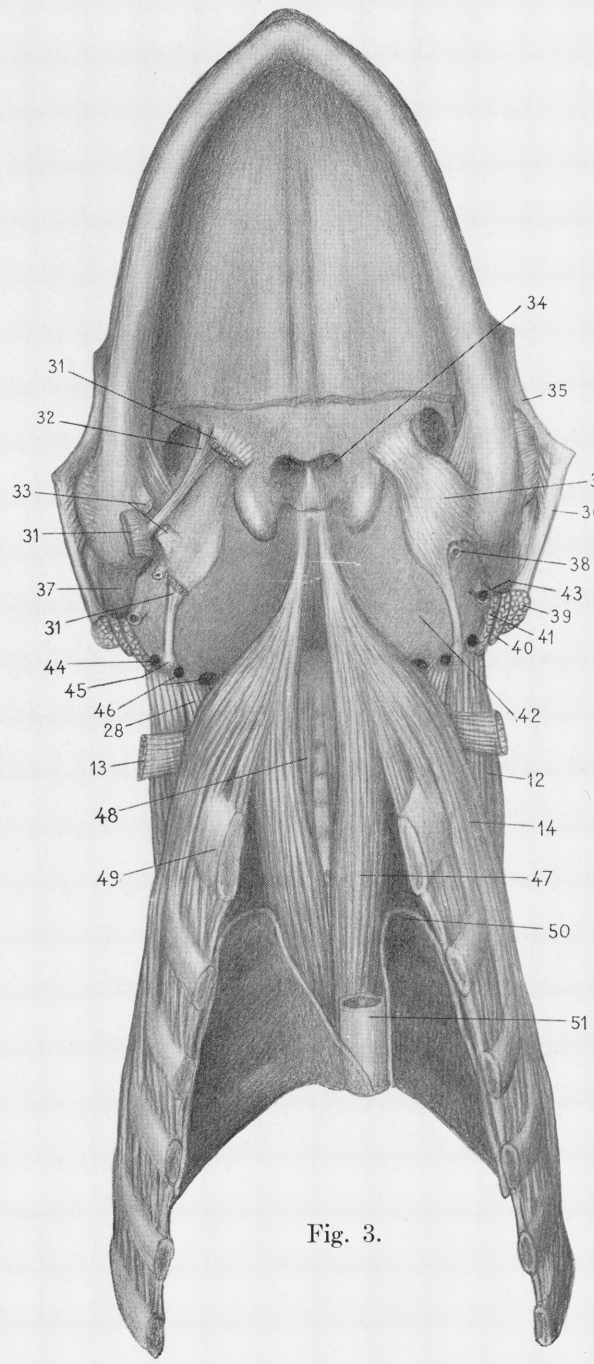


Fig. 3.

Balænoptera borealis.

inclusive. Thus they are separated into two districts, that of the neck and upper thorax and that of the lumbar region and pedicle. In the neck a great muscle complex is formed, in which the elements of the lateral group (scalene) are very imperfectly differentiated from those of the mesal (recti antici capitis). The complex is of great size and extends its insertion far upon the basis cranii, as well as its origin upon the ribs and spine. From these two sources the fasciculi converge and unite inside the arch of the first rib, thence extending as a single mass to the skull, so that the whole complex has the form of an inverted Y, the diverging arms of which embrace the dome of the pleura and limit its extension rostrad. Carte and MacAlister have an accurate description of this muscle, which they interpreted as "corresponding to the longus colli, longus atlantis, and rectus capitis anticus muscles, and in part also to the scalenus posticus and medius and supracostal muscles."

The lateral portion (scalene) arises broadly from the ectal surfaces of the first three ribs, interdigitating with the obliquus externus, and by narrower slips from the fourth and fifth ribs, dorsal to the origins of the serratus anticus. The fasciculi from the latter retain a measure of independence and forming the dorsal border of the muscle, ascend to the extremities of the transverse processes of the cervical vertebræ, into the dorsal aspects of which they are inserted from the second to the seventh inclusive.

They thus represent a highly developed and partially independent scalenus posticus. The fasciculi from the first three ribs are reinforced laterally by a portion of those from the fourth and fifth, and mesad by a very considerable increment from the ental surface of the first rib. These last arise from the region of the bifurcation ventrad for about two thirds of the length of the rib between its bifurcation and its sternal extremity, and occupy this surface in its whole breadth. Entally they rest against the pleura. They seem therefore the equivalent of the scalenus minimus of human anatomy. In their ascent to the spine they occupy a mesal and caudal position in the scalene mass, so as to reach the transverse process of the seventh cervical vertebra. They are however incorporated so intimately in the general complex that they cannot be traced as a separate element, and many of them extend to a higher level in company with the bundles derived from the first three ribs. As these pass dorsal to the subclavian vessels they correspond to the scalenus medius, the anticus being absent. The insertion is into the ventral aspect of the cervical transverse processes close to their tips, and in common with the rectus anticus upon the basi-occipital, occupying with reference to the fasciculi of spinal origin a lateral position in the common belly. Near the first rib the muscle is cleft for the passage of the nerves of the brachial plexus, those of the cervical piercing it separately and somewhat laterad as well as rostrad to the brachial hiatus. It is innervated by short branches from the cervical nerves as they pass through its substance.

The mesal group falls into two planes, a massive superficial portion extending from the thoracic vertebræ to the basioccipital, which enters into relation with the scalene, and which I believe is better interpreted as an enormously extended rectus anticus major, and a small deeper stratum confined to the spine and having the arrangement typical of the longus colli. In addition a considerable belly arises from the atlas and joins the deep surface of the belly to the occipital bone; this seems clearly to be the rectus capitis anticus minor.

The superficial stratum arises from the venter and sides of the first five dorsal vertebræ, extending caudad to the point where the aorta comes into contact with the spine. In the region of the upper dorsal and last cervical vertebræ it receives very delicate tendons from the sides of the vertebræ well dorsad, towards but not actually from, the transverse processes. The bulk of its fasciculi arise from the fifth, fourth and third dorsal vertebræ ventrally, those from the sides of the bodies and from the second and first dorsals form but a small fraction of the belly. This has nearly a sagittal course, but in the cervical region the muscles of the two sides diverge, again converging towards the occipital so that an oval space is left between them in which appears the deeper plane. As the belly ascends in the neck it receives laterally the scalene, and as it passes the atlas it is joined by a short thick muscle from the transverse process (rectus capitis anticus minor). These three elements are blended in a common belly which inserts into the base of the cranium at the mesal margin of the auditory bulla as far rostrad as the alæ of the vomer. Here the fasciculi from the dorsal vertebræ extend farthest rostrad, the scalene are laterad and for the most part at the caudal margin of the bulla, the rectus minor near the caudal margin of the occipital.

The deeper stratum is small and confined to the spine. Three portions can be distinguished, one longitudinal and two oblique. The longitudinal is best developed and extends along the ventral common ligament of the vertebræ from the third dorsal to the ventral arch of the atlas, arising from the more caudal and inserting into the more rostral vertebræ. The majority of its fasciculi, however, reach the atlas. The caudal oblique portion, arising in common with the longitudinal, is inserted into the transverse processes of the fifth and sixth cervical vertebræ. The rostral oblique portion arises from the transverse processes of the fifth and fourth, and inserts in common with the longitudinal portion into the atlas. Thus in the deep plane, which is not described by Carte and MacAlister, we find a perfectly organized longus colli independent of the superficial stratum, which for this reason seems better taken as the representative of the rectus anticus major.

The hypaxial muscle of the lumbar region and pedicle is an enormous mass occupying the region between the transverse processes and the bodies of the vertebræ and extending from the last caudal vertebra to the eleventh rib. Dorsad it is in relation in its whole length with the transversarius. Mesad it is in contact with its fellow, the chevron bones being interposed as far rostrad as the anus, beyond which the muscle twists somewhat on itself, so that its mesal surface becomes meso-ventral. Against this surface rest the kidneys and ureters, and between the muscles of the two sides are interposed the aorta and postcavæ. Superficially in the abdominal region the muscle is covered by the transversalis, the obliqui and lumbar aponeurosis; in the pedicle it is partially overlain and concealed by the ischio-caudalis and the aponeurosis of the rectus. The lumbar and caudal nerves and blood vessels pass dorsal to it to the cleft between it and the transversarius.

In structure it resembles the longissimus dorsi, being divided caudally into two tracts which become merged rostrad. Its lateral tract begins as a great tendon attached to the ventral aspect of the caudal vertebræ, and receiving minor tendons laterad from the region of the rudimentary transverse processes. From the beginning of the flukes rostrad to the level of the hypogastric arteries, this great tendon resolves itself into a series of five smaller tendons of origin, which add themselves to the mesal tract of the muscle. This tract begins at the junction of the flukes and pedicle by fleshy fasciculi derived from the deep surface of the great tendon. Rostrad it increases in size, deriving additional fasciculi from two sources, mesad from the chevron bones and laterad from the tendon slips before mentioned. In the abdominal region it gains attachments to the bodies of the vertebræ and the ventral surfaces of the transverse processes, extending farther laterad upon the latter as it proceeds rostrad, and making fibrous arches over the lumbar vessels, beside the vertebral bodies. The lateral tract is situated between the foregoing and the transversarius. At the beginning of the pedicle it arises from the sides of the vertebræ, receiving also a tendon of origin from the great tendon of the mesal tract. It enlarges rostrad deriving fleshy fasciculi from the sides of the vertebræ, and in addition receives seven tendons of origin from the interval between it and the transversarius. These arise from the bodies of the vertebræ and are at first incorporated in the intermuscular septum, their line of origin extending rostrad about half the length of the pedicle. They are directed mesad as well as rostrad passing superficial to the fleshy belly of the lateral tract until they come to lie beside the great tendon of the mesal tract. They end in fleshy bundles which are added to the mesal aspect of the lateral tract. As it is followed rostrad this portion of the muscle comes more and more to overlie the mesal tract, with which in the lower abdomen it becomes inextricably blended. The fasciculi of both tracts, while in general longitudinal, have an inclination laterad, passing from mesal origin to lateral insertion, exception made of the vertebral insertions already mentioned, which belong to the mesal tract. In the pedicle the whole muscle including its tendons is covered by a dense aponeurosis which is attached mesad to the extremities of the chevron bones, and laterad to the septum between it and the transversarius. From the first chevron rostrad this becomes replaced by a muscular layer which ensheaths the longitudinal tracts and their tendons, its own fasciculi having a more oblique direction. On its deep surface it is closely joined to the rest of the muscle by exchange of fasciculi.

The insertion is into the bodies of the abdominal vertebræ as far rostrad as the first lumbar, into the ventral surfaces of their transverse processes to a degree which increases rostrad, into the caudal border and ental surface of the last rib in its whole length, and into the ental surfaces of the twelfth and eleventh ribs in the region of their angles. It is innervated by branches of the lumbar nerves as they pass obliquely through its substance.

Dorsal musculature.— In the description of these muscles I have used the terminology and classification of the human anatomists, following Eisler [1] as closely as the nature of the case permitted. I have made but few references to the literature of cetacean myology, because this is almost confined to the Odontoceti and has been summarized by Leche,[2] while Carte and MacAlister's account of *Balænoptera* is too abbreviated and incomplete to be of much assistance. I have therefore limited myself to memoranda of the conditions observed, and here have sought to describe the general relations and extent of the several systems rather than to enter upon their structure in detail, for which the small size of this fœtus makes it rather unfavorable material.

Spino-costal muscles.— This layer is very rudimentary as it is for the most part represented by a fascial layer. The serratus posticus inferior is very thin and its fasciculi insert upon the 6th, 7th and 8th ribs near their angles. It is covered by the latissimus dorsi. I failed to find a serratus posticus superior. Neither are mentioned by Carte and MacAlister.

Spino-dorsal muscles.— These muscles are of enormous size and for the most part so intimately connected by exchange of bundles, that their resolution into tracts is more than usually difficult and at best schematic. An exception is present in the transversarius, which in its whole length is separated from the other spinodorsal muscles by a definite septum. From this mesad

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[1] Eisler, P. Die Muskeln des Stammes, in Bardeleben's Hanb. der Anat. des Mensch. Jena, 1912. See also Henle, Anat. des Menschen. Braunschweig, 1873.

[2] Braun's Thierreich, Säugethiere.

to the spines by far the greatest area is occupied by the longissimus, which increases in bulk as far rostrad as the thorax, there diminishing so that only a ribbon-like band, narrow and deep, is continued to the head. Between this and the transversarius, beginning in the upper thorax, is interposed the triangular trachelo-mastoid, which is well demarcated from the longissimus by a strong septum, while less firm and but scanty connective tissue intervenes between it and the transversarius. It seems to receive no fasciculi from that muscle. The longissimus abuts upon the spines in the pedicle, yet even here fasciculi of the transverso-spinalis tract separate it deeply from their bases. These elements increasing in size rostrad come to occupy more and more of the sides of the spines and in the upper lumbar region form a narrow tract intervening between the longissimus and the spines. In this region the separation of the two muscles is very imperfect. From the last dorsal vertebra the superficial stratum of the transverso-spinalis, the semispinalis, increases enormously in size and forces the diminishing longissimus laterad, its very massive belly (semispinalis capitis) is the largest muscle of the neck and gains a broad and deep insertion upon the occipital. Superficial and partly concealing this muscle in the neck is the splenius capitis, which inserts in intimate association with the trachelo-mastoid into the mastoid region. With this by way of introduction we may turn to a brief consideration of the individual muscles.

The splenius arises from the aponeurosis covering the longissimus by means of which it is attached to the spines in the dorsal region. Its fasciculi are directed rostrad and laterad, and condensing towards its insertion and blending to some extent with the trachelomastoid, it inserts into the caudal extremity of the squamosal close to its junction with the mastoid and into a strong tendon, which passes rostrad from this region to the postorbital process of the frontal and the base of the zygoma. In its course this tendon is adherent to the underlying periosteum. It gives insertion caudad in addition to the splenius and trachelomastoid, to some of the fasciculi of the sternomastoid and mastohumeral. In front it gives origin in part to the deep portion of the masseter.

The trachelomastoid is of moderate size and triangular in shape. It arises from the ectal surfaces of the first four ribs, mesal to the transversarius slips, and from the transverse processes of the lower cervical vertebræ. It is inserted, fused with the splenius, into the caudal portion of the squamosal and into the tendon just described.

The longissimus dorsi occupies the region between the transverse and the spinous processes as far as the thorax, where it is displaced laterad, yielding an increasing area immediately adjacent to the spines to the transversospinalis (semispinalis capitis). Here the muscle rapidly diminishes in size and only a rather slender belly gains attachment to the exoccipital. In the pedicle a ventro-lateral portion, the iliocostalis (sacrolumbalis of Stannius) is distinguishable, separated from the dorso-median portion by a fibrous septum, which is nevertheless pierced for the passage of tendons which give origin to fasciculi of the iliocostalis. Rapp considered that the two portions were so intimately united as to constitute a single muscle. Stannius found them separated throughout by a septum and assigns all the fasciculi that insert into transverse processes and ribs to his sacrolumbalis. The longissimus begins by a stout tendon arising from the dorsum of the last vertebra. It passes rostrad receiving slips from the spinous processes, muscular fasciculi first appearing near the extremity of the pedicle. Throughout the caudal and lumbar region it is recruited by slips from the spinous and accessory processes, and continues to receive slips from the latter source in the thorax, where it has abandoned its position beside the spines. In addition it receives augmentation of fasciculi from the strong aponeurosis, which covers its surface. This is especially conspicuous in the thorax and neck, where a considerable portion of the muscle along its ventro-lateral margin is derived from this source. The iliocostalis begins as a series of tendons derived from the ventrolateral margin of the longissimus. The first of these leaves the tendon of origin of the latter at the junction of the pedicle with the flukes. Ten such tendons in all were present, increasing in size to the middle of the pedicle and then diminishing. The fourth, fifth and sixth are the largest. These all pierce the septum which separates the longissimus and iliocostalis. In addition the muscle receives slips from the accessory processes. The fasciculi are directed nearly longitudinally, but with a slight deviation laterad and ventrad, to their insertions by mixed tendinous and fleshy fibres into the transverse processes of the lumbar, thoracic and cervical vertebræ (iliocostalis), and into a vertical line upon the exoccipital between the trachelo-occipital muscle mesad and the obliquus superior laterad (longissimus). In the thoracic region slips are also attached to the ribs mesal to their angles and to the insertions of the transversarius.

The transverso-spinalis consists of fasciculi extending from the transverse processes to the spines of the vertebræ with a general direction rostro-mesad. It may be resolved into a superficial portion (semispinalis) and a deep portion, multifidus, though many fasciculi extend from one to the other. In the pedicle where the whole system is of small size and for the most part under cover of the longissimus, from which it is but imperfectly separate, I was obliged to give over the attempt to analyze its components. As the thorax is approached the semispinalis increases in size and attains considerable depth, gradually making its appearance between the spines and the longissimus. Its fasciculi arising from accessory processes are inserted into the spines of more rostral vertebræ. The fasciculi have a very oblique course and pass over several vertebræ from origin to insertion. From about the mid-dorsal region the insertion into spines ceases, indeed a few fasciculi now arise from this source, and the origin from the accessory processes enlarges spreading on to the bases of the transverse processes. The muscle becomes very bulky rising high above the level of the spines as it approaches its insertion into a large area on the supraoccipital, between the midline and the attachment of the longissimus. This portion is the semispinalis capitis and constitutes by far the major part of the whole system. From its deep surface, in the upper thoracic and cervical region, several large bundles are given to the underlying multifidus. The semispinalis cervicis, rectus capitis posticus, obliquus and multifidus are exposed on its reflection.

The semispinalis cervicis is a small muscle arising from the transverse processes of the lower cervical and the first three thoracic vertebræ. It is directed obliquely rostro-mesad and inserts upon the arches of the epistropheus and atlas, many of its fasciculi passing uninterruptedly into the rectus capitis posticus.

The multifidus is composed of bundles passing between spines and transverse processes. In the upper lumbar region they have a moderate obliquity passing over three or four vertebræ in their course from origin to insertion. In the thorax their course becomes more longitudinal and some of the superficial bundles are of reversed obliquity passing from thoracic spines to cervical transverse processes. As a whole this system is of small size filling the interval between accessory and spinous processes. Caudad it resisted my efforts to separate it from the semispinalis, rostrad while more independent it yet receives several slips from the deep surface of that muscle. I did not examine the submultifidus. Interspinales are present, paired and of moderate development.

The rectus capitis posticus I could not resolve into major and minor. It arises broadly from the arches of the atlas and epistropheus and the intervening ligament, receiving a broad superficial fasciculus from the semispinalis capitis and having some of its bundles below this continuous with that smaller member of the transversospinal system, which I have taken for the semispinalis cervicis. The muscle has considerable thickness and inserts into the occipital between the margin of the foramen magnum and the attachment of the semispinalis capitis. Stannius[1] in *Phocœna* found this muscle incorporated into the semispinalis. Murie[2] finds two recti in Globiocephalus closely woven together.

The rectus capitis lateralis is a short thick muscle arising from the transverse process of the atlas and the adjacent border of the articular process, and inserting upon the paroccipital process, its fasciculi having a slightly oblique direction and spreading out at their occipital attachment.

The obliquus capitis superior arises from the transverse process and dorsal arch of the atlas, and ascends to a rather large insertion upon a ridge at the extremity of the exoccipital dorsal to the insertion of the rectus capitis lateralis, and lateral to the next following muscle.

This is a sagittal trachelo-occipital muscle, the origin of which extends from the accessory process of the first thoracic vertebra to the dorsal arch of the atlas, arising from the arches of the cervical vertebræ in a position corresponding to the prolongation of the line of the accessory processes. Increasing greatly in size in the upper cervical region it is inserted into the occipital bone between the rectus capitis posticus and the longissimus and seems to be a derivative of the semispinalis capitis. It is placed dorsomesal to the dorsal divisions of the cervicle nerves. This muscle is described and figured in *Globiocephalus* by Murie[3] who interprets it as trachelo-mastoid. He also describes, in addition to the rectus capitis lateralis, two atlanto-occipital muscles, which he designates superior and inferior oblique.

The transversarius occupies the region of the transverse processes extending from the last caudal vertebra to the atlas. It is separated from the longissimus by a strong septum and is itself enclosed in a sheath, of great strength in the pedicle and abdominal portion of its course, but becoming tenuous in the thorax. In the pedicle the muscle is present in two divisions, one dorsal to the transverse processes, one ventral, this latter being the transversarius inferior of Stannius. The muscle broadens in surface view to the middle of the pedicle, then gradually contracts becoming a narrow band opposite the vulva, where the inferior division is greatly reduced and merges with the body of the muscle. From this point it is continued narrow but of very considerable transverse depth to the last rib. In its costal portion the muscle is thinner but somewhat broader giving slips from its ventral margin to each of the ribs near their angles as far as the first, where it enters the interval between the scalene mass and the trachelo-mastoid, and is continued as a slender fasciculus to the transverse process of the axis, being placed immediately dorsal to the origin of the levator scapulæ. In this portion of its course it is distinct from the intertransversarii dorsales and separated from them by the cervical insertions of the longissimus, having much the position and arrangement of the human intertransversarius lateralis longus. The thoracic portion is considerably narrower than in *Phocœna* where Stannius found it expanding ventrad as a thin sheet as far as the origin of the obliquus externus. Rapp

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[1] Stannius, *op. cit.*, p. 29.
[2] Murie, *op. cit.*, p. 282.
[3] Murie, *op. cit.*, p. 282 and figs. 67, 68.

described it as an independent muscle — m. costalis, but Stannius concurs with Meckel in assigning it to the system of the transversarius, which it continues forward upon the thorax. The transversarius arises by a series of slips from the side of the last vertebra and from the transverse processes of the caudal, lumbar and thoracic vertebræ. It is inserted similarly by slips into the transverse processes of more rostral vertebræ and in the thoracic region into the ribs. The inferior division in the pedicle has an analogous arrangement ventral to the transverse processes, arising from the side of the last vertebræ and from transverse processes, inserting into more rostral transverse processes. It becomes much reduced near the level of the vulva and its remnant there merges with the portion situated dorsal to the transverse processes.

The Upper Alimentary Tract.

(*Plate LXIX, Fig. 1.*)

Cavum oris proprium.— In the absence of prominent alveolar processes, though in the case of the maxillæ this requires some qualification, the dento-labial sulci may serve as the boundary between the vestibule and the mouth cavity proper. The course of the sulci has already been described. On dissection the inferior furrow was found to send ventrad into the alveolar gutter of the mandible a low keel, to which the dental anlages were attached or at least immediately adjacent. These were in general subhemispherical, about 1 mm. in diameter, although a few were slightly elongate sagittally. In the midregion they were separated by intervals about equal to the anlages in length, but towards the symphysis they were more closely set. The caudal third of the series was damaged by a crushing of the brittle jaw which occurred during dissection, so that their shape could not be satisfactorily determined. The total number was about thirty. The superior dento-labial sulcus was deepened along the margin of the maxilla, but had no dental anlages attached to it. These were contained in the cavity of the maxilla, which in its caudal two thirds presented a corresponding convexity on its palatine aspect, which would seem therefore equivalent to a alveolar process.

The floor of the oral cavity comprises the alveolingual region and the tongue. The alveolingual region is very extensive and is the expression of the disparity in size between the tongue and the wide arch of the mandibles. Its floor is wrinkled and furrowed, but upon depressing the tongue and so stretching the mandibular pouch, these surface markings are effaced and appear therefore to be but the accompaniments of the distensibility of the region.

The tongue is broad and squat, rising but moderately above the alveolingual region. It has a length of 48 mm. and its greatest breadth is 24 mm. Its tip is free for a sagittal distance of 11 mm. In spite of its great size the tongue comes far short of filling the enormous mouth, and there is at its sides a space of 1 or 2 mm. between it and the mandibles, while its tip fails of reaching the symphysis by 7 mm. Similarly between the base of the tongue and the faucial orifice there is an interval of 6 mm. Here the floor of the mouth is depressed to a shallow fossa, the mucosa of which is marked by fine grooves and ridges. This depression is situated entirely rostrad of the hyoid. Its floor forms a prominence between the hyoglossi and is reinforced by a local increase of the transverse lingualis. Its presence appears to be associated with the feeble development of the radix linguæ. These facts and especially its position seem to preclude all attempt to bring it into any direct relation with the pharyngeal pouch of the elephant described by Watson.[1] There is no foramen cœcum and no circumvallate papillæ are present. The tip of the tongue is rounded, and has a thin crenate border covered by slightly roughened epithelium. On the dorsum, from each end of this border a low ridge, rather rough and papillated is prolonged for about half the length of the organ. Elsewhere the surface is very smooth. The midline is marked by a depression which broadens at the tip, and only partially corresponds to the vomerine ridge on the palate. The sublingua is represented by a triangular area on the ventral surface of the free extremity. It is defined by two furrows which converge towards the free margin which they fail of reaching by about 2 mm. Their terminal segments do not meet but become parallel. They thus define a triangle the apex of which is produced into a narrow strip. This latter is slightly depressed, while the triangle is convex and rises a little above the adjacent surface. There is no frenulum, and no plica fimbriata. The tongue is very soft, which depends in part upon the arrangement of the genioglossi and the interposition between them of a considerable quantity of fat.

The roof of the mouth is narrower and more pointed rostrally than the floor, depending upon the less development of the upper lips and their being overlapped in a considerable portion of their course by the prominent margins of the lower. The palate in the region of the rostrum is triangular attaining its greatest breadth in front of the temporal muscles. It then narrows rapidly, a shallow depression being formed on each side, between the margin of the palate process of the maxilla rostrad, the temporal muscle laterad, and the internal pterygoid mesad. This is separated from the orbital aponeurosis by a small quantity of fat; its epithelium is pigmented. Caudal of this the oral cavity is truncated by the transverse partition of the velum. The median line of the palate is marked by a sagittal ridge in its middle third, which corresponds to the ventral border of the vomer. This is bounded by two narrow concavities which run together in front of the ridge and continue almost to the tip of the rostrum. Lateral to these and extending to the labial sulci are two broader convexities — the displaced alveolar processes. In no portion of the oral cavity proper, nor in the vestibule could I find evidence of the presence of salivary glands.

Fauces.— The fauces are drawn out to a narrow canal, measuring in length 13.5 mm. from the oral orifice to the edge of the velum palati in the pharynx. Transversely the lumen is 4 mm., vertically it increases from a mere slit proximad to about 4 mm. distad as it joins the pharynx. Its oral orifice is about midway between the roof and floor of the mouth, the latter deepening to a shallow fossa between it and the tongue. The diaphragm-like plate that terminates the oral cavity caudad is formed by the palatoglossus muscle, a tubular extension of which is prolonged upon the faucial canal. This passage after a horizontal course caudad for about half its length, turns abruptly ventrad to reach the dorsum of the hyoid and again approaching the horizontal enters the most ventral portion of the pharynx to the right of the epiglottis. Its wall appears faintly granular under a lense, which is probably due to the presence of glands. I found no trace of a tonsil.

Pharynx.— As compared with the narrow fauces and œsophagus, the pharynx forms a marked dilatation of the alimentary canal, in the transverse as well as in its dorso-ventral diameter. It attains its greatest breadth between the hyoid bars; rostrad it is contracted between the auditory bullæ, here resting against the basis cranii and forming a funnel-shaped approach to

[1] Watson, M. Contributions to the anatomy of the Indian Elephant (*Elephas indicus*). P. XIII, The Head. Jour. Anat. and Phys., Vol. 8, 1873, p. 85. *Vide* Weber, Die Säugetiere, 1904, p. 722.

the choanæ. Caudad it diminishes more gradually as far as the thyroid cartilage, but opposite to it it abruptly narrows to join the œsophagus. The maintenance of its transverse diameter in the region of the laryngeal junction stands in relation to the great breadth of the trachea. The interior of the pharynx is profoundly modified as a consequence of the retrovelar position of the epiglottis and the concomitant lengthening of the fauces to a tubular passage, the bucco-pharyngeal canal of Turner. This latter depends for its formation upon a lengthening of the velum palati, which projects far caudad into the cavity of the pharynx terminating as a crescentic fold, the horns of which prolonged upon the sides of the pharynx are the arcus palatopharyngei. In the Odontoceti these are prolonged upon the dorsal wall of the pharynx forming a muscular annulus palato-pharyngeus (Rückert). In this fœtus the annulus is not circular, but rather pyriform with the wide end rostrad. Caudad the narrow part of the annulus is formed by a thick muscular ridge of the dorsal wall, prolonged upon the sides by fairly well defined ridges, which can be followed to the back of the hyoid beside the epiglottis. They owe their prominence chiefly to deep sulci at their caudo-ventral margins, which separate them from the larynx which between them rises into the pharynx. The position of this ridge would suggest that its muscular basis is a specialization of the middle constrictor, rather than an extension of the palatopharyngeus. The annulus in this fœtus is therefore composed of two crescentic ridges, with their cornua approximated but not actually continuous, nor even in line with one another. The dorso-caudal crescent embraces the arytenoids, the ventro-rostral corresponds to the epiglottis but abutts closely upon it only in front and on the left side. A low oblique ridge extends from the velum to join the horn of the dorso-caudal crescent opposite the interval between arytenoid and epiglottis. Their junction is marked by a small triangular elevation. This ridge defines the region of the faucial orifice, in which is also contained the base of the epiglottis. The position of the larynx is already asymmetrical and a rod passed into the fauces here emerges to the right of the epiglottis. Dorsal and caudal to the oblique ridge the lateral wall is concave and on the left side shows the impression of the arytenoid cartilage. This concavity is limited in front by a ridge which broadens ventrad, there forming a broad elevation upon which terminates the short arcus palatopharyngeus. Carte and MacAlister have noted the absence of the uvula in *B. rostrata* (= *acuto-rostrata*), an observation confirmed by Turner, and also true of this fœtus. The former authors describe a "peculiar, preëpiglottic hoodlike fold" which they found capable of being drawn over the epiglottis and inferred that it covered and protected the larynx during deglution. Turner states explicitly that no such fold was present in his specimen, but a comparison of the figures [1] leaves no room to doubt that both he and they had before them the same structure, which Turner correctly designated velum. That he failed to recognize in it the peculiar hood-like fold of Carte and MacAlister was in part due to their conjecture as to its function, but especially to their location of the faucial orifice dorsal and not ventral to their fold. In this, I believe, they were grossly mistaken, and that the probe in their illustrations does not follow the faucial passage but is thrust through the velum itself. A consideration of the position of the velum between the faucial canal and the pharynx reveals the possibility of such an error, especially if they were dealing with material advanced in decomposition — fourteen days elapsed between the capture of the whale and the beginning of their dissection.

As has been said, the faucial passage is not straight, but curves sharply ventrad in its caudal

[1] Carte and MacAlister, *op. cit.*, pl. vi, figs. 5–9.
Turner, *op. cit.*, pl. viii, fig. 31.

portion to reach the dorsum of the hyoid. In consequence the faucial surface of the velum does not form a simple plane, but conforms to the direction of the canal. It is at first nearly horizontal, it then slopes caudad and ventrad, and finally becomes horizontal again and, forming the crescentic fold described above, projects into the pharynx as a horizontal shelf. Its dorsal surface has a corresponding relief, with this difference, that at the junction of the first horizontal plane with the sloping portion a prominent transverse ridge is formed. This ridge corresponds to the caudal border of the tensor palati, though it is rendered more prominent by a diminution in the thickness of the mucosa behind it. From the ridge rostrad the velum forms a continuation of the floor of the nasal fossa continuing the plane of the palate. Caudal to the ridge the dorsum of the velum is deeply concave, forming a shallow bay or sinus, which extends distad to the shelf-like margin of the velum. Laterad the sinus involves the wall of the pharynx and attains considerable depth above the arcus palato-pharyngeus. In Carte and MacAlister's plate vi, fig. 6, the sinus and its limiting folds is tolerably well shown, and the probe, I believe, passes through its fundus to enter the mouth.

In the muscular wall of the pharynx Turner[1] found "at least two pairs of constrictors" arising from the hyoid and thyroid, nor could I find evidence of the presence of the superior, the internal pterygoid serving only to attach the very strong fibrous tissue of the pharynx, but giving it apparently no muscular fasciculi, nor could I find any of lingual origin. The inferior constrictor arises from the whole lateral or dorsal margin of the thyroid cartilage including its posterior cornu, and is inserted into the dorsal raphé of the pharynx. The rostral fasciculi were transverse and not clearly to be distinguished from those of the middle constrictor, so that the two muscles appeared to blend rather than overlie one another. This blending was due to a fibrous arch passing from the middle to the inferior constrictor, dorsal to the entrance between them of the glossopharyngeal nerve and stylopharyngeus muscle, and the fasciculi arising from this arch effectually closed the gap between the constrictors. The most caudal fasciculi from the posterior cornu have a very oblique course, ascending to their insertion. In their course they are nearly independent of the rest of the muscle and overlie the fasciculi from the base of the cornu. These fasciculi from the two sides make a V open caudad, at the apex of which the œsophagus emerges. As the origin of this muscle is much larger than its insertion, it is necessary that it become condensed on the dorsum of the pharynx, and this is secured by the ascent of its caudal fasciculi. The middle constrictor arises from the hyoid bar close to the cranium and thence radiates to the dorsum and side of the pharynx. Its most rostral fasciculi terminate with a very definite edge upon the pharyngeal aponeurosis at some distance from the pterygoid. The pharynx has a maximum length from the hard palate to the beginning of the œsophagus, of 32 mm. The greatest breadth of its lumen, just rostrad of the hyoid bars, is 13 mm.; its greatest dorso-ventral height, 12 mm.

Œsophagus.— From its emergence between the oblique portions of the inferior constrictors to its termination in the first stomach, the œsophagus has a length of 67 mm., of which 10 mm. belong to its abdominal segment. In the neck and mediastinum to the point where the aorta gains its left side, it is engaged between the hypaxial muscles and the trachea, and is dorso-ventrally flattened to such a degree that its lumen is reduced to a transverse slit with its walls in contact. Its greatest breadth is 4.5 mm. Where it is in contact with the aorta on the left

[1] *Op. cit.*, p. 224. See also to the same effect Carte and MacAlister, *op. cit.*, p. 245.

PLATE XLIX.

PLATE LXIX.

Balænoptera borealis.

Fig. 1. Tongue, pharynx and larynx. $2\frac{2}{3} \times$ natural size.
Fig. 2. Base and diaphragmatic surface of heart. $2\frac{2}{3} \times$ natural size.
Fig. 3. Cavities of the atria. $2\frac{2}{3} \times$ natural size.

1. Tongue.
2. Nasopharynx.
3. Ridge of velum corresponding to margin of tensor palati.
4. Free edge of velum and arcus palatopharyngeus.
5. Concavity of dorsum of velum palati.
6. Epiglottis.
7. Arytenoid cartilage.
8. Muscular ridge.
9. Oropharynx into which opens the faucial canal.
10. Middle constrictor.
11. Inferior constrictor.
12. Thyroid cartilage.
13. Œsophagus.
14. Trachea.
15. Depression of floor of mouth between the tongue and fauces.
16. Aorta.
17. Pulmonary artery.
18. Precava.
19. Postcava.
20. Coronary sinus.
21. Left pulmonary veins.
22. Right pulmonary veins.
23. Groove of right pulmonary artery.
24. Reflection of serous pericardium.
25. Interventricular furrow.
26. Atrioventricular furrow.
27. Valve of the foramen ovale.

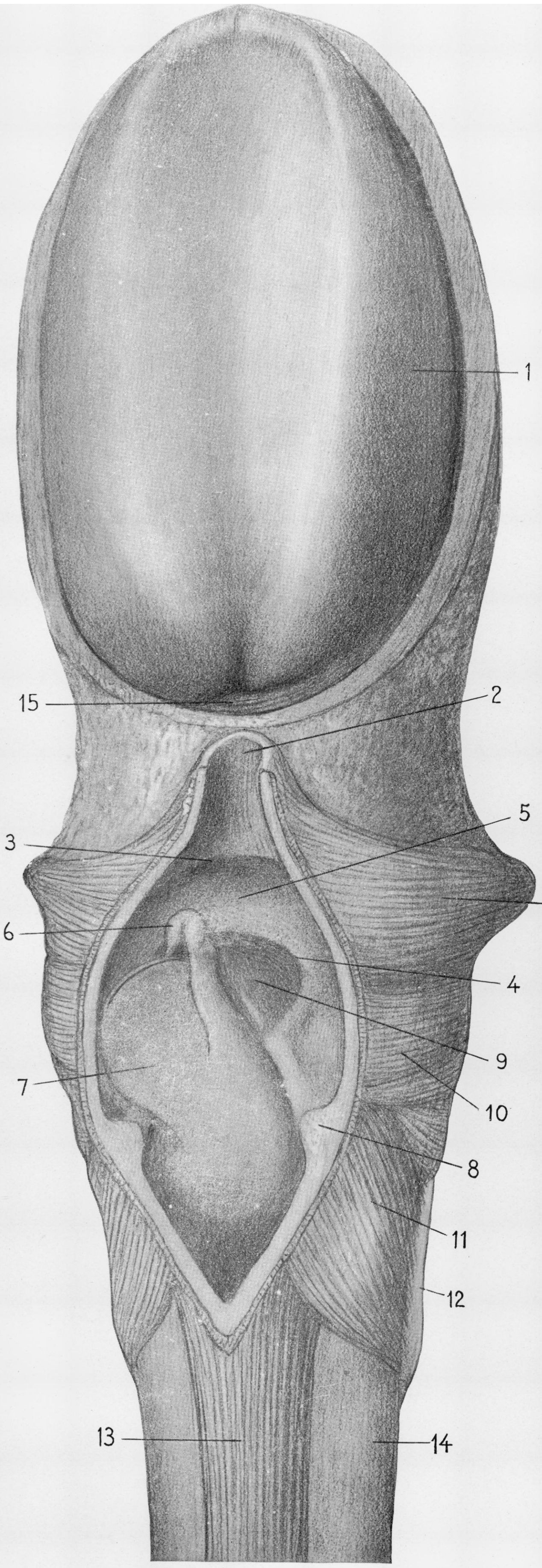

Fig. 1.

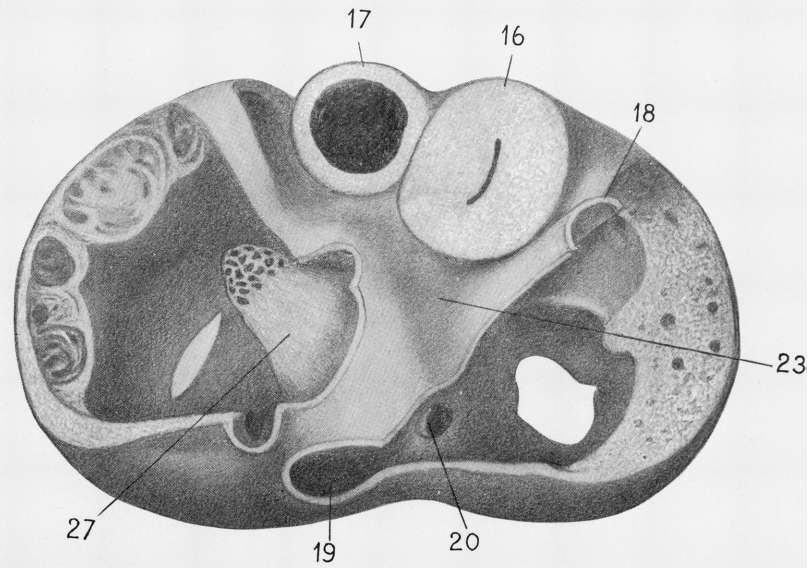

Fig. 3.

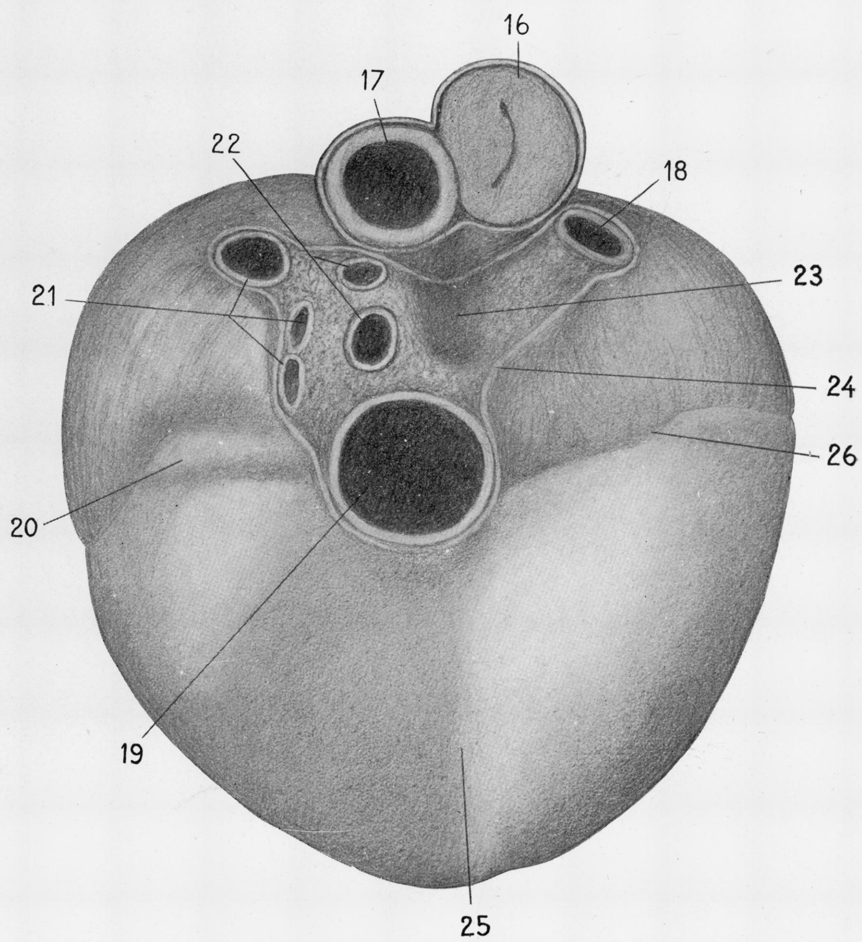

Fig. 2.

Balænoptera borealis.

it rather abruptly alters its shape, the left margin being displaced to make room for the descending aorta, while the right continues straight. Here the section becomes oval, the dorsoventral diameter slightly exceeding the transverse. This form it retains until it begins to move ventrad from the spine as it approaches the diaphragm. Here its section is circular and continues so to its termination. Its diameter is 3.5 mm., and that of its open lumen is 2 mm. Here also it shows the presence of low longitudinal folds.

The Respiratory Passages.

(Plates XLIX, Fig. 1, and LVI, Fig. 2.)

Nasal fossa: (by John D. Kernan, Jr.). It is convenient for purposes of description to distinguish between a respiratory passage and the olfactory region. The latter forms a subspherical diverticulum from the dorsal wall of the respiratory passage.

The respiratory passage is tubular, compressed from side to side, and is directed in a greater part of its extent obliquely rostrad and dorsad. At the margin of the nasal bone its direction changes, swerving dorsad almost vertically to the narial aperture. This passage has been divided by Weber into proximal and distal portions, the nasal and naso-pharyngeal ducts, which correspond approximately to the precerebral and subcerebral portions of de Burlet and other authors. The rostral limit of the cerebral cavity in this fetus lies in the same transverse plane as the crista semicircularis so that the whole olfactory region belongs to the pars subcerebralis.

The precerebral portion is about half as long as the subcerebral portion. It is more compressed from side to side and its lateral wall presents a somewhat complicated relief. This depends upon the presence of the "Spritzsack," an oblique diverticulum which attains considerable depth above the level of the osseous paries. Toward the interior of the fossa the diverticulum diminishes in depth, becoming a shallow furrow. It is bounded by two prominent folds, which with the diverticulum have a spiral course. The rostral fold at the narial aperture is broad and forms the lateral lip of the naris, here lying dorsal to the diverticulum and forming its roof. As it is traced into the respiratory passage it diminishes in height and terminates by passing upon the septum. It thus describes a spiral from the lateral to the mesal wall of the passage, crossing the rostral paries in a ventro-mesal direction. The second fold belongs to the caudal and lateral walls, upon which it descends in a semicircular course, and in its whole course occupies the concavity of the first fold. Toward the narial aperture it forms the floor of the "Spritzsack." It owes its prominence and direction to the cartilago cupularis and forms a cushion upon which the first spiral fold is molded, and against which it becomes firmly coapted when pressure is made upon the narial region from without. The arrangement of these folds would thus seem to secure the effectual closure of the respiratory passages when the animal is submerged. The furrow which separates these two folds at its termination upon the septum forms a shallow fossa, which corresponds in position to the open groove in which de Burlet recognized the rudiment of Jacobson's organ. Ventral to the nasal bone the lateral wall of the respiratory passage is concave, save for a longitudinal ridge situated midway between roof and floor. This has a length of 5 mm., a breadth of 1.5 mm., and a height not exceeding 1 mm. It is the expression of a ridge in the cartilaginous wall of the nasal fossa, and is probably the equivalent of the naso-turbinal. Its ventral margin is slightly undermined by a corresponding sulcus. The remainder of the respiratory passage, the naso-pharyngeal duct, is a smooth-walled tubular cavity in which the transverse diameter somewhat exceeds the dorso-ventral.

The olfactory region communicates with the respiratory passage by a narrow slit-like orifice between the broad septum nasi mesad and the crista semicircularis laterad. On the removal of the septum, the crista semicircularis is seen as a sharp falciform margin at the rostral limit of the olfactory region. The dorsal cornu extends to the cribiform plate; the ventral cornu is directed ventrad and caudad, becoming continuous with the maxillo-turbinal which forms the ventral limit of the olfactory region. Lateral to the crista and maxillo-turbinal is a deep narrow depression, the undivided recessus lateralis inferior. The dorso-lateral limit of this recess is formed by the "Sammelleiste," (de Burlet), a ridge of cartilage covered by mucous membrane extending from the crista semicircularis to the lamina transversalis posterior, which forms the caudal limit of the communication between the olfactory region and the respiratory passage. The space above the "Sammelleiste" is divided by the vertical ridge of the first ethmo-turbinal into a caudal recessus posterior and a rostral depression, the recessus lateralis superior. This, as its name implies, is a laterally directed diverticulum of the olfactory region; its fundus, however, is prolonged caudad into a deep recess on the lateral aspect of the first ethmo-turbinal. In its depth are visible two diminutive oblique fronto-turbinal ridges. Of these the second is considerably the smaller and is wholly concealed in median view by the first ethmo-turbinal.

The recessus posterior or ethmo-turbinal region is smaller than the recessus lateralis. Its rounded fundus occupies the cupula posterior of the nasal capsule. Its orifice is contracted and bounded rostrad by the first ethmo-turbinal, ventrad by the lamina terminalis, dorsad by the cribiform plate, caudad by the free edge of the mesal wall of the cupula posterior. Its lateral wall shows the presence of a well developed third ethmo-turbinal, between which and the first of the series a rudimentary second can be detected.

Larynx.— The larynx conforms so closely to the descriptions of previous writers that it here requires but passing notice. The elongated epiglottis rises high into the pharynx, its enlarged extremity lying above the level of the velum. Rostrad it is connected to the hyoid by a prominent hyo-epiglottic fold of mucous membrane (Turner). On its caudal surface I could find no trace of a Czermak's cushion such as Turner describes. This surface is deeply grooved axially and the lips of the groove are elevated to high triangular folds, which passing lateral to the free rostral margins of the arytenoids, diminish in height and are attached to their lateral surfaces. The arytenoids are high and broad, but very thin and leaf-like. Their dorsal margins are united in about half their extent, the ventral free and boldly curving. The free margins were closely approximated in this fœtus, but not adherent and fitted in between the high ary-epiglottic folds described above. There were no vocal cords. The muscles and the cricoid cartilage I did not examine.

Thyroid cartilage.— The thyroid cartilage consists of two symmetrical halves which have not yet fused in the median line, but are closely united by a narrow plate of connective tissue. In general shape it resembles Carte and MacAlister's [1] figure much more closely than Turner's,[2] but departs from both considerably. The lateral margin is distinctly concavo-convex and serves to give attachment to the inferior constrictor. Its length is 17 mm. The mesal margin, 6.5 mm. in length, was for rather more than half of this distance united with its fellow. Caudad

[1] Carte and MacAlister, *op. cit.*, pl. v, fig. 5.
[2] Turner, *op. cit.*, pl. viii, fig. 36.

there is a deep notch between the diverging borders. The rostral margin passes laterad and rostrad in a slightly concave course to the anterior cornu, which is but a pronounced angle at the junction of the rostral and lateral borders. The caudal margin is deeply concave between the great posterior cornu and a mesal process which marks its junction with the median border. To this process and the whole caudal margin is attached the muscle of the laryngeal pouch (M. thyreo-arytenoideus, Dubois [1]). The posterior cornu is rounded, directed caudad with a mesal concavity and has a length of 11.5 mm. Mesad it gives origin to the crico-thyroid, dorsad to the inferior constrictor. The thyro-hyoid arises from the anterior cornu, the lateral half of the rostral border and the adjacent ventral surface. The sterno-thyroid has a wide insertion into the ventral surface and lateral margin in the angle between the attachments of the thyro-hyoid and inferior constrictor muscles.

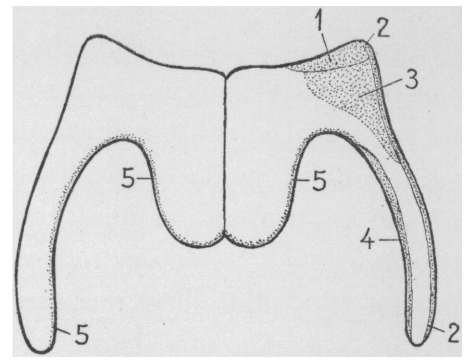

Fig. 5. Thyroid cartilage. 2 × nat. size. 1, Origin of thyrohyoideus. 2, Origin of inferior constrictor. 3, Insertion of sterno-thyroideus. 4, Insertion of circo-thyroideus. 5, Origin of muscle of laryngeal pouch.

Laryngeal sac.— The laryngeal sac in this fœtus has a length externally of 18 mm., a breadth of 11 mm. Its wall is very thick, its lumen a transverse slit. This has an elongated communication with the larynx through the gap in the cricoid and between the bases of the arytenoids. Its dorsal wall is attached in its whole length, rostrad to the cricoid, caudad to the tracheal rings, so that its fundus is not free as in Dubois's figure of *Balæna*. This connection is by muscular fasciculi. The muscle of the pouch, which Dubois considers to be the thyreo-arytenoideus on account of its innervation by the inferior laryngeal nerve, arises from the caudal margin of the thyroid cartilage and the ventral borders of its posterior cornua in their whole length. The superficial fasciculi radiate from the mesal process of the cartilage; the rostral are transverse and disappear beneath the cricothyroid muscles; the intermediate are oblique and turning round the sides reach the cricoid cartilage; the caudal are nearly longitudinal and insert upon the rings of the trachea as far caudad as the origin of the right eparterial bronchus. While many surmises have been made as to the function of this sac, I do not remember to have seen it suggested, that by its contraction and relaxation during submergence, a circulation of air in the wide trachea and bronchi might be set up, which would favor the absorption of oxygen by bringing the air in these passages more rapidly into contact with the respiratory membrane than could be done by the usual diffusion currents.

Trachea.— The trachea is short and wide; dorsally it is flattened against the œsophagus. Its external dimensions are as follows: length 9.5 mm.; breadth, rostral to right apical bronchus, 9 mm.; caudal to same 8 mm.; dorsoventral diameter 6 mm.; length to origin of right apical bronchus, 6 mm. As in the other members of the order, the cartilaginous wall is very complete, the rings being close-set and separated only by narrow intervals. The rostral ones as Dubois [2] and Müller [3] have observed are continuous with the lamina of the cricoid cartilage. Ventrally the ends of these rings are widely separated, the wall being completed by membrane. This condition obtains in almost the whole extent of the laryngeal sac. Rostrad the membrane

[1] Dubois, Eug. In Weber's Studien über Säugethiere, II, p. 101 D. Jena, 1886.
[2] Dubois, E., *op. cit.*, p. 92.
[3] Müller, O., *op. cit.*, p. 197.

is continuous with the cricoid cartilage, between the ventral bars of which the sac communicates with the larynx. Caudad the membrane diminishes in width terminating by a pointed extremity at the level of the origin of the right apical bronchus. From the end of the membrane a shallow groove, convex to the right, is continued to the angle of the bifurcation. Along this groove the ends of the tracheal cartilages are in contact but not fused, so that in this fœtus there are no complete rings. The number of those intervening between the membrane and the bifurcation is only three; of those with ends widely separated by the membrane, five. This condition of incomplete rings throughout agrees with Dubois' statement for Mystacoceti in general. On the other hand in *B. antipodum* (Beauregard and Boulart [1]) there are only three rings which are not closed ventrally and in *B. musculus* Müller finds that out of seven or eight rings only five are incomplete. As regards *B. rostrata* (= *acuto-rostrata*) Carte and MacAlister's [2] statement is incomplete, but their description I take as meaning that at least one complete ring is present. Turner [3] describes in *B. sibaldii* three "somewhat irregularly formed cartilaginous hoops immediately above the bifurcation." In the illustration of his plate viii, fig. 37, the ventral ends appear in contact but not fused. On the left side there are five free tips abutting on the membrane, on the right six, one being a small bit of cartilage opposite the tracheal bronchus. In the same species Beauregard and Boulart describe five open rings. The first and second are connected to the right of the median line, and similarly the third and fourth to the left.

Bronchi.— Only their extra-pulmonary portions are here considered. The tracheal, or right apical bronchus, is given off just caudad of the apex of the lung and immediately enters its substance, the lung filling the angle between it and the right stem-bronchus so completely, that only along its lateral aspect can it be said to be extra-pulmonary, and here it is lodged in a deep groove in the lung. Its diameter is 3 mm. The bifurcation is concealed by the arch of the aorta. The stem-bronchi diverge slowly and are in contact by their mesal walls as far as the level of the right pulmonary artery. The right then curves strongly dextrad and enters the lung under cover of the artery, having the pulmonary veins below it at the turn, though the upper vein soon passes to its ventral surface. The left primary bronchus takes a longer and more oblique course to the hilum, passing dorsal to the right pulmonary artery. At its entrance the left artery is rostral to it as is also the left upper vein, the remaining two pulmonary veins on this side are caudal to it. The right primary bronchus measures 4.5 mm. in diameter, the left 4 mm.

The Thorax.

(*Plates XLIX, Figs. 2 and 3, L.*)

The thorax is broad and deep, approaching the keeled form ventrally, the dorsoventral diameter apparently exceeding the transverse, though in consequence of the distortion of its right side but little reliance can be placed upon its proportions. The rostral closure of the cavity, inside the arch of the first rib, is largely effected by the great rectus-scalene muscle-complex, between the diverging arms of which the dome of the pleura is embraced, there being

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[1] Beauregard and Boulart. Jour. de l'Anat. et de la Phys., T. 18, p. 623.
[2] Carte and MacAlister, *op. cit.*, p. 243.
[3] Turner, W., *op. cit.*, p. 236.

left beyond the dome a pyramidal space containing fat. The existence of this space would suggest that the recession of the apices of the lung was due to intrinsic causes, and not primarily to the shortening of the neck or the great development of muscles in this situation. Ventrally are the sternohyoid and sternothyroid muscles; the triangular interval between them and the scalene gives passage to the great vessels, vagus and phrenic nerves, and is covered superficially by dense cervical fascia. The space thus defined though large is no more than adequate for the passage of the œsophagus, trachea and laryngeal sac. Caudad the diaphragm is attached ventrally between the ends of the sixth ribs, thence ascending in the midline to the fourth space. To this ascending slope is attached the pericardium. From the postcava the diaphragm slopes dorsad and caudad attaining its most caudal point at about the middle of the last rib. This division of the diaphragm into two sharply defined planes meeting at an angle, appears to be a fœtal condition dependent upon the unexpanded condition of the lungs.

Pleuræ.— The dome of the pleura is lodged in the interval of the scalene-rectus complex, rising high in the first space, but not reaching the caudal margin of the first rib. Here the posterior thoracic artery and accompanying vein cross its summit. The reflection of the pleura dorsally follows the margin of the rectus capitis anticus major, overlapping its ventral surface increasingly caudad, and this more on the right side than on the left, to reach the beginning of the descending aorta. From this point the sacs of the two sides are in contact and their reflections cross the aorta obliquely, passing from its right to its left side as they proceed caudad. On the diaphragm they are separated by the pericardial attachment, coming together again upon the ventral thoracic wall and so continuing to the first space, there passing transversely laterad to the posterior thoracic artery along which they ascend to the dome. On account of the obliquity of the diaphragm the pleura extends farther caudad dorsally than ventrally, and reaches farthest caudad in the angle of the diaphragmatic origin, between its attachment to the last rib and its lateral crus. This point is at about the middle of the rib, and is distant 76 mm. from the dome of the pleural. Ventrally in the midline the extent of the pleura is 43 mm. and in the approximate dorsal midline, along the aorta from the beginning of its descending portion to the hiatus aorticus, it is 46 mm. The pleural sacs are widely separated at the rostral thoracic aperture by the great size of the mediastinal complex as it passes into the neck, especially the trachea and the laryngeal sac. A well defined ligamentum latum descends from each hilum to the diaphragm.

Lungs.— The lungs are long and rather narrow, attaining their greatest vertical breadth at the junction of pericardium and diaphragm, where an angle is formed in the ventral margin. Beyond this they narrow slowly by the retreat of the ventral margin and are abruptly truncated caudad. As the ventral margin turns here to an approximately transverse course a small angular projection is formed, which is the most caudal point of the lung. Mesal to this the margin ascends slightly cephalad before becoming transverse. From the angle at the pericardio-diaphragmatic junction caudad the margin is very sharp and is formed by a narrow fold of visceral pleura, into which pulmonary tissue has not extended and which is translucent when held to the light. The rostral portion of the ventral margin is thick and rounded, extending to the apex with a sinuous course. At the sides of the pericardium it is concave, as is also the mediastinal surface, while rostrad, beyond the pericardium both margin and surface become convex. The dorsal border is thick and massive filling the costovertebral groove. It is straight except at its beginning and end where it curves ventrad to a slight degree. The surface of the lung is smooth and uniform showing no trace of fissures or of lobulation. The diaphragmatic surface is separated from the mediastinal by a massive ridge, which fills the shallow pericardio-diaphragmatic groove. On the costal surface, extending from apex to the projecting angle of the caudal margin is a low sagittal ridge which divides this surface into dorsal and ventral portions. It corresponds to the angles of the ribs. The foregoing, while applicable to both lungs, is based more particularly upon the left; the right in consequence of the bend of the thorax is somewhat flattened caudally and bears very deep impressions of the ribs on its costal surface. The left lung has a length of 59 mm. Its greatest vertical breadth, at the pericardio-diaphragmatic angle is 22 mm.; its greatest thickness, at the same point, 16 mm. The right lung measures 55 mm. in length, 25 mm. in breadth, 14 in thickness; but these dimensions, especially the last two, are altered by the deformation of the lung. The apices are blunt and are grooved by the posterior thoracic artery and the accompanying vein, which cross them in a dorso-lateral direction. The subclavian vessels in their arch over the first rib do not come in contact with the apices of the lungs; the thoracic portion of the left artery is however in contact with the mediastinal surface of the left lung. The interval between the subclavian arch and the apex of the lung, must in my judgment be ascribed to a reduction of the lung itself, coincident with and in excess of the skeletal shortening affecting the cervical and upper thoracic regions.

Müller [1] in the course of an elaborate study of the lungs of aquatic mammals has described those of *Balænoptera musculus*. A comparison with his figures shows a general close resemblance to the conditions present in this fœtus, but in his specimen the apex is more deeply grooved. His seventeenth figure shows a left lung dorso-ventrally flattened, the right having a well marked ridge, which probably corresponds to the angles of the ribs, in contrast to the flattened right lung and more smoothly rounded ridge on the costal surface of the left lung in this fœtus. Evidently the question of preservation and in particular the position of the fœtus in its containing jar is a factor, which ought not to be lost sight of in considerations upon the form and surface relief of the viscera.

The mediastinal surface is separated from the diaphragmatic by a well defined ridge which is in apposition with the fat pad of the pericardio-diaphragmatic junction. Both surfaces are concave, the mediastinal strongly so when it comes to be applied to the pericardium ventral to the hilum. Rostrad it becomes convex, on the left side presenting a gutter for the termination of the aortic arch, from which ascends towards the apex a shallow subclavian groove. On the right side in this surface is a deep notch-like groove extending to the apex, which lodges the tracheal bronchus. The depth of the groove seems to have been exaggerated and its angularity occasioned by the torsion of the fœtus to the right. The point of entry of the bronchus is 4 mm. from the apex. The hilum of the left lung has a length of 15 mm. Its upper extremity is 17 mm. from the apex and 7 mm. from the ventral margin, its lower 11 mm. from this margin. On the right side the entrance of the tracheal bronchus is independent of the hilum, with which it is connected only by a continuous pleural reflection. Between the two ventrally and the shallow groove of the precava is a prominence of the mediastinal surface. The main hilum has a length of 18 mm. and its rostral end is 12 mm. from the apex.

Pericardium.— The pericardium is broadly exposed between the ventral margins of the lungs and is separated from the thoracic wall only by the sinus costomediastinales of the pleuræ.

[1] Müller, O. Untersuchungen über die Veränderungen welche die Respirationsorgane der Säugetiere durch die Anpassung an das Leben in Wasser erlitten haben. Jena. Zeitschr. f. Naturw., Bd. 32, 1898.

PLATE L.

PLATE L.

Balænoptera borealis.

Fig. 1. Thoracic viscera, ventral view. Twice natural size.
Fig. 2. Thoracic viscera, ventral view. The heart and great veins have been removed. Twice natural size.

1. Thyroid cartilage.
2. Muscle of tracheal sac.
3. M. cricothyroideus.
4. Phrenic nerve.
5. Internal jugular vein.
6. Common carotid artery.
7. Thyroid gland.
8. Superior intercostal vein.
9. Posterior thoracic artery.
10. Precava.
11. Lung.
12. Thymus.
13. Pulmonary artery.
14. Right atrium.
15. Left atrium.
16. Right ventricle.
17. Left ventricle.
18. Pericardial fat pad.
19. Diaphragm.
20. Right brachiocephalic artery.
21. Left common carotid artery.
22. Left subclavian artery.
23. Arch of the aorta.
24. Stump of aorta.
25. Glandular body, possible parathyroid.
26. Reflection of serous pericardium.
27. Upper left pulmonary vein.
28. Lower left pulmonary vein.
29. Middle left pulmonary vein.
30. Right pulmonary artery.
31. Right pulmonary veins.
32. Postcava.
33. Cut edge of fibrous pericardium.

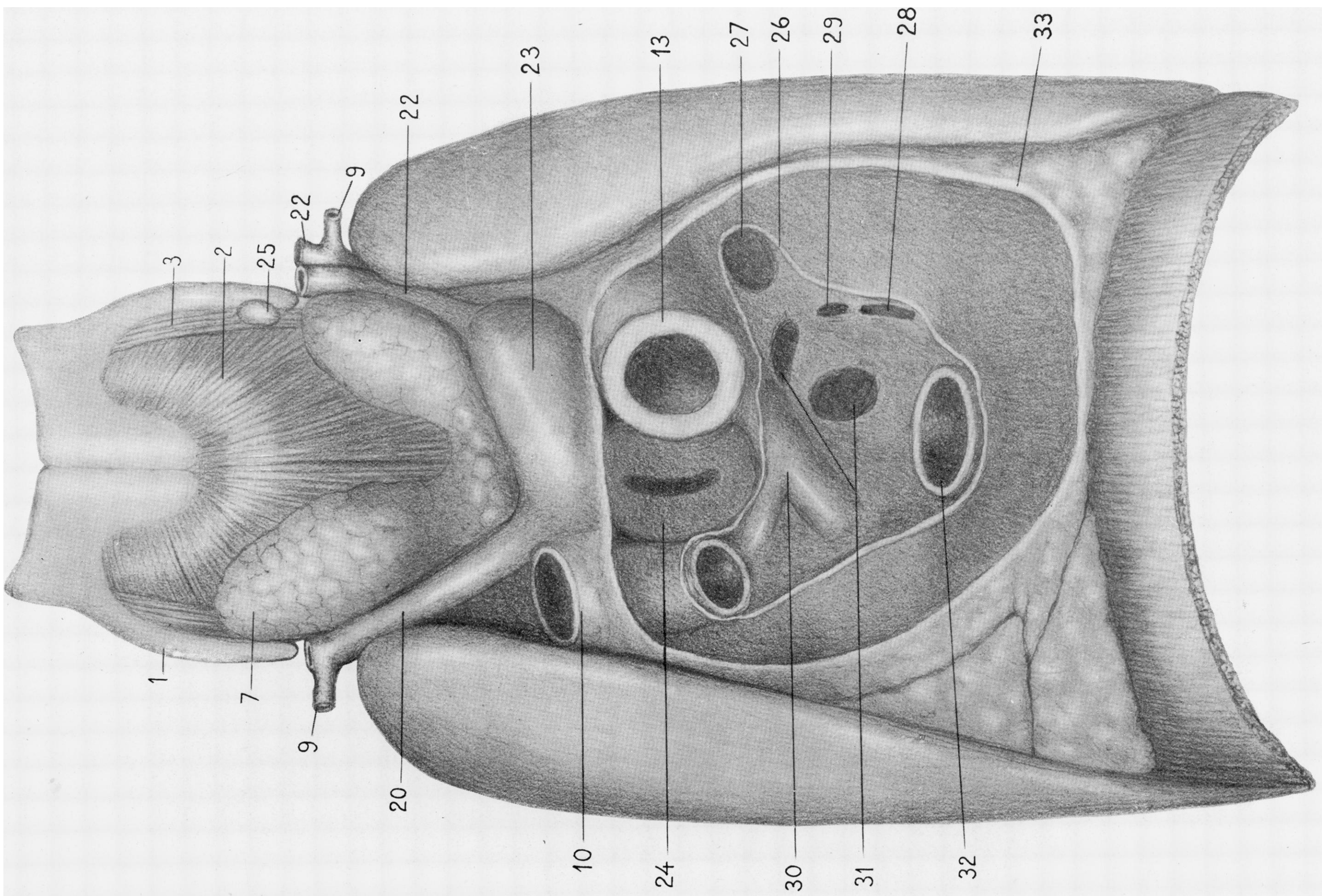

Fig. 2.

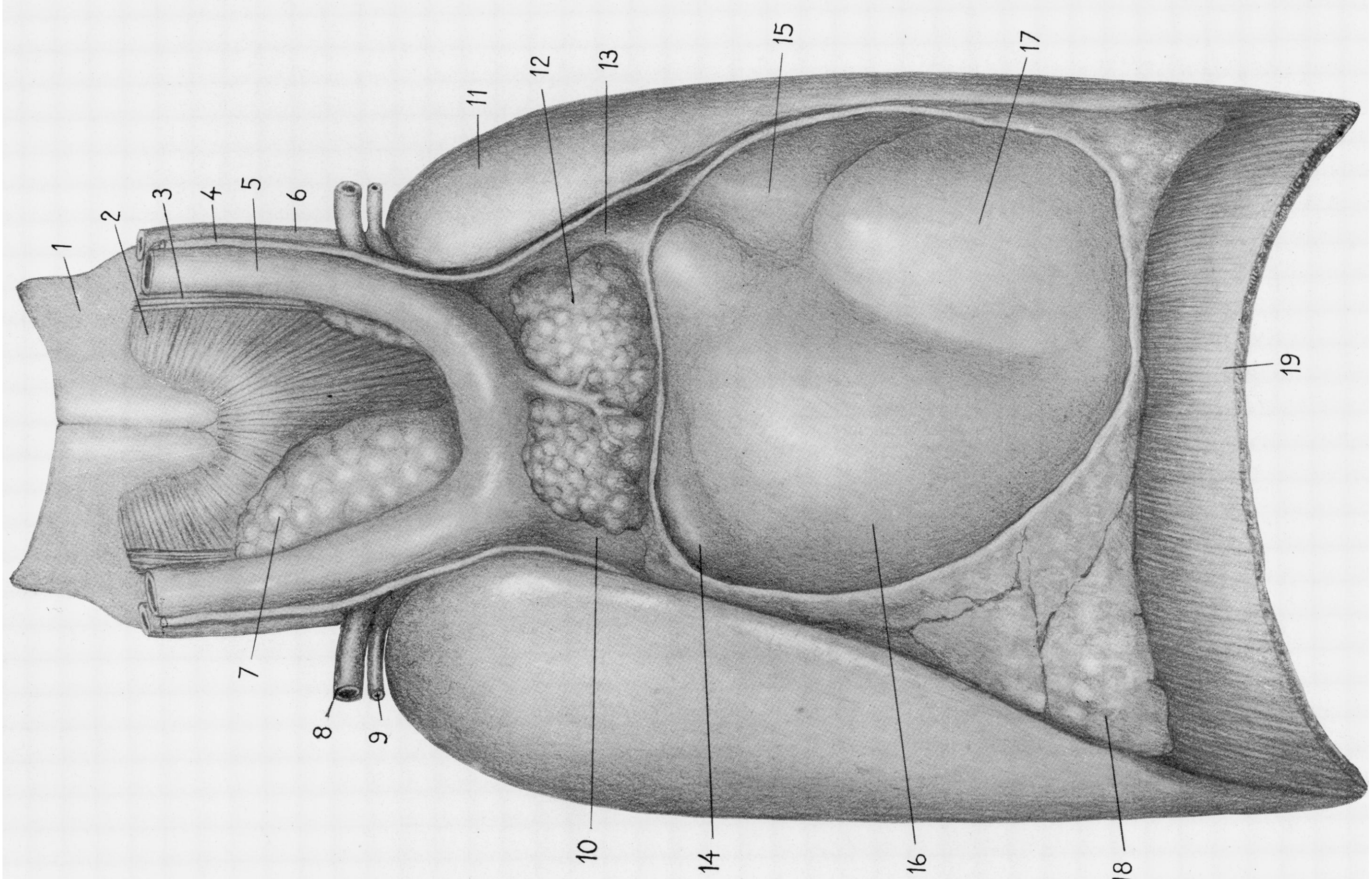

Fig. 1.

BALÆNOPTERA BOREALIS.

Above its fibrous layer blends with the adventitia of the precava, aorta and pulmonary artery. Below it is very broadly attached to the ventral slope of the diaphragm. The pericardium attains its greatest breadth at about its middle and thence contracts somewhat towards the diaphragm. The resulting groove at their junction is filled by a large subpleural fat pad, which is continuous across the median line, but attains its greatest size at the sides. While this compensates in large part for the contraction of the pericardium, it does not do it so completely but that the lung presents a ridge as the boundary between its phrenic and mediastinal surfaces.

Not only is the pericardiac-phrenic adhesion very extensive, but a further evidence of crowding in this region is offered by the serous layer of the pericardium, in which the oblique sinus has been obliterated. The reflection on the dorsal wall after passing from the right side of the precava to that of the postcava sweeps ventrad to the latter, and there passes directly to the lower left pulmonary vein, which is just to the left and rostrad of the postcava as it enters the atrium. The line of reflection then ascends to the upper left pulmonary vein, there turning obliquely to the right to reach the precava. In the area thus exposed are situated the pulmonary veins of which there are three on the left, a small intermediate one entering the auricle independently. To the right of the pulmonary veins is the large obliquely directed right pulmonary artery, which grooves the dorsum of the right atrium between the caval veins. The pulmonary artery and aorta are enclosed as usual in a common tube of serous pericardium. The circular sinus, on account of their large size and the rostro-caudal compression of the heart, is of small dimensions.

Heart.— The heart is markedly contracted in the diameter corresponding to the longitudinal axis of the fœtus and markedly broadened from side to side. Its greatest breadth is 31 mm.; from base to apex it measures 29 mm.; its base has a rostro-caudal height of 19 mm. That this shape of the heart stands in relation to the shortening of the ventral wall of the thorax and is one of the effects of adaptation of the body-form to aquatic life, has been demonstrated by Müller on the basis of unusually abundant comparative material. He has also found further consequences of these factors in the extensive adhesion of the pericardium to the diaphragm and the suppression of the lobation of the lungs. The long axis of the heart itself tends further to approach more or less a dorso-ventral direction. In this fœtus it not only deviates slightly to the left — the faint notch at the distal end of the interventricular furrow was situated about 3 mm. to the left of the midline — but it has in addition a distinct inclination caudad, corresponding to the slope of the ventral plane of the diaphragm. The heart itself has undergone but the slightest degree of rotation upon its axis, and the areas occupied by the ventricles on its phrenic and ventral surfaces are subequal. This may be expressed in terms of the right ventricle, the ventral surface of which at its middle has a breadth of 10 mm., the phrenic 9 mm. Similarly the phrenic surface of the left ventricle slightly exceeds the ventral. The right and left borders of the heart are equally acute and almost symmetrical in position. By reason of the great size of the pulmonary artery and the aorta, the interauricular notch is very wide and deep, and the atrial septum reduced to little more than the narrow limbus of the fossa ovalis and its valve. The postcava enters the right atrium far to the left in reference to the precava. The latter is marked at its entrance ventrad by a deep veno-atrial angle, which forms the starting point of the sulcus limitans. This can be followed only about two thirds of the way to the postcava. Between the cavæ the wall of the atrium is inflected by a deep oblique groove which lodges the right pulmonary artery, occasioning an ental prominence approximately in the position of the intervenous tubercle (Loweri). Entally the atrio-ventricular rings are very prominent and from them many muscular trabeculæ radiate to the walls of the auricles, which by their caudal margins overhang and conceal the atrio-ventricular sulcus. This holds true only of the ventral and lateral margins of the venous ostia; mesad and dorsad the rings sink to the level of the respective walls of the heart. The right auricle has a crista terminalis conforming in extent to the sulcus of the same name ectally. From this trabeculæ extend in an irregular manner to the wall of the auricle. On the left side there was an arched ridge from beside the upper pulmonary vein, bifurcating laterally and being attached to the atrio-ventricular ring at two points. From this also trabeculæ were given off. On neither side had the musculature of the auricle anything approaching a pectinate arrangement.

The right atrium is noteworthy for the total suppression of the right sinus valve. As in other Cetacea there is no Eustachian and no Thebesian valve. The large orifice of the coronary sinus has however a sharp and slightly overhanging margin in the caudal half of its contour. The limbus fossæ ovalis is a well defined but narrow frame to the fossa, which is placed immediately caudad of the intervenous tubercle. The atrial septum as has been said is small and the atria diverge widely ventrad, as in reptiles, and for the same cause, the great size of the vessels to be accommodated between them. The valve of the fossa ovalis is highly peculiar in that it is attached in its entire circumference to the limbus and has no free edge. It protrudes in the left atrium as a long funnel or cornucopia with a fenestrated fundus. Knox [1] described it in the heart of a fœtal *Balæna mysticetus* as "a membranous sac, the size of a full-sized thimble. presenting at the bottom a delicate reticulated network, and projecting into the left auricle." Turner [2] from whom this quotation is borrowed describes the structure in a fœtus of *B. musculus* measuring 19 ft. 6 in. in length. "In the interauricular septum an almost circular foramen readily admitting five extended digits was situated. Surrounding this opening and attached to its edge, a loose, membranous, annular fold, formed by a duplication of the endocardium was seen. When put on the stretch it projected into the auricle, and the projecting border was free and pierced with large fenestræ. Although this fold was situated in the right auricle, when I opened into that cavity, yet it could without difficulty be passed through the foramen into the left auricle. At the attached border, again, the membrane was almost entire, and most perfect in its anterior, external and posterior portions, where the depth from the attached to the free margin was four inches." In this fœtus the valve measures 7 mm. in length. The foramen at the limbus 6 mm. by 4 mm. The funnel depended completely free into the left atrium and was not maintained in position by reticnacula, save that near its base ventrally a very small fold, like a minute frenulum, connects it with the wall of the atrium. In a much larger heart from a fœtal *Megaptera* preserved in spirits by Mr. Andrews, the valve had the same general character, but had contracted adhesions ventrally with the atrial wall for about one third its length. These were not sufficient to prevent the valve from being inverted into the right auricle, where it was found folded and collapsed as in Turner's specimen. In the adhesions at the base of the valve may be seen the initiation of a process of closure, which appears to differ from that known in other vertebrates. Were these adhesions to continue distad to the fundus of the valve, its ventral portion would become fused with the atrial wall in its whole extent. The remainder would then occupy a posi-

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[1] Knox, R. Catalogue of Anatomical Preparations of the Whale. Edinburgh, 1838.

[2] Turner, Wm. An Account of the great finner whale stranded at Longniddy (*Balænoptera Sibaldii*). Trans. Roy. Soc. Edin., 1872.

tion on the left of the septum similar to that of the usual valve of placentals, from which it would differ in its great length and in its extensively fenestrated margin, which would be attached to the atrial wall by the numerous strands intervening between the fenestræ. The establishment of subsequent adhesions would effect the definitive closure of the foramen. The peculiarity of the valvula here consists primarily in its ballooning into the left auricle, a condition recorded by Röse[1] only in *Terrapene*, and it may be noted in passing that at the fundus the septum in this form was very thin in places and the separation of the atria was effected only by endocardium. Though actual communications are not formed in reptiles, the condition is certainly strikingly analogous to the funnel-like valve of the Cetacea with its fenestrated fundus. A second peculiarity, though one shared by birds, monotremes and marsupials (Röse) is in the site and multiplicity of the perforations of the septum primum. This maintains itself in its upper segment where the foramen ovale secundum of placentals is established, which so comes later to be covered on the right by the crescentic downgrowth of the septum secundum. Here the perforations are small and multiple and occupy the middle of the septum primum. In consequence, when the septum secundum develops on the right and comes to be amalgamated with the primum, the latter has no free edge but is attached in its whole circumference permitting communication between the atria by way of its fenestrated middle. In birds, monotremes and marsupials the perforations are closed by proliferation of the endocardium, and there is plain evidence of the embryonic process in the structure of the valve of the adult (Röse), which is marked by a reticulum of ridges with intervening thinner areas. In the adult Cetacean I have not found in the descriptions of the atrial septum a record of this type of structure. In view of the adhesions ventrally at the base of the valve, I have ventured to suggest the mode of closure outlined above. It is possible to see in the form of the septum primum provision for its valvular function. The funnel, on account of its length, can be applied as a whole to the wall of the left atrium, ventral to the region of the interatrial septum, and being here compressed against the wall and its lumen obliterated, may in this way prevent regurgitation from the left atrium to the right. Secondarily this position is favored and in part at least rendered permanent by the adhesions between the base of the funnel and this region of the atrial wall. There is of course a possibility that a circular arrangement of the muscle of the valve may by a sphinter action assist its function.

In other respects the heart conforms to the usual conditions and presents little that requires comment. The left atrium receives two pulmonary veins from the right lung, three from the left, the small additional vessel opening between the other two. The atrioventricular valves have the usual arrangement. As Turner has pointed out the papillary muscles are numerous, and are not very clearly separated into groups. In the right ventricle there is a large moderator band. The conus arteriosus is capacious in contrast to the rather narrow aortic vestibule. The same disparity obtains between the arch of the aorta and the pulmonary artery, the latter having a wide circular lumen, while that of the former is reduced to a narrow slit. The interventricular foramen is closed.

Thymus.— The two lobes of the thymus rest upon the pericardium and the arch of the aorta immediately caudad of the left brachiocephalic vein. They are subequal, disk-like, the right nearly circular, the left oval with its long axis transverse. Their ventral surfaces are

[1] Röse, C. Beiträge zur vergleichenden Anatomie des Hertzens der Wirbelthiere. Morph. Jahrb., Bd. XVI, 1890.

convex and distinctly lobulated, the dorsal nearly flat. Between them is a large thymic vein which opens into the left brachiocephalic. The right measures transversely 7 mm., sagittally 6 mm., and has a thickness of 4 mm.; for the left body these dimensions are respectively 8 mm., 6 mm., and 3 mm.

Thyroid.— The Thyroid has the form of a U; the isthmus is constricted and the lateral lobes retort-shaped with their broad extremities rostrad. The gland is in contact with the fundus of the tracheal sac, but has an asymmetrical position, the right lobe nearly sagittal, the left with a distinct inclination laterad, to such a degree indeed that it is wholly concealed by the left brachiocephalic vein, while the right appears in ventral view between the right vein and the tracheal sac. The right lobe measures 13 mm. in length; its greatest breadth is 5 mm., and greatest thickness 3 mm. The corresponding dimensions of the left are 7 mm., 5 mm., and 4 mm. It is thus not only asymmetrical, but the left lobe is also smaller. Near its rostral pole on the left is a small oval body about 3 mm. by 2 mm., of glandular appearance, possibly one of the parathyroids. The isthmus measures 4 mm. transversely, by 2 mm., sagittally.

Abdomen.

(*Plates LI–LIII.*)

The abdominal cavity is broad, deep and capacious in its rostral portion; caudad it is a narrow space of triangular cross-section bounded on its dorso-lateral sides by the great hypaxial muscles and ventrally by the bladder, urachus and accompanying hypogastric arteries. The conformation of the parts is such that the plane of the umbilicus affords a natural and convenient division between these regions. The caudal margin of the umbilicus is approximately in the same transverse plane as the tip of the last rib, in this specimen the thirteenth, and this rib by its extremity is in relation with the first third of the kidney. The large rostral region of the abdomen is thus at the sides wholly under cover of the ribs, its ventral closure being given by the massive recti. The attachment of the diaphragm in the ventral midline is at the level of the extremities of the sixth ribs, the highest point of the dome — the caval aperture — lies in the fourth space vertically above the extremity of the fourth rib. The caval aperture is situated in a transverse groove, which marks the abdominal surface of the diaphragm, dividing it into a ventral slope corresponding to the pericardium and a dorsal slope, which on its thoracic aspect corresponds to the diaphragmatic surfaces of the lungs and costophrenic sinus. The even slope of this dorsal or caudal plane of the diaphragm is marked on each side by a shallow fossa; that on the right is the result in the hardened specimen of moulding upon the right lobe of the liver; that on the left upon the first compartment of the stomach. In addition to the viscera named, the cephalic compartment of the abdomen contains the spleen and pancreas, the duodenum, the colic loop and practically the whole of the jejuno-ileum, only a very few of its most caudal coils lying caudad of the plane connecting the umbilicus with the last rib. Against its dorsal wall, retroperitoneally, are placed the adrenals, the suprarenal segment of the postcava and the upper poles of the kidneys. The liver predominates upon the right, approximately three fifths of its bulk lying to the right of the midplane, caudally overlying the right kidney for nearly half the length of the latter organ. To it caudally are closely applied the pancreas, the ampulla duodeni, and the stomach, the gastro-hepatic omentum being reduced to little more than reflec-

PLATE LI.

PLATE LI.

Balænoptera borealis.

Fig. 1. **Ventral view of genito-urinary apparatus *in situ*. 2 × natural size.**

Fig. 2. **Jejuno-ileum, ventral view. 2 × natural size.**

Fig. 3. **Jejuno-ileum, dorsal view. In these two figures the major coils which pass from left to right are tinted, those passing from right to left are uncolored.**

1. Adrenal.
2. Kidney.
3. Ovary.
4. Oviduct.
5. Ostium abdominale.
6. Cornua of uterus.
7. Bladder.
8. Colon.
9. Postcava.
10. Left adrenal vein.
11. Cœliac axis.
12. Superior mesenteric artery.
13. Umbilical artery.
14. Ligamentum latum.
15. Ligamentum teres.
16. Fold on venter of lig. latum.
17. Plica diaphragmatica ovarii.
18. Mesentery.
19. Reflection of peritoneum upon visceral complex.
20. Left coronary ligament.
21. Œsophagus.
22. Proximal jejunum.
23. Terminal ileum.
24. Centrum tendineum.

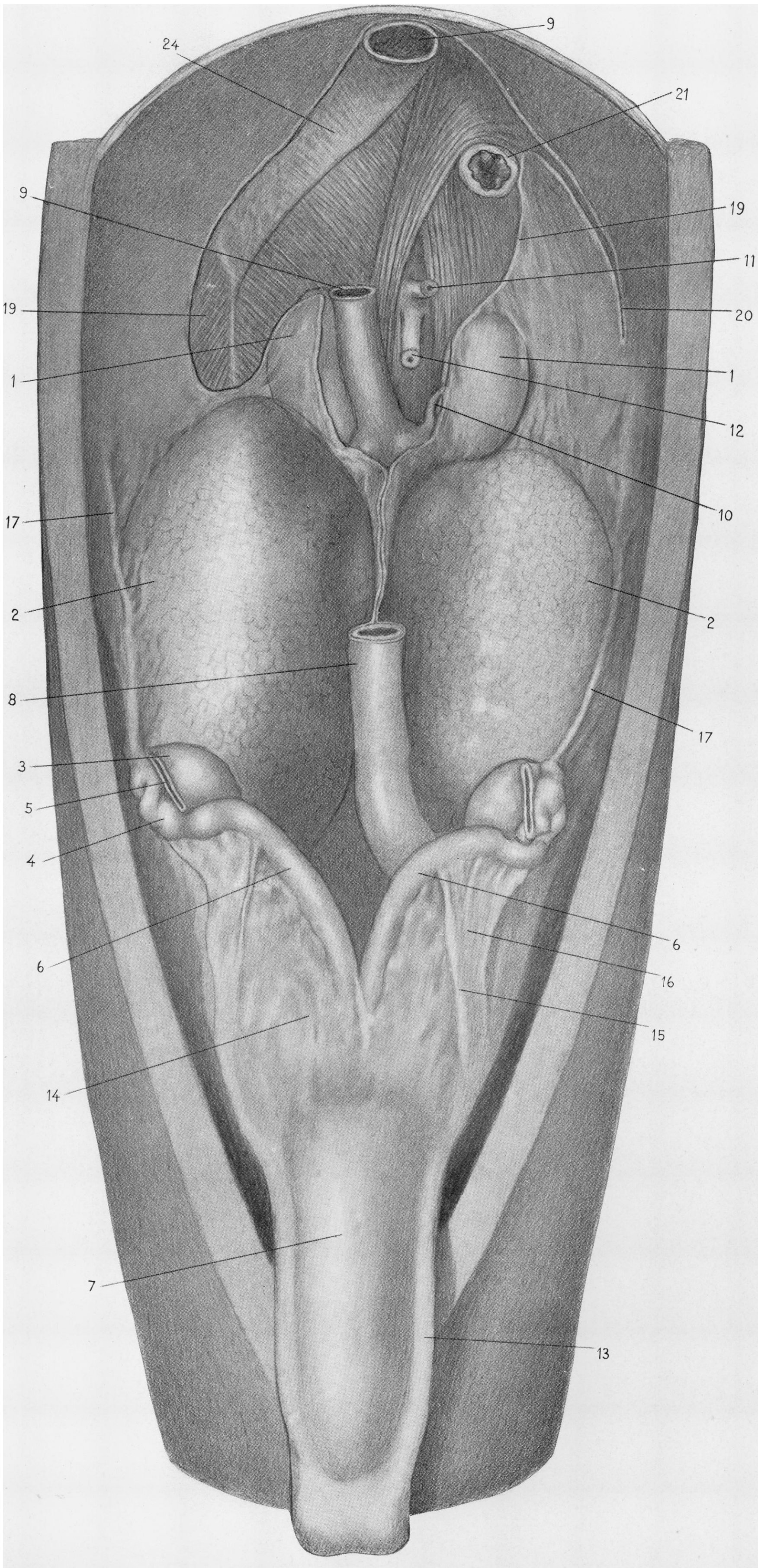

Fig. 1.

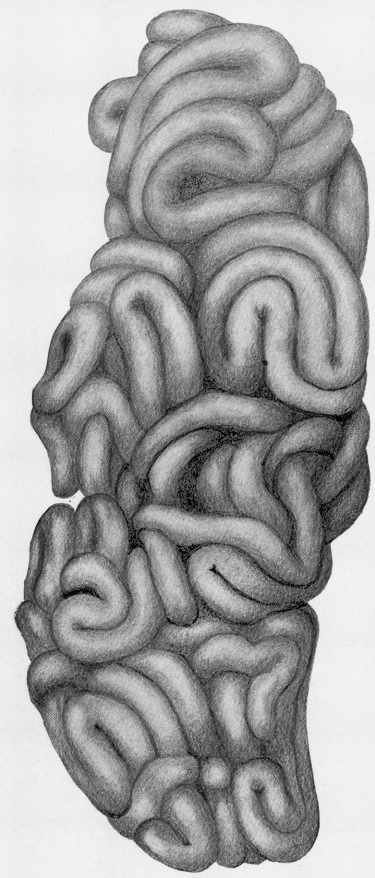

Fig. 2.

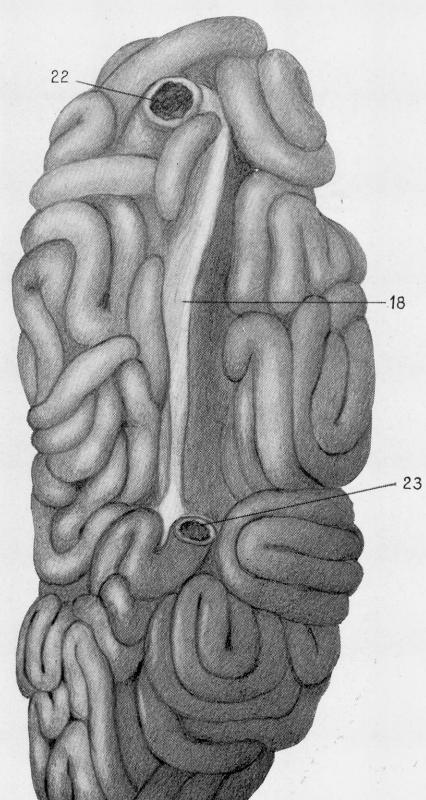

Fig. 3.

Balænoptera borealis.

tions of peritoneum. Thus there is left for the closely packed coils of the small intestine an oblong space extending from the diaphragm, rostrad and on the left, to the median surface of the right kidney, caudad and ventrad. The loop of the duodenum is anchored to the posterior parietes as is also the arch of the colon which loses its mesentery above the level of the transverse portion of the duodenum.

The postumbilical division of the abdomen is very narrow. It is contracted at its commencement by the projecting kidneys and, ventrally, by the large mass of the urachus and hypogastric arteries. Into the pyramidal interval between these project a few coils of the small intestine. Caudad of the kidneys the broad ligament divides the space into a dorsal compartment containing the colon and a ventral one containing the bladder. The ventral compartment is limited caudad by the reflection of the peritoneum from the neck of the bladder to the uterus. The dorsal compartment is prolonged as a narrow recess between the rectum and vagina, and eventually is brought to an end close to the perineum.

Œsophagus.— The intra-abdominal segment of the œsophagus has a very considerable length, measuring from the diaphragm to its cardiac orifice 10 mm. It descends with a slight sinistral inclination on the dorsal aspect of the first gastric compartment, in reference to which it is placed also somewhat to the right, as Jungklaus [1] has pointed out. On the left it is defined by a shallow furrow, while to the right and ventrally it is separated from the stomach by a deep incisure, which in the natural condition of the parts is filled with rather firm connective tissue. Caudad its relief gradually merges in that of the first compartment. The conformation of the cardiac orifice corresponds with the external character of this junction. Above and on the right it is marked by an arched ridge, which diminishes to the left, while below, its dorsal wall is continued into that of the stomach without demarcation. The lumen is marked by low longitudinal ridges; immediately below the diaphragm it is open, having a transverse diameter of 2 mm., but distad as it becomes applied to the stomach, its walls are in contact. The walls here are about 1 mm. in thickness and the tube as a whole is slightly flattened dorso-ventrally.

Stomach.— Four compartments are present exclusive of the duodenal ampulla, which is clearly marked off from the stomach by a sulcus ectally and by the flaring funnel of the pylorus within. This enumeration agrees with that of Pilliet and Boulart,[2] and with the more recent results of Jungklaus, who to a careful resumé of the literature has added his own observations, based so far as *Balænoptera* is concerned, upon three fœtuses of *B. musculus*, the youngest measuring 63 cm. While conforming in the main to Jungklaus' description, this fœtus shows marked differences in the conformation of the third compartment. The minor peculiarities in the shape and proportions of the other divisions are probably referable to the smaller size, possibly also to the species of this fœtus. The whole organ is admirably preserved.

The first compartment is too little expanded to deserve Hunter's appellation of egg-shaped. It is widest at its middle, thence diminishing towards both extremities. The fundus is bluntly rounded, almost truncated in external view. Here both muscularis and mucosa are thickest; then become thinner towards the apex of the stomach, which does not correspond accurately with the junction of the first and second compartments, but is formed by the second alone as in older fœtuses (Jungklaus). The long axis is directed caudad, to the left and somewhat dorsad, so that the fundus rests against the arch of the colon, and the right margin forms almost a right

[1] Jungklaus, F. Der Magen der Cetaceen. Jena. Zeitsch. f. Naturwiss., Bd. 32, 1898, p. 1.
[2] Pilliet et Boulart. L'estomac des Cétacés. Jour. de l'Anat. et de la Physiol., An. XXXI, 1895.

angle with the greater curvature of the second compartment. From this angle a shallow furrow ascends upon the venter of the stomach towards the apex to the level of the communication between the first two compartments. A rather deep cleft is present dorsally in a corresponding position; it is filled with areolar tissue and in it the gastric artery breaks up into its large branches. Except for the actual region of communication, therefore, the first and second compartments are well demarcated ectally. Entally the orifice of the œsophagus is placed at the junction of the upper and middle thirds. And here the folds of the dorsal wall are continued into the œsophagus. At the sides, however, there is no radiation from the orifice, the longitudinal folds passing it on the left with no disturbance of their pattern. This holds true of the right side also in general, but here a prominent ridge arches round the opening, and this is crossed by several shallow sulci which converge towards the œsophagus. They are confined to this single ridge and produce no alteration in the other folds. The folds are somewhat tortuous, and as the intervening sulci are narrow and deep, there is a distinct interlocking on the part of adjacent folds, which lends them the "cerebriform" appearance noted by Carte and MacAlister. Under the binocular this surface has the same texture as that of the œsophagus. The greatest length of this compartment from apex to fundus measures 21 mm.; its greatest breadth 6.5 mm.

The junction of the first and second stomachs is marked by an abrupt change in the mucous membrane, which has a softer, more succulent appearance in the second stomach. The character of the ridges changes also; ventrally the ridges of the first compartment simply subside, dorsally they become tortuous and irregular, in marked contrast to the even longitudinal folds of the second compartment. The line of junction is directed from the summit of the doubled wall, where the two compartments are in apposition, to the left and rostrad, passing very slightly to the left of the apex of the stomach. The orifice of communication has a nearly horizontal lower lip formed by the summit of the wall just mentioned; the remainder of its contour is arched. Vertically it measures 3 mm., transversely about 4 mm.

The second compartment is larger than the first and diverges from it to the right. It measures 24 mm. in a straight line from the apex to the orifice of the third stomach, 13 mm. in its region of greatest breadth. Its general shape is fusiform. The greater curvature is evenly convex; the lesser, at first strongly convex to the right, becomes concave distad and assumes a horizontal direction as the third stomach is approached. The walls are gently convex except where applied to the first stomach. Here, immediately below the proximal orifice, there is a slight bulging inwards of the left wall. The mucous membrane on the dorsal wall is thrown into several longitudinal folds, in some places connected by lower transverse ridges. The folds are best marked along the lesser curvature. A portion of the wall is smooth. The ventral wall, on the other hand, is marked by transverse, forking folds, which radiate from the base of the double wall which separates this compartment from the first. Farther distad are four or five oblique rugæ, running from the greater to the lesser curvature and converging towards the third stomach. Evidently in this compartment the primitive longitudinal folds are in process of being replaced by the transverse ones of the older fœtus (Jungklaus) and adult (Perrin). The surface of the mucosa is more delicate than that of the first compartment and appears finely granular; under the binocular this appearance is found to be due to the presence of small areæ gastricæ separated by shallow sulci.

The lower part of the second compartment adjacent to the greater curvature and leading to the orifice of the third requires a more particular description. It is partially set off from the remainder of the second stomach by an obliquely longitudinal ridge, which beginning near the middle of the greater curvature extends distad across the dorsal wall and reaching the lesser curvature changes direction, becomes transverse, and passes to the ventral wall. Here about midway between the curvatures it declines abruptly running out into small ridges which diverge towards the greater curvature. Beneath the arch of its transverse segment is left a small orifice of dorso-caudal position — that is in the region of the dorsal paries and greater curvature — which leads into the third compartment. A furrow on the ectal surface is associated with the proximal obliquely longitudinal segment of this ridge. It is very shallow and not of such a character as to suggest that the ridge may be the result of post mortem compression or shrinkage. A fold of that kind is present on the ventral wall of this compartment; it is easily obliterated by manipulation and has no resemblance to the formation we are considering, which is of solid massive structure. The portion of the second stomach distal to this ridge is marked by transverse folds of the mucosa and although it produces little external protrusion, evidently corresponds to Jungklaus's description of "einer relativ tiefen, ventralen, rinnenartigen Ausbuchtung auf der linken Seite; dieselbe führt direkt auf das Orificium des dritten Magens." [1]

The third compartment, defined against the second on the ectal surface by the slight furrow already mentioned, is distally without surface demarcation from the fourth stomach. Entally its boundary here is given by a ridge on the rostro-ventral wall, which displaces the orifice of communication to the region of the greater curvature dorsally. Thus both entrance and exit are adjacent to the greater curvature and of dorsal position. A third fold of intermediate size and corresponding to an ectal sulcus and angulation of the tube is placed between the other two. This springs from the dorsal wall and greater curvature leaving but a small communication close to the lesser curvature ventrally, to maintain the lumen of the compartment, which thus is rendered canal-like and of the shape of inverted U, for the intermediate fold is broad as well as high and appropriates a large part of the space between the other two folds. The mucous surface is smooth and shows no trace of other folds. The diameter nowhere exceeds 2.5 mm., the orifices are distinctly less. Its length is 6 mm., its diameter externally is 5.5 mm.

In older fœtuses of *B. musculus* Jungklaus describes a third compartment of radically different conformation. It was dilated, of thinner walls than the others, and defined by two changes of direction in the axis of the stomach, with resulting angulation and the formation of double separating walls at both its distal and proximal extremities. The two angulations of the distal portion of the stomach in this fœtus are incident, one at the middle fold of the third compartment, one in the terminal portion of the fourth stomach. It is difficult therefore to see in this stomach a stage antecedent to those of Jungklaus, for the supposition that such angulation can be effaced and new ones form has no observations to support it. This raises the question of divergence between the species of the genus in this character, a possibility which is in a measure suggested by the wide discrepancies in the literature of the third compartment in the adult.

The fourth compartment presents a change of direction in its course. In its proximal and longer portion its axis runs caudad, dorsad and to the right, in its short distal segment, rostrad, dorsad and very slightly to the left. This change is effected by a gradual curve on the greater curvature, but on the lesser is accompanied by a sharp angulation, immediately beyond which,

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[1] Jungklaus, F., *op. cit.*, p. 49.

indeed upon its distal slope, is situated the flaring pylorus. This projects strongly into the duodenum. The fourth compartment is thicker walled than the stomach elsewhere save at the fundus of the first. Its lumen diminishes rapidly towards the pylorus. In its widest portion it is smooth internally, but as it contracts it becomes marked with slight longitudinal ridges and sulci which are prolonged upon the projecting pylorus to its edge. In length this compartment measures 8 mm., in maximum diameter 6 mm. Its greatest lumen is 3 mm. which diminishes to less than 1 mm. just before the pylorus is reached.

Duodenum.— Four portions may be distinguished, the ampulla, descending, transverse, and ascending duodenum. The ampulla is a pyriform dilatation, attaining its maximum diameter a little distad of the pyloric sulcus and more gradually diminishing subsides to the dimensions of the rest of the duodenum at the sharp angle where it joins the descending portion. Its axis is directed dorsad, rostrad, and slightly to the left, continuing the direction of the terminal portion of the fourth gastric compartment. It has a length of 7 mm., a maximum lumen of 2.5 mm., which at its junction with the descending duodenum is reduced to 1 mm. Its walls are thickest at the pylorus and diminished in strength distad. The mucous surface shows no folds but is beset with numerous conical to finger-shaped villi. The ampulla rostrad and on the left is in relation with the horizontal portion of the pancreas and is crossed dorsad and to the right of this by the portal vein and hepatic artery on their way to the liver. On the right it is free and covered by peritoneum, while caudad it is in peritoneal contact with the descending duodenum.

The remainder of the duodenum describes a typical loop about the root of the mesentery. It is U-shaped with a tendency to angulation at the junction of its descending and transverse portions. The loop is occupied by the vertical portion of the pancreas, leaving a broad longitudinal space to the left for the large superior mesenteric artery and vein. The whole descending duodenum and the transverse, as far as these vessels, are free and covered by peritoneum dorsally, so that only the curved termination of the transverse and the ascending portion have become adherent to the parietes. The degree of anchorage of the duodenum is thus seen to be small and limited to the portions to the left of the median line. The descending duodenum runs caudad, distinctly ventrad and slightly to the right, being closely applied to the ampulla and pyloric extremity of the stomach, to which however no adhesions have been contracted. The transverse duodenum passes behind the ascending colon, from which and from the colic portion of the mesenterium commune it is free, the root of the mesentery persisting in its primitive condition and not being extended by secondary adhesions caudad and to the right, in the direction of the iliac fossa. This is the explanation I believe of Hunter's [1] statement: "in this course behind the mesentery it is exposed, as in most quadrupeds not being covered by it, as in the human," which Weber finds difficult to understand. The ascending duodenum passes cephalad and to the left, between the root of the mesentery and the descending colon, to both of which it is adherent though to the colon only close to the duodeno-jejunal angle. This flexure is placed immediately below the arch of the colon, the intestine here turning ventrad and to the right at a sharp angle. Thus the loop of the duodenum with the included portion of the pancreas and the root of the mesentery form a disk, to the front and left border of which the colon has been applied, and which has contracted secondary adhesions dorsally to the parietes only along

[1] Hunter, John. Observations on the structure and economy of whales. Philos. Trans., 1787.

the lines of the postcava on the right and the ascending duodenum and angle of the colic arch on the left of the primitive mesenteric root. As a result the descending duodenum, more than half of the transverse, and a considerable area of the pancreas are free on the right of the postcava, while the ascending colon covers and is adherent to the vertical portion of the pancreas, ventrally concealing it from view. On the other hand the duodenum is wholly excluded from the lesser sac, the usual peritoneal surface on the left of its first portion, here ampulla, is occupied by the horizontal portion of the pancreas, which from its high position and adherence to the liver must be considered to have invaded the gastro-hepatic omentum near its primitively free margin, following the line of the bile duct and portal vein ventrally, in the position occasionally taken by the development, as a variant, of the left ventral pancreatic anlage. The peritoneal covering of this region is still further reduced by the obliteration of the foramen of Winslow (*vide infra* p. 452).

In its interior the duodenum is smooth save for the presence of finger-shaped and conical villi. I did not lay it open in its full length, but only to the beginning of its transverse portion. In this portion there were no valvulæ conniventes and the only definite longitudinal ridge was related to the intramural portion of the bile duct. This elevation began at the angle between the ampulla and the second portion and continued through about half the length of the descending duodenum. At its distal extremity was a small punctate orifice. The several portions of the duodenum had the following lengths irrespective of their curvature: ampulla 7 mm.; descending 11 mm.; transverse 10 mm.; ascending 14 mm.

Jejuno-ileum.— The remainder of the small intestine forms a closely coiled mass which occupies an oblique position in the abdomen, extending from the first compartment of the stomach and the diaphragm on the left, caudad and dextrad to the interval between the extremity of the liver and the right kidney. The intestine is all but wholly confined to the preumbilical portion of the abdomen, only a few small coils project beyond the umbilicus into the space between the kidneys. The mesentery has a short attachment to the right of the ascending duodenum occupying the interval between it and the ascending limb of the colon loop. At the cephalic margin of the transverse duodenum the colon becomes free and here the mesentery is continuous with the mesocolon. As the ileo-colic junction is just caudad of the duodenum, the extent of free mesocolon at this point is but small, yet to this degree the mesenterium commune has been retained. The coils of the small intestine are closely packed and very numerous. They may be described in Gadow's terms as plagiocœlous with a very considerable degree of telogyry. While perhaps the majority of the coils showed a tendency to form a double spiral, in few did it much exceed a half turn and in none was a complete turn accomplished. On the other hand some of the coils were quite irregular. On further analysis the mass of small coils can be resolved into six major loops, each of which crosses the line of the mesentery transversely, from right to left or *vice versa* and having done so turns caudad to be continuous with the succeeding loop, which returns to the opposite side reversing the general direction of its predecessor. The first of these is directed from left to right, and its mass of coils of moderate size, is accumulated at the cephalic extremity of the mesentery. The second loop reverses this general direction, and so on, the odd numbered loops being directed from left to right, the even from right to left. The third and fifth are large, the intervening fourth is very short, while the sixth arching round the caudal extremity of the mesentery far exceeds any of the others in extent. At the ileo-colic junction the terminal ileum passes cephalad and somewhat ventrad and to the right, being closely applied to the cœcum. The change of diameter in the jejuno-ileum is not great, and in many places the coils were so appressed as to be flattened or otherwise deformed in contour. As a whole, however, the diameter diminishes distad and it can be said of the first three loops that they perceptibly exceed the last three in size of the tube. There was no trace of Meckel's diverticulum.

Colon.— From the ileo-colic junction, which faces to the left, the colon passes rostrad and to the left towards the spleen, where it turns sharply upon itself describing a narrow arch rostrad of the duodeno-jejunal junction and descends to the left of the ascending portion of the duodenum. It reaches the midline in the interval between the kidneys and following the contour of the left kidney makes a decided excursion to the left at its lower pole. Thereafter it gradually returns to the midline, which it regains opposite the upper third of the vagina, there continuing to its termination in the rectum. The mesocolon is narrow in its whole extent, attaining a maximum breadth of 5 mm. only for a short distance at the lower pole of the left kidney. From the cephalic border of the transverse duodenum rostrad to a little beyond the summit of the loop, that is, precisely, to a point vertically above the left margin of the ascending duodenum, the colon has lost its mesentery. Thence caudad as far as the transverse portion of the duodenum, the right leaf of the mesocolon is fused with the primitive mesentery of the duodenum, while its left leaf has become adherent to the parietes, and is reflected directly from the colon to the dorsal abdominal wall. These two segments of the intestine, ascending duodenum and descending colon are in contact, but retain their peritoneal covering, and are not otherwise attached to one another than by the fusion of their mesenteries in the manner just described. The arch of the colon is in contact on the left with the spleen and the tail of the pancreas which separate it from the first portion of the stomach. To the right it continues to have the pancreas adherent to its rostral aspect and is further overlain by the papillary process of the liver, from which it is separated by the lesser sac.

The obliquely ascending colon is fused with the lobe of the pancreas that occupies the duodenal loop. From the rostral margin of the transverse duodenum, as has been said, it is free and retains its portion of the mesenterium commune. The interval between the ascending and descending loops of the colon is small and is occupied by the root of the mesentery, the ascending portion of the duodenum, and the duodeno-jejunal junction. The ascending colon has a length of 23 mm.

Cœcum.— The cœcum is short, about 4 mm. in length, and closely applied to the terminal ileum. I could find no distinct folds between them. Ventrad however the two were adherent for a short distance, which may be taken as an indication of the anterior vascular fold. The cœcum is rounded at its apex but somewhat beveled at the expense of its right margin. The ileum joins the colon almost in line with its long axis, the region of junction lying upon the right kidney and against the right leaf of the mesentery. It is thus placed against the dorsal wall of the abdominal cavity and not well ventrad as is sometimes stated. As the ileo-colic junction faces to the left it is evident that not only has the gut as a whole undergone rotation, but that the further act of rotation of the ascending colon on its long axis has also been accomplished.

Liver.— The liver is of large size, massive and of relatively simple conformation. It occupies almost the whole of the preumbilical region on the right side, extending from the diaphragm well down upon the kidney. The left lobe is much smaller in all dimensions, as not only the stomach but the greater part of the intestine is contained in the left preumbilical region. Save for some damage to the surface of the left lobe, the liver is well preserved and so successfully hardened in situ that it retains distinct impressions of the adjacent viscera. The surface relief therefore merits a somewhat detailed description. It is convenient to recognize a ventral and a dorsal surface, the latter divided into diaphragmatic and visceral areas, which are further distinguished by their somewhat different orientation. The demarcation of the ventral and dorsal surface is facilitated by the coaptation of the liver to the diaphragm. This it will be remembered presents two sloping planes, corresponding to the caudal surfaces of the lungs and that of the pericardium, the two meeting in a transverse groove, in the right third of which is placed the aperture of the postcava. This groove expresses itself in the relief of the liver as a distinct transverse ridge, from which the surface falls away ventrad and dorsad, in consequence of which the organ in right profile view has a wedged shaped upper contour. To the left of the postcava the direction of the transverse ridge is continued by the border of the left lobe that gives attachment to the lateral or coronary ligament. Thus upon the diaphragmatic aspect of the liver there is given a natural demarcation of ventral and dorsal surfaces. Caudad the boundary is given by the sharp margin as far as the pointed prolongation of the right lobe which overlies the kidney. Running rostrad from this point a well marked ridge at the right margin of the renal impression divides the ventral from the dorsal surface for about half their sagittal extent. Rostrad of this the boundary is somewhat less definite and is given by a rounded eminence of the right lobe, which fits into a corresponding concavity of the diaphragm slightly caudad of its pulmonary plane, and corresponding to the sinus pleuræ on the thoracic aspect of the diaphragm. Thus the boundary between the ventral and the dorsal surface has been traced round the periphery of the liver to our starting point, the transverse ridge on its diaphragmatic aspect.

The sharp ventral or caudal margin demands a word of description. The notch for the umbilical veins is very deep. To the left of this the border has an oblique course, crossing the second compartment of the stomach, leaving exposed its greater curvature together with almost the whole of the first compartment, which is covered only by the large left coronary ligament. To the right of the umbilical notch the liver is prolonged caudad beside the vein for about a centimetre; the margin then turns obliquely to the right. Here the caudal extremity is formed by an angular projection which rests upon the right kidney. Thus defined the ventral surface is strongly convex from side to side, being moulded upon the diaphragm and recti, except rostrad where it presents a flattened triangular impression corresponding to the base of the pericardium. This is crossed by the attachment of the falciform ligament, with reference to which it is asymmetrical about three fifths belonging to the right lobe. Sagittally the remainder of the surface is nearly straight, only in the region of the renal prolongation on the right it slopes slightly dorsad in consequence of the contraction of the abdomen in the vicinity of the umbilicus.

The dorsal surface on the left is deeply grooved for the reception of the stomach. At the bottom of this groove is situated the ductus venosus buried in the substance of the liver, its fissure being marked only by the reflection of the peritoneum. The Spigelian lobe is of large size and peculiar in the great development of its processus papillaris. This projects strongly caudad and to the left, covered by peritoneum of the lesser sac; it is contact with the stomach dorsad to the left and ventrad, and with the upper lobe of the pancreas and the arch of the colon on the right, the latter being also caudal. On its dorsal aspect it is separated from the remainder of the Spigelian lobe by a deep groove, which lodges the gastric artery; at this point the reflection of the peritoneum of the lesser sac occurs, so that there is no proper Spigelian recess and the surface of that lobe becomes adherent to the diaphragm. On the right the processus papillaris is separated by a deep notch from the small depressed caudate lobe and here the upper lobe of the pancreas is adherent. On the right the Spigelian lobe is bounded by a narrow caval fissure, the approximated walls of which conceal the postcava deep in the substance of the liver. The dorsal surface of the right lobe is marked by an oblique ridge, beginning at a small pyramidal eminence beside the postcava, the rudimentary caval lobe, and terminating at the caudal pointed extremity of the organ. This ridge marks the right limit of the renal impression. Rostrad of it is the large triangular non-peritoneal surface and above this the eminence corresponding to the sinus pleuræ and the pulmonary impression. The renal impression is very large, concave and obliquely placed. It terminates just caudad of the caval eminence, which is non-peritoneal and adherent to the adrenal. Mesal to the renal impression, near the caudal margin, is a triangular area slightly concave, which is in apposition with coils of the small intestine. Between this and the deeply depressed hilum, the liver is in contact with the duodenum. The fissure for the umbilical veins is deep and broad. The two umbilical veins unite about a centimeter before reaching the hilum. The portal vein enters the hilum at the extreme right rostral angle, having the hepatic artery on the left and the bile duct on its caudal aspect. In the hilum it enlarges, as Carte and MacAlister also found, and is connected to the left by a very large branch with the common umbilical vein and the beginning of the ductus venosus. Before entering the liver the portal vein, lying in a groove between the upper and the duodenal portions of the pancreas, and directed ventrad, rostrad and to the right, is closely applied and adherent to the left side and venter of the postcava. In this way the foramen of Winslow is occluded, and the separation of greater and lesser sacs is further increased by the adherence of the superior lobe of the pancreas to the caudate lobe. This latter condition has the effect of replacing the right or transverse portion of the gastro-hepatic omentum by an extensive surface of contact and adhesion in the region of the pylorus, and of substituting for the usual peritoneal contact of these organs, a firm adhesion to the visceral surface of the liver.

As has been said, the Spigelian lobe is adherent to the diaphragm as far caudad as the groove of the gastric artery. In two regions, therefore, the adhesion of the liver to adjacent structures has been increased at the expense of the lesser sac. Nor was I able to convince myself that the lesser sac extended to the right side of the œsophagus, but here owing to the small size of the object and the friability of the liver at this point, the material was inadequate to permit a definite observation. In three specimens of *Tursiops truncatus* from the New York Aquarium, with very different conformation of the organs concerned, essentially the same conditions obtained in their peritoneal relations. The foramen of Winslow was obliterated; there was an extensive adhesion between liver and pancreas; the Spigelian lobe was extensively adherent to the diaphragm. Between its ventral extremity and the œsophagus however was a small remnant of the lesser cavity, but this was wholly cut off from the remainder of the lesser sac. It is apparent therefore that in both groups of the Cetacea similar processes have been at work to modify the topography of the upper abdomen, and that these have resulted primarily in a closer approximation and more intricate coaptation of the several viscera to one another, so that they have been welded into a complex with increased surfaces of adhesion, both to one another and to the diaphragm.

PLATE LII.

PLATE LII.

Balænoptera borealis.

Fig. 1. Ventral view of stomach, duodenum and arch of colon. 2 × natural size.
Fig. 2. Interior of stomach. 2 × natural size.
Fig. 3. Dorsal view of preumbilical visceral complex. 2 × natural size.
Fig. 4. Dorsal view of liver. 2 × natural size.

1. Œsophagus.
2. Stomach, compartment 1.
3. Stomach, compartment 2.
4. Stomach, compartment 3.
5. Stomach, compartment 4.
6. Duodenum, descending.
7. Duodenum, transverse.
8. Duodenum, ascending.
9. Cæcum.
10. Colon.
11. Ileum.
12. Attachment of great omentum.
13. Root of the mesentery.
14. Superior mesenteric artery.
15. Superior mesenteric vein.
16. Postcava.
17. Caval fissure.
18. Portal vein.
19. Hepatic artery.
20. Gastric artery.
21. Spleen.
22. Pancreas.
23. Diaphragmatic surface of the right lobe of liver.
24. Spigelian lobe.
25. Processus papillaris.
26. Left coronary ligament.
27. Falciform ligament.
28. Umbilical veins.
29. Renal impression.
30. Duodenal area.
31. Intestinal area.
32. Gastric area.

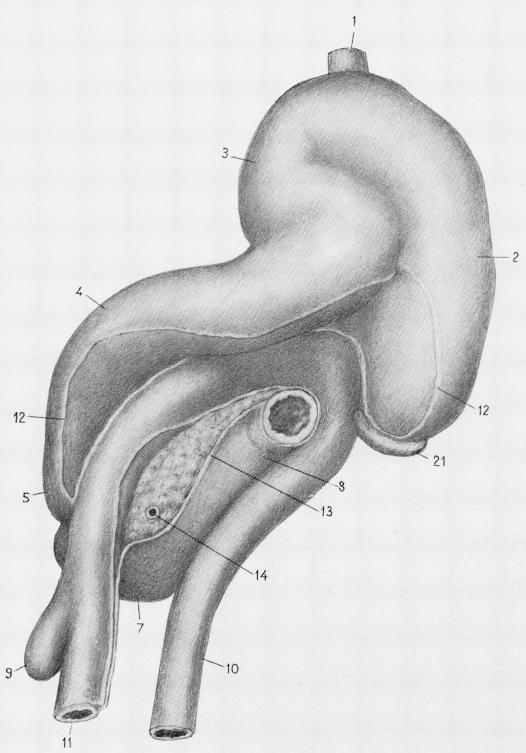

Fig. 1.

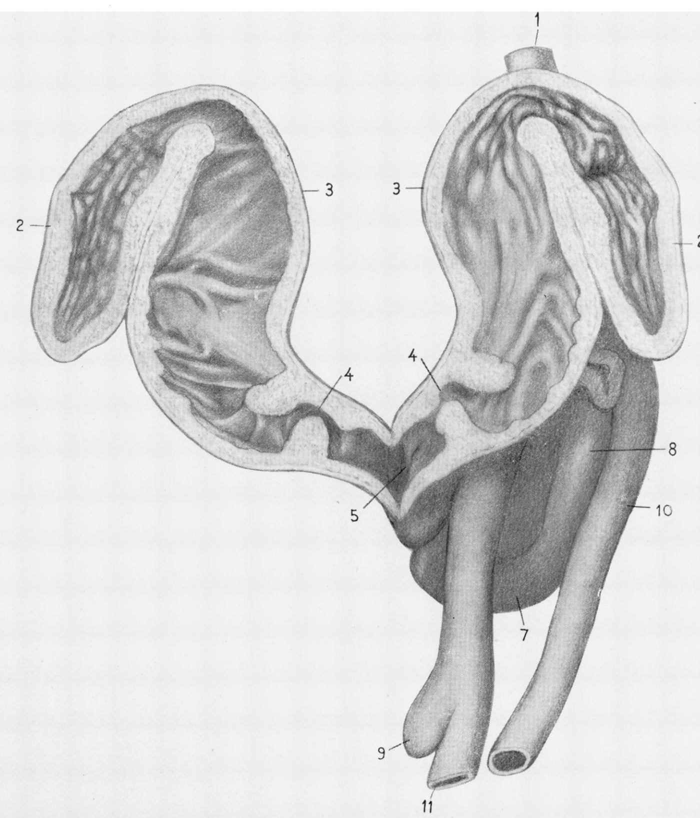

Fig. 2.

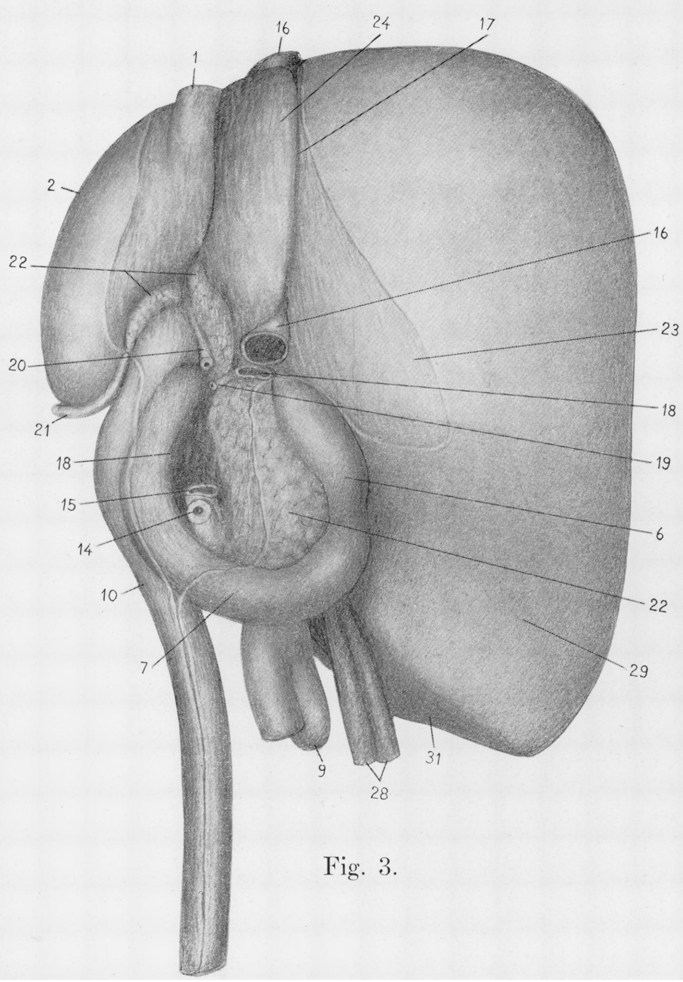

Fig. 3.

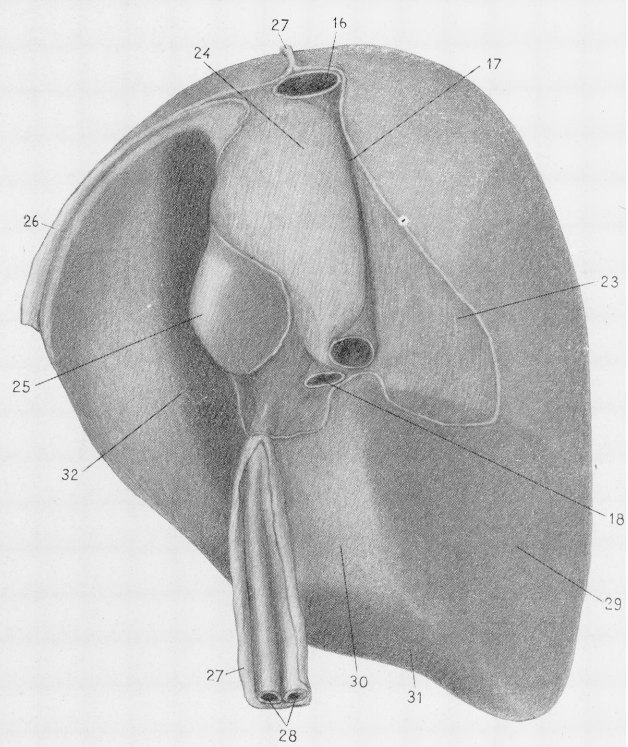

Fig. 4.

BALÆNOPTERA BOREALIS.

A major rôle in determining these conditions in this fœtus must be assigned to the general shape of the abdominal cavity, which caudad of the umbilicus is reduced to small dimensions and contains only the genito-urinary organs and the terminal colon. In consequence the whole, or all but the whole, of the small intestine has been displaced cephalad of the usual position in mammals and there has resulted a very compact massing together of the remaining viscera below the diaphragm. In the fœtuses of *Tursiops* from Mr. Andrews's collection, the post umbilical compartment was of larger size and contained a large part of the jejuno-ilium, while the enormous liver, of which the left lobe was far larger than in the *Balænoptera*, occupied the bulk of the space in the rostral compartment. To it the stomach, pancreas and duodenum were closely adherent.

Pancreas.— This organ has two large divisions or lobes which diverge from their region of union beside the ampulla duodeni; one, sagittal in position, passes caudad into the loop of the duodenum, the other, directed obliquely cephalad and to the left, lies upon the ascending colon and sends a prolongation beyond its arch upon the first stomach to touch the spleen. In dorsal view these two divisions are separated by a deep and nearly horizontal groove which lodges the portal vein and hepatic artery. The transverse lobe or body is placed immediately above the coeliac axis, which dividing into hepatic and gastric arteries, marks out a triangular area on the pancreas, that may be taken as the dorsal surface of the body. This is non-peritoneal; its upper margin is well defined, and separates it from the hepatic surface of the lobe. To the left of the gastric artery a small prolongation is wedged in between the arch of the colon and the first stomach, its extremity just touching the spleen. This portion, or tail of the pancreas, is wholly non-peritoneal and adheres to the organs with which it is in contact. The ventral surface of this division, body and tail, falls into two parts. The caudal, in its whole length, is adherent to the ascending colon and the colic arch. The rostral is covered by peritoneum of the lesser sac, which separates it from the stomach, save that the region between the gastric and hepatic arteries, forming the base of the triangular dorsal area and corresponding in a general way to the body of the more usual type of pancreas, is broadly adherent to the liver in the region of the transverse fissure and the base of the Spigelian lobe. The Spigelian recess is obliterated except in relation to the enormous papillary process, which retains its peritoneal covering. This transverse lobe of the pancreas, extending from the ampulla duodeni to the spleen forms with the ventrally placed stomach the boundary of a transversely oval retrogastric space, into which projects the processus papillaris, by which it is all but completely filled. This is the only portion of the liver which retains a covering by peritoneum of the lesser sac, and from its periphery reflection takes place upon the stomach, colon and gastric surface of the pancreas.

The sagittal portion of the pancreas in dorsal view is bounded by the descending and transverse portions of the duodenum and to the left by the root of the mesentery. The left portion of this surface is adherent to the postcava, which descends here with a strong inclination to the left. The right portion, more than half of the dorsal surface, is covered by peritoneum. The portal vein, formed by the junction of the gastric and superior mesenteric, is lodged in the deep groove between the two divisions of the pancreas, and is directed nearly horizontally to the right. Here it is not only in contact with the postcava immediately prior to its entrance into the liver, but the two veins are adherent to one another, entailing as a consequence the obliteration of Winslow's foramen. Ventrally this lobe of the pancreas is concealed by the ascending colon, except its most rostral portion, where it joins the transverse division, and this is adherent to the region of the hepatic hilum ventral to the portal vein. The ducts of the pancreas were not examined.

Spleen.— The spleen is small and attached closely to the fundus of the first stomach by a duplicature of the peritoneum of the greater sac. It is elongated and narrow, nearly transverse in position, its dorsal extremity prolonged to touch the pancreas. To the right it lay in peritoneal contact with the descending colon. The lesser sac failed to reach it.

Adrenals.— The left adrenal is oval, dorso-ventrally flattened, with a feebly convex mesal border, notched a little above its middle. This notch is prolonged as a furrow on the ventral surface where the adrenal vein emerges from it and descends to join the left renal vein. The body rests against the left crus of the diaphragm slightly overlapping the left kidney; its lower pole is in contact with the renal vein as it emerges from the kidney. Along its mesal border it is adherent to the duodenum, the remainder of the ventral surface being covered by peritoneum. The arteries enter its dorsal surface and are three in number, a branch from the aorta, a twig from the renal to its caudal portion, another from the phrenic, rostral to the aortic branch. Its dimensions are: length 10.5 mm.; breadth 6 mm.; thickness 2.5 mm. The right adrenal is more triangular in shape. Resting against the right crus of the diaphragm, it is wedged in between the postcava, the right kidney and the renal vein. Ventrally it is covered with peritoneum save that a strip along the mesal border is adherent to duodenum and at the upper pole to the liver. The adrenal vein enters the postcava. The right adrenal is of about the same size as the left but of slightly different proportions. Its length is 9.mm., its breadth 6, its thickness 3 mm.

Peritoneum.— It has been seen that the intestines have undergone a typical complete rotation to the left beneath the arch of the colon, a condition which Weber [1] has found to be characteristic of the Mysticete in contrast to the Odontocete. He has also pointed out the non-development or rudimentary condition of the transverse colon, which he is inclined to find represented by the arch between the oblique ascending and the descending colon. It would appear preferable however in the light of other investigations,[2] especially those dealing with the development of the alimentary canal to interpret this arch of the colon as the splenic flexure, for this is present at a period long antecedent to the differentiation of a transverse colon and is one of the fixed and almost invariable landmarks of the intestinal tract. It represents the apex of the third of the fundamental intestinal loops, the left colic of Bardeen, and at the completion of rotation, or even when it fails to occur, regularly swings to the left and becomes fixed below the spleen. The remainder of the colon at this period occupies an oblique position along the under surface of the right lobe of the liver, and only with the secondary growth of the abdomen and the diminution of the bulk of the liver, gains space for the development of an hepatic flexure, which establishes the limits of the ascending and transverse colon, these differentiating out of the early oblique colon limb rather than by growth of the splenic flexure. Apart from this point of interpretation, the general arrangement of the bowel conforms closely to the description of Hunter [3] and the more detailed study of Weber.[4] As the ileo-colic junction faces to the

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[1] Weber, Max. Studien über Säugethiere. II. Jena, 1886. Die Säugethiere. Jena, 1904.

[2] Huntington, Geo. S. Studies in the development of the alimentary canal. Report of the Lying-in-Hospital of the City of New York. 1893. The anatomy of the human peritoneum and abdominal cavity. Philadelphia and New York. 1903. Bardeen, C. R. The critical period in the development of the intestines. Am. Jour. Anat., Vol. 16, No. 4, 1914.

[3] Hunter, John., *op. cit.*

[4] Weber, Max., *op. cit.*

left it is evident that the axial rotation of the proximal colon has occurred. We are therefore dealing with a developed type of intestinal arrangement, in which the fundamental stages of rotation have been carried to completion. The secondary changes in the large intestine however are retarded or suppressed, there is no sigmoid, the differentiation of the transverse colon is not effected, the arched colon remaining primitive in form, and further the characteristics of the higher type of colon, the haustra, are lacking. On the other hand, the small intestine has lengthened enormously. Secondary peritoneal adhesions in the course of the intestine are present, but in the infracolic region they are of small extent. The primary root of the mesentery is retained and is confined by the arch of the duodenum. The ascending duodenum with the left extremity of the transverse portion have lost their mesenteries, as has also the splenic flexure of the colon. In addition the ascending limb of the colon has contracted an unusual adhesion to the venter of the pancreas, which I take to be a character of these whales. This is the sole departure from the common type of mammalian arrangement in this region of the abdomen, and seems to depend upon the early loss of the mesocolon, which it may be noted is very short in the whole length of the colon below the duodenum.

In the supracolic region on the contrary there are many peculiarities which seem to find their explanation in the crowding of the abdominal viscera into the preumbilical space. This has resulted in increased adherence of viscera to one another and to the diaphragm, which as they have taken place at the expense of the lesser sac, have materially reduced the extent of that region of the peritoneum. The chief changes thus induced are the reduction of the Spigelian recess by the increased adherence of the liver to the diaphragm, and the obliteration of the foramen of Winslow by the approximation of the portal vein to the postcava and the adhesion of the pancreas to the region of the transverse fissure. The splenic recess has also disappeared.

The lines of reflection of the peritoneum from the posterior paries of the upper abdomen are shown in Plate LI, Fig. 1, and the corresponding non-peritoneal area of the visceral complex in Plate LII, Fig. 3, the peritoneal relations of the liver in Plate LII, Fig. 4. With the exception of the covering of the processus papillaris in the last cited figure all the peritoneum shown is of the greater sac. With the aid of these illustrations we may proceed to trace the parietal visceral lines of reflection. From the right of the postcava at the diaphragm the line descends to the upper part of the kidney, then turns at a sharp angle to the left and rostrad towards the postcava again at its emergence from the liver. We have thus bounded the surface of diaphragmatic adhesion of the right lobe; the angle of this area is not prolonged by a coronary fold. The caudal limit of this field, the line from this angle to the postcava at its emergence, marks a reflection from liver to kidney and adrenal. The greater part of the latter is however covered by parietal peritoneum which separates it from the descending duodenum and the pancreas, so far as the latter is free dorsally. From the postcava, the line of reflection again turns caudad and laterad to the duodenal impression on the right kidney, at the upper margin of which it begins to turn to the left and having reached the lower margin of this impression in an obliquely curved course becomes continuous with the line of attachment of the right leaf of the mesentery. The line from cava to duodenal impression marks the reflection from adrenal and kidney to pancreas, that crossing the impression, from kidney to duodenum.

To the left of the cava at the diaphragm begins the very large left coronary ligament, which after extending laterad and caudad as far as the tenth rib, returns on itself almost to the cava. Turning again laterad it passes in front of the œsophageal orifice and assuming a sagittal course with sinistral convexity, at about the level of the emergence of the postcava turns mesad, and again taking a general longitudinal direction curves gradually into the line of attachment of the left leaf of the mesentery. From the coronary ligament to the mesal turn the reflection is from the diaphragm to the first stomach, passing at this point immediately rostrad of the spleen. The remaining portion marks the reflection, first from diaphragm to colon, and then from left adrenal to ascending duodenum.

In the non-peritoneal area thus bounded are exposed on the posterior parietes, the pillars of the diaphragm, which are in contact with the Spigelian lobe of the liver and the œsophagus; to the left an area of diaphragm adherent to the right portion of the first stomach, and higher up the linear space for the left coronary ligament. The aorta immediately on its emergence from the arch of the diaphragm gives origin in quick succession to the cœliac axis and superior mesenteric arteries, these branches being lodged in grooves on the dorsum of the pancreas. To the left of the aorta, the left adrenal is partially exposed and is in apposition with the ascending duodenum. The postcava as far as its bifurcation between the upper poles of the kidneys is retroperitoneal and has ventral to it the superior mesenteric vessels, the portal vein and partially the pancreas. While to the right of the cava again a strip of adrenal is exposed which is apposed to pancreas. Finally to the right of the caval line, from the diaphragm to the beginning of its subhepatic portion, is a large triangular exposure of the diaphragm. It deserves emphasis that on the right the peritoneum of the greater sac approaches the cava and portal vein at the transverse fissure of the liver, but is here reflected from these vessels and the rudimentary caudate lobe between them to the upper extremities of the right adrenal and of the vertical pancreas.

As the foramen of Winslow is obliterated and there is complete separation of the two peritoneal cavities, it is convenient to treat of conditions in the ventral mesogastrium first with reference to the greater sac alone. We have here to consider the falciform ligament and the reflection of peritoneum from the liver upon the upper abdominal visceral complex. The falciform ligament departs from the typical condition only in the duplicity of the umbilical vein in its caudal margin. It is attached to the ventral parietes in the midline from the caval orifice in the diaphragm to the umbilicus, and to the liver from the caval emergence to the deep notch in the caudal border which lodges the umbilical veins. It is broad and strong and in this fœtus directed distinctly to the left in its passage from abdominal wall to liver. The hepato-visceral reflection of the greater sac comprises from left to right the line of the outer layer of the gastro-hepatic omentum and the hepato-duodenal fold. In the region of the obliterated epiploic foramen there is a recess of the greater sac, of triangular form, with the postcava and portal vein at its apex. It is shown in the figure of the dorsal surface of the liver (Plate LII, Fig. 4) as a reëntrant angle with its apex abutting on the postcava to the left of the diaphragmatic area. This recess must not be confused with the larger retro-duodenal fossa formed by the hepato-renal and pancreatico-adrenal folds, which also has its apex upon the postcava (Plate LII, Fig. 3). The two are separated by duodenum and pancreas, and the one now considered is preduodenal in position and of much less extent. In this reflection we have to the left and ventrally, the hepato-duodenal fold, which in the typical conformation of the region forms the free edge of the gastro-hepatic omentum and contains the portal vein, hepatic artery and bile duct, thus forming the ventral boundary of the foramen of Winslow, the remaining boundaries being the caudate lobe above, the cava behind, the duodenum below. By the adherence of the two veins the foramen is closed and the peritoneum of the greater sac passes uninterruptedly over the cava from the portal vein, so that the gastro-duodenal ligament receives an extension to the right and dorsad, and one can follow the anterior layer of the gastro-hepatic omentum continuously from portal vein over postcava to adrenal and abdominal wall, passing in a horizontal direction from left to right. From above downwards the reflection is from portal vein, caudate lobe and cava to the ampulla duodeni. Thus the free edge of the gastro-hepatic omentum is lost and the site of the primitive foramen is marked only by a shallow preduodenal recess.

The remainder of the anterior layer of the gastro-hepatic omentum follows the usual line of reflection from the transverse fissure and that of the ductus venosus; it is peculiar only in its angular extension upon the proximal portion of the umbilical fissure, occasioned by the extensive adherence of the pancreas to the liver in this region. This has been accomplished by the extension of the pancreas into the gastro-hepatic omentum, with the consequence of first separating its layers, secondarily of effecting adhesions in the reduplicature of the ental layer interposed between liver and pancreas, and ultimately entailing obliteration of much of the retrogastric space. As a consequence of this process only the ectal layer of the omentum is retained in its transverse segment, and this is reduced to a mere reflection of peritoneum from the liver to the lesser curvature of the fourth and third gastric compartments, which are closely attached to the undersurface of the gland. Only beside the papillary process does the vertical segment retain its two layered condition, and only here has the gastro-hepatic omentum an appreciable length, spreading out from its attachment upon the liver to the lesser curvature of the second stomach. Above the papillary process the omentum becomes reduced again to a single layer — the consequence of the obliteration in large part of the Spigelian recess — and here again it is a mere reflection from liver to first stomach.

Arrived at the lesser curvature the ectal layer of the gastro-hepatic omentum passes over the ventral surface of the stomach to the greater curvature of the second, third and fourth compartments and thence descends as the ectal layer of the great omentum. Turning at its margin it ascends to the margin of the pancreas that intervenes between its colic and gastro-hepatic surfaces and is there reflected caudad upon the colon, whence it may be traced to the right leaf of the mesentery. Upon the first compartment of the stomach it passes to the fundus and there is reflected over the spleen as the gastro-splenic omentum, for here again the lesser sac is lacking and the region of the hilus is not in peritoneal contact with the stomach but is adherent to it. Beyond the spleen the line of this reflection ascends on the one hand to the angle between the first and second compartments, and on the other skirts the colic area of the fundus to the transverse division of the pancreas, at both of these points joining the lines of omental reflection that have already been described.

The lesser sac, it has already been pointed out, is peculiar in the loss of the foramen of Winslow, the obliteration of the splenic, and the reduction of the Spigelian recesses. These changes are undoubtedly secondary and associated with the collocation of viscera in the pre-umbilical region. The lesser sac as a result is reduced to a relatively simple retrogastric space and the cavity of the great omentum. Their mutual boundary is given by the attachment of the great omentum, which has already been traced in the description of its ectal layer. It is shown in Plate LII, Fig. 1.

The great omentum was crumpled into a mass which lay at the greater curvature of the stomach, to the left of the falciform ligament and above the coils of the small intestine. It was very delicate and gave away when the attempt was made to straighten it out, so that its extent could not be ascertained. It seemed of moderate size, but I do not think it would have reached to the umbilicus.

The retrogastric space is invaginated from above by the processus papillaris, which completely fills the oval between the stomach and the pancreas extending caudad as far as the colon. The cavity has then something of the shape of an oval dish with its marge applied to the periphery of the papillary process. Here the reflection of its peritoneum takes place, ventrad and to the left as the ental layer of the gastro-hepatic omentum to the lesser curvature and thence over the dorsal surface of the stomach into the omentum; to the right and dorsad upon the transverse pancreas and then into the dorsal wall of the omentum. From a comparison of the line of reflection at the papillary process and that of the great omentum, it is seen that the retrogastric space broadens markedly caudad. I could not find an extension of the lesser sac upon the right of the œsophagus corresponding to the isolated cavity here present in *Tursiops*, nor could I ascertain that it reached the dorsal paries at any point.

In the whales it is evident that very peculiar relations obtain in the topography of the upper abdomen and in the disposition of its peritoneum. Hunter first described the obliteration of the foramen of Winslow. "In some of this tribe there is the usual passage behind the vessels going to the liver, common to all quadrupeds I am acquainted with; but in others, as the small Bottle-nose, there is no such passage, which by the cavity becomes a circumscribed cavity." He does not specify further the forms in which the foramen persists, nor have I in the literature as yet come upon another reference to this condition. It is evident however that members of both suborders concur in this obliteration, and in *Tursiops truncatus*, of which I had the opportunity at the New York Aquarium to examine three specimens, there is also reduction of the lesser sac in the loss of the splenic and the all but complete obliteration of the Spigelian recess. Taken in conjunction with the wide differences between the suborders in the infracolic compartment as pointed out by Weber this resemblance is of some theoretic interest. For under conditions which are sufficient to produce in both the highly peculiar, and probably unique, modifications of the lesser sac, the divergent evolution of the lower digestive tract is evidence of the plasticity of the alimentary canal, and its potentiality of highly diverse modification within the limits of a single order. The major peculiarity is undoubtedly the reduction of the lesser sac, and may find its determining factors in the crowding of the upper abdomen by the huge liver and stomach under pressure from without, even though the extreme forward displacement of the intestine of the Balænoptera fœtus is not present in a somewhat larger fœtus of *Tursiops*, which has been examined for this point. Here however the relatively enormous liver, with its massive left lobe, had effected even a greater degree of crowding of the viscera in the upper abdomen, although the intestine was largely postumbilical in position. The primary condition, operative with differing details in both, would seem to be the torpedo-form of the body, with its major girth located in the preumbilical region.

Urogenital Apparatus.

(*Plate LI, Fig. 1, LII, Figs. 1, 2.*)

The urinary and reproductive organs of *Balænoptera,* apart from descriptions contained in reports of individual specimens, have been the subject of more particular investigation on the part of Beauregard and Boulart,[1] and more recently of Daudt,[2] to whom we owe a most thorough and critical study of these organs in the Cetacea. In most respects conditions in this fœtus closely resemble his descriptions of *B. musculus;* there are, however, some differences of which the most important is the mode of fixation of the kidneys.

Kidneys.— These organs are adherent to the parietes in the whole extent of their dorsal surfaces, and not suspended from their mesal borders as in the older fœtus of Daudt (length 104 cm. ♂, *cf.* his text figs. 4, 5 and 6). On the contrary the peritoneum passes over the kidneys from the mesentery to their lateral margins and thence to the abdominal walls in the manner usual in mammals and as in Eschricht's[3] fœtus of *B. rostrata.* This seems also to have been the case in Daudt's younger fœtus (length 50 cm.). I could not detect on either side a muscular connection with the diaphragm. The kidneys are slightly asymmetrical, the right lying farther rostrad and overlapping by its upper pole the origin of the diaphragm, while the left just falls short of reaching the diaphragm. The degree of asymmetry in this fœtus is thus very small, but is in the same sense as in Daudt's fœtus and is additional evidence that the greater bulk of the liver on the left is not the determining factor in the position of the kidneys, when as so generally happens in mammals the right is slightly lower than the left. In addition to the peritoneum which covers their ventral surfaces the kidneys are invested by a thick and strong fascia renalis, which in this preserved fœtus is somewhat redundant and masks the real shape of the kidneys, causing them to appear larger and more plump than actually they are. Upon this thick investment of the kidney are the impressions of the duodenum at the upper pole and of the colon in the rostral half of the mesal border on the right side, and of the colon again on the left side along its mesal border caudad. But the kidneys themselves show no traces of contact with these organs upon the removal of their capsules. The fascia renalis has much the same arrangement as Gerota[4] has described for man. Its ventral layer crosses the aorta and postcava to become continuous with that of the opposite side. The dorsal layer is easily stripped up from the sheath of the hypaxial muscle to near its mesal border, where it becomes firmly adherent. Somewhat lateral to the kidney the two layers unite and are continued as the endabdominal fascia. Rostrad the adrenal is included between the layers, which fusing are continued as the very thick fascia on the abdominal surface of the diaphragm. Caudad they are continued dorsal and ventral to the ureter, and here fat appears between them for the first time. They now become thinner and difficult to follow and apparently are lost as in man in the areolar tissue of the region.

Beneath the fascia renalis the kidney is invested by a thin transparent tunica fibrosa. This is without much difficulty resolvable into two layers, one relatively thick and strong of super-

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[1] Beauregard and Boulart. Recherches sur les appareils genito-urinaires des Balænopterides. Jour. de l'Anat. et de la Phys., An. XVIII, 1882.

[2] Daudt, Wm. Beiträge zur Kenntins des Urogenitalapparates der Cetaceen. Jena, Zeitsch. f. Naturwiss., Bd. XXXII, 1898.

[3] Eschricht. Zool.-anat.-phys. Untersuchungen über die nordischen Waltiere. Leipzig, 1849.

[4] Gerota, D. Beiträge zur Kentniss des Befestigungsapparates der Niere. Arch. f. Anat. und Entwickel., Jahr. 1895, p. 265.

ficial position, the other extremely delicate investing the individual renculi and sending septa between them into the interior of the organ. These are both recognized and described by Daudt, who terms the ectal one the capsula fibrosa, the ental tunica albuginea. In addition to these delicate septa, coarser ones are present surrounding groups of lobules, and in these both layers of the tunica fibrosa appear to participate. I have not however verified this point histologically. Of these latter by far the largest and strongest is on the ventral surface extending from the point of entry of the renal artery to the emergence of the ureter. There thus is in addition to the renculus, a larger architectural unit composed of groups of renculi, defined by coarser connective tissue septa, and this type of organization appears to be an additional difference between the kidney of the mystacete and that of the odontocete with its smaller number of renculi. These groups are irregular in shape and variable in the number of renculi they contain. There is a tendency on the ventral and dorsal surfaces to the rectangular form with longitudinal and transverse septa; laterally the arrangement becomes wholly irregular. The number of renculi in a group varies between seven and thirty, but a large majority of the groups are composed of nine to fifteen. In size the individual renculi varied between 1 and 1.5 mm. A rough count of the number in the left kidney, the smaller of the two yielded 1350. This is far below the count of Beauregard and Boulart, 3000, and Daudt states his own counts to have been but little less. In this connection the process of increase becomes important. Nearly half of the renculi in this kidney show signs of subdivision, into two, three or even four parts. A count of 100 showed 60 to be simple, 30 divided by a sulcus into two parts, 6 into three, and 4 into four. If all these subdivisions were actually accomplished, the count would be still a third less than that of Beauregard and Boulard.

The right kidney has a length of 35 mm. Its greatest breadth and thickness coincide with the level of its penetration by the blood vessels; the former dimension is 18.5 mm., the latter 9.5 mm. Caudad of the vessels the organ diminishes in breadth to the rounded caudal pole, the margins being straight; the mesal is blunt, but the lateral is expanded to a surface well defined from the dorsal and ventral faces. It is well shown in Daudt's [1] schematic cross-section. Rostral to the vessels the ventral surface is beveled off so that it looks rostrad and laterad as well as ventrad; here it is in contact with the liver. In the region of the vessels and separated from the hepatic surface by a sagittal prominence a small area is directed mesad, ventrad and slightly rostrad, which is in contact with the duodenum and coils of the small intestine. The borders of the kidney rostrad converge almost to a point, which is inserted between the liver and the adrenal.

The left kidney is appreciably smaller than the right, measuring 32 mm. in length, 14 mm. in breadth and 9 mm. in thickness. It is distinctly more slender, its margins more nearly parallel, and it lacks the marked broadening at the level of the vessels. In consequence the lateral margin lacks the angle present on the right at this point. The rostral pole is broadly convex and not pointed. The lateral surface is well demarcated from the flat dorsum, but passes into the ventral surface by a gradual curve.

The dorsal surfaces of both kidneys are nearly flat resting against the hypaxial muscles. Their lateral surfaces are in apposition with loose areolar tissue, which fills the angular space between them and the transversalis, but as yet no fat has been deposited here. The ventral

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[1] *Op. cit.*, text fig. 4, p. 274.

PLATE LIII.

PLATE LIII.

Balænoptera borealis.

Fig. 1. Genital tract, dorsal view. Twice natural size.
Fig. 2. Postcava, aorta and right kidney. Twice natural size.
Fig. 3. Left lung, lateral view. $1\frac{1}{2} \times$ natural size.
Fig. 4. Pylorus and ampulla duodeni. Twice natural size.

1. Umbilical artery.
2. Bladder.
3. Ovary.
4. Cornu of uterus.
5. Body of uterus.
6. Vagina, proximal portion with folds.
7. Vagina, distal portion.
8. Ligamentum latum.
9. Fold for ovarian vessels.
10. Adrenal.
11. Kidney.
12. Ureter.
13. Cavo-vertebral communication.
14. Adrenal vein.
15. Renal vein.
16. Phrenic vein.
17. Right postcava.
18. Left postcava.
19. Inferior mesenteric artery.
20. Ovarian arteries.
21. Caudal artery.
22. Iliac artery.
23. Groove for superior intercostal vein.
24. Stomach, compartment 4.
25. Pylorus.
26. Ampulla duodeni.
27. Orifice of bile duct.

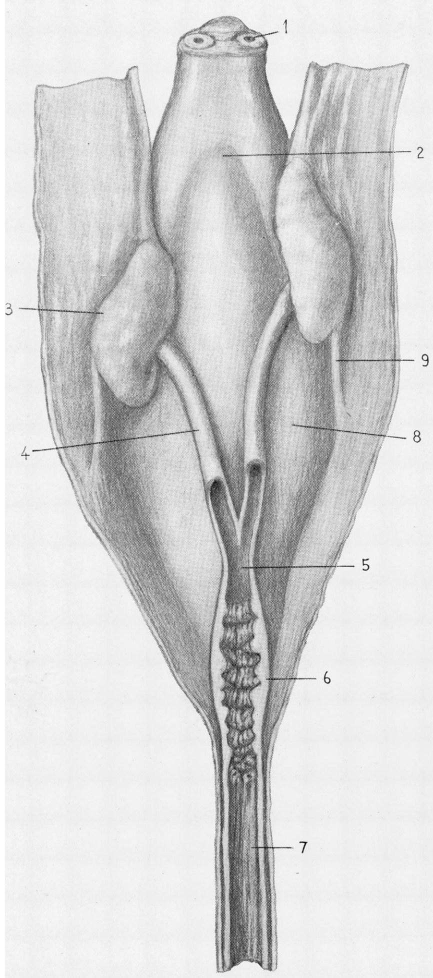

Fig. 1.

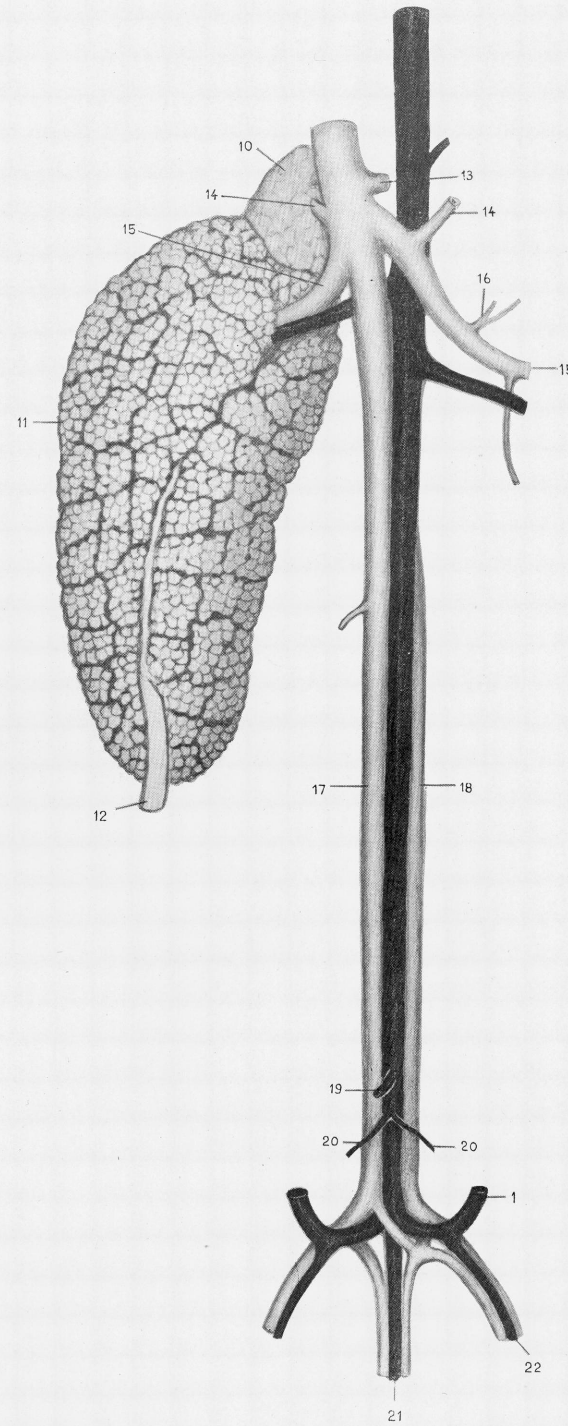

Fig. 2.

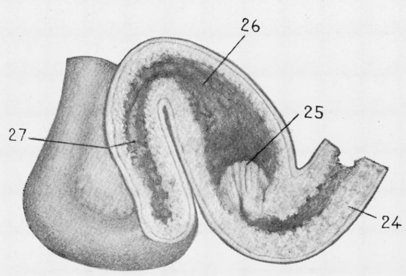

Fig. 4.

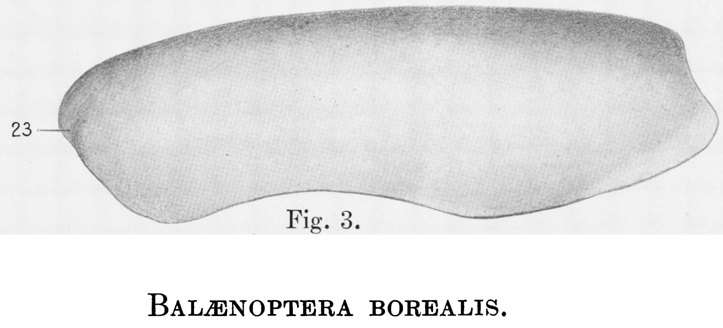

Fig. 3.

BALÆNOPTERA BOREALIS.

surfaces are inclined mesad below the entry of the vessels; the colon is interposed between them dorsally, the bladder and hypogastric arteries ventrally. Rostral to the vessels the surface of the right kidney has already been described; that of the left is convex and in contact with coils of the small intestine. The adrenal is applied to its mesal border.

The renal veins emerge from a deep groove on the venter of the kidney in its rostral fourth. The distance from the rostral pole to the vein is on the right side 7 mm., on the left 5.5 mm. Both veins ascend to the postcava, the left much more steeply than the right. The arteries lie caudal to the veins which do not overlap them, so that they are exposed to ventral view in their whole breadth. The ureters emerge ventrally also and are lodged in a deep groove of the ventral surface as far as the caudal pole. As has been said their point of emergence is connected by a strong septum to that of the vein and artery. From the ventral position of these structures it is clear that the kidney has not undergone complete rotation, and that the caudal portion has rotated to an appreciably less degree than the rostral, for the ureter is almost directly ventrad, while the vessels are turned a little further in a mesal direction.

Ureters.— The ureters emerge from the ventral surface of the kidneys near their caudal poles. Here they are received in grooves in the kidneys and do not project beyond the general level of the surface. Arrived at the pole they make a short bend laterad and then pass with a slightly sinuous course caudad at the same time inclining mesad. Arrived at the sides of the dilated portion of the vagina, they curve ventrad to the sides of the bladder, in contact with which they ascend rostrad for several millimeters before piercing its walls. As they do this very obliquely and the muscularis of the bladder is thick they have a long intramural segment. Their orifices are close together on the fundus, 6 mm. from the urethral orifice, each at the summit of a longitudinal ridge which corresponds to the terminal portion of the ureter. These ridges are separated by a deep notch rostrad; caudad their reliefs merge into a median elevation which continues to the urethral orifice. This is smooth, the mucous membrane adhering firmly to the underlying muscle, and represents the trigone. From the notch a faint median sulcus is prolonged, which partially separates it into two halves. The elevations upon which the ureters open, in the undisturbed position of the parts, are in apposition with the blunt extremities of longitudinal folds of the mucosa. These fit close against the apices of the ureteral elevations, and would seem able during contraction of the bladder to guard against regurgitation into the ureter.

The ureter at its emergence from the kidney is dorso-ventrally flattened. As it descends it makes a spiral turn, as Hyrtl and Daudt have observed, and in such a direction that the ventral surface becomes median. As it enters upon its longitudinal course, it becomes cylindrical and so continues to its termination. It diminishes in diameter from kidney to bladder, but only to a slight degree. As Daudt has stated it is invisible through the peritoneum. On leaving the kidney it is placed inside the tubular prolongation of the fascia renalis, within which at this point there is a deposit of fat. Distad this diminishes and the ureter is surrounded by firm areolar tissue which forms the continuation of the renal fascia. This separates it from the peritoneum as it passes between the vagina and the hypogastric artery to reach the bladder. Of course it does not break through the peritoneum to do this; Daudt's statement to that effect must be an oversight in the correction of his proof.

Bladder.— The bladder is long and narrow, extending rostrad almost to the umbilicus before it is reduced to the urachus. It agrees with Daudt's description in being flattened ventrally and strongly convex dorsally. Its length is 32 mm.; its greatest breadth is 8 mm. Caudad it tapers to the urethra, the diameter beginning to be reduced from the level of the ureteral orifices. At about this level dorsally the peritoneum is reflected from it upon the uterus and broad ligament. Ventrally it is loosely adherent to the abdominal wall. At the sides the hypogastric arteries are closely united to its walls and the three structures are enclosed within a common sheath, which Daudt finds to be muscular. At the umbilicus the arteries have a dorsal position, the urachus ventral. The muscularis is very thick, the lumen is reduced to a narrow cavity. The mucous membrane is thrown into longitudinal folds, of which three are conspicuous; a mid-dorsal one beginning between the ureteral orifices, and two more lateral in position, in line with the ureteral elevations and approximated to them in the manner already described. The latter are continued to the junction with the urachus. The median fold diminishes rostrad, and gives place to two folds one on each side, intermediate between it and the lateral folds. Ventrally there is a low median fold. As more numerous and less definitely arranged folds are described by Daudt in older fœtuses, it is to be concluded that in the bladder as in the alimentary tract in general a few primary folds are secondarily replaced in development by more numerous and smaller ones.

Urethra.— The urethra is very long having a length of 23 mm. to its external orifice. Its external diameter is 3 mm. Its lumen stellate at its junction with the bladder gradually becomes a transverse slit as it is followed distad. Near its termination it is about 1 mm. in breadth. Its dorsum is flattened against the vagina. The two are contained in a common fibrous sheath, but only near the orifice could I find the urethra surrounded by the circular muscle layer of the vagina.

Ovaries.— The ovaries rest against the lower poles of the kidneys. Ventral to them are the uterine cornua, which the elongated ovaries cross obliquely so that their rostral poles are nearer the median plane than their caudal. Only a small portion of the ovary is caudal to the horn of the uterus and rests against the broad ligament. Rostrad of the cornu the left ovary rests against the hypogastric artery and bladder, the right against the artery without touching the bladder. Their position is thus slightly asymmetrical, the right ovary being somewhat more ventral and rostral than the left, but not more than 2 mm. in either direction. The ovaries are elongated, tapering at their rostral poles, more bluntly rounded caudad, attaining their greatest breadth transversely just caudad of the uterine cornua and their greatest dorso-ventral thickness just rostrad of them. In these three dimensions the right ovary measures 10.5 mm., 5 mm., and 3 mm. respectively, the left 10 mm., 4.5 mm., and 3 mm. The surface shows many small pits and shallow sulci which cut it up into polygonal areas. The ventral surface is deeply concave to receive the uterine cornu. The convolutions of the oviduct are laterally placed and the summit of its fimbriated extremity is attached to the rostral pole of the ovary. The true and false ligaments about the ovary in *Balœnoptera* have been described by Beauregard and Boulart [1] and studied in more detail by Daudt [2] in *B. musculus.* Their condition in this fœtus agrees closely with the findings of the latter investigator. Each ovary has a slit-like hilus along its lateral border, which deepens caudad and here gives passage to the ovarian vessels, contained in a process of the broad ligament. This fold which is very short constitutes the mesovarium.

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[1] Beauregard et Boulart. Recherches sur les appareils genito-urinaires des Balaenides. Jour. de l'Anat. et de la Phys., An. XVIII, 1882.

[2] Daudt, W. Beiträge zur Kenntnis des Urogenitalapparates der Cetaceen. Jena. Zeitsch. f. Naturwiss., Bd. XXXII, 1898.

Near its caudal extremity a very short band connects the caudal pole of the ovary to the uterine cornu, opposite the point at which the ligamentum teres begins. For this reason I take it to be the ligamentum ovarii. Daudt in his larger fœtus describes this fold as passing from the junction of the middle and last thirds of the ovary to the cornu, so that it appears to shift rostrad during development. The short transverse fold, which he describes as passing from ovary to oviduct between this ligament and the ovarian attachment of the ostium abdominale, is not yet indicated. The plica diaphragmatica is long and high. It attaches to a convolution of the oviduct close to the ovary and extends lateral to the kidney somewhat beyond its rostral pole.

Oviduct.— The infundibulum is long and slit-like with even margins, forming a flattened funnel, the rostral extremity of which is attached to the ovary. Its interior is at first smooth, but in its depth becomes marked by small folds and furrows, which converge towards the ampulla. The oviduct is closely convoluted, its turns obscured by their peritoneum. Of these there seems to be four on each side. As a whole the tube has a general sagittal course on the lateral aspect of the ovary and terminates by turning mesad and ventrad to join the uterine cornu. To its commencement is attached the plica diaphragmatica already mentioned.

Uterus.— The uterus consists of a short body and long arched cornua, which turning laterad upon the ventral surfaces of the ovaries diminish rather abruptly in diameter and are continued as the oviducts. Ectally this junction is marked by a change in direction, the proximal segment of the oviduct forming a small angular bend below the ostium abdominale, just mesad of which it enlarges to become the cornu. Distad the cornua are in contact for about a third of their length before they unite to form the body of the uterus. This junction is perfectly symmetrical in external view. The cornua have a length of 17 mm. measured along their convexity; their diameter is 3 mm. The body of the uterus is short measuring from the union of its cornua to the first transverse sulcus of the vagina only 6 mm. Its form resembles that of an hour-glass, diminishing to about its middle and again expanding towards the vagina. Ventrally it is somewhat flattened against the bladder, but dorsally it is strongly convex. The cornua and broad ligament also rest against the convex dorsum of the bladder, and curve ventrad upon its sides so that the terminations of the horns rest against the hypogastric arteries. Here there is a slight degree of asymmetry, for the axis of the uterus deviates from the midline to the left as it is followed rostrad and in consequence the left cornu is at its termination slightly caudal to the right. The same holds true of the ovary. The difference between the two sides is however so small that it may well be dependent upon the curvature of the fœtus.

Internally the uterus is not more clearly demarcated from the vagina than externally. Following Daudt I take the first of the transverse folds as the boundary. Here also the character of the surface begins to change. The surface of the fold is faintly crenate and the sulci extend a little beyond it, but soon fade out and the mucosa of the uterus becomes smooth. Not even with the binocular could I detect traces of the longitudinal folds of later stages either in the body of the uterus or in the cornua. From the point of union of the cornua a septum extends a short distance into the body, but ends before its constricted middle region is reached. There was no asymmetry internally in the union of the cornua, such as Daudt records of his fœtus.

Ligamentum latum.— The broad ligament, as has been said, is concave ventrally. As it nears the lateral walls of the abdomen it becomes bent upon itself dorsad along a line running from the arch of the hypogastric artery to the proximal convolution of the oviduct. Beyond this line the ligament is directed dorsad as well as laterad gaining attachment to the parietes approximately at the transverse level of the body of the uterus. Adjacent to the uterus and cornu as far laterad as the line just mentioned the substance of the ligamentum latum is thickened and almost opaque, beyond the line thin and delicate. Beauregard and Boulart [1] describe a mass composed of fat and a vascular plexus in the broad ligament, to which this thickening as to the structure of which I am uncertain, may be antecedent. It appeared like the thick areolar tissue elsewhere beneath the peritoneum, in which a beginning deposit of fat was taking place. The injection of the aorta and postcava failed to extend into the smaller vessels and I was unable to follow any into this region of the broad ligament. The attachment of the body of the uterus is flush with its ventral surface. As a result of this, taken together with the thickening of the ligament, the outlines of the body and also of the proximal portions of the cornua are obscured in ventral view. Towards the middle of the cornua small furrows appear along their concave margins, which mark them off from the ligament. Dorsad both uterus and cornua project strongly and the cornua are further demarcated by sulci. It is as though these structures in being moulded ventrally upon the smooth bladder had lost their individual relief, while retaining it dorsally where less intimately in contact with other viscera. At the sides of the bladder the ligament follows its contour entering the cleft between it and the lateral abdominal wall, thence returning dorsad to its attachment with the resulting formation of the fold before mentioned. This lateral portion is triangular in shape broadening rostrad, and to its summit is attached the oviduct.

Two accessory folds, in addition to the mesovarium, are present in the domain of the broad ligament, one on its ventral the other on its dorsal surface. The former has a free edge extending from the distal portion of the cornu, 2.5 mm. from its junction with the oviduct, to the arch of the hypogastric artery, where it is lost in the parietal peritoneum. Within it is a delicate band which disappears at about the same point, thus representing the round ligament. The second dorsal fold is larger. It extends from near the lower pole of the ovary caudad and laterad, finally sweeping mesad in the dorsal paries but fading out before it reaches the aorta. It appears to carry the ovarian vessels.

Vagina.— The vagina begins as a fusiform dilatation which has a length of 12 mm. and is then continued as a long narrow passage to the vulva, a distance of 19 mm. This distal segment is in contact with the rectum, to which it presents a concave dorsal surface as far as the perineum where it turns ventrad to the vestibule. The dilatation is marked by seven very shallow transverse furrows, which correspond to transverse folds in its interior. They are deeper and farther apart at its middle, fainter and nearer together at its ends. Ventrally only the rostral extremity of the dilation is covered by peritoneum, which is here reflected upon the bladder. Dorsally the whole length of the vagina as far as the perineum is peritoneal, a narrow pouch extending between it and the rectum. Ventrally this portion is in relation to the urethra, which is adherent but not included in its wall and the two are surrounded by a thick fascia.

The interior of the vagina, after the removal of its dorsal wall, shows in its distal segment a mucosa smooth save for the presence of delicate longitudinal folds, which become obscure as they approach the dilated portion. Here in addition to the seven transverse folds, corresponding to the grooves of the exterior are indications of the formation of two and possibly three more folds at the junction with the distal portion. These last are represented by rows of tubercular elevations separated by shallow sulci, which are more advanced upon the ventral wall,

[1] Beauregard and Boulart, *op. cit.*

where the first forms a transverse ridge with a notched margin, like the fully developed folds farther rostrad. The latter are largest at the middle of the dilatation and all of them present the characteristic crenate appearance. Several points of difference emerge in the comparison of this with Daudt's older fœtus of *B. musculus*. In his specimen the annular folds were more numerous, and the distal smooth portion of the vagina was relatively short. This makes it highly probable that the region of the folds is during development extended caudad. Of this extension by formation of new folds there is further evidence in the rows of tubercles referred to above. Nor is the process apparently ended in Daudt's fœtus of 121 cm. For here in addition to twelve well formed rings, were a few of little prominence and not completely encircling the vagina. These are described as follows; "Die ersten unteren Ringe sind nur durch höheres Hevorspringen der einzelnen Fältchen veranlasst, während bei den folgenden auch immer der betreffende Teil der Vaginalwandung mit in das Lumen einspringt und so ein Gürtel bildet, worüber die Falten verlaufen." It would appear therefore that the formation of the annuli is accomplished by the appearance of tubercles, which at first involve only the mucosa, with the secondary formation of annular folds, upon which the primary elevations appear as crenations. In the second place the folds in Daudt's fœtus fall into two sets, a proximal with their edges turned towards the uterus, a distal turning their margins toward the vulva. Between the two sets is an especially well developed fold, with a T-shaped cross section. The equivalent of this fold is not present in this fœtus. The fourth and fifth folds are slightly undermined on the caudal aspects, but the others are not inclined in either direction. For the most part also the rings are incomplete, the ridges of the ventral and of the dorsal walls being independent and interlocking at the sides.

Angeiology.

(*Plate LIII, Fig. 2*).

Arteries.— Only the aorta and the proximal portions of the great vessels were examined and these correspond so closely to Turner's[1] description of their arrangement in *B. Sibaldii* (= *musculus*) as to require but the briefest mention here. The aorta arching over the root of the left lung reaches the vertebral column on the left of the fifth thoracic vertebra, and arriving at the median line at the level of the diaphragm there continues to the hæmal canal within the arches of the chevron bones. The branches of the arch are a brachiocephalic, left common carotid and left subclavian. The distance between the first and second is very considerable, dependent no doubt upon the width of the trachea. The left subclavian arises from the dorsal aspect of the arch. It then ascends to the rostral margin of the first rib and passes on its way to the flipper, ventral to the scalene. In its arch over the first rib, and this is true of the right as well, it is widely separated from the dome of the pleura, which does not extend beyond the caudal margin of this rib. On each side an artery arches over the dome of the pleura, and produces a slight groove on the apex of the lung; this is the posterior thoracic of Turner, a branch of the subclavian, which is traceable into the thoracic rete. The descending aorta gives off the twelve pairs of intercostals, the more rostral of which ascend sharply to reach their respective spaces.

[1] Turner, W. An account of the great finner whale (*Balænoptera Sibaldii*), stranded at Longniddy. Pt. 1. The soft parts. Trans. Roy. Soc. Edin., Vol. IV, 1872.

The lumbar segmental arteries are peculiar in that each pair arises by a single trunk from the aorta. The ventral branches in the abdomen are the cœliac, superior mesenteric, and inferior mesenteric. The first two arise in close proximity immediately below the diaphragm. The cœliac divides into a hepatic and gastric, from which latter the small splenic branch is derived. The inferior mesenteric is a very small vessel arising but a short distance above the hypogastrics. Of the ventrolateral series, inferior phrenic, adrenals, renals and sex arteries were found. Of the latter two pairs seemed to be present. The inferior were large and arose opposite the inferior mesenteric, the superior were large and situated below the poles of the kidneys. Their course carried them into the base of the folds on the dorsum of the ligamentum latum, which ascend to the ovaries. The hypogastrics are of minute size and arch ventrad to the sides of the bladder, where they ascend to the umbilicus, being invested and attached to the bladder by a thick sheath, which Daudt finds to be muscular. From the arch of the hypogastric a large trunk is given off, which entering the foramen in the rectus, divided into a large ascending branch to the rectus muscle, deep epigastric, and a descending vessel which is distributed to the pelvic viscera and muscles.

The arteries are distinguished by the enormous thickness of their wall. In the ascending and transverse aorta, the lumen is reduced to a mere slit between two longitudinal cushion-like ridges, which ascend with a spiral curve from the region above the sinuses of Valsalva. Not until it receives the ductus arteriorus does the aorta attain a circular lumen. The sinuses of Valsalva are deep and narrow. They are not visible externally.

The pulmonary artery is wide and short. Its wall, though very thick, is less than that of the aorta, and its circular lumen appears more capacious. The right pulmonary artery has a very oblique descending course, grooving the right atrium between the orifices of the cavæ. It gives off its apical branch as it crosses the primary bronchus. The left is nearly transverse and much shorter than the right, and is distinctly diminished in diameter after giving off the ductus arteriosus.

Venous system.— The systemic venous return to the right auricle is effected by a postcava and a single precava. The arrangement of the great veins at the root of the neck and in the upper mediastinum is of the common asymmetrical type resulting from the suppression of the left precava and has no peculiarity of first importance save in the reduction and modification of the azygos veins. The great vessels here considered have wide lumina and walls which are thin but not excessively so; the internal jugular veins are especially capacious and stand in marked contrast to the small subclavia. These trunks unite at the ventral margin of the scalene to form the brachiocephalica, which are appreciably less in cross-section than the sum of the cross-sections of the confluent vessels. The same is true in higher degree of the precava as compared with the two brachiocephalicæ. The left of these veins has a very oblique course within the thorax resting upon the thyroid gland and the arch of the aorta and having the thymi on its caudal aspect, from the interval between which it receives the large thymic vein. The right brachiocephalica runs directly caudad. At the level of the dome of the pleura a large vessel joins the brachiocephalic of each side. This accompanies the posterior thoracic artery, draining its plexus, but in addition by a large spinal tap affords an outlet to the intravertebral plexus. The precava is very short and immediately enters the pericardium, within which it turns ventrad and slightly to the left. The angle its ventral wall makes with the auricle is deepened to a narrow cleft, which marks the rostral extremity of the sulcus terminalis.

The azygos system is rudimentary. It is described as absent in *Phocœna* by v. Baer.[1] The azygos major in this fœtus is absent; no vessel arches over the root of either lung, and the absence of this vein on the right side may well be associated with the presence and large size of the tracheal bronchus. Three lines of drainage for the intercostal veins are however present on each side, in addition to the intraspinous trunks, with which the intercostals communicate through the intervertebral foramina. These are the internal mammary and lateral internal mammary of the subclavian, and the superior intercostal of the posterior thoracic vein. On the right side of the bodies of the thoracic vertebræ, dorsal in position to the ganglionic cord, there is a small zigzag vessel, which rostrad is continued into the superior intercostal vein. Laterad it receives the intercostals of the right side, mesad those of the left, which cross the vertebral centra at their middle to reach it. In this way a portion of the return flow from the left intercostal spaces below the fifth reaches the right side. The upper left spaces drain into the superior intercostal of the left side. In the small longitudinal vessel of the right side must be seen the representative of the hemi-azygos major, but in a reduced condition, for the physiologically important drainage seems to be into the vertebral canal.

Through the intraspinous vessels a communication is established between the precaval and postcaval veins, for the latter has large spinal taps, especially in the subhepatic segment. These intraspinous vessels are placed ventral to the nerve roots, against the bodies of the vertebræ, in the space between the theca medullæ spinalis and the periosteum and posterior common ligament of the vertebræ; beyond these points they are continued as smaller vessels, rostrad communicating through the foramen magnum with the occipital sinuses. Through the intervertebral foramina they communicate with the segmental veins. On the centra they are connected by cross branches, which receive tributaries from the centres of ossification. In spite of these numerous cross-anastomoses these intraspinous trunks are not plexiform, but are well formed veins of sinuous course, in size exceeding that of the postcava distad of the renal vessels, from which it is evident that physiologically they form an important element of the venous system. From their connections it is evident that they may serve as an equilibrating anastomosis between the precaval and postcaval systems. With the former they communicate by means of the large tap between the third and fourth thoracic vertebra into the posterior thoracic vein. In the lumbar region they communicate with the postcava by a large communication with its subhepatic segment, and by a series of smaller anastomoses between the lumbar veins and the supracardinal cross-anastomoses between the postcavæ on the dorsum of the aorta. It would seem probable that the great development of this system is associated with the suspension of thoracic respiration for considerable periods, and the less favorable condition of the venous return depending upon the cessation of thoracic aspiration. Assuming this relative impediment, the system may operate to prevent venous congestion of the cerebrum by affording an outlet from the precaval to the postcaval drainage area, in which latter engorgement might be better tolerated by virtue of the great distensibility of the abdominal veins, which is usual in mammals. There is thus a means of maintaining equilibrium between the precaval and postcaval systems, in accordance to the demands of which the current in the vertebral plexus may be reversed and drain at need into either cava. Of such collateral anastomoses between the caval districts there are in general among vertebrates three longitudinal paths, the spinal, the lateral abdominal, and the azygos, of which the first two are characteristic of reptiles, the last of mammals.

[1] Baer, C. E. von. Uber die Gefässysteme des Braunfisches. Nova acta physico-medica, T. 70, 1835.

The azygos depends developmentally upon the appearance in mammalia of the supracardinal veins, a neomorphic longitudinal system, intermediate in position between the postcardinals and the vessels of the spinal canal, with both of which it communicates at frequent intervals. The fact that the azygos as well as a large portion of the postcava, is of supracardinal origin offers a satisfactory explanation of the differences obtaining in these systems as between mammals and reptiles, in which latter the supracardinals are not developed, and in the second line affords a standpoint for the interpretation of the variations in the azygos and spinal collateral circulation within the class mammalia. As regards the latter, communications between the postcava and the spinal plexus are so universally found when looked for, though not always of large size, that their omission in the description of a specific type of circulation, is far from being evidence of their absence. In my judgment they are to be looked upon as a general, though not always conspicuous, feature of the mammalian plan of circulation. Their common rostral drainage is by way of the vertebral veins. Large thoracic taps are infrequent, but an approach to the condition present in the Cetacea exists in the usual large spinal tap of the artiodactyl cervico-costal vein, which in our experience is normally present. In these communications we have a persistence of a part of the far greater system of anastomoses of the embryo mammal, as well as in its definitive pattern a retention of the reptilian type. With the appearance of the azygos — the thoracic supracardinal — and the development of its prevertebral anastomoses with the postcava, a collateral equilibratory line is established, which is evidently favorably placed with regard to the mechanics of circulation in most mammals, for its presence as a rule is associated with a reduction, not suppression, of the spinal taps and of the longitudinal anastomosis of the abdominal wall. As a rare variant it may even supplant the suprahepatic postcava which then discharges by way of the azygos major into the precaval trunk.[1] In the case of forms such as the one under consideration we are of course in doubt from lack of knowledge of the embryo, whether we are dealing with a rudimentary supracardinal system, or whether the supracardinals have here developed and undergone a subsequent reduction in the embryo. Their evident rôle in the formation of the postcava favors the latter supposition. We have here an illustration of the difficulties inherent in the comparison of adult types of the venous system, when their development is not known, for in view of the multiplicity of the embryonic vessels, almost any variant is easily explainable as a retention of some portion of the primitive network which is usually lost, and convergence may be achieved by differing developmental processes.

The postcava has but a minimal prehapetic segment on account of the dorso-ventral orientation of the heart, its lack of rotation, and the close adherence of the pericardium to the diaphragm. Its hepatic segment lies at the bottom of a deep caval fissure, the apposition of the walls of which conceals it from view. It receives just before its emergence proximad a large right and left hepatic vein, and separately on rather a more dorsal plane the ductus venosus. It leaves the liver caudad beside a very rudimentary caval lobe, and descends with an inclination to the left to the level of the renal veins. In this portion of its course it is entirely retroperitoneal, having the portal vein and sagittal portion of the pancreas ventral, and both adherent to it. In this portion of its course it receives the right adrenal vein and communicates by a large dorsal branch with the vessels of the spinal cord. This anastomosis permits of the blood conveyed

[1] *Cf.* McClure, C. F. W. A contribution to the anatomy and development of the venous system of Didelphys marsupialis (L.). Pt. 2. Development. Am. Jour. Anat., Vol. 5, 1906. McCallum, W. G. Anomaly of the inferior vena cava with thrombosis. N. Y. Path. Soc., Vol. XII, 1912.

by the distal postcava finding its way to the heart by two paths, that of the postcava itself, or through the intraspinal veins to the posterior thoracic veins and so through the brachiocephalicæ to the precava. In consequence the subhepatic cava may be reduced in size, in this fœtus to but a very moderate degree, and this reduction has been cited by Beddard [1] as evidence of edentate affinities on the part of the Cetacea. Such cavo-spinal communications are of wide distribution among the mammalia and are a normal feature of the more extensive venous system of the embryo. It is therefore difficult to evaluate their taxonomic importance, even when highly developed, and in view of the variability of the venous system their character ought to be determined by numerous observations upon the forms compared. Morphologically they must be regarded as phyletically primitive characters — for the intraspinal path is highly organized and of large size in reptiles — and not as specializations, except to the degree that the selection and hypertrophy of a widely distributed character, if proved to be constant and uniform in a species or order, may have this value. A venous peculiarity is a criterion which must be used with extreme caution, and even when of considerable magnitude is not always a proof of genetic relationship. In Marsupials and in *Tragulus* the postcava has in general the preaortic position, yet in some Marsupials, departures from this type are recorded. In *Petauroides volans* the postcava lies to the right and dorsal to the aorta (Hochstetter, Schulte); in *Pseudochirus* it sometimes does so, sometimes is preaortic; in *Didelphys marsupialis* it may as a variant have a *left* dorso-latreal relation to the aorta (McClure).

The region of the subcardinal anastomosis has here the form of a confluence of the two renal veins with the postcava. The renal veins emerge from the ventral surfaces of the kidneys near their upper poles and ascend in a curved course to join the cava, the distal trunk of which but little exceeds either of the renal veins in size. The left vein enters at a slightly lower level, turning its proximal segment almost into the line with the cava as it does so. Here the veins are demarcated for a short distance by a sulcus which prolongs their angle of union. The left renal vein receives the left adrenal and the left phrenic veins as tributaries. The right is joined by the phrenic of its side.

The cava continues distad only a short distance as a single trunk. In the greater part of the lumbar region it is double, the vein of the right side slightly preponderating in size. The junction of the left postcava with the right is effected dorsal to the aorta by numerous oblique branches of anastomosis. This condition is found in Monotremes, a resemblance which may serve to illuminate that subsisting between Cetacea and Edentates (Xenarthra) in the cavo-vertebral anastomosis. These communications ascend obliquely from left to right, and are of considerable relative size. In the region rostrad of the hypogastric arteries nine were present. By them, as may be inferred from their direction, blood is conveyed from the left to the right postcava. The left vessel is thus depleted and the last of the oblique vessels connects its termination with the right cava. Between these supracardinal anastomotic vessels, the dorsal segmental branches of the aorta pass to their distribution. The whole arrangement, apart from the size of the vessels, is very similar to that of *Ornithorhynchus*.[2]

[1] Beddard, F. E. Mammalia. Cambridge Nat. Hist., Vol. X, 1902, p. 120. *Cf.* Gregory, W. K. Orders of Mammals. Bull. Am. Nat. Hist., Vol. XXVII, 1910, p. 414.

[2] Hochstetter, F. Beiträge zur Entwickelungsgeschichte des Venensystems der Amnioten. 3. Säuger. Morph. Jahrb., Bd. XX, 1893. Schulte, H. von W. The range of variations in Monotremes and Australian Masupials. Proc. Am. Ass. Anat., 21st Sess. Anat. Rec., Vol. 1, 1907. Schulte, H. von W., and Tilney, F. A note on the organization of the venous return with especial reference to the iliac veins. Anat. Rec., Vol. 3, 1909.

At the level of the hypogastric artery the postcava receives on each side a large iliac vein, beyond which they are continued into the caudal veins which soon become plexiform. While draining into both postcavæ the connection is distinctly larger on the right side. Between the origins of the hypogastric arteries a small ventral anastomotic branch ascends from the left iliac to the right postcava. This is connected on each side by a slender vessel with both caudal veins. In anastomoses placed ventral to the arteries we have the retention of an embryonic condition common to Monotremes, Marsupials and Placentals, which is highly developed in the first, a frequent variant in the second, and is regularly replaced by a dorsal anastomosis in the adults of the third. The passage of the anastomosis dorsal to the aorta at this point is also common to the three subclasses, and is frequently of high development among the Marsupials, although they show much individual variation in this arrangement.

Of the several axial embryonic venous channels which may form the postrenal segment of the postcava, it is practically certain that it is the supracardinal of Huntington and McClure which has here persisted, for the ureter is free of the postcava and does not twist around it as is the case with the retention of the postcardinal, while the possibility of the existence and retention of the cardinal collateral of McClure seems excluded by the lateral position of the postcava beside the aorta. The existence of this vessel, in the present state of our knowledge, can hardly be asserted except of Marsupials and *Tragulus*, and its retention gives rise to a cava of preaortic position. We may then recognize in the postcaval system of this fœtus distad of the liver, a subcardinal portion comprising the subhepatic trunk and the debouchment of the renal veins, and a supracardinal represented by the double veins and the anastomosis dorsal to the aorta.

In the course of the postcavæ numerous small tributaries enter laterally from the plexus upon the hypaxial muscle and from the substance of the muscle itself. The sex veins failed to be injected and I was unable to recognize them with any certainty. A rather large vein near the middle of the cava was directed laterad towards the ovary, but I could not determine its drainage area.

The postcava of this fœtus differs in one respect from that described and figured by Daudt [1] in *B. musculus*. In this specimen the left postcava was carried up to the renal level and its contents gained access to the single subhepatic cava by means of the subcardinal anastomosis, which is the typical placental arrangement in cases of double postcava. In his specimen dorsal anastomoses are not recorded and the cavo-spinal anastomosis is represented by several vessels.

Cervico-Brachial Plexus.

Cervical plexus.— The ventral divisions of the first four cervical nerves conform to the usual mammalian type as far as their muscular branches and communications are concerned; cutaneous branches I was unable to examine. The first and second communicate ventrad of the transverse process of the atlas. From this loop the decendens cervicalis is given off to the hypoglossal. The communicans arising from the second and third, crosses the carotid and joins the decendens shortly after it parts company with the hypoglossal. Thus a very short anser is formed, from which a trunk descends in the carotid sheath and resolves itself into branches for

[1] Daudt, W., *op. cit.*, pl. vii, fig. 7.

the infrahyoid muscles. From the second nerve a branch is given to the sterno-mastoid which anastomoses on its deep surface with the spinal accessory, and a large branch from the third behaves in a similar manner with reference to the trapezius and masto-humeralis. These branches of the second and third nerves emerge from a cleft in the scalene, in its upper third and on its ventrolateral aspect, not in line with the more ventral cleft in the caudal third of the muscle, which gives passage to the brachial plexus. The phrenic nerve emerges from the ventromesal aspect of the scalene, opposite the middle of the cleft for the plexus. It is derived mainly from the fourth nerve but on the right was joined by a small branch of the fifth. These first four cervical nerves join in the supply of the scalene and hypaxial muscles of the neck. The suboccipital nerve gives branches to the rectus capitis lateralis and to the obliquus. All communicate with the large superior cervical ganglion of the sympathetic.

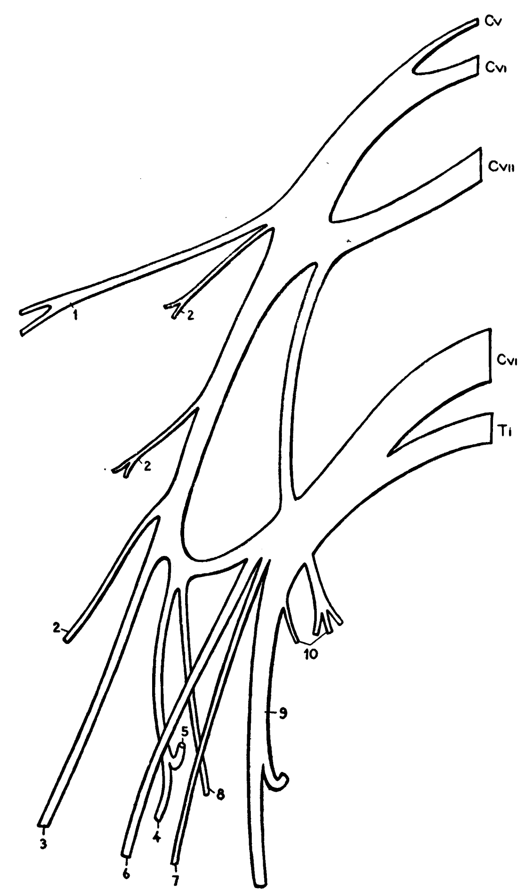

Fig. 6. Schema of brachial plexus. 1, Suprascapular nerve. 2, Subscapular nerves. 3, Musculocutanens nerve. 4, Musculo-spiral nerve. 5, Circumflex nerve. 6, Ulnar nerve. 7, Internal cutaneous nerve. 8, Nerve of the latissimus dorsi. 9, Nerve of the panniculus carnosus. 10, Anterior thoracic nerves.

Brachial plexus.— The ventral divisions of the nerves entering into this plexus increase in size caudad to the eighth cervical, which is at least ten times the size of the fifth; the first thoracic is of large size but distinctly less than that of the eighth cervical. In the scalene cleft the usual primary trunks are formed, the upper by the union of the fifth and sixth, the lower by that of the eighth cervical and the first thoracic, while the seventh cervical remains single forming a middle trunk. Before emergence the upper and middle trunks unite to form a short upper cord, which promptly resolves itself into branches of distribution and anastomosis. Of the latter one joins the lateral cutaneous branch of the lower trunk, its fibres being largely but not entirely continued into the internal anterior thoracic nerves to the pectoralis. The other anastomotic branch joins with a similar branch of the lower trunk in a loop, from the apex of which is given off the combined circumflex and musculo-spiral trunk. It is therefore representative of the posterior cord of more usual plexus types, the chief peculiarity being incident to the complete union of the upper and middle primitive trunks prior to the origin of the so-called posterior branches, so that these are represented by a common branch, which in addition to the usual components carries fibres destined for the musculo-cutaneous nerve. There is further no separate median nerve.

The suprascapular nerve is given off from the short cord resulting from the union of the upper and middle trunks. It enters the interval between subscapularis and supraspinatus, the latter of which it supplies, and passing between the supraspinatus and the border of the scapula crosses the bone dorsally to reach the infraspinatus.

The subscapular nerves are three in number. They are derived from the lateral branch of communication of the upper cord; the third is the largest and ends in the teres major. The nerve to the latissimus is derived from the beginning of the circumflex-musculo-spiral trunk. If it gave any branches to the subscapularis I failed to find them.

The musculo-cutaneous nerve arises from the lateral branch of anastomosis close to its union with the branch of the lower trunk. It crosses the humerus obliquely passing beneath the bicipital ligaments. At the elbow it gives off a branch to the flexor carpi radialis and the radial side of the flexor communis digitorum. Its cutaneous filaments were distributed along the preaxial margin of the flipper. In its muscular supply it is seen to carry fibres which are usually included in the median. The nerve to the coraco-brachialis was given off from its upper portion near its origin.

The musculo-spiral and circumflex nerves are derived from a common trunk which constitutes the posterior cord of the plexus. This lies upon the subscapularis as far as its caudal border, where it divides. The circumflex turns dorsad in the interval between the teres major, subscapularis and humerus to reach the dorsum of the scapula, where it supplies the deltoid and subdeltoideus. The musculo-spiral passes in its usual position behind the humerus to the preaxial border of the flipper. It supplies the triceps and the extensor digitorum.

The ulnar nerve arises from the lower cord by a short trunk in common with the communicating branch and the internal cutaneous. It passes distal to the interval between the flexor carpi ulnaris and the flexor digitorum to both of which it gives branches. At the wrist it divides into branches which pass down the spaces between the digits and along the ulnar side of the fifth digit. The internal cutaneous nerve was smaller. I succeeded in following it only to the region of the olecranon.

The internal anterior thoracic nerves are derived from the lower trunk immediately opposite the point where it receives the mesal communicating branch. Some of the fibres from this source form a ridge upon the trunk and are directly traceable to the thoracic nerves, which are largely yet not wholly the continuation of these fibres. They enter the sternocostal portion of the pectoralis on its deep surface.

The pannicular nerve, lateral cutaneous of English authors, is the largest branch of the brachial plexus and forms the continuation of its lower trunk after it is joined by the mesal communicating branch. It is directed caudad under cover of the pectoralis, to the abdominal portion of which it distributes small branches, and continues caudad beneath the lateral raphé, breaking up beside the vulva into large branches for the ventral and dorsal divisions of the panniculus, to both of which throughout its course it supplies numerous smaller twigs. At the caudal border of the axilla it gives off a large branch on its mesal aspect, which dividing in two turns round the latissimus dorsi and is distributed to the dorsal panniculus in the scapular and postscapular regions.

The lower four cervical nerves and the first thoracic communicate with a stellate ganglion. It is situated upon the lateral surface of the rectus anticus, in the triangular space between that muscle and the scalenus in close proximity to the vertebral vessels, which are lateral to it. It measures 6 mm. by 4 mm. $\times$ 1 mm. Its branches of distribution upon the subclavian artery and the arteries arising from it are conspicuous for their large size.

The Skeleton.

(*Plates LIV–LVII*).

SKULL.

The cranium is broadly oval with a high arched vertex. The rostrum, though large, is far from approaching its adult proportions, and the frontal and squamosal project as yet but moderately from the sides of the brain-case. As a result of these several factors, together with the decurvate tip of the rostrum and the caudal position of the temporo-maxillary articulation, the skull has a strikingly avian appearance. The definitive elements in detail are well defined, and, proportions aside, have the same general arrangements and connections as in the adult. The most important exception to this statement is the all but complete exposure of the interparietal, with the concomitant wide interval between the frontal and supra-occipital. There is a broad fontanelle at the rostral margin and sides of the interparietal. On the base, the auditory bullæ are conspicuous for their relatively enormous size.

The following calliper measurements are intended to afford some basis for estimating the differential growth, by which eventually the skull attains its adult proportions:

Table V. Measurements of skull of fœtus of Balænoptera borealis.

	mm.
Length from tip of septal cartilage to condyle	100.
Breadth between rostral angles of orbital processes of frontals	48.
Breadth between caudal angles of orbital processes of frontals	61.
Breadth between rostral extremities of zygomatic processes of squamosals	61.
Breadth between extremities of postglenoid processes of squamosals	52.5
Breadth between parietal eminences	42.5
Breadth between extremities of exoccipitals	39.5
Depth from rostral margin of supra-occipital to hamular process	47.
Length of rostrum	53.
Greatest breadth of rostrum	38.
Length of maxilla, from frontal border	48.
Breadth of same at orbital process	25.5
Breadth of same at base of rostrum	21.
Length of premaxilla	55.5
Greatest breadth of same, at middle of rostrum	5.5
Length of nasal in median line	5.5
Breadth of same at rostral end	3.5
Distance from rostral end of nasal to rostral border of supra-occipital	42.
Distance from rostral end of nasal to rostral border of interparietal	23.
Sagittal length of orbit	21.
Greatest dorso-ventral diameter of same	18.
Depth from base to apex	11.
Length of hard palate	67.
Greatest length of palate bone	18.5
Length of fibrous bulla	21.5
Breadth of fibrous bulla	16.
Length of hamular process	9.5

In the description which follows I have concerned myself chiefly with the general architecture of the skull, omitting details regarding the individual elements, except in a few instances where they show important departures from adult conditions. For the study of the cartilaginous structures deBurlet's fine studies of the chondrocranium have been of the greatest assistance, and I am also under obligations to Prof. W. K. Gregory, who has allowed me to consult him upon many points of difficulty.

Norma occipitalis. As a whole this surface narrows towards the vertex from the postglenoid processes; this outline is however broken at the sides by the projection of the zygomatic processes of the squamosal and, farther dorsad, by the rounded convexities of the parietals. The foramen magnum is enclosed between the exoccipitals and basioccipital which are represented by a continuous cartilage in which three ossification centres have appeared. Those of the ex-occipitals are quadrangular and occupy the greater part of the intervals between the paroccipital processes and the condyles. The third is much smaller and situated in the basioccipital. The foramen magnum is oval with its long axis dorsoventral; it narrows ventrally between the condyles and in its dorsal contour a similar but slighter narrowing is present. Vertically it measures 10 mm., transversely 8 mm. The plane of its orifice looks caudad and to a slight degree dorsad. The condyles are born on very short condylar processes. They are almost flat transversely, moderately convex dorsoventrad. The lateral margins are strongly convex, almost angulate at their region of greatest convexity where they pass on to the base of the skull. The mesal borders are nearly straight except towards the extremities where they arch laterad. These straight mesal margins converge until they are only 1.5 mm. apart. Between them and the margin of the foramen magnum is a small area serving for the attachment of ligaments and showing near its apex the section of the notocord. The condyles measure 13 mm. in length, 7 mm. at their greatest breadth. The distance between their caudal extremities is 10 mm., between their ventral 4 mm. Lateral to the condyle is a narrow gutter in which is inserted the combined scalenus and rectus anticus; beyond this the cartilage rises in blunt elevations. Of these the most ventral is the paroccipital (paramastoid) process, which gives attachment to the rectus capitis lateralis, and is placed dorsolateral to the jugular foramen. It is separated by a depression from a more prominent vertical ridge, which gives attachment to an atlanto-occipital muscle, the superior oblique. Dorsal to this, again separated by a concavity, is a broad convexity serving for the attachment of the longissimus dorsi and of the muscle which I have described as the trachelo-occipitalis.

The supra-occipital is excluded from the foramen magnum by the exoccipitals. It is obscurely pentagonal in form, the rostral and lateral margins tending to fall into an irregular arch. In its whole extent it affords attachment to the semispinales muscles. Rostrad its margin slightly overrides the interparietal and here gives origin to the occipitalis. Near its lateral margin it is in contact with the parietal, between which and the interparietal is a broad membranous area.

Lateral to the exoccipital, between it and the parietal and squamosal, is a deep depression, filled in the natural condition of the parts with dense connective tissue. On the removal of this, the otic capsule is exposed presenting a surface concavo-convex dorsoventrad and rising almost to the level of adjacent bones as it approaches the base of the skull, where it is joined by the hyoid bar. Here the facial nerve emerges on the caudal aspect of the stylo-hyal.

Ventral to the exoccipitals appears the auditory bulla, and in the angle between it and the ex- and basi-occipital is the jugular foramen, which affords passage to the hypoglossal nerve in addition to the ninth, tenth and eleventh, there being no condyloid foramen. The jugular foramen is divided by membrane into a mesal compartment for the nerves mentioned above and a lateral one for the jugular vein.

Norma verticalis.— The norma verticalis differs from that of the adult not only in the short and broad rostrum, but even more conspicuously in the broad and rounded form of the brain-case and its great size as compared with the laterally projecting portions of the squamosal and frontal. The interparietal is single, free, and of a pentagonal shape. The supra-occipital is in contact with it caudad and is beginning to override its caudal margin, but only to a very slight degree. Except at this border it is surrounded by a wide fontanelle of complicated outline, which at the sides extends to the parietals and frontals, rostrad to the frontals which are in sutural contact in the median line. The orifice of the nasal fossa is bounded as in the adult, the nasal bones being short in proportion to their breadth; they are slightly expanded at their free extremities. Their margins are sharp and slightly concave. The premaxillæ, in correspondence to the short rostrum, are less slender than in the adult, but otherwise are closely similar. They are separated by a strip of cartilage, the dorsal margin of the cartilage of the septum. The maxillæ are more broadly triangular than those of the adult. Their nasal processes ascend more vertically, in consequence of the greater convexity of the forehead, and their mesal inclination is distinctly less. They are marked by a high transverse ridge near their articulation with the orbital plate of the frontal, which marks the limit caudad of the origin of the deep stratum of the transverse rostral muscle; the groove caudal to it, in which laterally the lachrymal is seen, gives attachment to part of the occipitofrontalis and to the muscle arising from the supra-orbital margin. The orbital plate of the frontal has a strong sagittal arch, and broadens laterad to the supra-orbital margin. The postorbital process is slender and decurved, it is joined to the zygomatic process of the squamosal by a quantity of fibrous tissue, to which is attached on a more ventral plane the zygoma. The slenderness of these processes of the frontal and squamosal and their small degree of lateral projection are among the striking differences of the fœtal from the adult cranium.

Norma basalis.— The hard palate has nearly attained the adult conformation of its component parts. The vomer is more exposed rostrad, where the maxillæ abut upon it by a rounded margin; in their caudal thirds they begin to cover it with their marginal plates. The palate bones overlap it to a greater degree and eventually meet in the midline, leaving a small knob of the ventral border exposed caudal to them. The maxilla has a wide alveolar sulcus in its caudal half, which opens into a large cavity, in which are contained the dental anlages and which the maxillary division of the quintal nerve enters from behind after passing ventral to the orbit. Mesal to the alveolar region there is a sagittal concavity which becomes deepest in the region where the horizontal plate of the palate is received between the mesal and lateral processes of the maxilla. The lateral border of the maxilla is thick and convex, differing here in contour as well as in proportions markedly from the adult. The caudal extremity of the maxilla was very imperfectly ossified and covered by thick and strong periosteum, in the removal of which the delicate caudal border was damaged. So far as could be ascertained this portion of the bone was blunt and rounded and did not end in a thin sharp-edged plate, as in the adult, resembling in this respect less modified types of maxillæ. The orbital process is deeply grooved between the alveolus and the orbital margin for the passage of branches of the facial nerve and vessels to the dorsum of the rostrum.

The horizontal plate of the palate requires no special comment; the vertical plate is short and narrow. It is inserted between the tuberosity of the maxilla and the internal pterygoid. Between its summit and the presphenoid is a moderate sphenopalatine foramen.

The internal pterygoid appears on the base between the palate and the external pterygoid, sending a narrow process dorsad which joins and underlies a descending process of the frontal. The hamular processes are very large, curving ventrad and mesad and overhanging the auditory bulla. The exposed surface of the external pterygoid is interposed between the squamosal and internal pterygoid, and lies in the same plane as these bones, with which it is suturally united. From its junction with the latter arises the m. pterygoideus externus, the internus taking origin from the internal pterygoid and that margin of the palate bone which articulates with it. There is thus no pterygoid fossa.

From the basisphenoid the small triangular processus alaris projects laterad nearly at the level of the dorsal surface of the sella turcica. This is still wholly cartilaginous. It is continued laterad by the processus ascendens alæ temporalis, in which ossification has begun. The latter process is cylindrical, slightly expanded at its extremity, which ascends and comes to the surface in the temporal fossa in the interval between the parietal, squamosal and external pterygoid. In the adult *Balænoptera* a bone presenting in this position has been taken by Carte and MacAlister [1] for basisphenoid, and Dwight [2] concurs in this usage, remarking that he does so "from information derived from the works of other observers, for it would be impossible to name it from the little that is seen on the unopened skull." He states that in *B. musculus* it lies between the parietal and the alisphenoid; in *B. rostrata* (= *acuto-rostrata*), he quotes Carte and MacAlister as finding it in contact also with the squamosal. As a matter of literal fact they say mastoid, but as this is inconceivable, I prefer with Dwight to take their meaning to be squamosal. As this region of the skull is highly specialized and in the adult many of the sutures are obliterated, it is not surprising that attempts at its analysis on the basis of adult material alone should have been largely erroneous. The matter is much simpler in the light of deBurlet's [3] fine studies of the chondrocranium in Cetacea, which have revealed the small size and cylindrical form of the ala temporalis. In his reconstruction of *B. rostrata* (= *acuto-rostrata*) this process, which corresponds in shape and position closely with that of this fœtus, projects freely into the wide fenestra sphenoparietalis, its extremity approaching close to the orbitoparietal commissure. It is therefore evident, that, when the fenestra is closed by the development of membrane bones, their margins will come in contact with the ala temporalis, the extremity of which will appear in the definitive temporal fossa as is usual in mammals, the peculiarity of the Cetacean skull consisting merely in the small size of the ala temporalis (alisphenoid).

If, then, the basisphenoid of the authors quoted becomes ala temporalis, a reinterpretation is necessary of the ventrally placed element, which they take for alisphenoid. This I have already described as external pterygoid. Carte and MacAlister, to be sure, term it alisphenoid or pterygoid bone, but then state that ventrally it divides into two pterygoid plates, which include between them a large ovoid pterygoid fossa. I have already expressed the opinion that the pterygoid fossa is absent in this skull, from which it follows that the fossa here in question must receive another interpretation. I take it to be the scaphoid fossa. To substantiate

[1] Carte and MacAlister, op. cit., p. 208.

[2] Dwight, T. Description of the whale (Balænoptera musculus Auct.) in the possession of the Society, with remarks on the classification of fin whales. Mem. Boston Soc. Nat. Hist., 1871, Vol. 11, p. 208.

[3] deBurlet, H. M. Zur Entwicklungsgeschichte des Walschädels, III. Das Primordialcranium eines Embryo von Balænoptera rostrata (105 mm.). Morph. Jahrb., Bd. 49, 1914, p. 119. Cf. also I. and II., Morph. Jahrb., Bd. 45 and Bd. 47, p. 644. Phocæna communis; and IV. Morph. Jahrb., Bd. 49, p. 393. Lagenorhynchus albirostris.

PLATE LIV.

PLATE LIV.

Balænoptera borealis.

Fig. 1. Skull, norma verticalis. Twice natural size.
Fig. 2. Skull, norma basalis. Twice natural size.

1. Maxilla.
2. Premaxilla.
3. Nasal.
4. Mesethmoid.
5. Lachrymal.
6. Frontal.
7. Anterior temporal ridge.
8. Postorbital process.
9. Zygoma.
10. Alveolar gutter.
11. Zygomatic process of temporal.
12. Squamosal.
13. Parietal.
14. Exoccipital.
15. Supraoccipital.
16. Interparietal.
17. Vomer.
18. Palate.
19. Orbital plate of frontal.
20. Ala orbitalis.
21. Sphenoidal fissure confluent with optic foramen.
22. Ala temporalis.
23. Internal pterygoid plate.
24. Hamular process.
25. External pterygoid plate.
26. Processus falciformis of squamosal.
27. Foramen ovale.
28. Meckel's cartilage.
29. Postglenoid process of squamosal.
30. External auditory meatus.
31. Os tympanicum.
32. Stylohyal.
33. Stylomastoid foramen.
34. Jugular foramen.
35. Exoccipital ossification centre.
36. Basioccipital ossification centre.
37. M. pterygoideus internus.
38. M. pterygoideus externus.
39. M. masseter.
40. M. depressor mandibulæ.
41. Mm. scalenus et recti capitis antici.
42. M. rectus capitis lateralis.
43. Mm. recti capitis postici.
44. M. trachelo-occipitalis.
45. M. longissimus.
46. M. obliquus superior.
47. M. sternomastoideus.
48. M. mastohumeralis.
49. M. trachelomastoideus.
50. M. semispinalis capitis.
51. M. occipitalis.
52. M. frontalis.
53. M. temporalis.
54. M. transversus rostralis, deep portion.
55. The same, superficial portion.
56. Oblique nerial muscle.
57. M. retractor naris.
58. Fontanelle.

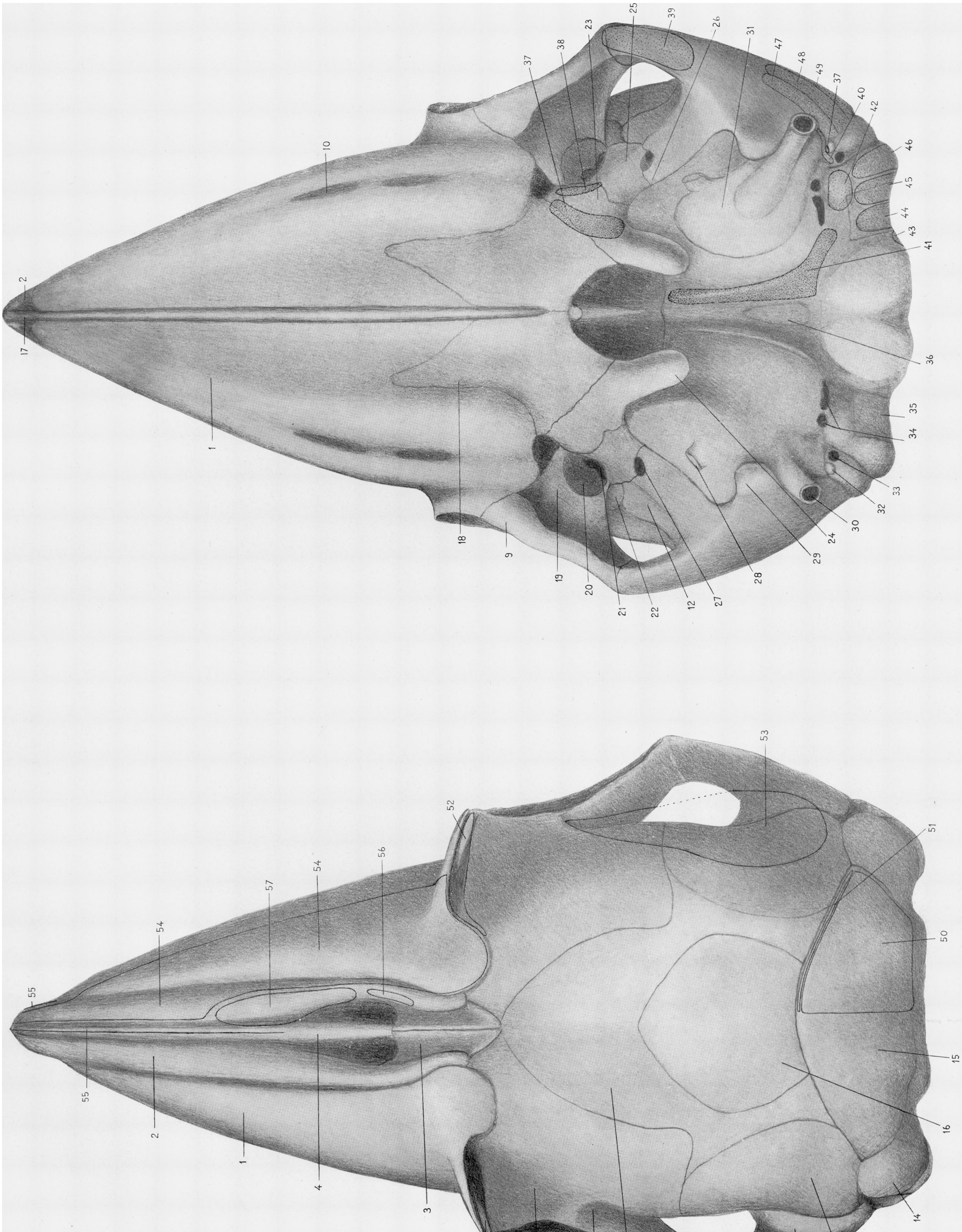

Fig. 1.

Fig. 2.

BALÆNOPTERA BOREALIS.

this view it is necessary to enter into details. The external pterygoid, the ectal surface of which has been described, is not a thin plate but a massive bone of irregular pyramidal shape. By its summit entally it joins the as yet cartilaginous processus alaris, beyond which it is continuous with the base of the processus ascendens. It thus conforms literally to the definition of the external pterygoid, being a descending process of the alisphenoid and ossifying from a centre common to it and the processus ascendens. Notwithstanding this typical conformation in the basal region, we are confronted ectally in the temporal fossa with a suture between the ala temporalis and the external pterygoid, and it is this highly aberrant and peculiar character which requires explanation. In less modified skulls these elements ectally are widely separated, a portion of the zygomatic fossa intervening between them. Here it appears that incident to the expansion of the external pterygoid to a pyramidal mass, it has come to be secondarily appressed to the ala temporalis (alisphenoid) with concomitant reduction of the zygomatic fossa, the highly significant remnant of which, and index of the whole process, persists as the suture between the external pterygoid and alisphenoid.

The caudal surface of the external pterygoid is exposed on removal of the otic capsule. Dorsad it extends to the processus alaris, ventrad to the base of the hamular process, from which it is separated by a suture. Laterad the bone is drawn out into a stout process, which lying mesal to the foramen ovale, is superficially overlain by the squamosal, so that the ectal orifice of the foramen lies in the suture between that bone and the external pterygoid. The apex of this process touches and is very firmly united by fibrous tissue to the tegmen tympani. Mesad the external pterygoid extends to the nasal fossa and here intervenes between the hamular and vaginal processes. These are both of large size, and immediately rostral to them the external pterygoid comes into the lateral wall of the nasal fossa, to a degree usurping the place of the internal pterygoid plate and taking part in the formation of the choanæ. The caudal surface of the external pterygoid is crossed by a transverse ridge extending from the lateral process to its mesal margin opposite the vaginal process.[1] Dorsal to this ridge the surface is concave and in apposition with the first turn of the cochlea. Ventrally the surface is also concave and lodges the Eustachian tube, giving origin also to the tensor tympani. For this reason it seems that the concavity bounded by this surface laterad and rostrad, and mesally by the vaginal process, should be considered scaphoid and not pterygoid fossa.

Beauregarde, in his description of this region in a young specimen of *B. rostrata* (= *acutorostrata*), records essentially similar conditions. The fossa in the pterygoid is ovoid, it is limited "en dedans par un crête elévée fournie par le pterygoïde, en avant par une apophyse digitiforme de pterygoïde que fait saillie en dedans, au dessous de la crête susdite et qui limite entre elle et cette crête un espace dans lequel passe la trompe d'Eustache." The last fact and his excellent illustration makes it clear that the structures in question are the vaginal and hamular processes of the internal pterygoid plate.

The internal pterygoid lies in general rostrad of the external, in which relative position it appears both on the ectal surface of the skull and in the nasal fossa. Ectally it overrides the external pterygoid by its caudal margin, while its vaginal process is prolonged on the mesal, its hamular process on the ventral aspect of the latter bone. Thus the external pterygoid is mortised into the internal from behind.

The squamosal in ventral view has a triradiate form; the stout zygomatic process projects

[1] Cf. Beauregarde, H. Recherches sur l'appareil auditif chez les mammifères. Jour. de l'Anat. et de la Phys., An. XXIX.

laterad and rostrad to articulate with the zygoma and postorbital process of the frontal; the more slender postglenoid process is directed ventrad and caudad and gives attachment to the dense fibrous envelope of the auditory meatus as well as to the capsule and fibro-cartilage of the temporo-maxillary joint; mesad and rostrad a narrow plate, the ventral surface of the squama, extends to the external pterygoid and represents the glenoid region. In the line of union is situated the foramen ovale. This is bounded mesad by a process of the squamosal, which overlies the pointed caudal extremity of the external pterygoid. It is the processus falciformis of Beauregard, and in this foetus is broad and very short in comparison to its proportions in his adult of *B. musculus* (= *physalus*). The angle between this process and the postglenoid is filled with dense fibrous tissue through which Meckel's cartilage makes its way to the tympanum. Rostrad the glenoid region is separated from the squama by a ridge, which sweeps laterad to the ental surface of the zygomatic process, and here becoming more prominent affords a very definite boundary between the temporal and zygomatic fossæ; thus corresponding to the anterior root of the zygoma and the beginning of the infratemporal crest.

Of the elements of the basicranial axis only the basi-occipital is exposed, the basisphenoid being covered by the expanded alae of the vomer and their articulations with the vaginal processes. The basi-occipital is, relative to that of the adult, very long. It lies in a deep depression between the auditory bullæ, and on each side sends ventrad, a low falcate process to which the fibrous wall of the bullæ is attached. These ridges serve also for the insertion of the rectus-scalene tendon. Rostrad they become lower but can be followed to the vaginal processes. Here laterally placed and partially overlapped by the vaginal process is the ectal orifice of the canal in the basisphenoid for the internal carotid artery. The exoccipitals extend caudad of the bullæ to the exposed bases of the otic capsules, which appear between them and the squamosals, here articulating with the hyoid bars, and on their caudomesal aspects giving passage to the facial nerves. Between the exoccipital and the bulla, is the large posterior lacerated foramen which is divided by membrane into two compartments, a mesal one for the IX–XII nerves, and a lateral one for the jugular vein.

The enormous auditory bulla occupies the region between the external pterygoid, the squamosal, the basi- and ex-occipital. Laterad it is prolonged into the external auditory meatus which is directed to the notch in the squamosal dorsal to its postglenoid process. Its wall is composed of extremely thick lamellated connective tissue, which is attached mesad and caudad to the vaginal process and occipital, rostrad and laterad to the external pterygoid, squamosal, and otic capsule, and is prolonged upon the floor of the auditory meatus. In this fibrous capsule is embedded the tympanic, which is relatively of small size and irregularly crescentic in form. It sends two cornua laterad. Of these the caudal is far the longer and extends to the base of the otic capsule, to which it is loosely attached by connective tissue. The rostral cornu is situated caudal to Meckel's cartilage, where it ends without other than membranous attachment to adjacent structures. Save at one point the tympanic is then isolated from other bones, and constitutes at this time a small plate in the extensive fibrous wall of the bulla. The size of the auditory bulla makes it the dominant feature of this region of the skull, and joined to the small development of the squamosal, and the relatively long basi-occipital, renders the basis cranii at this stage of development exceedingly dissimilar from that of the adult.

Norma lateralis. The high convexity of the cranium, the concavity at its junction with the rostrum, the horizontal base-line, together with the less prominent orbital margin and zygomatic process of the squamosal, and the much less projection caudad of the postglenoid process, combine to lend this aspect of the skull also an appearance very different from that of the adult. In particular the undeveloped processes and rostrum render the brain case more prominent, which to be sure is usual in fœtal skulls, but is more than ordinarily striking in this instance on account of the enormous size ultimately attained by these projections. The temporal ridge is present only rostrad and here ascends from the orbital margin with a caudal curvature a short distance upon the frontal, marking the limit of the origin of the temporal muscle in this direction. Elsewhere on the cranial wall the fossa is without definite limits. The ridge before mentioned upon the maxillary is clearly outside the confines of the fossa.[1] In the adult [2] the configuration of this region changes markedly and the maxillary ridge is continuous with the crest that bounds the temporal fossa, the fœtal ridge above the supraorbital margin being no longer recognizable. The dorsal surface of the orbital process of the maxillary and the whole of the orbital plate of the frontal are thus within the arch of the united ridges. The temporal muscle cannot occupy the whole of this extensive surface. Carte and MacAlister expressly state that in *B. rostrata* (= *acuto-rostrata*) it does not extend forward beyond the posterior angle of the orbit and the maxillary surface is already preëmpted by the frontalis muscle.

The zygomatic process of the squamosal projects strongly, but is more slender than in the adult. From its junction with the zygoma and the postorbital process of the frontal a strong tendinous reinforcement of its periosteum extends to the caudal margin of the bone, where it overlies the otic capsule. The insertions of the sterno-mastoid, masto-humeral, trachelo-mastoid and splenius are prolonged upon the tendon and the fibrous tissue covering the otic capsule, but can hardly at this period of development be said to insert upon the mastoid itself, for this process is still in a most rudimentary condition. The postglenoid process is directed caudad and ventrad in front of the external auditory meatus which is lodged in a notch between this process and the caudal part of the squama. It is separated dorsad from the superior root of the zygomatic process by a shallow groove. Its surface especially rostrad is covered by a very thick periosteum. Caudal to the squama an oval surface of the otic capsule is exposed. Caudal again is the extremity of the exoccipital, mesad of which the convexity of the occipital condyle is just visible, in profile forming the most caudal point of the skull. Important changes in proportion occur in this region subsequently and depend in the main upon the enormous enlargement of the postglenoid process which eventually projects beyond and conceals the condyle in profile view.

Orbit.— A complete osseous roof is afforded by the orbital process of the frontal; this broadens laterad to its pre- and post-orbital processes, the latter of which is prolonged into a strong process far less massive than in the adult, which joins the zygomatic process of the squamosal by means of a mass of fibrous tissue interposed between their extremities. Ventrad this bar is produced into a plate, which affords a partial caudal wall to the orbit. The preorbital margin of the frontal is prolonged into a similar ventrally directed plate, the mesal extremity of which descends in a stout process which overlies the ascending process of the internal pterygoid and abuts caudad upon a similar process of the external plate. Mesad the orbital surface of the frontal terminates in an arched margin of dorsal convexity which connects the mesal end of the

[1] A similar configuration of this region is shown in the skull of Cetotherium. Cf. Abel, O. Die vorzeitlichen Säugetiere. 1914. Fig. 53. Also in Rhachianectes. *Cf.* Andrews, R. C. The Calfornia Gray Whale. Mem. Am. Mus. Nat. Hist., N. S., Vol. 1, Pt. V., pl. xxvii.

[2] Cf. Andrews, R. C. This memoir pl. XLII.

postorbital plate with the descending process of the preorbital. This arch abuts against the flat cartilaginous orbito-sphenoid, which overlaps the frontal on its cranial surface, and mesally completes the roof of the orbit. The distance between the ends of the frontal arch just described is 10 mm., that between the lateral extremities of its pre- and postorbital processes is 21 mm. The depth of the orbital plate is 11 mm. It is thus evident that the orbital plate of the frontal has a more flaring form, and in particular is transversely far shorter than in the adult. A further difference lies in the complete exposure of its orbital surface in its whole extent, and the absence of any overrolling on the part of the preorbital plate or of the postorbital, such as occurs in the subsequent transverse lengthening of the orbital process, with the result of reducing the orbital roof to a small triangle at its lateral end, and the concealment and exclusion of the orbito-sphenoid from this secondary orbital cavity.

The floor of the orbit is almost wholly membranous. Ventral to the preorbital plate of the frontal a triangular surface of maxilla presents in the floor and articulates with the zygoma. The latter is very slender, ventrally convex, slightly expanded at its ends, having mesal and lateral margins and dorsal and ventral surfaces. To its mesal margin the suborbital aponeurosis is attached. At the mesal extremity of the orbit, the external pterygoid plate forms a ledge ventrally comparable to the frontal arch dorsally, but less regular and lying in a more lateral position relative to the ala orbitalis and the body of the sphenoid, to which latter it is here joined by a considerable mass of connective tissue. Caudad the margin is completed by the ala temporalis and by the ventral angle of the parietal, the margin of which participates in the ledge and continues it to the mesal extremity of the postorbital plate of the frontal. The ledge thus constituted serves for the mesal attachment of the suborbital aponeurosis, which caudally joins the edge of the postorbital plate and rostrad is connected to the orbital process of the maxillary, the preorbital plate of the frontal, and its descending process. As a whole the floor of the orbit is less convex than the roof, it is however longer transversely, for the zygoma is more laterally placed than the receding supra-orbital margin. The intimate relation of the floor of the orbit ventrad with the vestibulum oris has already been mentioned, as has also the insertion of the superficial division of the masseter into its aponeurosis.

The apical region of the orbit between the frontal arch and the infraorbital ledge is closed by the orbito-sphenoid and a portion of the presphenoid. These arches form together an oval with its long axis obliquely directed caudad and ventrad. In this aperture appears above a broad flat surface of orbito-sphenoid. Caudo-ventrad to this is the large sphenoidal fissure, at the ventro-rostral margin of which appears a portion of the presphenoid. This is separated by a fibrous interval from the external pterygoid. The optic foramen pierces the orbito-sphenoid below its middle, and is connected by a narrow cleft in the cartilage with the sphenoidal fissure, from the contents of which the optic nerve is separated by a broad partition of connective tissue. The sphenoidal fissure in addition to its usual contents, transmits the maxillary division of the fifth nerve.

Cranial cavity.— The long axis, extending from the foramen magnum to the dorsal margin of the frontal ossification centre, is approximately parallel to the basis cranii and has a length of 49 mm. The greatest dorso-ventral diameter, between the rostral margin of the supra-occipital and the sella turcica is 29 mm., and the greatest transverse, which falls in the same plane, is 40 mm. Caudad of this transverse plane the cavity narrows like a funnel to the foramen magnum, while rostrad it is rounded and broadly concave in the frontal region. The floor is

PLATE LV.

PLATE LV.

Balænoptera borealis.

Fig. 1. Skull, norma occipitalis. Twice natural size.
Fig. 2. Skull, norma lateralis. Twice natural size.

1. Interparietal.
2. Superior fontanelle.
3. Parietal.
4. Squamosal.
5. Zygomatic process.
6. Postorbital process of frontal.
7. Optic foramen.
8. Exoccipital.
9. Supraoccipital.
10. Occipital condyle.
11. Lateral fontanelle.
12. Otic capsule.
13. Stylohyal.
14. Postglenoid process of squamosal.
15. Hamular process.
16. Jugular foramen, compartment for vein.
17. Jugular foramen, compartment for nerves.
18. Auditory bulla.
19. External auditory meatus.
20. Paroccipital process.
21. Exoccipital ossification centre.
22. M. semispinalis.
23. Mm. recti postici.
24. Mm. recti antici et scalenus.
25. M. rectus lateralis.
26. M. obliquus superior.
27. M. longissimus dorsi.
28. M. trachelo-occipitalis.
29. M. depressor mandibulae.
30. M. splenius.
31. M. trachelo mastoideus.
32. M. sternomastoideus.
33. M. mastohumeralis.
34. Frontal.
35. Lachrymal.
36. Orbital process of maxilla.
37. Descending process of frontal.
38. Ala orbitalis.
39. Palate.
40. Internal pterygoid.
41. External pterygoid.
42. Ala temporalis.
43. Sphenoidal fissure.
44. Maxilla.
45. Transverse rostral muscle, superficial layer.
46. Transverse rostral muscle, deep layer.
47. Retractor naris.
48. Oblique narial muscle.
49. Nasal bone.
50. Premaxilla.
51. Insertion of deep stratum of occipito-frontalis and of supra-orbital muscle.
52. Attachment of ligamentum apicis dentis.
53. Origin of supraorbital muscle.
54. M. masseter.
55. M. sternomandibularis.
56. Septal cartilage.
57. M. temporalis.

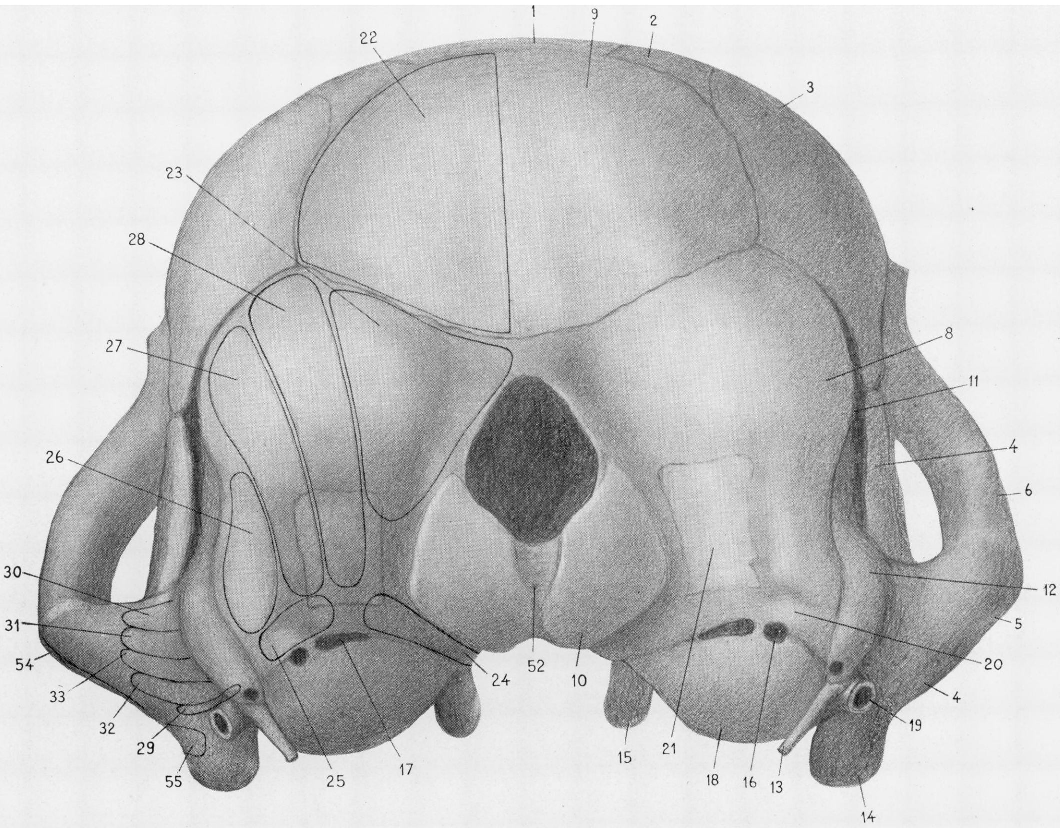

Fig. 1.

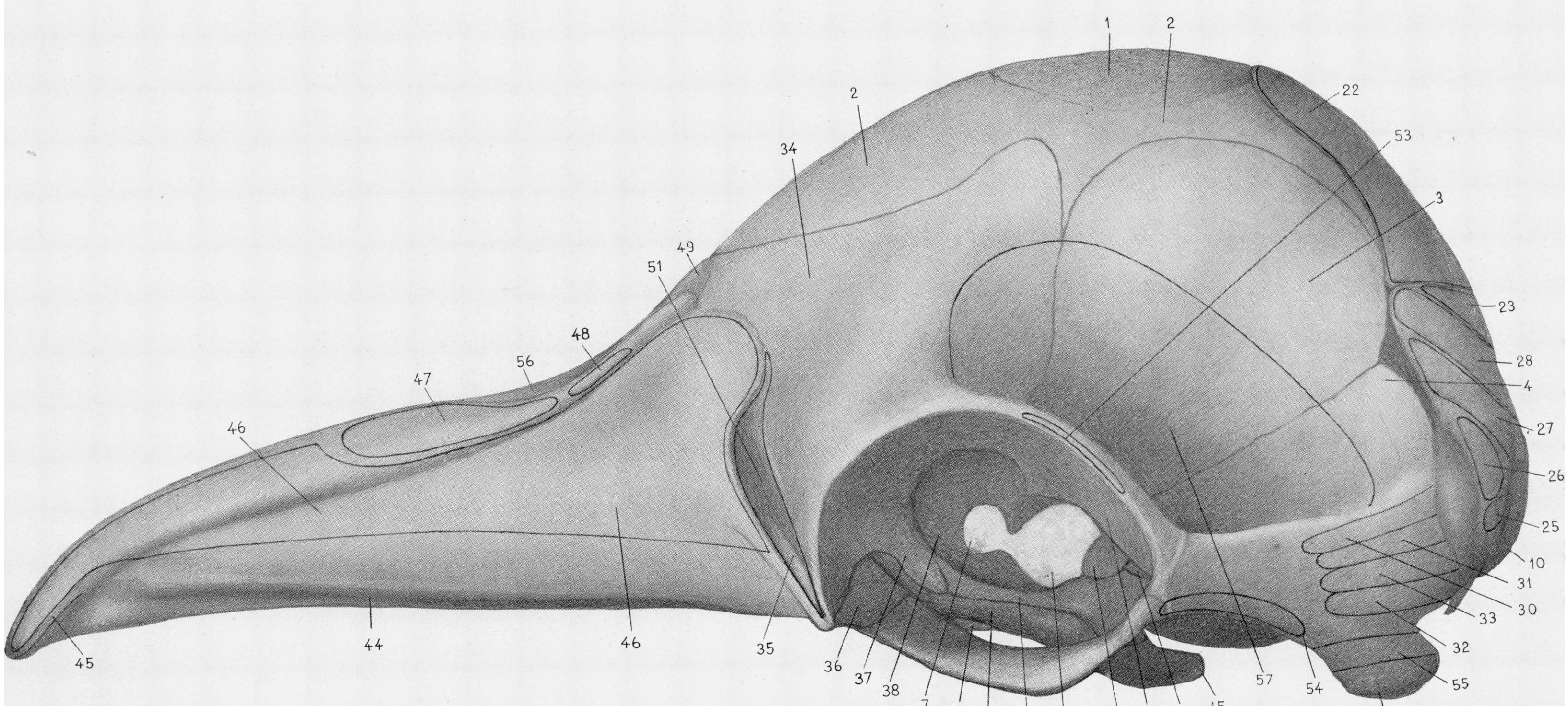

Fig. 2.

BALÆNOPTERA BOREALIS.

obliquely directed, rising rostrad and making an angle of about 30° with the long axis of the head. With the dura in place the cavity is smooth walled, the irregularities between the bones being filled with dense connective tissue; especially is this the case around the otic capsule. The falx cerebri is narrow, beginning upon the mesethmoid which has a low median ridge for its attachment, and extending to the supra-occipital where it meets the tentorium. Beyond this the falx cerebelli is represented by a minimal median fold. The tentorium is broader than the falx; it rises steeply, its plane making an angle of about 70° with the basis cranii. Its aperture is elongated dorso-ventrally, contracted from side to side. Ventrad its margin broadens to its attachment to the rudimentary dorsum sellæ and the side of the shallow sella turcica. A second low fold of dura extends from the dorsal margin of the foramen magnum obliquely ventrad and rostrad, terminating in an arch which surrounds the porus acousticus internus on its dorsal and rostral contours. Beneath the middle third of this fold is the jugular foramen, divided by dura into a rostral compartment for the hypoglossal, this subdivided into two parts, for the nerve pierces the dura in two divisions, and a caudal one for the glossopharyngeal and vago-accessorius. The facial and acoustic nerves as noted above pass out beneath its extremity, while the fifth has a large dural foramen midway between this fold and the tentorium. For the rest, the posterior fossa offers little to comment upon; its floor is concave and rises caudad to the foramen magnum, so that the region of the clivus does not form a continuous ascent.

The middle and anterior cerebral fossæ are but very imperfectly demarcated on the floor, owing to the lack of prominence of the ala orbitalis. This however is recognizable and the distance from its caudad margin to the rostral pole of the cavity exceeds that from the same point to the tentorium. The anterior fossa appears therefore enlarged at the expense of the middle. The sella turcica is shallow but broad, and the cavity in the dura which lodges the hypophysis has corresponding proportions. The diaphragma sellæ is narrow and zonular with a large foramen. The optic nerve enters the dura at the side of the olivary eminence and has a long subdural course before reaching the optic foramen. The cribriform area is depressed and a sharp lateral and rostral margin defines it from the frontal and from the lateral ethmoid. In it are three small foramina for olfactory nerves.

After the removal of the dura the conditions of the cranial elements, apart from the appearance of ossification centres and of membrane bones, was found to correspond very closely to the pattern of the chondrocranium of *B. acuto-rostrata* of 105 mm., modelled and described by deBurlet. There are a few changes however, the tænia metoptica has been partially absorbed so that the optic foramen is now confluent with the sphenoidal fissure, but otherwise the fenestra spheno-parietalis has much the same shape and relative size as in deBurlet's model. The commissura orbito-parietalis persists as a narrow and thin bar of cartilage at its dorso-lateral margin, now overlain ectally by the parietal bone. Caudally the commissura expands moderately and joins the otic capsule at the origin of the commissura præfacialis, but here stops without reaching the occipital, so that the lamina parietalis seems largely to have been absorbed. In consequence there is in this region a small lateral fontanelle between exoccipital, parietal and otic capsule; in the angle between the two latter a small triangle of squamosal appears, which in the natural condition is covered by fibrous tissue excluding it from the cranial cavity.

The fenestra spheno-parietalis is partially subdivided by the rod-shaped ala temporalis. This as in deBurlet's model falls short of reaching the commissura orbito-parietalis by a narrow interval. The extremity of the ala temporalis appears in the temporal fossa, as has been noted in the account of the exterior of the skull, between the external pterygoid and the parietal. Mesad it is suturally attached to a process of the basisphenoid (processus alaris) which completes the boundary of the sphenoidal fissure caudad. Owing to the interval which exists between the lateral extremities of the ala temporalis and ala orbitalis a small segment of parietal closes the fissure at this point. The sphenoidal fissure is confluent with the optic foramen, but not broadly for a remnant of the tænis metoptica persists as a process of the ala orbitalis. In addition to its usual contents it transmits the maxillary division of the quintus, there being no foramen rotundum. Caudal to it is the foramen ovale at the bottom of the triangular interval between it and the otic capsule. This space is largely filled with fibrous tissue, upon the removal of which the ventral angle of the parietal and a small area of squamosal are seen closing the space lateral and dorsal to the foramen ovale.

The otic capsule has advanced little beyond the condition recorded by deBurlet. The fissura basi-capsularis is marked by a deep groove, in the caudal part of which is situated the jugular foramen, and more mesally but close to it the foramen perilymphaticus still confluent with the fenestra rotunda. Rostrad toward the dorsum sellæ there is a very broad basi-cochlear commissure of cartilage and here the surface of the otic capsule slopes into that of the basisphenoid without visible demarcation. The ental orifice of the carotid canal is situated as in deBurlet's model at the caudal margin of the processus alaris with the alæ-cochlear commissure forming its lateral boundary. The canal begins ventrad, at the caudal margin of the internal pterygoid plate and is directed rostrad, dorsad and laterad through the basisphenoid. It is of small dimensions as the carotid artery is smaller than the vertebral in this fœtus. The line of attachment of the tentorium to the otic capsule is indicated by a low ridge which terminates between the foramen perilymphaticus and the porus acousticus internus. The latter is narrowed by a zonular fold of dura, but in the cartilage gapes widely and is divided by a ridge of cartilage into a dorsal and a ventral portion. The canalis facialis is hardly more roofed in than in deBurlet's fœtus and the commissura præfacialis is not proportionately increased in size. The ridge for the tentorium becomes grooved in its dorsal portion and in this groove appears the foramen endolymphaticus.

The ental surface of the basi-occipital descends from the foramen magnum and again rises towards its junction with the basisphenoid. Its ossification centre, which presents ectally as a narrow strip, expands towards the cerebral cavity and on its ental surface occupies the whole breadth of the cartilage. It is separated from the spherical ossification centre of the basisphenoid by a wide mass of cartilage which dorsally projects as a low ridge into the cranial cavity. Rostrad of this there is a concavity which lodges the hypophysis. The ridge must therefore be the dorsum sellæ, the concavity the sella turcica. This in turn is limited rostrad by a second low transverse ridge, the olivary eminence, which laterally terminates in a small conical projection, the remains of the tænia postoptica. Rostrad of this again is a shallow concavity, the cerebral surface of the presphenoid, in which have appeared a pair of small ossification centres, which have not yet united in the midline. The ala orbitalis is very large and terminates on the ental surface of the frontal with a concave margin. The tænia prooptica is broad and convex dorsad where it forms the boundary of the orbito-nasal foramen which gives passage to the large nasal nerve. Elsewhere the orbito-nasal fissure is reduced to linear dimensions and closed by membrane.

The large and wide area between the presphenoid and the frontal is occupied by the cere-

PLATE LVI.

PLATE LVI.

Balænoptera borealis.

Fig. 1. Medisection of skull, showing nasal fossa and dura mater. Twice natural size.
Fig. 2. Medisection of skull, dura removed to show cranial cavity from within.

1. Maxilla.
2. Premaxilla.
3. Nasal.
4. Frontal.
5. Interparietal.
6. Parietal.
7. Squamosal.
8. Lateral fontanelle.
9. Mesethmoid.
10. Ectethmoid.
11. Cribiform plate.
12. Orbito-nasal foramen.
13. Vomer.
14. Presphenoid ossification centre.
15. Basisphenoid ossification centre.
16. Basi-occipital ossification centre.
17. Carotid canal.
18. Processus alaris.
19. Ala temporalis.
20. Ala orbitalis.
21. Tænia metoptica.
22. External pterygoid.
23. Commissura orbito-parietalis.
24. Commissura præfacialis.
25. Canalis facialis.
26. Porus acousticus.
27. Foramen endolymphaticus.
28. Foramen perilymphaticus.
29. Hamular process.
30. Vaginal process.
31. Auditory bulla.
32. Auditory tube.
33. Ductus naso-pharyngeus.
34. Nasoturbinal.
35. Rostral narial fold.
36. Caudal narial fold. Between these folds the **Spritzsack**.
37. M. retractor naris.
38. Maxillo-turbinal.
39. Recessus lateralis inferior.
40. Sammelleiste.
41. Crista semicircularis.
42. Recessus lateralis superior, with two fronto-turbinals.
43. Ethmoturbinal I.
44. Ethmoturbinal II.
45. Ethmoturbinal III.
46. Lamina terminalis.
47. Foramen magnum.
48. Supra-occipital.
49. Tentorium.
50. Falx cerebri.
51. Optic nerve.
52. Cavum hypophysitidis.
53. Foramen in dura for quintus.
54. Porus acousticus internus.
55. Jugular foramen.
56. External pterygoid plate.

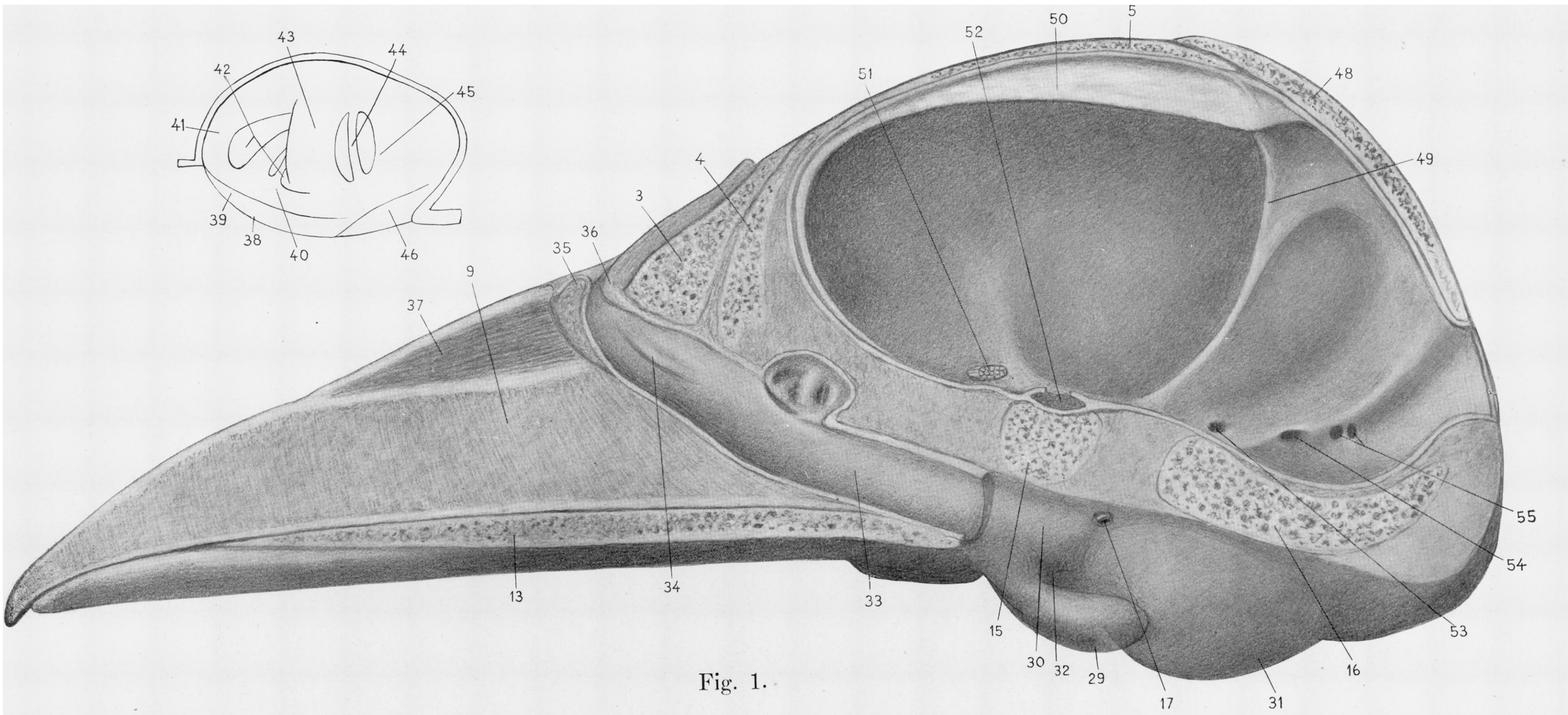

Fig. 1.

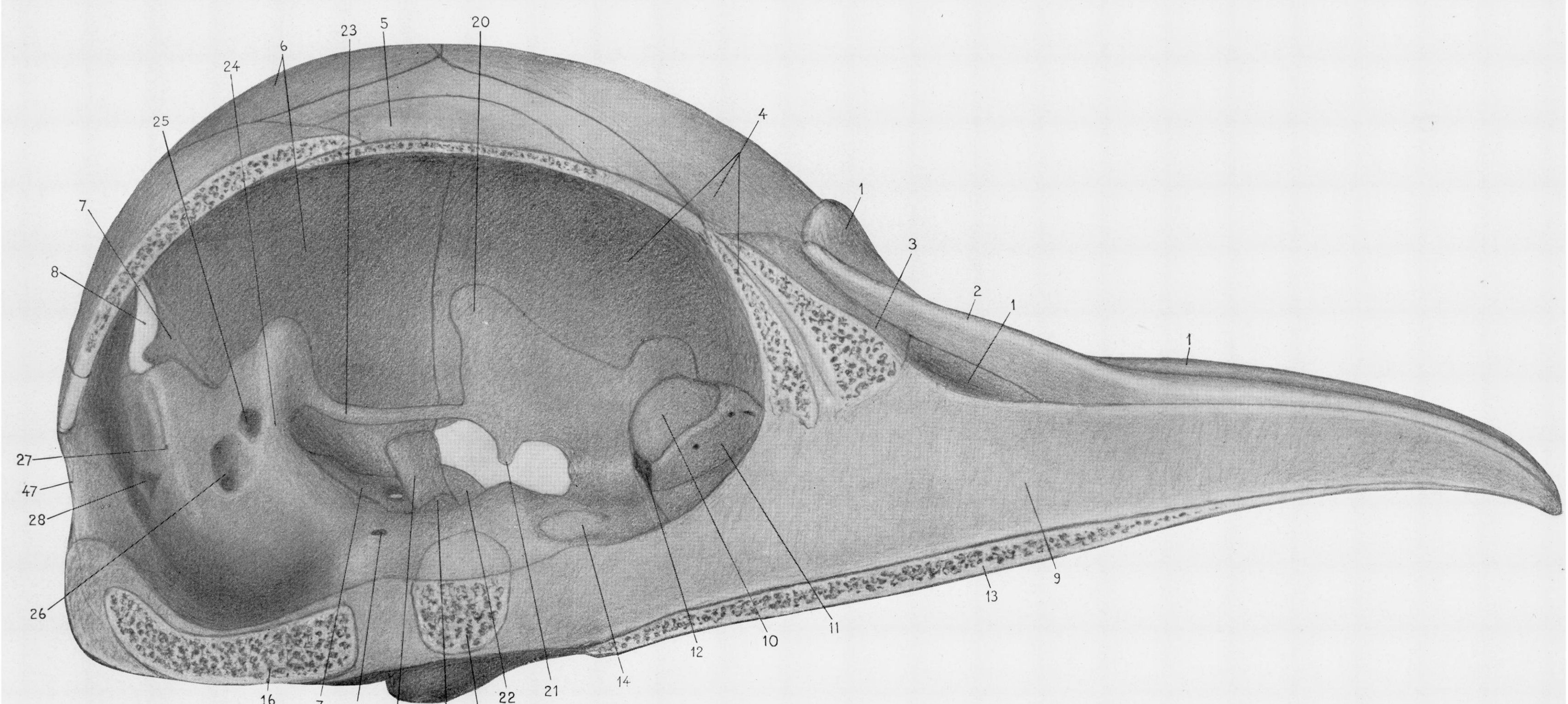

Fig. 2.

Balænoptera borealis.

bral surface of the nasal capsule. The mesethmoid in which no centre of ossification has yet appeared, is represented by a very thick plate of cartilage continuous caudad with the pre- and basisphenoid and extending the whole length of the rostrum without as yet a sign of division into parts. To its ventral margin is applied the broad trough-like vomer. The cerebral surface of this extensive cartilage rises in the midline in a low sagittal ridge to which is attached the falx cerebri. The lateral area of the nasal capsule has ossified on its cerebral surface, which has a quadrangular outline and abuts by its caudal end upon the orbito-nasal fissure. This lateral ethmoid is joined to the mesethmoid by a delicate cribriform plate, which is slightly depressed and contains three rather large foramina. It is still cartilaginous.

The axial elements of the cranium are all remarkable for their transverse breadth, especially is this true of the sphenoidal segments, and further for the low relief of their projections, notably the dorsum sellæ. There are no clinoid processes. As a whole the brain-case is less elongated than in deBurlet's fœtus, but is still far from the shortened condition of the adult, from which it further differs in the lack of any pronounced bending at its junction with the rostrum.

Mandibula.— The mandible is strongly arched, measuring 87 mm. along its convex ectal surface and but 75 mm., along the arc of this curve. Its height at the coronoid process is 13.5 mm., at the condyle 12 mm. It differs from the adult bone in the massive proportions of its proximal portion, which far exceeds the body in its vertical and transverse dimensions. The condylar process is better developed, and is distinctly produced craniad, so that the margin of the mandibular notch ascends distinctly towards the articular surface. The ventral margin rostrad of the angle is slightly convex becoming straight below the coronoid. In consequence the whole post-coronoid portion of the jaw has a slight ascent, the reverse of its direction in the adult. The articular surface is ovoid, with its major axis obliquely directed craniad, mesad and rostrad, and in this direction narrowing to a blunt point. It is covered by a thick fibrous pad which joins it to the glenoid fossa. I could make out no synovial cavities, but the tissue adjacent to the bones was loose and easily stripped off. A firm capsule was attached at the circumference of the condyle. An oblique, shallow groove separates the condyle from the region of the angle, which is elevated and massive giving attachment to the depressor mandibulæ. The coronoid process is high and triangular, its caudal margin vertical and slightly concave. Entally a deep groove separates the condyle from the angular process which is strongly marked and massive. In the groove is attached the internal pterygoid muscle. The mandibular foramen is large, the lingula but little developed and more nearly horizontal than in the adult. Meckel's cartilage is lodged in a groove near the ventral margin, and is visible on the surface from the mandibular foramen almost to the symphysis though much diminished in size distad. From the interval between the mandibular foramen and the insertion of the depressor craniad the cartilage is free, passing mesad of the temporo-maxillary articulation to become continuous with the malleus. The body of the mandible diminishes gradually toward the symphysis. It has the form of a trough enclosing the large dental gutter, which begins immediately distad of the coronoid process.

Hyoid.— The hyoid is well ossified and shows no sutures between its component parts. The lesser cornua point directly rostrad and are separated by a deep and narrow notch. To their apices are attached the strong and rounded stylohyoid ligaments, which run dorsad to the extremities of the stylohyals. The greater cornua are of large size, extending laterad and slightly dorsad; between their extremities the caudal border of the bone is transverse, and straight save for two slight convexities near the midline where the thyrohyoidei insert. The greatest sagittal extent is 8 mm.; the transverse distance between the tips of the greater coruna is 29 mm. The stylohyals are cylindrical at their attachment to the otic capsule. They extend ventrad, mesad and rostrad to the vicinity of the lesser coruna of the hyoid. Here their extremities are somewhat compressed from side to side. They are cartilaginous in their whole extent.

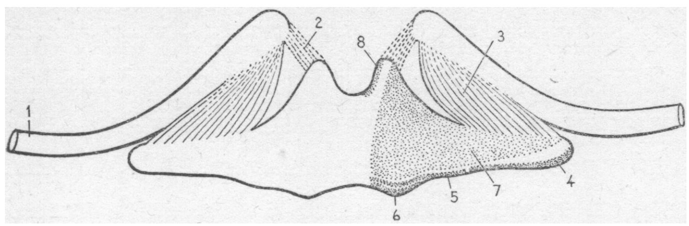

Fig. 7. Hyoid. 1, Stylohyal. 2, Stylohyal ligament. 3, Basiokeratic muscle. 4, Omohyoid. 5, Sternohyoid. 6, Thyrohyoid. 7, Genioglossus.

Vertebræ:— In form the vertebræ correspond already quite closely to those of the adult. The tubercles which serve for muscular attachment are but feebly developed and the surfaces are without muscular rugosities, conformably to their cartilaginous condition, only the centra as yet being possessed of ossification centres. The vertebral formula is C. 7, T. 13, L. — C. 35.

In view of the differential growth of the spine, which is an important factor in determining the form of the thorax and abdomen, a topic upon which Müller has made most interesting observations, the following measurements of the length of the bodies of the vertebræ are given. They are taken from a medisection of the spine and do not correspond exactly to the length of the ventral faces of the centra which are somewhat shorter, the vertebræ of the lumbar and caudal series being biconvex, and the disks biconcave. In the cervical and thoracic regions the centra are nearly flat.

Measurements of the lengths of the vertebral centra.

	mm.		mm.
Vertebra 2	4.	Vertebra 29	6.5
" 3	2.	" 30	6.7
" 4	2.1	" 31	7.
" 5	2.4	" 32	7.1
" 6	2.5	" 33	7.1
" 7	2.6	" 34	7.2
" 8	3.	" 35	7.3
" 9	3.6	" 36	7.4
" 10	4.	" 37	7.5
" 11	4.2	" 38	7.5
" 12	4.4	" 39	7.5
" 13	4.5	" 40	7.0
" 14	5.	" 41	6.9
" 15	5.	" 42	6.9
" 16	5.2	" 43	6.6
" 17	5.2	" 44	6.0
" 18	5.5	" 45	5.4
" 19	5.8	" 46	5.0
" 20	6.	" 47	4.5
" 21	6.	" 48	4.1
" 22	6.	" 49	4.0
" 23	6.	" 50	3.6
" 24	6.	" 51	3.0
" 25	6.	" 52	2.5
" 26	6.	" 53	2.2
" 27	6.5	" 54	2.0
" 28	6.5	" 55	1.8

PLATE LVII.

PLATE LVII.

Balænoptera borealis.

Fig. 1. Left mandible, lateral view. Twice natural size.
Fig. 2. Left mandible, mesal view. Twice natural size.
Fig. 3. Left otic capsule and auditory ossicles, ventral view. 4 × natural size.
Fig. 4. Cervical vertebræ, ventral view. 3 × natural size.

1. M temporalis.
2. M. masseter, deep portion.
3. M. masseter, superficial portion.
4. M. depressor mandibulae (M. digastricus, posterior belly).
5. M. digastricus, anterior belly.
6. M. pterygoideus internus.
7. M. mylohyoideus.
8. Meckel's cartilage.
9. Lingula.
10. Malleus.
11. Incus.
12. Stapes.
13. M. stapedius.
14. Canalis facialis.
15. Canalis semicircularis externus.
16. Tegmen tympani.
17. Cochlea.
18. M. tensor tympani.
19. Foramen, conducting vessels to the interior of the cochlea.

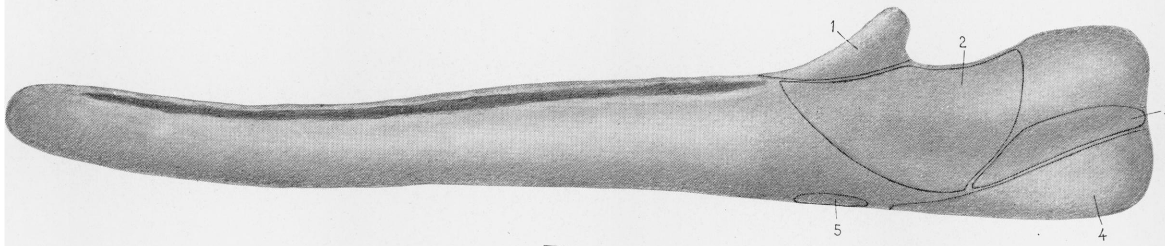

Fig. 1.

Fig. 2.

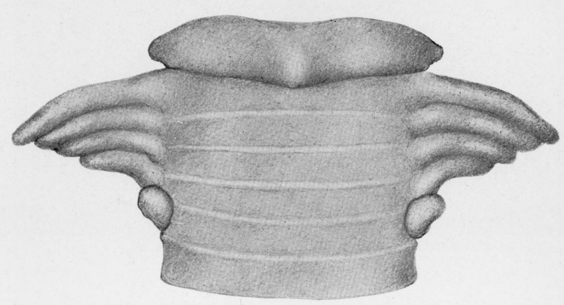

Fig. 4.

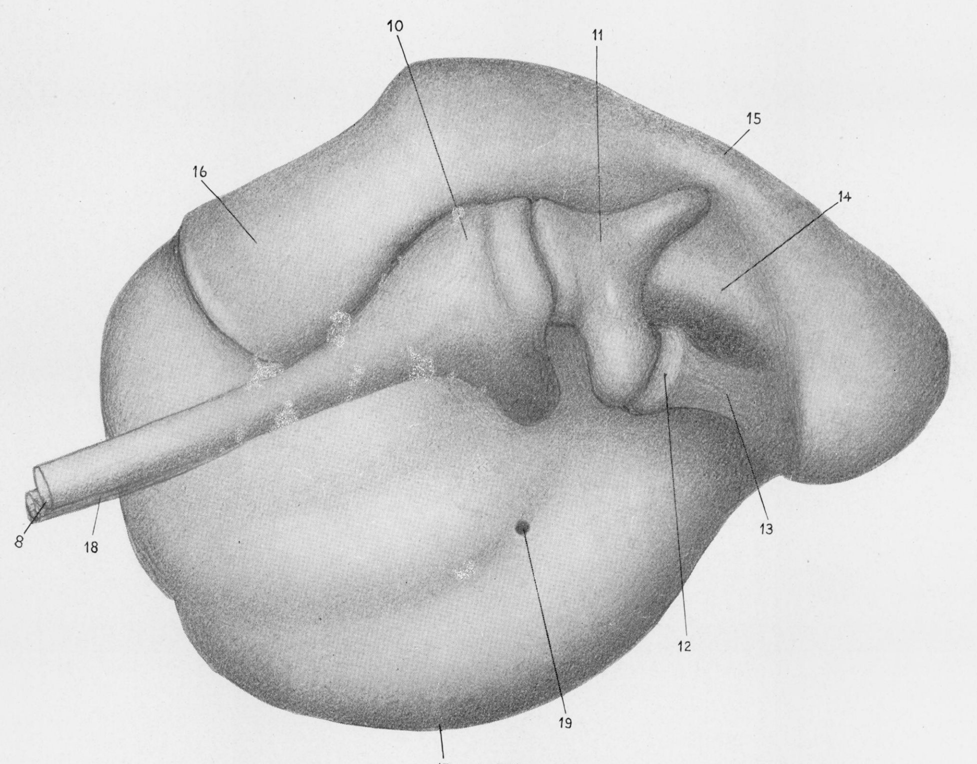

Fig. 3.

Balænoptera borealis.

In all of the bodies except the last five, a center of ossification is present. These in section are oval as far as the midthoracic region, beyond this circular. In the terminal vertebræ the cartilage has begun to calcify except in the last two.

The spinal cord extends to the level of the thirty-second vertebra, beyond which it is continued as the filum terminale surrounded by the nerves of the cauda equina. The neural arch is lacking in the last ten vertebræ, and in the seven or eight vertebræ rostral to these it was of minute dimensions.

The intervertebral disks are in general biconcave, expanding towards the periphery of the centra and very thin in the middle. The width of the expanded circumference increases caudad, being greater opposite the larger chevron bones. At the end of the series it diminishes rapidly. A few of the disks of the upper thoracic region departed slightly from this simple type showing a small lenticular thickening in their centers.

The chevron bones are ten, possibly eleven in number, the last being so minute a nodule in the dense fibrous tissue of the region that I am not sure it was cartilage. No joint was present between it and the corresponding intervertebral disk as in the case of the other ten. The second is the longest of the series; the last three or four are very small. The first articulates with the disk between the thirty-sixth and thirty-seventh vertebra.

Cervical vertebræ.— These vertebræ have the compressed bodies and large hoop-like transverse processes of the adult, with the exception of the first in which the transverse process is reduced to a tubercle, and of the second where it is a large plate perforated by a rather small foramen. These processes converge by their tips, in consequence of the inclination of those of the second and third vertebræ. The inclined and enlarged transverse process of the axis overhangs that of the third vertebra, its tip lying opposite the interval between the transverse processes of the third and fourth, but not descending actually to the level of the latter vertebra. The process of the fourth cervical is transverse as is also that of the fifth. In comparison with *B. musculus* (= *physeter*)[1], there is much less convergence of these processes, and the lower ones of the series do not ascend as in that species, in consequence of which a somewhat greater range of movement in the neck may perhaps be inferred of *B. borealis*.

The costal process of the sixth cervical vertebra is reduced to a small nodule of cartilage, which is not fused with the centrum, but articulates with it, and within a narrow range is movable upon it. The condition is symmetrical. The seventh cervical vertebra has lost its costal process. This is now represented by the upper bar of the so-called bicipital rib. That we are dealing here with a structure analogous to the variant cervical rib of man seems certain. The element in this fœtus would seem to represent the distal portion of the rib beyond its tubercle, for it is connected by ligament to the true transverse process of the seventh cervical. The proximal portion, the neck and head, are absent.

It is possible to find in the great size of the vertebral plexus a factor in the interruption of the costal processes of the last two cervical vertebræ. This large plexus has expanded in the foramina transversaria of the third, fourth and fifth vertebræ, reducing the transverse processes to slender bars of cartilage. That this may be a real factor in the modification of these parts and not simply a correlated peculiarity, is borne out by the well known phenomenon of absorption of cartilage or bone under pressure from blood vessels. At the root of the neck, the vertebral

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[1] Struthers, J. On the cervical vertebræ and their articulations in fin-whales. Jour. Anat. and Phys., Vol. VII, 1872.

venous plexus turns ventrad and condensing to a large but short vertebral vein joins the superior intercostal and the large spinal tap to form the posterior thoracic vein of Turner, which arches over the dome of the pleura to the vena brachiocephalica. The confluence of these vessels occupies the pyramidal space above the pleura and between the rectus anticus and scalenus muscles. In the dorsal portion of this space, approximately at the level of the pleural dome projects the neck of the second rib. This is crossed ventrally by the superior intercostal vein, which meets the vertebral at its rostral border. The interval between the second rib and the costal process of the fifth cervical vertebra, on account of the shortening of this region of the spine, is small and is occupied in its entirety by the vertebral plexus as it turns ventrad to its debouchment, the only other structures present being the vertebral artery and the very large stellate ganglion of the sympathetic. Had the costal processes in this region persisted, the intervals between them would have been entirely inadequate to the drainage of the plexus. Its presence therefore seems to have modified the development of this region reducing and separating from the vertebræ the costal elements. In a sense this argument of room for drainage seems to be borne out by the conditions in *B. physeter* as described and figured by Struthers, where the requisite space is gained, not by the interruption but by the inclination rostrad of the costal processes. That of the sixth cervical is in *B. borealis* only retarded in development, for it may form a complete arch in the adult. That of the seventh is separated from its vertebra, losing its mesal segment, from tubercle to capitellum while its remainder hypertrophies and fuses with the first thoracic rib. This also has lost its proximal segment and articulates only with the transverse process.

The spinous processes of the atlas and axis are of small size, in fact are little more than tubercles; those of the remaining vertebræ increase in height caudad. They are compressed from side to side, blunt and almost rectangular at their summits; none of them have a pointed profile. On the transverse processes dorsally at a short distance laterad of the prezygapophyses are very small conical processes, better marked on the more caudal vertebræ, which give origin, to the trachelo-occipital muscle and supply points of attachment to the semispinalis capitis. These processes are well shown in Andrews's figures of the adult vertebræ of this species. In Struthers's illustration [1] of *B. physeter* they appear on each side as a small tubercle, between what he designates as the nerve groove stage and the tubercular stage of the transverse process.

The atlas is less massive in its build and more ringlike in form than that of the adult. This depends upon the relatively smaller size of the lateral masses and the enlargement at their expense of the ventral portion of the neural canal embraced between them, which in the fœtus exceeds in cross-section the region occupied by the spinal cord and its membranes. The surfaces of articulation with the occipital condyles converge ventrad extending well upon the ventral arch where their extremities are separated by an interval of 2 mm. Their mesal margins are distinctly concave and of a curvature almost concentric with that of their lateral margins. Their extremities are rather pointed, their breadth far less than that of the condyles. Dorsally at their junction with the dorsal arch there is a deep groove for the vertebral artery, and this groove is not bridged over and converted into a foramen as in the adult. The spinous process is reduced to a tubercle; the transverse process is very short, blunt and imperforate. The ventral arch increases in sagittal depth towards the midline and here its caudal margin protrudes slightly beyond the body of the axis to give attachment to the longus colli. The articular sur-

[1] Struthers, F. Op. cit., pl. 2, fig. *iv*.

face for the axis is narrower than in the adult. Its long axis is dorso-ventral. It sends upon the ventral arch a slender prolongation, which fails by a narrow interval of meeting its fellow of the opposite side.

The capsule of the atlanto-occipital articulation is very strong and is attached round the margin of the articular surface, a faint groove being present on the lateral mass for its reception. The space between the lateral masses entally is filled with strong connective tissue, of which the bundles are for the greater part oriented transversely and seem therefore to represent the transverse ligament of the atlas. This is broad and thin and passes as Struthers has shown rostral and not dorsal to the odontoid process. Its margins are concave; between the ventral one and the arch of the atlas, the ligamentum apicis dentis passes to its insertion on the basioccipital in the fossa between the condyles and the ventral to the foramen magnum. In cross section this ligament appears to contain a cavity, which is probably related to the degeneration of the notochord, about which the ligament develops.

Dimensions of the atlas.

	mm.
Breadth between tips of transverse processes	21
Dorso-ventral diameter	18
Dorso-ventral diameter of neural canal	12
Dorso-ventral diameter of its dorsal compartment	6
Dorso-ventral diameter of its ventral compartment	6
Transverse diameter of its dorsal compartment	7
Transverse diameter of its ventral compartment	8
Length of articular surface for occipital	13
Greatest breadth of articular surface for occipital	5

Axis: — This vertebra is characterized by the large size of its transverse processes, which in consequence of a smaller foramen are more massive than those of the succeeding vertebræ. They are directed obliquely caudad and laterad in the form of plates with rostral and caudal surfaces. Their extremities are broad and rounded and contrast in this respect with the more pointed form of the adult. The spinous process is feebly developed. The articular surfaces for the atlas are concave from side to side, dorso-ventrally they appear flat. Their ventral extremities are not confluent but are separated by a very narrow interval. They differ from those of the adult chiefly in the regularity of the curve of their lateral contour. The space between them rises very slightly in a low cone, the odontoid process. Dorso-ventrally the axis measures 16.5 mm., transversely 27 mm. The spinal canal in the corresponding diameters is 6 mm. by 7 mm.

Ribs: — There are thirteen pairs of thoracic ribs, and in addition a well developed cervical rib fused with the first of the thoracic series. The thoracic ribs with the exception of the first are a series of slender bars increasing in length to the seventh and then diminishing. The last, however, is not greatly reduced. The last three ribs diverge by reason of the increasing obliquity of the more caudal ones, so that the corresponding intercostal spaces broaden ventrad; the last rib makes an angle of something under 45° with the horizontal. The second and third ribs have well developed necks and heads, the latter articulating with the vertebral centra; that of the second articulates with the second thoracic vertebra near its rostral margin impinging slightly upon the preceding intervertebral disk. The head of the third rib articulates with the disk between the third and fourth vertebræ, touching their bodies to only the slightest degree.

The fourth rib has a rudimentary neck and head, which fails to reach the vertebræ. The remaining ribs lack these parts and articulate by their proximal extremities with the transverse processes. The lengths of the ribs are given in the following table. The measurements were taken with callipers from end to end.

	mm.
1	30
2	45
3	50.5
4	52.5
5	54.5
6	57.5
7	60.5
8	58
9	54.5
10	51.
11	46.
12	45.
13	35.

The first rib, as has been said, is bicipital, a cervical rib being fused with its rostral aspect. A narrow cleft, diminishing ventrad, separates the two portions as they approach the spine, this interval has a length of 12 mm. It is filled with muscle of the same orientation and continuous with the scalenus. The cervical rib expands proximad, becoming flattened rostro-caudad and articulating with the transverse process (dorsal bar) of the seventh cervical vertebra. Ventrally it is connected with the transverse process of the fifth cervical by ligament. The proximal extremity of the first thoracic rib is also flattened and expanded. It articulates with the transverse process of the first thoracic vertebra. In both, the head and neck are wanting. The condition is identical upon the two sides.

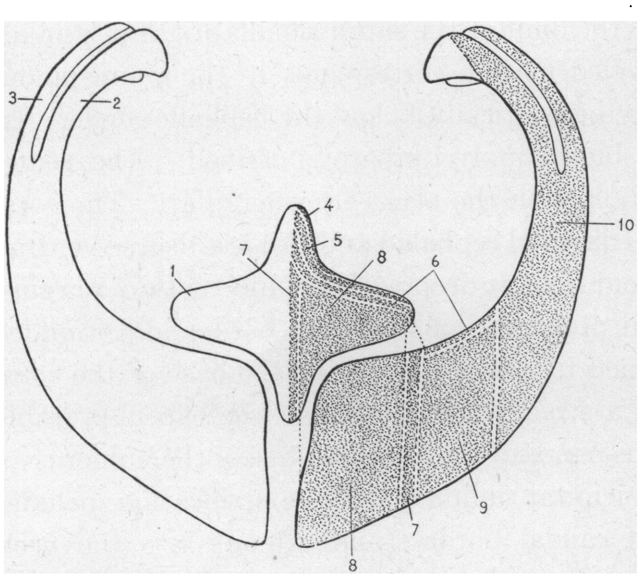

Fig. 8. Sternum and first rib. 1, Sternum. 2, Cervical rib. 3, First thoracic rib. 4, Sternohyoid. 5, Sternomastoid. 6, Sternomandibularis. 7, Pectoralis. 8, Rectus. 9, Obliquus ext. 10, Scalenus.

That the additional element in this fused rib is a cervical rib is shown not only by its topography and connections, but also by the absence of the ventral bar (costal process) of the transverse process of the seventh cervical vertebra.

While the morphology of the two-headed rib presents no especial difficulties, its taxonomic value has been the subject of much discussion.[1] It has been argued that as the cervical rib in man is a variant, so it is also in *Balænoptera borealis*, an argument evidently wrong in principle, for the question of normal vs. variant in a species must be answered by establishing with a

[1] Turner, W. On the so-called two-headed ribs in whales and man. Jour. Anat. and Phys., Vol. 5, 1870–1871, p. 349. This article is useful for the older literature. Also, by the same author, the transverse processes of the seventh cervical vertebra in *Balænoptera Sibaldii*. Jour. Anat. and Phys., Vol. 5, p. 382. The so-called two-headed ribs in whales and man. Jour. Anat. and Phys., Vol. 6. p. 445. Cervical ribs and so-called bicipital ribs in man, in relation to corresponding structures in the Cetacea. Jour. Anat. and Phys., Vol. 17, p. 384.

sufficient number of observations, the constancy or preponderating frequency in that given species of the structure in question. The doubt of the normality of the cervical rib in *B. borealis*, is only such as is incident to the necessarily limited number of individuals examined of an animal so difficult to procure.

The sternum.— The sternum is lozenge-shaped with produced angles; the elongation of the caudal one is much less than in Fischer's,[1] or even Flower's [2] illustration of the adult bone. It measures 13.5 mm. in breadth by 11.5 mm. in length. Its caudal margin rests against the ventral extremities of the rib of the first pair, and the short caudal process is inserted between them. It is joined to the ribs by a firm connective tissue, without the presence of a joint cavity.

The Pectoral Limb.

Scapula:— The scapula is rather low, its length being nearly twice its breadth (40 mm., 22 mm.). The vertebral border presents three convexities separated by slight concavities. The caudal border is concave near the neck, slightly convex at the distal limit of the teres origin, and thence nearly straight to the caudal angle which is rounded. The cephalic border is slightly convex as far ventrad as the acromion, and in this part of its course beveled and separated by a low ridge from the dorsum. As this ridge defines the limit of the supraspinalis origin it is taken to represent the spine of the scapula and the beveled margin corresponds to the supraspinous fossa. The acromion is very long, its extremity lying vertically below the cephalic angle. Its borders dorsal and ventral are parallel; its tip is blunt; only its base is ossified. The venter of the scapula is very slightly concave at its junction with the neck, elsewhere flat. The coracoid is robust, tapering slightly to its summit. It is directed cephalad and to a less degree ventrad and mesad. It is wholly cartilaginous. The glenoid fossa is deep with prominent thin margins. Its shape is nearly triangular owing to the marked projection of its dorsal border in a rounded angle. The articular surface is almost wholly formed by the scapula. To the base of the coracoid as it presents in the joint-cavity is attached a strengthening band of the capsule, visible from within the joint and continuous with the fibrous bands of the flexor surface of the humerus — a fact which fully justifies their interpretation as bicipital rudiments. The ossification includes the greater portion of the blade, the cephalic and caudal borders and extends into the neck and the base of the acromion, leaving the parts adjacent to the vertebral margin (suprascapula), the glenoid region, and the whole coracoid still cartilaginous. The surface for muscular origin is increased by two strong aponeuroses. One at the caudal margin stretches across the concavity between the origin of the teres and the glenoid margin and serves as an intermuscular septum between this muscle and the subscapularis. The other stretching between the dorsal margin of the acromion and the ridge representative of the spine increases the surface of origin of the supraspinatus and deltoid muscles.

Humerus.— The humerus is short and stout, its long axis oblique from the shoulder caudad, ventrad and slightly laterad. The head which looks chiefly dorsad, to a less degree mesad and cephalad, meets the shaft at an obtuse angle. The articular surface is globular except that it is

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[1] Fischer, M. Cétacées du sud-ouest de la France. Actes Soc. Linn. Bordeaux, 1881. Quoted in Beddard, F. E., A book of whales. New York, 1900. Pl. iii, fig. 10*a*.

[2] Flower, W. H. On a specimen of Rudolphi's rorqual taken recently on the Essex coast. P. Z. S., 1883, p. 513.

abruptly planed off when it joins the flexor surface of the shaft, so that here it rises very slightly above the level of this surface, from which it is separated by an arched margin. The articular surface of the humerus exceeds that of the glenoid fossa considerably in the transverse diameter, to only a slight degree in the sagittal, so that it may be inferred that the movements of ab- and adduction are more free than those of flexion or extension. The capsule of the scapulo-humeral articulation is attached close to the margins of the articular surface, the neck of the humerus being extremely short and marked only by a groove between the head and radial tuberosity in which the capsule is attached. This tuberosity juts out from the preaxial border, its flexor and extensor surfaces falling into the level of the corresponding surfaces of the shaft. Proximally it presents a quadrangular surface which like the rest of the tuberosity is rough for muscular attachments. Further mesad, close to the articular surface, on the flexor surface and not at the postaxial border is a second rough and slightly projecting area into which the subscapularis muscle is inserted. It is separated from the radial tuberosity by a groove which lodges the tendon of the masto-humeralis. The shaft is oval in section proximad becoming more flattened towards the elbow. The margins are concave, especially the postaxial. The extensor surface is convex, the flexor rather flat. Distad there are two articular surfaces separated by a low ridge for the radius and ulna, the latter being considerably the larger. Only the middle third of the shaft is ossified and here the process seems less in degree than in the shafts of the radius and ulna. The length of the humerus is 14 mm., its greatest breadth from head to tuberosity is 8 mm., that of the lower extremity is 7 mm., of the middle of the shaft 5.5 mm. The junction of the humerus with the bones of the antibrachium is at an angle, the long axis of the humerus deviating slightly in a dorsal direction from the long axis of the limb so that at this point both the preaxial margin and flexor surface are slightly concave.

Radius:— The radius is the stouter of the bones of the antibrachium. It is slightly flattened dorso-ventrally and the shaft presents a marked curvature, convex preaxially in the middle and curved in the opposite sense at the two extremities. While occupying a smaller area than the ulna upon the humerus, at the carpus its surface is the greater, articulating with the radiale and the whole of the intermedium. The shaft is ossified, the extremities cartilaginous. The total length is 18 mm., the proximal cartilage 3 mm., the distal 4.5 mm., the remaining 10.5 mm. being comprised in the ossified diaphysis.

Ulna:— The ulna is longer and more slender than the radius. Its proximal extremity is prolonged upon the postaxial border of the humerus thus enlarging their articular surface. This is on the whole concave comprising a smaller vertical and larger transverse portion, the two meeting at a rounded angle. In this region the ulna is dorso-ventrally flattened. Here it is joined by the very large olecranon cartilage which projects in a dorsicaudal direction. It is compressed, broadens towards its free extremity which is convex giving the whole cartilage much the shape of an ax-head. The shaft of the ulna is rounded and ossified. Its carpal extremity again expands slightly and is flattened. It articulates with the ulnare and with the pisiform. Its length is 22.5 mm., of which 10.5 mm. is occupied by the ossification of the diaphysis, 7 mm. by the proximal cartilage, 5 mm. by the distal, thus corresponding closely with the radius in the length of diaphysis and distal cartilage.

Carpus:— The carpus is wholly cartilaginous. In the first row there are four elements, radiale and intermedium articulating with the radius, ulnare and pisiform articulating with ulna, which is partially united with the ulnare. The carpalia are much reduced. Carpale

I,[1] is represented by a very minute cartilage at the preaxial border of the metacarpus interposed between the radiale and the metacarpal of digit II, with which latter it is partially fused. A second element of this row is of larger size. Proximad it articulates with radiale and intermedium, distad with the metacarpalia of digits II and III, by its postaxial border with the fourth metacarpal. This element is imperfectly separate from metacarpale II. It probably represents the fused carpalia II and III.

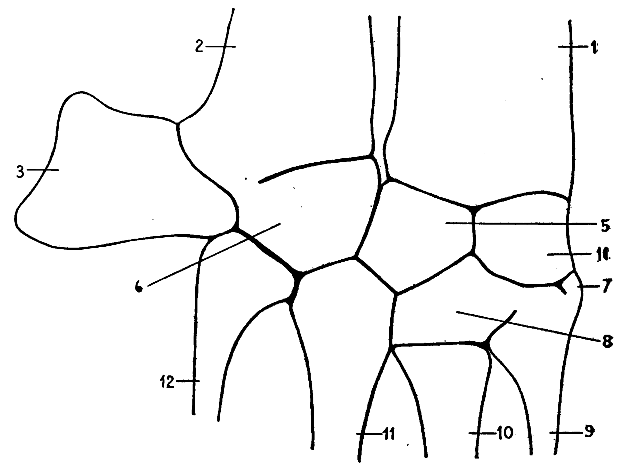

Fig. 9. Section of carpus. Camera lucida tracing. 1, Radius. 2, Ulna. 3, Pisiform. 4, Radiale. 5, Intermedium, 6, Ulnare. 7, Carpale 1. 8, Carpalia 2 and 3. 9–12, Metacarpalia 2–5.

Digits:— In all the metacarpalia are assimilated in form to the phalanges. Those of digits IV and V articulate with elements of the first row of the carpus; metacarpale IV with the intermedium and ulnare, metacarpale V with the ulnare and pisiform. There is no sign of a first digit. The number of elements in each digit, the metacarpal included, is as follows: II–4; III–7; IV–7; V–4.

Pelvis:— The os innominatum is embedded in the junction of the ischio-caudalis and the rectus muscles, so that only the pubic region is exposed in ventral view, and this is situated close to the lateral margin of the neuro-vascular foramen in the latter muscle. The extremities of the ilia are connected by ligaments, the prepelvic bands of Struthers,[2] to the termination of the linea alba. In shape the innominate bone resembles that of *B. rostrata* figured by Eschricht [3] more closely than that of *B. borealis* in Struthers' illustration.[4] The ilium is slender and rod-like, the ischium expanded and dorso-ventrally flattened. Entally the two portions fall into one continuous curve, while ectally the region of junction is marked by the small projection of the pubis. The total length of the cartilage is 9.5 mm.; the breadth of the ischium is 2 mm., that of the ilium about half as much. The ischia of the two sides are separated by an interval of 10 mm., the tips of the ilia by a distance of 6 mm. There was no femoral cartilage.

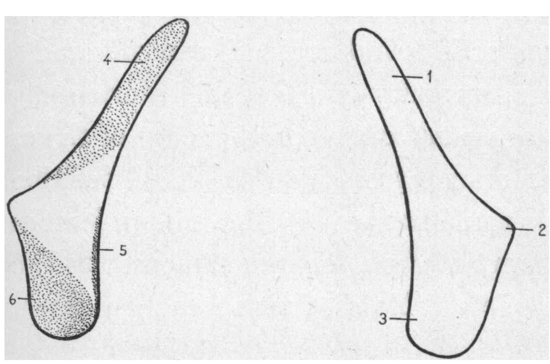

Fig. 10. Pelvic rudiments. 2× nat. size. 1, Ilium. 2, Pubes. 3, Ischium. 4, Insertion of rectus abdominis. 5, Origin of ischio-caudalis. 6, Origin of ischio-cavernosus.

[1] Leboucq, H. Recherches sur la morphologie de la main chez les mammifères marins, Pinnipèdes, Siréniens, Cétacés. Arch. de Biol., T. IX. 1889, p. 571. Cf. pl. xl, figs. 50–52.

[2] Struthers, John. On the rudimentary hind limb of a great fin-whale (Balænoptera musculus) in comparison with those of the humpback and the Greenland right-whale. Jour. Anat. and Phys., N. S., Vol. XXVII, 1893, p. 290.

[3] Eschricht, D. F. Untersuchungen über die nordischen Waltiere, I. fig. 42. Cf. Abel, O. Die Morphologie der Hüftbeinrudimente der Cetaceen. Denkschr. der Akad. der Wiss., Math.-Naturw. Klasse, Bd. 81.

[4] Id. Plate XX, Wien 1908, Fig. 7.

THE EAR.

By John D. Kernan, Jr.

(Plate LVII, fig. 3).

External auditory meatus: — The external orifice of the auditory meatus is a minute opening situated 24 mm. caudal to the center of the eye and 9 mm. dorsal. No auricular cartilage could be found on gross examination, which alone was possible, nor were the muscles described by Hanke[1] definitely ascertained to be present.

The auditory meatus itself passes rostro-mesad in a groove in the squamosum, as described by various authors. In the lateral part of its course it is an exceedingly small tube. Mesally it expands like the mouth of a speaking trumpet and the ental extremity is attached to the concave edge of the tympanum, and to that part of the squamosum which completes the tympanic ring. The lumen of the meatus is laterally circular. The mesal expansion takes place in a horizontal axis, caudo-rostrad, and scarcely at all vertically. Thus the inner extremity of the tube presents on cross section the appearance of a horizontal slit with dorsal and ventral walls almost in contact. The plug of cerumenous material described by Lillie[2] and Hanke, was not present.

The membrana tympani is elliptical with the long axis pointing rostro-mesad, thus continuing the direction of the auditory meatus. The plane of the membrane is horizontal, so that in place of forming an inner wall for the meatal canal, such as is found ordinarily in mammals, the membrana forms in reality part of the roof. The inner extremity of the canal is formed by the meeting of the dorsal and ventral walls at their joint attachment to the concave edge of the os tympanicum. The extreme horizontal position of the membrana agrees with the basal position of the whole auditory apparatus as found in *Balænoptera* (van Kampen).[3] The circumference of the membrana is attached to the sharp, concave outer margin of the os tympanicum, and to the squamosum where the circle of the tympanic is incomplete. No distinction can be drawn between pars tensa and pars flaccida.

From the description of the membrana tympani thus far given it will be seen that at this stage it is typically mammalian, that is a thin, oval membrane, slightly concave toward the inner surface, attached by its margin to the tympanic ring. There is as yet no evidence of the finger-like projection of the membrane outward into the lumen of the external meatus found in the adult (Beauregard)[4] nor even any indication of its approaching formation as found by Hanke in a somewhat older fœtus of *B. musculus*.

In one important respect the membrane differs from that of other mammals; namely, in its relation to the malleus. From this structure it is separated by a considerable space, the membrane forming part of the ventral wall, the malleus lying close to the dorsal wall of the tympanic cavity. The space between the two, which is triangular, is occupied by a fold of tissue formed from the membrane itself. From the tip of the manubrium mallei to the inner

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[1] Hanke, H. Ein Beiträge zur Kenntnis der Anatomie des aüsseren und mittleren Ohres der Bartenwall. Jenaische Zeitschrift fur Natur Wissenschaft, 1914.

[2] Lillie. On the Anatomy and Biology of the larger Cetacea. Proc. Zool. Soc. London, Vol. II, 1910.

[3] v. Kampen, P. N. Die Tympanalgegend des Säugetierschädels. Morph. Jahrb., Bd. XXXIV, Hefte 3 u. 4, 1905.

[4] Beauregard, H. Recherçhes sur l'Appareil Auditif chez les Mammifères. Jour. de l'Anat. et de la Phys., An. 29–30, 1893–4.

surface of the membrana this fold forms a free edge, which is the base of the triangle. The apex is at the outer border of the tympanic cavity where malleus and membrana approach one another though not in contact. The sides of the triangle lie along the attachment of the fold to malleus and membrana respectively. This attachment of malleus to the membrana tympani corresponds to that found in adults of this species, except that in them the fold is greatly elongated, owing to the outward projection of the membrane.

Cavum tympani: — The cavum tympani is a bowl shaped cavity, having dorsal and ventral walls which meet in a sharp angle at their margins. The ventral wall contains in the lateral area the membrana tympani, surrounded by the crescentic os tympanicum. The rest of the ventral wall is made up of the fibrous bulla which fills in the space between os tympanicum and the marginal attachment of the bulla.

The dorsal wall of the tympanic cavity is made up of otic capsule centrally placed, and circumferentially of a ring of fibrous tissue which connects the petrosum to the surrounding bones. As it presents itself after removal of the os tympanicum and bulla, it is seen to be covered by a layer of thick tissue which completely conceals the underlying cartilage and almost fills the cavity. In the outer area of the cavity this structure throws folds about the ossicles, and only on its removal can they be examined. The formation of this tissue shows it to be of a cavernous nature (Beauregard) and its function is variously stated as hydrostatic or auditory.

Tuba auditiva: — The tuba auditiva passes from the choana laterad between hamular and vaginal processes of the internal pterygoid and penetrates the wall of the bulla obliquely. Its entrance into the tympanic cavity is at the rostral circumference of the same, in the angle formed by the meeting of ventral and dorsal walls. The opening is a crescentic slit capable of valve-like closure. The tube is very short, merely an oblique passage through the fibrous wall of the bulla. The expansion of its distal end into the scaphoid fossa as found in the adult is not yet indicated.

Ossicula auditus: — The ossicles are typically mammalian in their arrangement. Meckel's cartilage passes beneath the edge of the tympanic bulla, caudad and slightly dorso-laterad, closely roofed over by the tegmen tympani. Mesad to its shaft is the belly and tendon of the tensor tympani muscle. Within the tympanic cavity, the cartilage expands into a fairly large caput mallei, and forms a mesal projection, the manubrium, to the base of which is attached the tensor tympani. A groove in its surface completely encircles the caput, close to the edge of the articulation with the incus. The border itself expands, thus increasing the depth of the groove.

The incus has a triradiate form. On the well developed body is a saddle-shaped articular surface for the malleus. The processus brevis is stout and of large size. Its extremity is in contact with the crista parotica, to which it is firmly attached by a ligament. The processus longus, which actually is shorter than the brevis, is also bulky in form. It is directed ventrad to articulate through an os lenticulare with the apex of the arch of the stapes.

The stapes which is lodged in a deep fossula, does not fill with its foot plate the large fenestra, but is united to its circumference by a rather wide annular ligament. The bone closely agrees with the adult form; its arch is high and narrow, the limbs thick, the foramen small.

Capsula otica: — The otic capsule, in contrast to its relatively small size in the adult, is here a large cartilage forming a considerable portion of the floor and lateral wall of the posterior fossa.

Caudad the capsule is in contact with the exoccipital, a thick layer of perichondrium being interposed. The line of union is interrupted by the opening of the jugular foramen. Mesally, the capsule extends under the basi-occipital and basi-sphenoid, in such a way as greatly to narrow the ventral surface of these structures as compared to the dorsal. Although the contact is intimate there is no real union of substance, except at the most rostral part of the line, where there is found the broad basi-capsular commissure already mentioned in the description of the cranial cavity as a whole. It should be noted that this commissure does not affect the whole thickness of the apposed structures, but is merely a thin shell of cartilage joining their ental edges. So that here also the basi-capsular fissure is all but complete.

DeBurlet in a 104 mm. embryo of *B. rostrata* (= *acuto-rostrata*), found five commissures present in the course of the basi-capsular fissure. In each case the union of substance involved only the ental surface, the fissure being deep and continuous in ectal view. On the basis of a single embryo deBurlet found himself unable to decide whether the union between basal plate and otic capsule was in process of formation or of resolution, inclining to the latter view, because of the freedom of the periotic in the adult, an opinion which receives support from the further reduction of the commissures in this older fœtus.

Rostrad the otic capsule enters into the border of the fenestra sphenoparietalis. Here its pole is received into a concavity of the external pterygoid,[1] which on its lateral aspect is drawn out into a stout conical process under cover of a process of the squamosal, which forms the mesal boundary of the foramen ovale and in its position and relations evidently corresponds to the processus falciformis of Eschricht [2] and Beauregard. The process of the pterygoid is of late development, for it is not represented in deBurlet's model.

In the lateral wall of the cranium, the capsule is largely under cover of the squamosal, a small oval area alone appearing in the interval between this bone and the exoccipital. In the natural condition of the parts, this surface is covered by a thick connective tissue, which further closes the gap above the capsule between the exoccipital, the squamosal and the parietal. While this area corresponds in a general way to the elongated mastoid of the adult, it is to be noted, that in this fœtus, the relief of the posterior semicircular canal is visible on the surface and the definitive mastoid is as yet barely indicated.

Under cover of the squamosal, the otic capsule still retains its continuity with the primitive cartilaginous lateral wall, a well marked commissura orbitoparietalis, extending as a horizontal strip from the ala orbitalis to the capsule, which it joins at the origin of the commissura præfacialis.

The ventral surface of the capsula otica is concealed by the fibrous auditory bulla, in the substance of which the tympanic is embedded. As in other mammalian chondrocrania, when, as yet in this region, ossification has not begun, two portions of the otic capsule are distinguishable, the pars canalicularis and pars cochlearis, of which the latter is remarkable for its disproportionately large size.

Pars cochlearis: — The pars cochlearis has the form of a circular disc with a slightly concave ental surface, and convex ectal surface. The axis about which the coils of the cochlea turn is almost vertical, pointing from above downward and slightly outward. This causes the surfaces to face dorsad and ventrad. The vertical direction of the cochlear axis is an indication of the

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[1] Beauregard. Journal de l'Anatomie et de la Physiologie, V. 29, 1893.

[2] Eschricht, D. F., og Reinhardt, J. Om. Nordnvalen (Balæna mysticetus) Klg. Danskevidensk. Selek. Skriftet (5), nat. og math. Afd., V.

extent to which the displacement of the otic capsule from its primitive position in the side wall of the cranium, toward a basal position has proceeded in *Balænoptera*. These surfaces are demarcated by the convex edge of the first turn of the cochlea, except dorso-laterally, where the border is interrupted by the junction with the pars canalicularis. In this region the dorsal surface passes without interruption into the mesal surface of the pars canalicularis. Not all the dorsal surface appears in the cranial cavity. It will be recalled that the cochlea dips under the basi-occipital and basi-sphenoid, and this causes a crescentic shaped area mesally and rostrally, to be shut off from the cranial cavity by that overhang of the basal plate, designated by deBurlet as lamina supracochlearis. An additional portion of the dorsal surface is outside of the cranial cavity, owing to the attachment of the dura to the prefacial commissure and to the ridge on the surface leading from it rostro-mesad. Laterad to this ridge is an area which forms the floor of the cavum supracochleare.[1] In the center of the cranial surface is a large circular opening, the foramen acusticum. Laterad to this opening, divided from it by a sharp ridge, is the ental opening of the facial canal. Caudal to it is a ridge which has its origin upon the mesal surface of the pars canalicularis, and passes ventro-mesad upon the pars cochlearis, diminishing in prominence as it descends. Caudal to this ridge is a large opening in the cartilage which has the shape of a figure eight, and extends to the edge of the surface. This opening is the combined ductus perilymphaticus and fenestra rotunda. Their approaching separation is indicated by the shape of the orifice.

The ventral surface of the pars cochlearis is entirely hidden from view by the tympanic bulla. Upon removal of this it is seen to be convex, and to give indication in the form of alternating depressions and elevations of the cochlear turns within the capsule. Dorso-lateral there is a deep depression in the surface. In this depression is the fenestra ovalis partially filled by the foot plate of the stapes. Caudad to this depression the surface is raised to form the promontory which intervenes between the fenestræ. The dorso-lateral edge of the depression presents a ridge which marks the situation of the facial canal. Above the facial ridge, the surface meets the ventral surface of the overhanging pars canalicularis.

Pars canalicularis: — The pars canalicularis has four surfaces, a ventral entering into the tympanic cavity, a rostro-mesal, caudo-mesal, lateral, and two extremities, caudal and rostral.

The rostro-mesal surface joins smoothly the dorsal surface of the pars cochlearis, facing only slightly more mesad than the latter. The line of demarcation can be drawn from the facial canal to the foramen perilymphaticus. The surface is bounded caudally by a ridge which marks the line of the crus commune of the vertical semicircular canals, and which has already been described as forming a ridge upon the dorsal surface of the pars cochlearis. Upon this ridge is seen a slit like opening, from which extends upward a shallow groove. This slit is the orifice for the ductus endolymphaticus and the groove lodges its intracranial portion. The surface is framed rostrally and laterally by the arching superior semicircular canal, and is hollowed to make a well marked subarcuate fossa.

The caudo-mesal surface is bounded rostrally by the crus commune, ventrally by the large common opening of the ductus perilymphaticus and fenestra rotunda, and for the rest of its boundary has the ridge marking the course of the posterior semicircular canal. It shows a slight depression bordering on the crus communis, which may indicate a posterior subarcuate fossa

[1] Voit. Das Primordial cranium des Kaninchens Anat. Hefte, Bd. 38, 1909.

such as Voit found in the rabbit. The rest of the surface shows a vertical ridge which renders it convex latero-mesad.

The lateral surface has as its boundaries, dorsally the arch formed by the vertical semicircular canals, and ventrally the line of the external canal. The dorsal boundary is thus crescentic and meets the ventral edge at either extremity. The ventral edge, rostrally begins at the caudal extremity of the prefacial commissure, and caudally ends at the tip of the processus mastoideus, at the origin of the hyoid bar. This marks the caudal extremity of the crista parotica, which is the surface relief of the external semicircular canal. Rostrad to the canal the border serves for the attachment of the tegmen tympani.

The lateral surface, having the boundaries described above is roughly triangular, each side of the triangle being formed by a semicircular canal. As a whole it is convex, due to the projection of that mass of cartilage known as the "massa angularis." [1]

The caudal portion of the surface, which shows in relief the underlying posterior semicircular canal appears upon the ectal aspect of the skull between exoccipital and squamosum. This area corresponds in its position to the adult mastoid, though there is as yet no indication of the definitive mastoid.

The ventral surface of the pars canalicularis is triangular, the apex pointing mesad. The inner half of the surface rests on the pars cochlearis, and there is an intimate union of their substance. The lateral portion of the surface forms the roof of the middle ear and is in relation to the structures contained in it. The base of the triangle, which is placed laterad, corresponds with the inferior border of the lateral surface, already described.

The surfaces narrow at either extremity as do those of a triangular pyramid. Each apex thus formed has attached to it a cartilaginous process. The caudal of these is the hyoid bar. From this region is eventually developed the mastoid process. The rostral prolongation extends to the pars cochlearis, roofing over the primitive facial canal, and thus forming the commissura præfacialis.

Canalis facialis: — The facial nerve passes laterad, reaching the ental opening of the facial canal by crossing over a prominent ridge of cartilage which divides it from the foramen acusticum. The two apertures for the facial and acoustic nerves are surrounded by a fairly well marked cartilaginous rim. Thus is delimited the porus acusticus internus. At the ectal end of the primitive facial canal, the nerve lies under the tegmen tympani entirely concealed from view. The hiatus Fallopii is represented by a slit in the line of apposition of the tegmen tympani to the ectal surface of the pars cochlearis. Beneath the cover of the tegmen tympani the nerve turns sharply caudad. In its course above the fenestra ovalis it lies in a closed canal below the crista parotica. Turning ventrad in this canal it appears at the caudal apex of the pars canalicularis, mesal to the hyoid cartilage.

Tegmen tympani: — The tegmen tympani is a quadrangular plate of cartilage, taking origin by its caudo-dorsal border from the pars canalicularis. At its point of origin it covers the angle formed by the meeting of the anterior and external semicircular canals. Its convex ectal surface is continuous with the lateral surface of the pars canalicularis. The ental surface roofs in the tympanic cavity, and conceals from view the outer end of the primitive facial canal and its continuation to the point where it meets the crista parotica. To the rostro-dorsal

[1] Macklin, C. C. The skull of a human fœtus of 40 mm. Am. Jour. Anat., Vol. XVI, 1914.

border is attached the ventral border of the parietal plate in the region from which springs the orbito-parietal commissure. The rostral extremity of this border is in relation to the tip of the external pterygoid to which it is firmly united by fibrous tissue. The caudo-ventral border forms a free edge overhanging the proximal portion of the shaft of Meckel's cartilage and the ossicles of the middle ear. At its caudal extremity it meets at an obtuse angle the crista parotica. The rostro-ventral border is also free, and is in contact by one extremity with the prefacial commissure, by the other with the shaft of Meckel's cartilage.

The tegmen tympani is related by its ectal surface to the squamosal by its ental surface to the cavum tympani and the otic capsule, filling in like a wedge the space between the two.

ILLUSTRATIONS.

Plates.

Plate XLIII.

Fig. 1. Superficial dissection exposing panniculus.
Fig. 2. Musculature of ventral pouch.

Plate XLIV.

Fig. 1. Dissection of musculature of ventral pouch and the sternomandibularis.
Fig. 2. Superficial muscles of face, hyoid musculature, muscles of flipper, of neck and of intermandibular region.

Plate XLV.

Fig. 1. Musculature of flipper, mesal view.
Fig. 2. Skeleton of flipper, mesal view, showing attachments of muscles.

Plate XLVI.

Fig. 1. Skeleton of flipper, lateral view, showing attachments of muscles.
Fig. 2. Suprahyoid and infrahyoid muscles.

Plate XLVII.

Fig. 1. Deep muscles of the thorax and abdomen, dorsal musculature.
Fig. 2. Situs viscerum, and hypaxial muscle of pedicle.

Plate XLVIII.

Fig. 1. Thoracic, abdominal and pelvic muscles.
Fig. 2. Suboccipital muscles.
Fig. 3. Hypaxial muscles of neck and thorax, pterygoid muscles.

Plate XLIX.

Fig. 1. Tongue, pharynx and larynx.
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Plate L.

Fig. 1. Thoracic viscera, ventral view.
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Fig. 1. Ventral view of stomach, duodenum and arch of colon.
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Fig. 1. Genital tract, dorsal view.
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Fig. 1. Skull, norma verticalis.
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Fig. 1. Skull, norma occipitalis.
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Fig. 1. Skull, medisection showing nasal fossa and dura mater.
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Fig. 1. Left mandible, lateral view.
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Fig. 3. Otic capsule and auditory ossicles.
Fig. 4. Cervical vertebræ, ventral view.

TEXT FIGURES.

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EXPLANATION OF THE PLATES.