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Article VIII. — MEMORANDA UPON THE ANATOMY OF THE RESPIRATORY TRACT, FOREGUT, AND THORACIC VISCERA OF A FŒTAL *KOGIA BREVICEPS*

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Contents

Introduction

The present paper forms a continuation of the report[1] upon the structure of the fœtal *Kogia* [Physeteridæ; Odontoceti] in the collection of the American Museum of Natural History. The specimen was removed by Mr. Roy C. Andrew from a large female which was stranded at Long Beach, Long Island, and was preserved in alcohol. It measures 109.7 cm. in length. Its external characters, myology, and peripheral nerves have been described previously.[1] In taking up the visceral structures above the diaphragm, our task has been greatly lightened by the labors of Benham[2] and of le Danois,[3] who have preceded us in the study of the soft parts of this

[1] Schulte, H. von W., and Smith, M. deF., 1918, Bull. Amer. Mus. Nat. Hist., XXXVIII.

[2] Benham, W. B., 1901, On the larynx of certain whales (*Cogia, Balænoptera and Ziphius*), Proc. Zool. Soc. London, I, p. 278. On the Anatomy of *Cogia breviceps*, Idem, 1901, II, p. 107.

[3] Le Danois, E., 1910, Recherches sur l'anatomie de la Tête de *Kogia breviceps* (Blainv.), Arch. de Zool. Exp. et Gen., (5), VI, p. 149. Recherches sur les visceres et la squelette de *Kogia breviceps* (Blainv.) avec un résumé de l'histoire de ce Cétace, Idem, 1911, p. 465.

interesting whale. As both investigators worked under the difficulties of more or less dismembered material, imperfectly preserved, it has seemed worth while to review briefly the results already attained in the light of our material, while concerning ourselves mainly with topics which, for the reasons stated, these excellent observers were obliged to pass by. In the following report, one of us (Kernan) has charged himself with the examination of the upper respiratory tract and ear, while the other assumes responsibility for the thoracic viscera; other topics touched upon have been worked out in collaboration.

Nasal Passages

The nasal passages of *Kogia* have been described by Benham and by le Danois, both of whom had full grown specimens at their disposal. Their accounts differ one from the other in a number of points, and the material at our disposal appears to present still other variations. To account for these discrepancies, it must be remembered that both the above authors secured their material some days after the death of the animal and after it had been considerably cut up by the neighbors. Thus Benham was able to make no mention at all of the spermaceti organ, which is so intimately connected with the nasal passages. The fact, moreover, that the air passages now to be described are those of a very immature animal undoubtedly accounts for many more of the unlike details.

All accounts agree as to the blow-hole. Its distance from the tip of the snout naturally varies with the size of the animal. It is here situated 10.5 cm. caudad from the rostral extremity, largely to the left of the midline, crescentic in form, with the concavity of the crescent dextro-caudad. It is bordered by two thick lips made up of dense white fibrous tissue covered by smooth, black epithelium. The rostral lip overlies the caudal in a manner to provide for closure by water pressure. The muscles controlling the movements of the blow-hole have been described elsewhere.[1] A distinct sphincter was not found here, such as was described by le Danois, though the appearance of the tissue on cross-section suggests the presence of encircling muscle bundles.

In addition to its dorsal fold, which is thin and overlies the caudal lip, the rostral has also a ventral fold which juts under that structure. Thus, on cross-section, it is semilunar in shape and holds in its concavity the caudal lip, which on its part is convex.

This ventral ridge of the rostral lip of the blow-hole merits further

[1] Schulte, H. von W., and Smith, M. deF., 1918, Bull. Amer. Mus. Nat. Hist., XXXVIII.

description. At the dextral limit of the orifice it is sharp, prominent, and presents on its very edge a transverse slit, which is the opening into the right nasal passage. As it passes sinistrad it assumes a rounded contour and turns ventrad till, finally vertical in direction, it forms on the rostral wall of the left nasal passage a rounded eminence which gives a crescentic cross-section to that canal. This is doubtless the prominence which both Benham and le Danois described as forming the floor of the vestibule.

The blow-hole opens into a canal 2 cm. long, designated as the vestibule. It is merely the space between the lips, has no floor, and passes directly into the left narial passage. The line of demarcation between the two can be drawn at the ventral margin of the rostral lip, the left nostril being the space between this and the groove below the caudal lip into which it fits. The right nostril is the small slit in the edge of the fold near its dextral extremity.

Both Benham and le Danois described the vestibule as having a floor; of this there is here no trace. According to Benham, this floor is formed by a protrusion of the rostral lip which juts caudad near its dextral extremity. This turns sinistrad, rendering the left narial passage crescentic, and is continued in the mesal wall of that passage to the naso-pharynx. Le Danois describes the same protrusion in the floor of the vestibule and ascribes it to the presence of the head of the caudal spermaceti chamber.

In the animal here under description, the ventral fold of the anterior lip, doubtless identical with that portrayed by Benham, takes a vertical position in the rostral wall of the left air passage. It may be that growth converts the above described fold into the prominence pictured by Benham, and then the vestibule would indeed have a floor. That this floor is due to the presence of the spermaceti organ does not seem probable from the evidence at hand, for, as we shall see later, the caudal spermaceti chamber turns its pole in the opposite direction.

Benham placed the right nostril in the caudal lip of the blow-hole, exactly opposite to where we find it. This discrepancy may be explained by a shifting of the opening due to age and growth. Le Danois placed the right nostril in the floor of the vestibule, and from his figure we gather that it penetrated the mass which, according to Benham, formed the floor. If it is correct to conceive of the ventral margin of the rostral lip of the blow-hole eventually developing into the floor as described by Benham, then we should expect to find the right nostril just where le Danois put it.

Ventral to the vestibule is a large space, 1 cm. in dorso-ventral extent, the caudal wall of which is so lax as to lie in parallel folds. These take their origin in the extreme dextral angle of the canal and run sinistro-ventrad. Evidently this short portion of the canal is distensible. Close examination of the wall here shows it to have faintly trabecular structure.

In the sinistral angle of the blow-hole sac are a number of small openings which lead into finger-like pouches. These are placed in three layers. The most dorsal of these consists of a single pouch which has its orifice in the rostral lip. The second layer of several pouches has a single large opening, a slit .5 cm. in extent in the caudal lip opposite the first. The third layer,

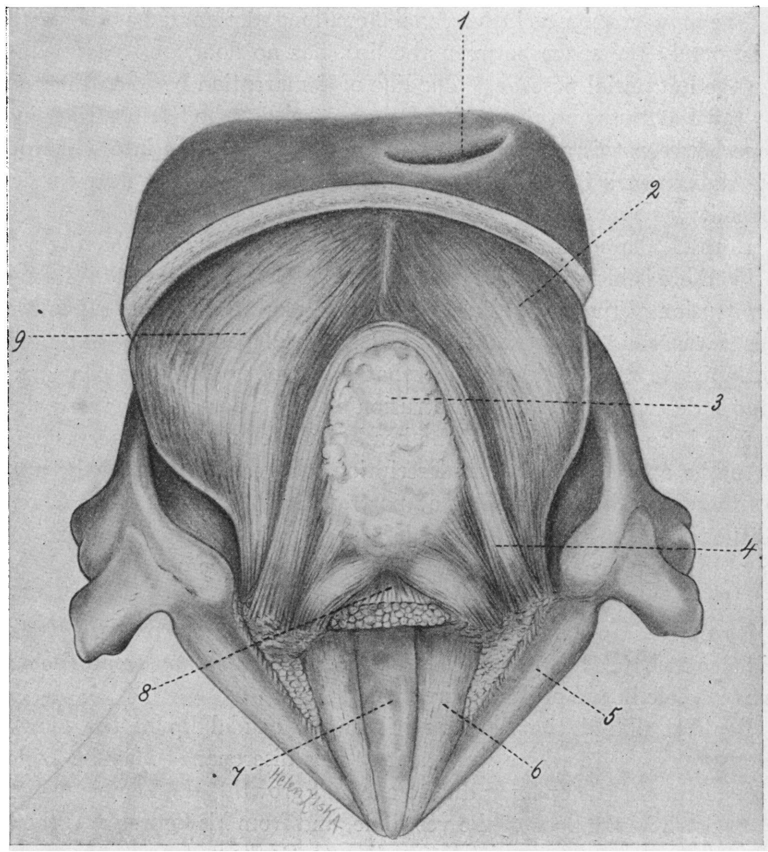

Fig. 1.— Exposure of muscle of spiracular sacs, rostral view.

1. Blow-hole.
2. Pouch from dorsal spiracular sac covered by muscular sheath.
3. Head of caudal spermaceti chamber.
4. Mass of muscle bundles about tip of spiracular pouch.
5. Maxilla.
6. Premaxilla.
7. Meso-rostral cartilage.
8. Longitudinal muscle bundles from rostral walls of air passages.
9. Roof of dorsal spiracular sac sheathed by fibro-muscular layer.

most numerous, takes origin by several mouths from the distensible space below the caudal lip.

The whole conglomeration of tab-like pouches forms a mass 2.5 cm. in

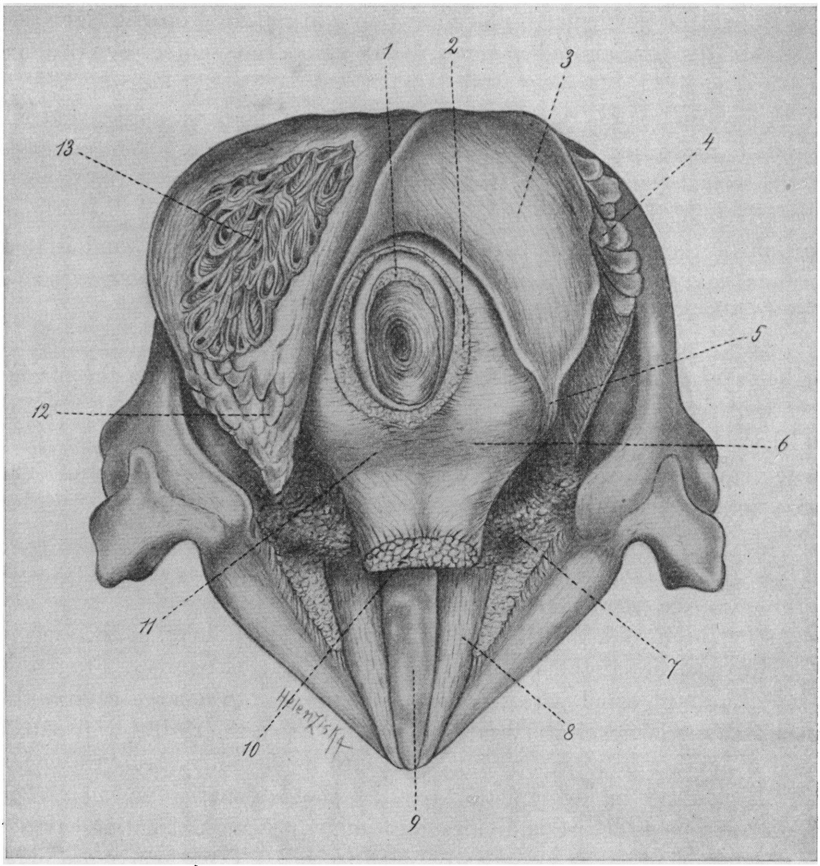

Fig. 2.— Exposure of spiracular sacs and spermaceti organ, rostral view.

1. Cut edge of spermaceti organ.
2. Cut edge of "case."
3. Spiracular pouch, extension to left of dorsal spiracular sac.
4. Spiracular pouch from left air passage.
5. Tip of spiracular pouch bound down by muscle.
6. Rostral wall of left air passage.
7. Cut edges of muscular sheath overlying air passages and spermaceti organ.
8. Premaxilla.
9. Meso-rostral cartilage.
10. Cross section of longitudinal bundles from rostral walls of air passages.
11. Rostral wall of right air passage.
12. Spiracular pouches from dorsal spiracular pouch.
13. Exposure of trabeculated roof of dorsal spiracular sac.

length extending sinistro-caudad from the wall of the air passage. These pouches are closely bound together by fibrous tissue, and the mass is interlarded with muscular fibres.

The trabeculation and pouching of this portion of the left narial passage should be particularly noted, as they are repeated on the right side in a greatly exaggerated manner. They were not noted by Benham and le Danois.

From this area of trabeculation and pouching the canal passes ventrad, gradually narrowing till it reaches the opening in the bone. The convexity of the rostral wall increases in extent till the cross-section of the passage is nearly semicircular. The convexity is not continued through the bony portion of the passage into the naso-pharynx, as Benham found it, but terminates at the level of the bone with a free extremity, which serves as a plug to block the nasal passage and prevent the ingress of water.

As to structure, the convexity in the rostral wall of the left air duct is the relief of a mass of muscular fibres which take origin in the fibrous sheath of the wall and pass mesad and rostrad to insert mainly in a raphe which separates these fibres from similar ones of the right air passage. The more ventral fibres reach far forward on the midline of the rostrum. The more dorsal fibres arch about the caudal spermaceti chamber and insert in the fatty areolar tissue which forms the mass of the snout.

The function of this muscle is, apparently, the opening of the canal to permit the free passage of air.

As has been said, the right nostril is a slit, .75 cm. long, in the margin of the rostral lip of the vestibule near its dextral extremity. From this opening a short canal passes dextrad and opens into a large cavity, the so-called superior respiratory sac (Benham). From the rostral wall of the canal a number of large openings lead into a purse-like structure which extends ventrad and completely overlies the left narial passage. The interior of this structure is divided into numerous communicating cavities by anastomosing bands passing from wall to wall. These spaces are lined by smooth membrane. The walls are fibrous. The whole structure is overlain by a sheet of fibro-muscular tissue which is attached dorsally about the blow-hole and ventrally to the maxilla. The muscular tissue concentrates about the tip of the structure and there forms a distinct band which firmly anchors it to the maxilla. This extension of tubules from the right narial passage toward the left is correctly described by Benham and figured in a diagram given by him. It is not mentioned by le Danois.

The so-called superior respiratory sac is a large oval expansion of the right nasal passage, measuring 3.5 by 5 cm., the long measurement passing dorso-ventrad, the short caudo-rostrad. In a general way, the cavity faces dextrad. It may be described as having a floor and a roof, which meet at an acute angle at every point of the circumference.

The floor is markedly convex, rising to a sharp eminence in its center.[1] The apex of this shows a thin-lipped, transverse slit, 1.8 cm. in length; the aperture leads into the continuation of the passage.

The roof of the cavity, 1 cm. thick, is composed of a mass of anastomosing trabeculæ. The spaces between the trabeculæ communicate freely with one another and with the main cavity. So the ental surface of the roof is exceedingly irregular. This surface and the intertrabecular spaces are lined by a continuous, smooth, dark membrane.

From the junction of the floor and the roof, for the whole of the circumference except directly rostrad, spring numerous glove-like pouches, such as were found on the left side. Along the caudal border, they are so long as to be folded back on themselves and the closed extremities of these point dorsad. Elsewhere, they point ventrad. The whole mass is overlain by fibro-muscular tissue, the muscular fibres of which concentrate about the circumference where they form a distinct sheet and firmly bind the whole to the maxilla.

Both Benham and le Danois, in their text and cuts, gave fairly adequate descriptions of the right respiratory sac, its trabeculated wall, and the surrounding pouches. If we compare conditions here with those found on the left side, we will see that it represents a great development of identical structures. There, too, is found a distensible cavity with trabeculated walls, from whose margins spring a fringe of pouches forming a mass covered by fibro-muscular tissue and interlarded with muscular fibres. So we may say that equivalent structures are found on the two sides, though greatly reduced on the left.

Benham raised the question as to where the true right nostril lies: at the opening into the vestibule, or in the floor of the respiratory sac. On account of the change in the color of the epithelium in the respiratory sac, he decided in favor of the former location. If we consider the condition found in *Kogia* a development from that found in such forms as *Tursiops,* where there is a single, large, dilatable pouch from which open two equal-sized air passages, guarded by valves, we may decide that the division of the right and left pouches is only a secondary separation of what was originally one cavity and that the true right nostril lies in the floor of the respiratory sac. On the other hand, if we hold that the condition found in *Balænoptera* — two nostrils, each with a "spritz-sac" — is the primitive one and that *Kogia* is merely a midway stage toward the complete fusion of

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[1] ***Musseau du singe*** **of Pouchet and Beauregard.**

Tursiops, then we should be justified in putting the right nostril at the termination of the right air passage in the vestibule. Since *Kogia*, as far as its nasal passages are concerned, is much more highly specialized than *Tursiops*, the first interpretation, placing the nostril in the floor of the respiratory sac, appears more probable. However, such a question could only be surely decided upon a basis of much more material than is at our disposal.

In the matter of the function of the respiratory sac and the pouches connected therewith, we are as much in the dark as in that of anatomical interpretations. That they are widely distensible, we know from their structure; and that they actually are widely distended in respiration, Andrews has demonstrated, at least for baleen whales. On the other hand, we may surmise from the arrangement of the muscles around them that they are powerfully compressed at times. Their large development and copious blood supply argue an active function. This must have something to do with the preparation of the inspired air for respiration, though, after all, it can effect only a small portion of it since the larger percentage goes directly to the lungs through the more direct left nasal passage.

The object of the powerful compressor muscles is doubtless to insure against the entrance of water when the animal dives.

The continuation of the right nasal passage begins at the prominent papilla, above described, in the floor of the respiratory sac. At this point it is as wide as the slit, that is 1.8 cm., with flat walls rostrad and caudad which are in close contact. It narrows as it passes ventrad and, at its entrance into the bony passage, is only 0.4 cm. wide. On reaching the surface of the rostrum, it turns sinistrad a little, then caudad as it enters the bone and proceeds to the naso-pharynx. It nowhere has any connection with the so-called second repiratory sac. Its walls are composed of a mass of fibro-muscular tissue, the fibres of which lie in the horizontal plane and turn inward to insert in the median raphe, which also receives the fibres from the left side. This would indicate that this nasal passage is capable of distension like the left, though much less so as the muscular wall is much thinner. A probe can be passed on into the naso-pharynx.

This condition of the right air passage is entirely different from that found by Benham and le Danois. Both of these authors state that the air passage, on leaving the first respiratory sac, enters directly into the second. In this specimen, we find the connection with the second or lower respiratory sac just at the point where the nasal passage turns sinistrad before entering the bony canal. In this portion of its course it loses its caudal wall, the gap being the opening into the sac. Thus this structure is a caudal protrusion from the air passage.

The ventral spiracular sac is so intimately connected with the organ of spermaceti that it seems best to describe that structure first. Its rostral extremity lies in an arch formed by the two nasal passages as they

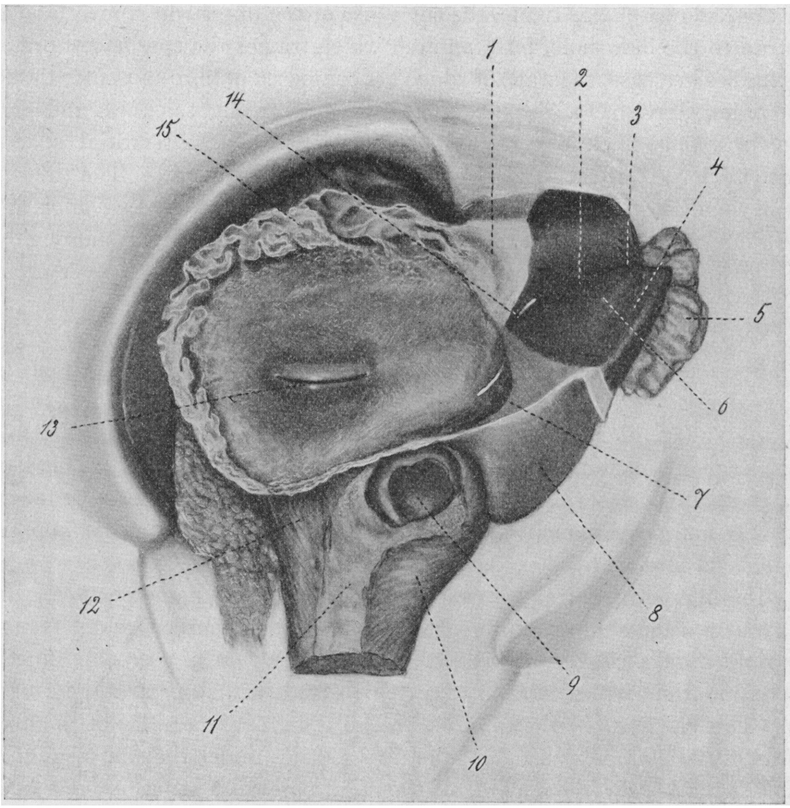


Fig. 3.— Exposure of floor of dorsal spiracular sac and vestibule.
1. Cross section of caudal lip of blow-hole.
2. Orifice of left nasal passage.
3. 4. Openings into spiracular pouches.
5. Mass of spiracular pouches, left side.
6. Rostral lip of blow-hole, ventral fold.
7. Orifices of "spiracular pouch" extending to left.
8. "Spiracular pouch," extension to left from spiracular sac.
9. Spermaceti chamber.
10. Wall of "case."
11. Median raphe.
12. Rostral wall, right air passage.
13. Orifice of right air passage.
14. Probe passed through canal from vestibule to dorsal spiracular chamber.
15. Cut edge of roof of dorsal spiracular sac.

ascend from the surface of the rostrum to the blow-hole. The wall of each is composed of fibro-muscular tissue, the fibres of which converge below into a median raphe. More dorsal bundles pass rostrad and lose themselves in the great mass of fatty areolar tissue which forms the bulk of the snout. On the removal of this tissue, the cut edges of the fibres which meet above, rostrad to the blow-hole, form an arch which frames the spermaceti organ. So this lies in a case, the walls of which are composed of fibro-muscular tissue. The organ itself has a fibrous wall of greatly varying thickness and contains a sponge-like network of delicate fibres. The interstitial spaces, which are largest at the rostral extremity, are filled with fluid. The tissue is not in condition to make a histological examination of value. Le Danois and also Pouchet and Beauregard have covered this matter rather thoroughly. The illustration of le Danois of the sagittal cut of the head gives a very good idea of the box-like character of the space in which the spermaceti organ lies. No distinct wall covering the rostral extremity of the spermaceti organ could be made out. The tissue seemed to change quite suddenly from the rather dense fatty areolar tissue, which forms the bulk of the snout, to the delicate sponge-like structure of the spermaceti organ. Le Danois found the spermaceti chambers completely encased by a fibrous wall. This lack of a complete enclosure, rostrally, of the spermaceti chamber may be taken, with the non-development of the anterior spermaceti chamber, as another evidence of immaturity.

From its rostral extremity, where it has its greatest diameter, the organ, which is a tube-like structure, passes caudad, then curls dextrad behind the right nasal passage. Its general shape is like that of a crooked finger. Its termination, which is again directed rostrad, turns upward at its very tip. This elevation of the tip gives rise to the great convexity of the floor of the dorsal spiracular sac, and the tip itself lies under the sharp summit, which is marked by the opening of the nasal passage. It has already been mentioned that the wall of the spermaceti organ varies greatly in thickness. This is due to the presence of a dense mass of white, fibrous tissue which may be designated as the pillar of the spermaceti organ. This structure first appears as a small protrusion into the lower spiracular sac just dextrad of the orifice of the nasal passage. Rostrad and caudad to it are recesses, which meet below its ventral tip and together form a small pouch which constitutes a lateral dilatation of the air passage. The pillar quickly expands from its small beginning till it forms the ventral half of the wall of spermaceti organ. It is this portion of the wall which is related to the skull, the ventral spiracular sac intervening. In the continuation of its course the pillar occupies the same relative position in the wall of the spermaceti organ — that is, the ventral half — till the caudal extremity is reached.

Here, as the dextral turn is made, it passes to the caudal wall and it remains in this position in the subsequent turns. As has been said, the pillar is made up of dense, white, fibrous tissue and it is undoubtedly its presence that gives to the spermaceti organ its peculiar winding course.

The remaining portion of the wall of the spermaceti organ is comparatively thin, especially so at the rostral extremity where it consists merely of a thin, fibrous sheath forming the roof. This remains opposite the pillar

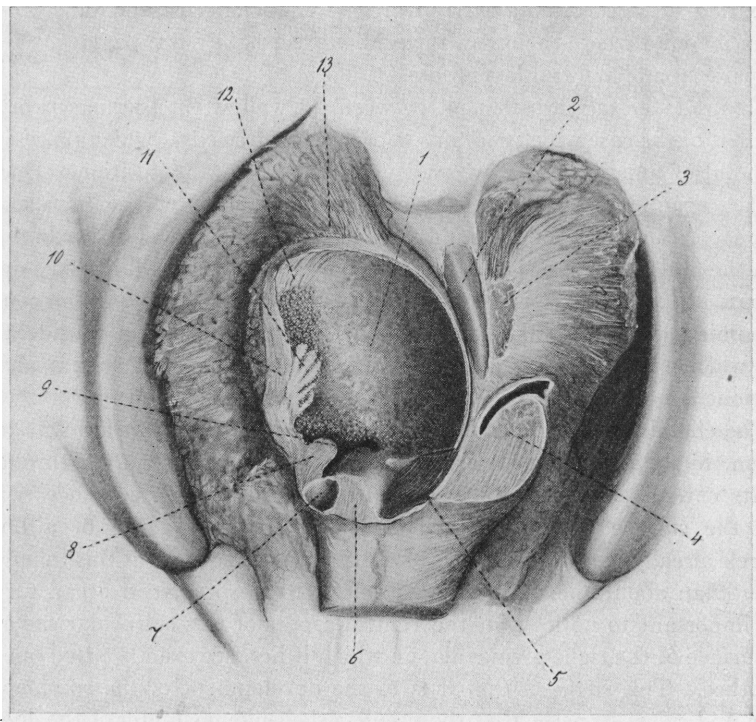


Fig. 4.— Exposure of floor of ventral spiracular sac.

1. Floor of ventral spiracular sac lying in concavity of right premaxilla.
2. Median crest, right premaxilla.
3. Muscle bundle to dextral angle of caudal lip of blow-hole.
4. Rostral wall of left air passage.
5. Wall of "case."
6. Rostral wall, right air passage.
7. Small cavity in rostral wall, right air passage.
8. Rostral tip of "pillar" of spermaceti organ.
9. Right air passage.
10. Muscular wall of ventral spiracular sac.
11. Vertical column of folds covered by papillæ.
12. Transverse folds in wall of ventral spiracular sac.
13. Deepest layer of transverse muscular sheath.

and so shifts to the rostral wall in the winding portion. In this region, however, it has become thicker, so that a cross section of the spermaceti organ at the dorsal termination shows a ring of white fibrous tissue surrounding a core of yellow fat, which is the representative of the sponge-like tissue found farther rostrad.

The second spiracular sac bears the same relation to the spermaceti organ as the pleura does to the lung: that is, it forms a cavity into which that structure is thrust, as the lung is into the pleura, with the resulting formation of visceral and parietal areas. A region corresponding to the hilum is found where the organ turns about the right nasal passage. Here the parietal and visceral layers join.

Rostrad, the sac thrusts itself between the wall of the spermaceti organ and that of the case which contains it. A sharp, free edge, which represents the point of junction of its two walls, can be seen in this position. Dorsal to the organ, it intervenes between it and the floor of the first spiracular sac. Sinistrad, it lies against the muscular wall formed by the bundles from the anterior wall of the left nasal passage; and ventrad, it forms upon the rostrum a bed in which the organ lies. To the right, along the course of the air passage running dorso-ventrad from the apex, is a considerable area which stands out clear of the sac and thus forms the hilum above mentioned.

The chamber floor upon the surface of the rostrum forms an oval area 4.5 cm. by 3.25 cm. Sinistrad, the margin of this area is convex throughout its extent. Dextrad, the margin is indented by a prominence rising from the surface of the premaxilla — due to the presence of a bony tubercle already mentioned by one of us (Schulte). It is about this tubercle, rather than about the right air passage, that the spermaceti organ turns. It is important to notice that the ventral aspect of this spiracular sac and the surface of the right premaxilla, on which it lies, are exactly fitted one to the other. This suggests that it is to the development of the spermaceti organ and spiracular sacs that the peculiar shelf-like character of the dorsal surface of the premaxilla owes its origin. We may, moreover, conclude that the variations in the contour and depth of that shelf are responses to variation in the size and shape of the spermaceti organ.

The tubercle gives origin to a number of vertical folds in the wall of the spiracular sac which extend dorsad into the elbow of the crook. Between them lie deep recesses. These folds and recesses undoubtedly serve to increase secretive or absorptive surface. They were described and portrayed by both Benham and le Danois.

The visceral portion consists of a fibrous base covered by a smooth shining layer of black epithelium. The opposing wall, on the other hand, is studded as thickly as possible with tiny papules, which appear to have no regular arrangement and get their varied shapes from mutual compression. They are flattened on the roof of the sac, but they hang in dense masses on the sides, over the ridges above mentioned, and in the groove where the two walls join. They have been described and figured by le Danois and Benham, and their histological structure has been given by the latter. This wall varies considerably in thickness. A layer of muscle bundles from the right side of the air passage forms the bulk of the dextral and caudal portion. The muscular fasciculi are thick rostrad but become thinner as they pass caudad and encircle the pillar of the spermaceti organ, about which they form a sort of sphincter. They finally disappear in the caudal region of the wall. As they encircle the pillar they throw the inner surface of the sac into transverse folds, studded by papillæ, similar to the vertical ones already described.

The roof of this sac, which separates this cavity from the dorsal one, is also composed of encircling muscular fibres of the same origin as those just mentioned. They are of considerable thickness dextrad and caudad. Elsewhere, they are not present.

The remainder of what I have called the parietal wall of the lower cavity — that is, the portion lying upon the rostrum, and lining the wall of the case on the left — is of a thin fibrous structure.

The visceral portion of the wall of this cavity, as has been shown, lies in contact with the spermaceti organ. Rostrad, it is but loosely connected thereto and can be easily separated; but, in the curving portion and approaching the tip, it is so closely adherent that any separation is impossible.

Le Danois described a second chamber of the spermaceti organ, larger than the caudal and lying on the anterior part of the rostrum. This is not present in our specimen. But, just at the point where the right nasal passage enters the bony canal, in the anterior wall, is a tiny cavity the size of a pea. It is smooth-walled and appears to have no communication with the larger chamber. This may possibly be the as yet undeveloped anterior chamber of the spermaceti organ.

As le Danois describes these organs they are arranged in the following order counting from the blow-hole: (1) the superior respiratory sac, (2) the inferior respiratory sac, (3) the posterior spermaceti chamber, (4) the anterior spermaceti chamber. They adapt themselves to the shape of the anterior face of the skull and mutually to one another. Benham does not describe the spermaceti chambers. In our specimen, the various chambers are arranged in the order and manner that le Danois describes, except for the slight development of the anterior spermaceti chamber.

A connection which we did not find is that between the spermaceti chambers and the respiratory passage. Pouchet and Beauregard described it for the cachalot. The evidence here at hand seems to point to the spermaceti chambers being a closed system. Le Danois says nothing on this point. Since *Kogia* and the cachalot are so closely related, if the connection were present in one we should expect to find it present in the other. Pouchet and Beauregard were very positive, saying that it is owing to the presence of the free openings from spermaceti organs into the right nasal passage that the former contained no spermaceti. We may, indeed, think of the spermaceti chambers as belonging embryologically to the nasal tract. That no open connection remains at birth in *Kogia* appears to us as certain. Confirmation of the findings in respect to this point seems desirable.

Pouchet and Beauregard remark as follows:

Il recouvre immédiatement l'organe du spermaceti, qui se présente après la dissection comme formé de deux parties distinctes: c'est d'abord en arrière un sac pyriforme adossé à la muraille verticale et concave formée par le frontal et le maxillaire accotés. Nous appelons ce sac *réservoir postérieur*. Il se continue en avant en une sorte de large boyau qui repose sur la partie horizontale du maxillaire et se prolonge jusqu'à l'extrémité de la tête. Nous appelons ce boyau, *réservoir antérieur*. Les deux réservoirs forment l'un avec l'autre un angle à peu près droit. Ils communiquent entre eux par un orifice de la largeur du petit doigt. En arrière de cet orifice, le réservoir antérieur se continue en un canal qui occupe la fosse nasale droite atrophiée comme on le sait par rapport à la fosse nasale gauche. Ce canal s'ouvre finalement dans l'arrière-cavité des fosses nasales; on ne peut mettre en doute, par suite, que les réservoirs à spermaceti soient, comme nous l'avions indiqué déjà, les représentants de la narine droite modifiée pour un usage spécial.

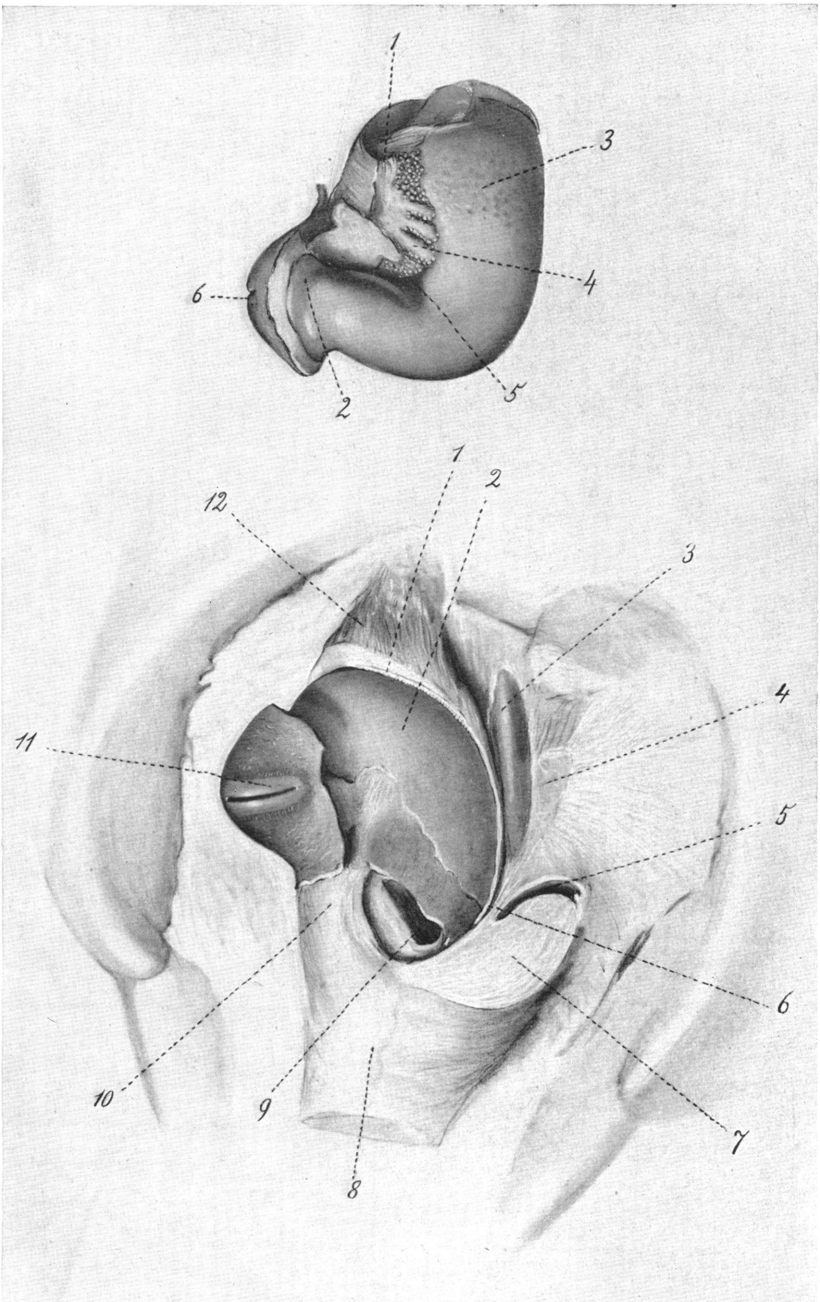
Le mode de terminaison du réservoir antérieur à l'extrémité de la tête est la

Fig. 5.— Ventral surface of the pillar of the spermaceti organ.

1. Rostral tip of "pillar" of spermaceti organ.
2. Caudal tip of pillar of spermaceti organ.
3. Ventral surface of spermaceti organ indented by papillæ.
4. Vertical folds covered by papillæ.
5. Elbow of spermaceti organ.
6. Opening of air passage.

Fig. 6.— Dorsal surface of spermaceti organ lying in its bed on the rostrum.

1. Fissure between parietal and visceral walls of ventral spiracular sac.
2. Dorsal wall of spermaceti organ covered by visceral wall of ventral spiracular sac.
3. Median crest of premaxilla.
4. Cross section of deepest layer of muscle bundles which passes to dextral angle of caudal lip of blow-hole.
5. Left nasal passage.
6. Wall of "case."
7. Rostral wall of left air passage.
8. Median raphe.
9. Open rostral end of spermaceti organ.
10. Rostral wall of right air passage.
11. Orifice of right air passage in floor of dorsal spiracular sac.
12. Layer of muscle inserting into caudal wall of ventral spiracular sac.



Figs. 5 and 6.

suivant. Ce réservoir n'est pas clos; il se termine immédiatement au-dessous de la peau, par un orifice en forme de longue fente transversale limitée par deux lèvres épaisses; cette fente s'ouvre dans une cavité sous-cutanée verticale en communication d'autre part avec l'évent. Cette *cavité verticale* s'étend beaucoup plus à droite qu'à gauche. Quand, par une incision cruciale de la peau, on ouvre sa paroi antérieure, on aperçoit l'orifice transversal du réservoir antérieur qui, avec ses deux lèvres, a l'aspect d'un *museau de singe* (1) nom que nous lui conservons.

En résumé, l'organe du spermaceti communique en avant indirectement avec l'évent, et en arrière directement avec l'arrière-cavité des fosses nasales. On s'explique ainsi pourquoi nous avons trouvé les réservoirs vides.[1]

It would seem from this description that they have mistaken the orifice of the right nasal passage, designated by them as "museau de singe," for the opening of the rostral spermaceti chamber. In *Kogia,* at least, there is no connection between the two.

Some of the muscles associated with the nares have been described elsewhere[2] and the others have been incidentally mentioned in the course of our description of the nasal passages. For purposes of clearness, however, it seems best, in spite of the repetition, to give in one section a brief description of them all.

We could find no distinct trace of a sphincter of the blow-hole. The lips are made up of an exceedingly dense, white, fibrous tissue, in the mass of which may lie muscle bundles. We were unable to identify these, and so were drawn to the conclusion that the chief factor in closing the orifice must be water pressure. Le Danois described a sphincter and it may very well be that, as the animal advances in age, a sphincter develops.

Immediately beneath the integument and the fatty coat underlying it is a great sheet of muscle radiating in all directions from the blow-hole. It takes origin from the margins of both maxillæ, extending from near the median line caudad well rostrad to the antorbital notches. The bundles converge from this extensive origin toward the air passages, splitting into many layers. The more superficial insert into the lips of the blow-hole and evidently have the function of dilators of that orifice. Immediately beneath them is a sheet intimately related to the spiracular sac of either side. It forms a thin fibro-muscular sheath adherent to their dorsal surfaces, sends fibres among the finger-like pouches extending from their cavities, and, gathering into thicker bundles at their borders, anchors them firmly to the maxillæ.

Finally, another layer of bundles from the same origin passes, on the left side, behind the spiracular pouches and inserts into the dextral angle

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[1] Pouchet and Beauregard, 1885, Note sur l'organe des spermaceti, C. R. Soc. Biol., Paris, An. 37.
[2] Schulte, H. von W., and Smith, M. deF., 1918, Bull. Amer. Mus. Nat. Hist., XXXVIII.

of the posterior lip of the blow-hole and the upper part of the caudal wall of the case. The upper fibres of this layer concentrate into a thick bundle, which reaches the dextral angle of the blow-hole and inserts as well into a raphe which lies between it and certain vertical fibres of the wall of the case now to be mentioned. These fibres take origin with those composing the rostral wall of the left nasal passage. They pass around the mesal angle of the canal, caudad to the bundle just described, turn dorsad, and insert into the raphe just mentioned and the dextral angle of the blow-hole. The action of these muscles would be to fix and retract the caudal lip, and perhaps to move it sinistrad.

The bundles related to the nasal passages take origin from the dorsal surface of the rostrum in the midline, from a median raphe, and from the mass of tissue covering in the rostral end of the spermaceti chamber. On the left side, they form the great mass of the rostral wall of the air passage, as described in connection with that structure. On the right side, also, they form the rostral wall of the air passage, but the bulk of the fibres pass about its lateral angle and form the thick muscular wall and the periphery of the roof of the ventral spiracular chamber. These walls thin out as they pass caudad, the muscle bundles finding insertion in the fibrous sheath of the wall. It has already been mentioned that the more dorsal of these fibres encircle the pillar of the spermaceti organ and the right nasal passage in the manner of a sphincter.

The bundles originating in the fibro-areolar mass about the rostral end of the case and those from the caudal portion of the raphe form the walls of the case as has already been described. When the mass of the snout is removed, it is the cut edges of these fibres which form the arch about the rostral extremity of the spermaceti organ.

Larynx

Benham has given a very complete and adequate description of the larynx of *Kogia*, and we find little to add to his description. We shall be content, then, with mentioning the few particulars in which our specimen appears to differ from his and omit a detailed description.

We have already mentioned the manner in which the laryngeal tube rises from the pharyngeal floor and protrudes into the naso-pharynx, where its thickened tip is closely embraced by the areus palato-pharyngeus. This arrangement is one which *Kogia* shares with other odontocetes. Le Danois gives an excellent cut showing the embracing collar. On dorsal view, a decided asymmetry is apparent, the left side of the larynx being flattened, due doubtless to the sinistral displacement of the whole structure.

The extrinsic muscles have been described in another section. As concerns the intrinsic muscles, in certain respects our animal differs from that of Benham. First, as to the crico-thyroid muscle: Benham described and pictured this as a small slip lying mesad to the posterior cornu of the thyroid cartilage and entirely concealed from view by that structure and a mass of muscle arising therefrom. This slip we failed to find. In its place was a bundle taking origin from the mesal surface of the cornu and inserting into the arytenoid near the muscle process. This band appears to be that which Benham described as crossing the bay between the cornu and the body of the thyroid cartilage. Its action, with the thyroid cartilage fixed, would be to pull the arytenoid away from the epiglottis: in other words, to open the larynx.

The crico-arytenoid muscles, lateralis and posticus, are arranged as Benham described. It is to be remembered that the arytenoids in the cetacean have lost their rotary motion and move in only two planes, the sagittal and coronal; so the crico-arytenoid lateralis muscle has shifted dorsad and no longer serves to rotate the ventral end of the cartilage outward, but acts as an opponent of the inter-arytenoideus which approximates the cartilages. The more dorsal bundles perhaps assist the posticus in turning the arytenoids dorsad, thus opening the larynx.

These three muscles then act as a group to retract the arytenoid cartilages from the epiglottis.

The inter-arytenoideus muscles have the usual arrangement, passing between the dorsal surfaces of the two cartilages and, in their action, approximating them.

We find the hyo-epiglottic muscles arranged as Benham pictured them, passing from the dorsal surface of the hyoid bone and finding insertion in the venter of the epiglottis midway from the extremities. They have a direct pull forward on that structure. We can not analyze the muscles opposing the retractor group in the same manner as Benham did. Taking origin from the outer surface and ventral edge of the base of the arytenoid and passing ventrad to the angle between epiglottis and thyroid plate is a mass of muscle which that author divided into three. The most dorsal bundle he called thyro-epiglottic. We do not find the insertion he gave it on the epiglottis. The bundle next caudad, according to him, extended from ventral margin of the arytenoid to the dorsal edge of the epiglottis. He called this the ary-epiglottic. Finally, a third bundle passed from base of arytenoid to entel surface of thyroid plate. As we said above, it appears to us that the dorsal connection of all these bundles is the base of the arytenoid. The ventral connection is the ventral surface of the caudal extremity of the epiglottis, a few fibres passing to the thyroid. So perhaps a better designation of the muscle would be aryteno-epiglottic.

However these muscle groups are analyzed and designated, their action is clear and comparatively simple. The hyo-epiglottic and crico-arytenoid group open the laryngeal passage, separating arytenoid and epiglottis. The inter-arytenoid muscle approximates the arytenoids, and the crico-arytenoid muscles oppose this action.

We have nothing to add to Benham's account of the cartilages. The divided thyroid is as he described it. In this specimen, the tubercle of the epiglottis, where it juts ventrad between the thyroid plates, is much more prominent than he pictured it. His analysis of the arytenoid cartilage is of great interest and, for it, we refer to his original account.

Trachea and Bronchi

The trachea, owing to the collapse and elongation of its walls by stretching, is not in condition to furnish accurate measurements. Its shape, moreover, can not be accurately ascertained. It appears to have a tendency to take the contour of an hour glass on cross section, with longitudinal grooves on either side. Its length to the bifurcation is 4 cm.; to the origin of the eparterial branch on the right side, 3 cm., this branch being thus tracheal in origin. The length of the eparterial branch is 2.5 cm. from its origin to its entrance into the substance of the lung, just short of which point it gives off another branch to the apex. The right main bronchus is 2 cm. long. As for the left main bronchus, it has a total length of 5 cm., of which 2 lie caudad to the first branch.

The trachea measures 2 cm. in its greatest diameter; the right main bronchus, 1.25 cm.; the left main bronchus, 1.5 cm. The striking thing about these measurements is the relative width of the trachea and the great proportional length of the stem bronchi. This latter is due to the hilum of each lung being a deep recess, comparable to the hilum of a kidney. Only in the depth of these recesses do the bronchi actually enter lung substance. The arrangement of the eparterial branch on the right side points to a greater functional importance of that lung. This is another indication that the smaller measurements of that lung are, as is noted below, due to the unequal distribution of blood (*post mortem*).

From the ventral aspect, the trachea appears to have eight rings, of which the first has twice the breadth of the others. On the dorsal aspect, the rings are complete and are united by cross strands in groups of four, thus forming two compound rings. Each main bronchus, just caudad to the bifurcation, has one broad complete ring, then a number of narrow ones as far as the entrance into the lung substance. All of these rings are complete. Investigation of the histological structure of the trachea and bronchi was not undertaken, nor was their arrangement within the lung investigated.

Thorax

The thorax is rather broad ventrally in correspondence to the width of the sternum. Dorsad, its transverse diameter increases for about two-thirds the length of the ribs, contracting again in the region of the deep pulmonary grooves. On account of the flaccidity of the parts, the following dimensions are but approximate and, of course, represent proportions in an unexpanded chest:

	cm.
Length along ventral midline	12.5
Length dorsally, right side	27.0
Length dorsally, left side	26.0
Width between fourth ribs	11.5
Depth at level of fourth ribs, sternum to spine	8.5
Ditto, sternum to pulmonary groove	13.5

The plane of the superior aperture is very oblique, its dorsal limit, the neck of the first rib, standing 6 cm. rostrad of the margin of the sternum. The form of the opening in the soft parts is subrectangular and measures about 7 cm. dorso-ventrally by 5 cm. transversely. The unusual contour is due to the presence of a large, vascular fat pad which fills the concavity of the ribs, extending into the interval between the scalenus and small longus colli muscles and caudal as far as the third rib; its ventral limit coincides with the line of pleural reflection and dorsally it reaches the pulmonary groove.

The diaphragm has the usual extreme obliquity observed in cetaceans. The caval orifice lies at the level of the sixth thoracic vertebra. From this point the diaphragm slopes ventrad as well as dorsad. The ventral slope corresponds to the heart and pericardial fat pads and reaches the ventral body wall at the end of the sternum. The dorsal slope is much longer, extending to the fascia of the hypaxial muscle mass at the level of the third lumbo-caudal vertebra.

The topography of the thoracic viscera is peculiar in the extensive apposition and adhesion of the mediastinal contents to the thoracic wall. The thymus and pericardium are attached in the whole extent of the sternum and costal cartilages and for a considerable, distance upon the ribs. The pleuræ are, in consequence, widely separated, and the lungs are distinctly dorsal to the heart and do not overlap it at the sides. Dorsally, there is further evidence of this ventral gravitation of the mediastinal viscera in the wide separation of aorta and œsophagus towards the diaphragm. The latter organ retains its relation with the pericardium and is suspended in a broad fold like a mesentery, formed by the approximation of the two pleural sacs.

Pleura

The dome of the pleura extends but a short way into the neck, rising to the upper border of the first rib in the region of its neck, but, on account of the obliquity of the ribs in the uninflated thorax, this point lies 6 cm. beyond the rostral margin of the sternum. The dome by no means fills the wide interval between the scalene and longus colli, which is mainly occupied by adipose tissue containing a highly developed rete mirabule. Ventrad, the parietal pleuræ are widely separated by the mediastinal complex, which is very broadly adherent to the thoracic wall. The line of pleural reflection is displaced farther on the left than on the right, but on neither does it anywhere reach the sternum. Its course is peculiarly modified by the folds associated with the pericardial fat bodies. These latter are of crescentic shape, attached ventrally in the line of junction between fibrous pericardium and diaphragm, and thence extending upon the thoracic wall at the caudal limit of the area of pericardial adhesion in a transverse direction, on the left side, to a point on the third rib 3 cm. from its cartilage and, on the right side, in the second space about 1 cm. farther ventrad. Correspondingly, a fold of parietal pleura is formed, its base attached in the area described and turning a free edge dorso-mesad towards the lung in the interval between the base of that organ and the diaphragm. The pleural cavity is thus partially subdivided ventrally on a level with the highest part of the diaphragm; and the incomplete partition is located, with reference to the lung, just caudal to its region of greatest breadth, at the beginning of the long tapering prolongation which rests upon the dorsal slope of the diaphragm. The folds in the specimen are flaccid from the dissolving of the fat during a long period of preservation, and, caudally, there depends on each side a long free process into the caudal portion of the pleura.

The two pleural sacs converge from their domes towards the thoracic aorta, which begins at the fifth thoracic vertebra. The line of reflection of the right sac crosses the aorta obliquely and from the seventh vertebra caudad to the diaphragm the sacs are in contact, forming the broad fold (described above) which extends to the œsophagus. On the diaphragm the lines of reflection are widely separated by the pericardium and its fat bodies, on account of which the pleural reflection at first runs dorsad on the thoracic wall of the third rib at some distance from its extremity and then turns rostrad along the ventral limit of the thoracic fat pad to the dome, crossing the first rib at a point rather nearer to its angle than its extremity. Thus the pleuræ cover only a narrow area of the fibrous pericardium near its dorsal limit and altogether fail to reach thymus, or sternum, or its attached cartilages.

The visceral pleura requires no special comment. The ligamenta lata are broad and extend to the diaphragm. Mesad, they join the sides of the aorto-œsophageal fold dorsal to the œsophagus.

Lungs

The lungs, compressed from side to side conformably to the deep costo-vertebral groove, have considerable dorso-ventral height. The apices, retaining this compressed form, are roundly curved in profile, and, mesially, each has a shallow groove for the posterior thoracic vessels. The lung broadens from the apex to the junction of pericardium and diaphragm, thence narrows at the expense of its ventral portion, and caudally runs out into a tapering point. The diaphragmatic surface is defined by sharp margins, which become rounded and obscure when the pericardium is reached, so that here and rostrad the compressed lung can be described as having a costal and a spinal surface, and thick dorsal and ventral margins, the latter apposed to the pericardium where it is not occupied by the hilus. The left lung is deeply grooved in its upper portion by the arch of the aorta. Le Danois has noted the rounded apex and pointed extremity of the lung of *Kogia;* in his specimen, the right lung was much the larger. In this fœtus, there is a remarkable reversal of usual proportions, for the left lung is larger than the right. It is, however, engorged with blood, as shown by its darker color and firmer consistency throughout, and its otherwise incomprehensible dimensions are probably to be assigned to this.

Measurements of Lungs

	Right *cm.*	Left *cm.*
Total length	17.8	19.8
Length of diaphragmatic surface	11.6	14.8
Greatest thickness	3.5	3.4
Greatest dorso-ventral diameter	5.7	6.1

Pericardium

The fibrous pericardium is bluntly conical, having a wide rostral termination upon the great vessels on account of their huge size and, caudad, being broadly adherent to the diaphragm. Ventrad, it is broadly adherent to the thoracic wall and also at the sides, for the mediastinal pleura is reduced in extent and has but a narrow contact with the pericardium. The serous layer resembles that of *Balænoptera* and shows the same evidences of sagittal shortening in the narrow circular sinus and the total reduction of the oblique sinus.

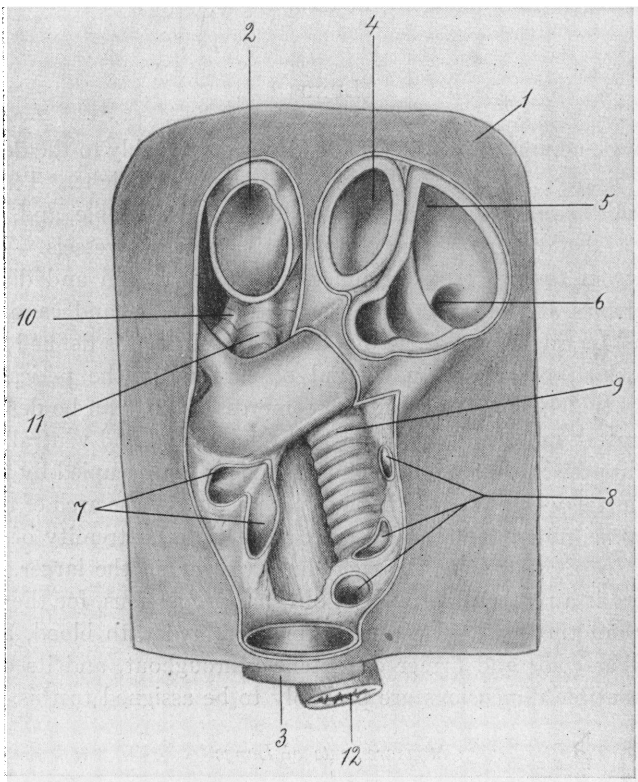

Fig. 7.— Interior of pericardium, showing reflection of serous layer and exposure of mediastinal structures in relation to its dorsum.

1. Fibrous pericardium.
2. Precava.
3. Postcava.
4. Aorta.
5. Pulmonary artery.
6. Ductus arteriosus.
7. Right pulmonary veins.
8. Left pulmonary veins.
9. Left primary bronchus.
10. Tracheal bronchus.
11. Right primary bronchus.
12. Œsophagus.

HEART

Le Danois has described briefly and illustrated the heart of the adult, calling attention to its great breadth, the high relief of the columnæ carneæ of its ventricles, the great size of aorta and pulmonary artery, and the absence of the corpora aurantii on the sigmoid valves, and noting the character of the atrio-ventricular valves and the papillary muscles. This heart corresponds to the conditions described, allowance made for the fœtal condition.

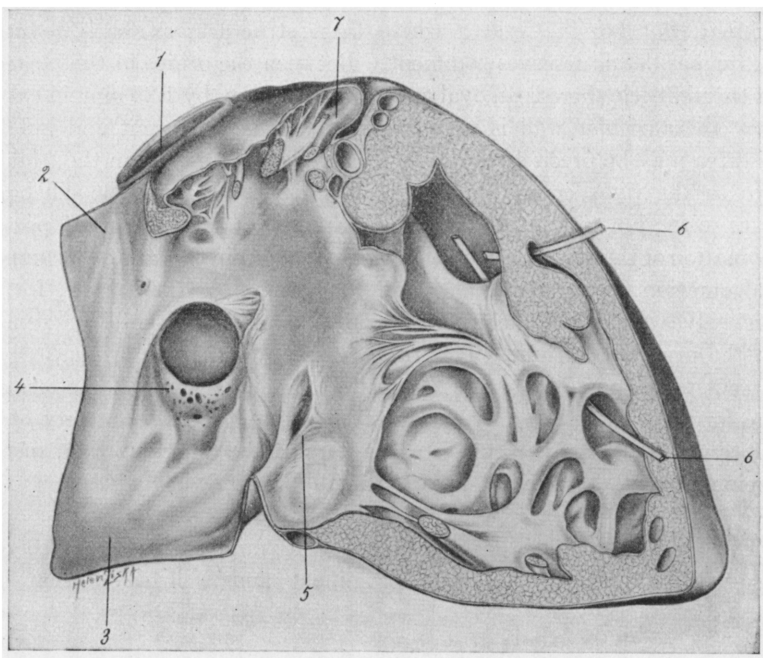

Fig. 8.— Sagittal section of right auricle and ventricle.

1. Aorta.
2. Precava.
3. Postcava.
4. Valvula fossæ ovalis.
5. Thebesian valve.
6. Probes passing under columnæ carneæ into conus.

It is placed with more of its bulk to the left than to the right of the median line; its long axis is slightly oblique, and a small degree of rotation has taken place, as the area of right ventricle in its sterno-costal surface exceeds that of the left. Unfortunately, the organ is somewhat deformed by a bending dorsad of the sides of the ventricles which prevents accurate measurement. The apex is obscurely notched.

The auricles are peculiar in the incomplete amalgamation of their atrial and venous portions. The sulcus terminalis on the right side is deep and complete, especially at the orifice of the postcava where its internal projection forms a high ridge in the position of and clearly has the function of the Eustachian valve. The ridge is continued to the limbus ovalis, where it forms the dorsal limit of the orifice of the coronary sinus. A well developed Thebesian valve extends from the ventral aspect of this ridge to the septum atrio-ventriculare guarding the orifice of the coronary sinus, as is usual in mammals but not in Cetacea where these structures are early reduced.[1] One further detail deserves comment. Between the orifice of the postcava and the ventricle there is an oval area, about 1.5 mm. by 1.25 mm. in extent, where the auricular wall is so tenuous as to be translucent and bulging. This area may be precisely located: it extends sagittally from the terminal ridge to the right coronary vein, and transversely from the Thebesian valves to the junction of the floor and right wall of the auricle. A possible explanation of this peculiar condition may be sought in the failure of complete amalgamation of the two embryonic constituents of the auricle, for the sinus valves owe their inception to the telescoping of the sinus venosus into the primitive atrium. This process, being retarded and markedly so adjacent to the postcava, expresses itself in the substitution of the terminal ridge for the Eustachian valve and indicates that the larger moiety of the right sinus valve has here persisted as part of the auricular wall, instead of being invaginated as usual to form the duplicature which gives rise to the valve.

The foramen ovale is large, measuring 18 mm. sagittally by 16 mm. dorso-ventrally. The annulus is prominent and well developed. The

Fig. 9.— Tongue, oropharynx, nasopharynx, larynx, and œsophagus. The alimentary passages are opened by a dorsal median incision; the right half of the nasopharynx has been removed.

1. **Tongue.**
2. **Oropharynx.**
3. **Œsophagus.**
4. **Nasopharynx.**
5. **Velum palati.**
6. **Arcus palato-pharyngeus.**
7. **Larynx.**

Fig. 10.— Plicate organ and crypts of the nasopharynx, left side. Below is the arcus palato-pharyngeus, the "repli en collerette" of le Danois.

Fig. 11.— Thymus, ventral view. One-half natural size.

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

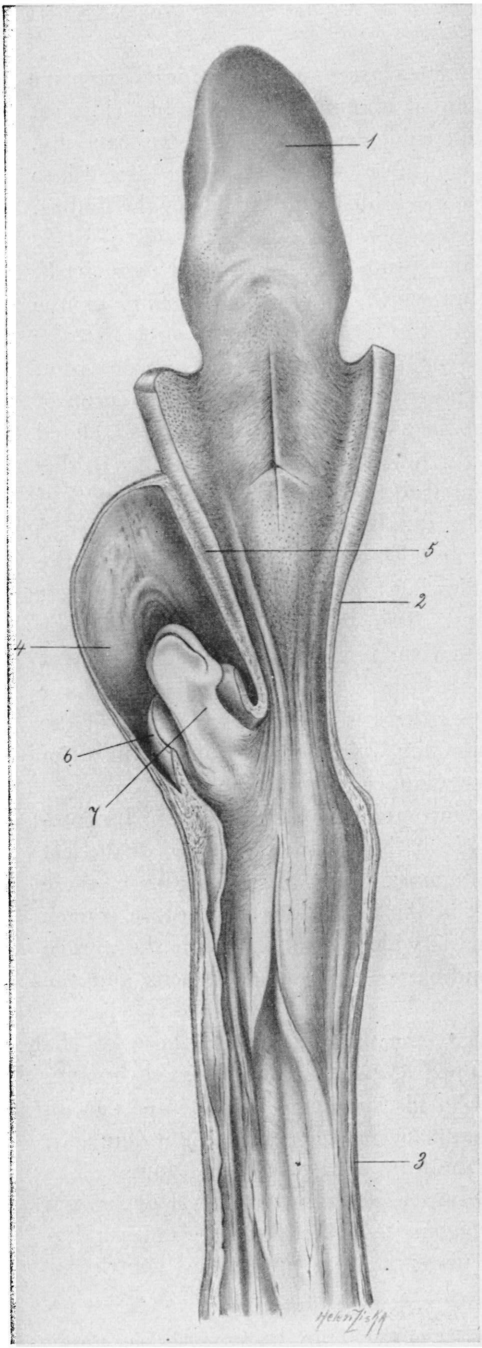

Fig. 9.

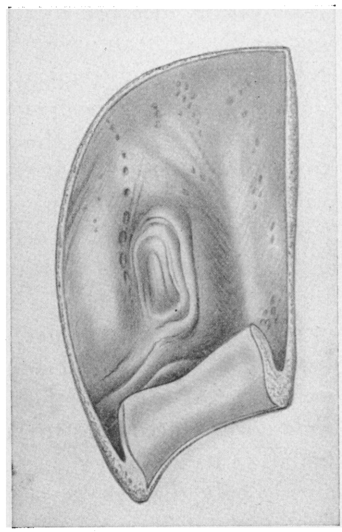

Fig. 10.

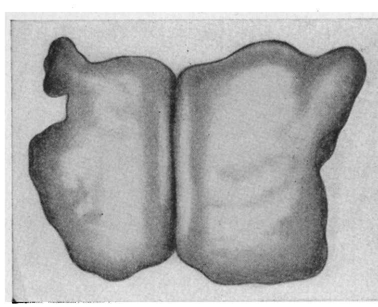

Fig. 11.

valvula seems adequate to effect complete closure were it not for its extensive fenestration, for in much of its extent it abounds in minute but close set perforations. Its line of attachment coincides with the limbus caudally, but its dorsal cornu deviates more and more to the left, being carried into the left auricle and terminating fully a centimeter to the left of the limbus. The ventral cornu has an analogous deviation in the opposite sense — being carried to the right of the auricular septum and here folded upon itself, to judge by the relief of the septum which, above the extremity of the valvula over a triangular area, has a cribriform appearance as though the fenestrated valve had secondarily become adherent. If the interpretation of this area is correct and it does represent the tip of the ventral cornu of the valvula, then it may be said that the cornua of the valve have extended around the whole circumference of the limbus and would have met in this fœtus had not the dorsal cornu deviated to the left. This observation is of some interest in connection with the thimble-shaped valvula of *Balæna*,[1] *Balænoptera* (according to Turner), and *Megaptera* being attached to the limbus in its whole periphery and allowing the passage of blood to the left auricle only through its perforations. The valve of *Kogia* throws some light on the evolution of this form, which could be derived by the enlargement and fusion of such cornua as here described, could their extension have occurred in one plane. In both types there is the same great size of the valvula, its fenestration, and its balooning into the left auricle; in all of which, the known mystacocetes have advanced beyond *Kogia.*

The left auricle shows the same incomplete amalgamation of its component parts; a deep sulcus terminalis, if the term may be used of the left auricle, descends beside the left pulmonary veins. In consequence, these veins, together with the short trunk of the right side, open into a convex sac at the back of the atrium; this is widely confluent with the auricle proper between the ridge corresponding to the terminal sulcus and the valve of the fossa ovalis.

The atrio-ventricular valves have the usual flaps and those of the tricuspid are at least as well developed as usual; this is stated because le Danois found the tricuspid valve in his specimen "représentée par un repli solide membraneu." Of the papillary muscles of the right ventricle, the posterior alone has anything of the form suggested by its name. The chordæ tendinæ going to the septal muscle are inserted into a depression in the surface of a large fleshy ridge which in its further course becomes undermined and a probe may be passed under it from the general ventricular

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[1] Knox, R., 1838, Catalogue of Anatomical Preparations of the Whale. Edinburgh. Quoted by Turner, *loc. cit. ante.*

cavity into the conus. The lateral papillary muscle, similarly, is represented only by a portion of a ridge on which chordæ tendinæ insert. This ridge also has a free portion which joins the ridge associated with the septal papillary muscle, constituting a moderator band. All of these muscles are placed at the junction of the middle and upper thirds of the ventricle. Those of the left ventricle are somewhat more projecting and occupy the usual position in the intervals of the flaps of the mitral valve. As le Danois has noted, the wall of the left ventricle is much thicker than the right — and this is striking as regards the compactum, but the massive development of the columnæ carneæ, especially on the right side (which le Danois has also noted), renders the disparity in thickness not greater than is usual in mammals. Owing to the large size of the trabeculæ in the right ventricle, the approach to the conus is subdivided into several passages. On the left side, the vestibule of the aorta is not so obstructed; trabeculæ are numerous but of moderate size and do not stretch across the cavity to so great an extent as on the right side.

Thymus

This organ is represented by bilateral bodies which are asymmetrical in their rostral portions, the left exceeding the right in size. They are placed against the pericardium behind the manubrium sterni and extend into the root of the neck, under cover of the infrahyoid muscles and resting upon the great vessels. Neither is in contact with the pleura. The left innominate vein grooves them dorsally, and its junction with the vessel of the right side and the beginning of the precava are similarly related to the right thymus. Beyond the veins, the thymus comes in contact with the branches of the aorta; on the right side, an oblique process is given off which rests against the concavity of the brachiocephalic and subclavian arteries; on the left side, the corresponding process is larger and fills the wide interval between common carotid and subclavian. It is in the development of these processes that the asymmetry between the two halves of the thymus chiefly consists, and this asymmetry is evidently to be referred to inequality in the reduction of the cervical portions of the two sides. The dimensions are as follows:

	Right *mm.*	Left *mm.*
Length sagittally along mesial border	46	42
" obliquely to extremity of process	57	66
Breadth	40	34
Thickness	7	8

Thyroid

The thyroid body is broad and thin, resting against the thyroid and cricoid cartilages, the upper rings of the trachea, and, on each side, upon the jugular vein. The rostral margin is nearly transverse with a median concavity. The lateral lobes are somewhat prolonged caudally and acutely angled. Between them is a wide shallow notch. This notch and the concavity of the rostral margin serve to define an isthmus, which is not greatly shorter sagittally than the lateral lobes. The capsule is thick and contains a rich vascular plexus. The substance of the body is very soft; this and its thinness are presumably due to the action of the preservative. Its dimensions are:

	mm.
Lateral lobe, right, sagittally	40
" ", left, "	40
Isthmus, sagittally	28
Transverse diameter	37
Thickness	1 to 3

At each lower pole, within the capsule, was found a small oval body of firm consistence, measuring about 7 mm. by 4 mm. These are probably parathyroids.

Tongue

The tongue is firm and muscular. The dorsum is flatly convex, the tip rounded, and the margin uniform and well defined. The frenulum is short and thick, and rostrad of it, on the free under surface of the tip, is a depressed triangular area of slightly darker hue than adjacent parts. Caudad, the tongue sinks rapidly to the level of the alveolingual region. This conformation seems very similar to conditions observed in *Balænoptera* and is presumably to be referred to a retarded development of the radix linguæ. In *Kogia,* this portion of the tongue is situated between the arcus palatoglossi; and, on the surface, there is no demarcation between the tongue and the floor of the oropharyngeal passage. The genio-glossi, however, stop abruptly; and their sharp junction with the fibrous coat of the oropharyngeal passage is taken as the caudal limit of the tongue. From this to the tip, it measures 105 mm.; its greatest breadth is 32 mm.; the free portion has a length of 17 mm. Rostrad, the surface of the tongue is perfectly smooth. In its middle third, the punctate orifice of glands appear and become very numerous caudad. Here also, the tongue presents a median fissure of about 2 mm. depth, which terminates behind in a triradiate figure. Few and shallow transverse furrows are given off from its sides.

Oropharynx

The oropharyngeal passage is long and narrow; its lumen is dorso-ventrally flattened (le Danois). The wall is very thick in the region of the arcus palato-glossus; but, caudal to this for a distance of 2.5 cm. until the pterygo-pharyngeus is reached, it is thin and poorly supplied with muscle. Entally are numerous longitudinal ridges. These all continue into the pharynx. The passage on the left, very narrow as le Danois describes it, appears more as a lateral addendum than as an actual portion of the pharynx. Le Danois describes the median ventral sulcus bifurcating in a V and sending one branch into the left passage, the other continuing into the œsophagus. This arrangement is not present in our fœtus. Everywhere upon the ridges are the punctate orifice of glands.

The tonsils are represented by two crypts, one on each side, and dorsally placed in the oropharyngeal passage close to the median line. This position of the tonsil was ascertained of *Phocœna* by Rapp. The orifices of the crypts are slit-like, curved like an *f*, and measure 5 mm. in length. They each lead into a little pocket of about the same depth, which is directed dorsad and laterad. There are no conspicuous lymph follicles.

Pharynx

The pharynx consists of a dorsal naso-pharynx and a ventral portion which receives the oropharyngeal canal. Separation between these cavities is effected by the lengthened velum and the strongly developed arcus palato-pharyngei. The latter form a short tube — *repli en collerette* — closely embracing the epiglottis and arytenoids; it is well shown in le Danois' figure.

The naso-pharynx, at first embraced between the pterygoid and otocranial plates of the occipital, rests dorsally against the basis cranii and ventrally upon the velum which is stretched between the bones mentioned. As they diverge caudad, it increases in breadth, attaining its maximum diameter between the attachments of the stylopharyngei.

The surface of the mucous membrane shows the orifices of numerous small glands which are everywhere present. In addition, there are many large crypts, such as are usually associated with the presence of adenoid organs. In the floor, they are abundant rostrad and are grouped in double or irregularly treble rows separated by strips of smooth mucosa. In the lateral wall is a curious arrangement of low folds of the mucosa. The first of these is parallel to the arcus palato-pharyngeus, from which it is separated by a row of large crypts. On the left side, it terminates rostrad by joining the arcus; on the right, it is less prominent and gradually fades out. A second fold, at first parallel to this, on reaching its rostral extremity curves ventrad and then ascends sharply on the lateral wall. In the concavity of its curvature are several similar but loop-like folds forming an oval structure measuring 16 mm. by 9 mm. On the right side, all of these folds are less developed and those of the plicate structure are indicated only by scattered crescentic grooves like nail prints in miniature. This organ presents not a little resemblance to the human pharyngeal tonsil, as depicted by Sklabounos,[1] and is probably its homologue notwithstanding its lateral position and asymmetrical development.

The muscular wall of the pharynx is well developed and of complicated structure. We record our findings without attempting a complete morphological analysis, which is hardly possible without more detailed knowledge than is at present available upon conditions existing in other odontocetes.

The inferior constrictor (thyreo-pharyngeus) is a large muscle, divisible into caudal and rostral portions. The former portion arises from the dorsal margin of the thyroid cartilage, its caudal cornu here encroaching upon the lateral surface. Its fasciculi spread out with a rostral inclination, eventually becoming transverse to join those of its antimere in the dorsal midline of the pharynx without the interposition of a raphe. Caudad, this muscle is continuous with the superficial layer of the œsophagus. These bundles are transverse in direction; they surround the œsophagus like a constrictor as far as the thorax, but there the caudal fasciculi of the layer assume a sagittal direction and blend with its longitudinal coat. The rostral portion of the thyreo-pharyngeus is thicker, more coarsely fasciculated, and partially overlaps the caudal portion, being the most superficial of the pharyngeal muscles. It arises from a large triangular area on the lateral surface of the thyroid cartilage, occupying the region between its rostral and dorsal margins and the attachment of the sterno-thyroid. From this origin, it passes as a thick ribbon of parallel bundles to join its fellow in a feeble raphe which permits much digitation and some continuity between the fasciculi of the two sides. It covers the junction of the caudal portion of the thyreo-pharyngeus with the pterygo-pharyngeus and is so located with reference to the spout-like prolongation of the larynx within

[1] Sklabounos, G. L., 1908, Anatomike tou anthropou. II, fig. 89. Athens.

the naso-pharynx as to reinforce the arcus palato-pharyngeus in its rôle of preventing the entrance of water from the œsophagus into that cavity. This muscle was mistaken by Benham (who had but stumps attached to the larynx he so carefully described) for the thyrohyoid, which entailed another slight error, hardly to be avoided in the circumstances, in his diagnosis of attachments upon the thyroid cartilage. His sterno-thyroid is correct (cf. his plate XXVI, fig. 6), but the muscle ventral to it (leadered) is the true thyro-hyoid and not an accessory slip. The direction of bundles for all these muscles in his cut corresponds with our findings and the unleadered dotted area on the dorsal margin corresponds closely to the origin of the caudal part of the inferior constrictor as we find it.

The stylo-pharyngeus arises from the stylohyal mesially and nearer the skull than the styloglossus. It is a medium-sized muscle which expands to its insertion upon the lateral wall of the naso-pharynx between the pterygo-pharyngeus and the palato-pharyngeus. The naso-pharynx is dilated transversely, and its major diameter lies between the insertions of the stylo-pharyngei.

The rostral portion of the pharynx — the naso-pharynx — has a thick muscular wall, the fasciculi of which have a general longitudinal direction. A dorsal muscle arises from the pterygoid entally as far as the margin which abuts upon the basi-sphenoid. The fasciculi converge from the two sides and meet in a dorsal raphe, which terminates at the margin of the caudal segment of the inferior constrictor and is covered superficially by the rostral section of that muscle. Laterally, the pterygo-pharyngeus extends to the insertion of the stylo-pharyngeus, beyond which it blends with the palato-pharyngeus.

This latter arises from the velum palati and, by its deeper layer, also from the ental surface of the pterygoid bone. The deep layer completes the investment of the naso-pharynx with longitudinal muscle, some of its bundles meeting the stylo-pharyngeus in an inscription, some passing ventrad of that muscle to the border of the caudal division of the inferior constrictor to which they are united by a tendinous line. These latter blend dorsally with the pterygo-pharyngeus. Ventrally, the bundles arising from the velum make a strong muscular arch on each side of the junction of the bucco-pharyngeal passage with the pharynx. This forms the substance of the arcus palato-pharyngeus, which closely surrounds the spout-like prolongation of the larynx.

The superficial portion of the palato-pharyngeus arises exclusively from the fibrous tissue of the velum. It is directed caudad and ventrad to the angle between the arytenoid and thyroid cartilages, and, expanding widely, is inserted into the ental surface of the latter. From its deep surface, a flat band of fasciculi is given off which sweeps dorsal to the under surface of the rostral division of the inferior constrictor, with which it unites in part by the interposition of a linear inscription.

Œsophagus

The œsophagus measures 12.25 mm. from the cricoid cartilage to the diaphragm. It is distinctly displaced to the right at its commencement and rests against the right side as well as the dorsum of the trachea. The trachea of this specimen is prominent and keeled, and, by its sharp convexity, indents the œsophagus. Accordingly, this organ has a kidney-shaped cross-section, with a convex dorso-dextral and a concave sinistro-ventral wall. The œsophagus inclines to the left as far as the arch of the aorta, which displaces it again towards the right; thence to the diaphragm, it gradually regains a median position. The maximum external dimensions, just rostrad of the aortic arch, are 23 mm. transversely, 11 mm. dorso-ventrally. At the bifurcation of the trachea, the œsophagus alters its form and, projecting ventrad to a slight degree in the angle between the primary bronchi, becomes flattened from side to side. At the diaphragm it measures 18 mm. dorso-ventrally and 9 mm. transversely. The wall has a thickness of 3 mm.

Inside, the mucosa is thrown into longitudinal folds which do not wholly disappear on stretching. Among these, four are distinguished by their larger size. The folds are somewhat irregular, dividing and uniting at acute angles in several places.

Fig. 12.— Lateral view of skull with exposure of auditory region.

1. Roof of dorsal spiracular chamber cleared of muscle and fibrous tissue.
2. Seventh nerve.
3. Spheno-maxillary fossa.
4. Infraorbital nerve.
5. Optic nerve.
6. Attachment of pterygoid muscle.
7. Rostral air sac.
8. Meckel's cartilage. (The leader should be half an inch longer).
9. Os tympanum.
10. Hyale.
11. Sigmoid process.
12. Tympano-mastoid.
13. Exterior auditory meatus.
14. Opening of lateral air sacs.
15. Zygomatic process.
16. Postorbital process of frontal.

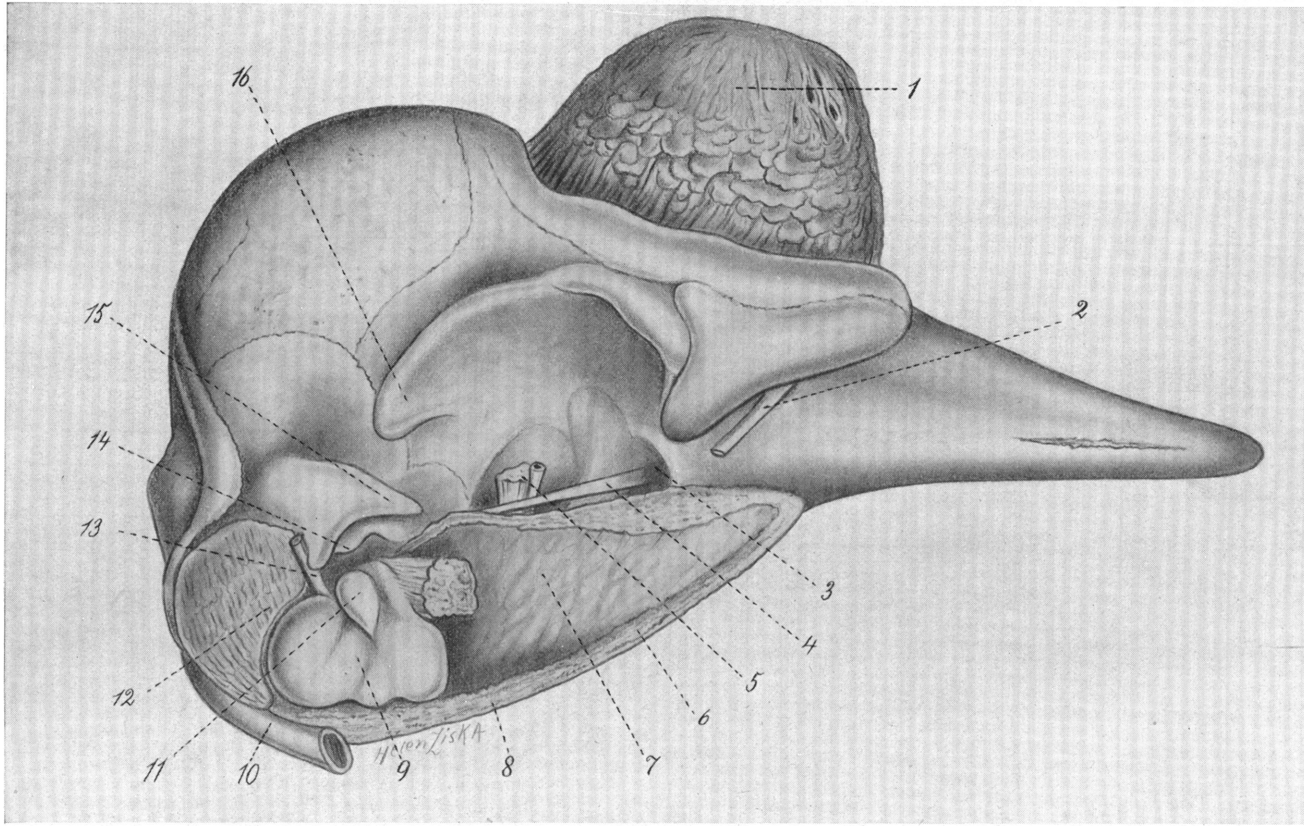

Fig. 12.

Ear

The bones related to the organ of hearing in *Kogia* have already been thoroughly treated by one of us (Schulte). No detailed description is called for here. We should like to recall one or two points concerning their position and nature, then go on to deal with the soft parts.

There is no bony canal. The os tympanum has the form of a semi-cylindrical sea-shell, with a thin irregular lateral border and a massive rolled-over mesal border. It encloses a small tympanic cavity and a larger space in the bulla ventrad thereto.

The periotic consists of the two divisions usual to the auditory apparatus of mammals: the canalicular and cochlear, the first of minute size. From

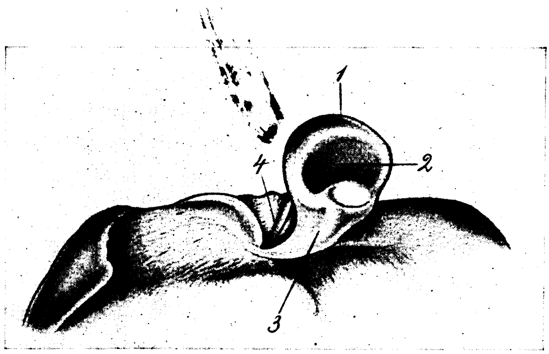

Fig. 13.— Mesal view of fragment of tympanum with malleus attached.
1. **Caput mallei.**
2. **Articular surface for incus.**
3. **Processus longus.**
4. **Recession in border of os tympanum laterad to processus longus.**

the canalicular region, a massive process extends in either direction rostrad and caudad; the first representing the tegmen tympani of other mammals, the second, the mastoid process.

These two bones are united by bony union in two comparatively small areas and are elsewhere separated by fissures of varying width. Together, they lie entirely outside the cranial cavity in a space bounded by the basi-occipital, the exoccipital, and the squamosal, and are buried in a mass of cavernous tissue enclosing blood and air spaces which will later be described.

The external auditory orifice is a minute opening situated caudad and ventrad to the eye. There is no trace of an auricle, nor can we define any distinct muscles related to the margins of the orifice. The meatus passes mesad and slightly rostrad, in a groove of the glenoid process of the squamosal, to terminate at its attachment to the os tympanum in the notch just caudad to the sigmoid process. The walls of this canal are of firm fibrous structure, of moderate thickness, and without cartilage as far as we could ascertain. The mouth of the canal and at first its lumen are so minute as to forbid probing. Approaching the tympanum, the lumen expands in a trumpet shaped manner, though still being of an insignificant size.

The tympanic membrane is an exceedingly thin sheet, faces dorso-mesad, and is attached to the caudal and ventral borders of the notch it bridges. Rostrad, it passes beyond the border to find attachment in a groove on the ental surface of the sigmoid process in the manner described by Denker[1] for *Phocœna.* Dorsad, it is attached to the fibrous band which bridges over the space between the anterior and posterior conical processes. As far as could be ascertained, the surface of the membrane is slightly concave ectad, as in other odontocetes and in young baleen whales. It possesses the usual "triangular ligament" connecting its inner surface with the malleus.

The tympanic cavity, lying between the periotic (dorsad) and the broad rolled-over mesal border of the os tympanum (ventrad), is a comparatively limited space, owing its dorso-ventral extension chiefly to the hollowing of the tympanic surface of the periotic. It has, however, communications with extensive air spaces lying beyond the borders of the limiting bones.

The cavity, in its natural state, is occupied by a mass of thick tissue which lines its walls and nearly fills it, in this manner concealing the contents. Wherever the tympanum and the periotic fail to meet it fills in the space between them and is continuous with the mass of cavernous tissue in which the whole complex lies buried. So it, too, is undoubtedly of a cavernous nature. It fills in the hollow of the bulla and extends into the excavation beneath the inverted mesal border of that structure, also into the excavation of the tympano-mastoid. This cavernous tissue is of the greatest importance in regulating the pressure within the middle ear when the animal is submerged.

On removal of the cavernous tissue the structures of the middle ear come into view. The inner wall (or dorsal wall, as it is here) presents, caudad, a short caudo-rostrad groove bordered by prominent ridges, the channel for the seventh nerve. Mesad to the groove is a ridge which is overlain by the stapedius muscle, and, just at its termination, the stapes is firmly secured but not ankylosed in the fenestra ovalis. Rostrad to this is a

[1] Denker, A., 1902, Zur Anatomie des Gehörgans der Cetacea, Anat. Hefte, XIX.

large depression occupying half the width of the tympanic surface of the bone. When the various parts are in their natural position this depression is occupied by the head of the malleus. Jutting underneath the orifice of the ductus fallopii is a prominent spicule, against which rests the short process of the incus. No tensor tympani was discovered though a groove for one has been noted (Schulte) in the position in which we should expect to find that muscle. It is of interest to state here that in another odontocete (*Tursiops*) a distinct tensor tympani has been found by one of us (Kernan) — a fact not hitherto noted and by some specifically denied (Denker). It is here much less defined than in the baleen whales.

The ossicles, in their general formation, do not differ from the usual mammalian type. The malleus has a proportionally large head, which lies in the depression in the periotic already described. The manubrium mallei is fused to the os tympanum along the border of a narrow cleft which, according to Denker, in *Phocœna*, contains that structure. We have found

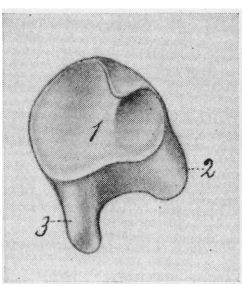

Fig. 14.

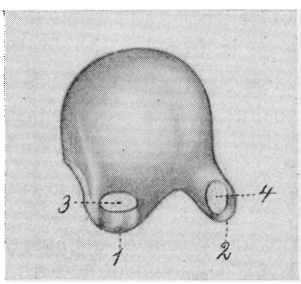

Fig. 15.

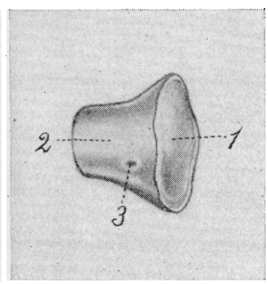

Fig. 16.

Fig. 14.— Lateral view of incus.

1. Articular surface for malleus.
2. Processus longus.
3. Processus brevis.

Fig. 15.— Mesal view of incus.

1. Processus longus.
2. Processus brevis.
3. Facette for stapes.
4. Facette for tubercule on crista facialis.

Fig. 16.— Stapes.

1. Foot plate.
2. Shaft.
3. Dimple indicating fenestra.

in *Tursiops* an arrangement like that in *Kogia*. The usual saddle-shaped articulation unites malleus and incus. The latter bone is distinguished by the fact that the two processes are of equal length, although the processus longus is the thicker. The processus brevis meets, at its tip, a small tubercle which juts out from the crista facialis dorsad to the fenestra ovalis. The stapes is not fenestrated and sits firmly in the oval window. The non-fenestrated condition is doubtless secondary, as Denker describes small depressions in the stapes of *Phocœna* which indicate the existence of a fenestra, and we have observed the same in other of the odontocetes, namely, *Ziphius* and *Tursiops*.

The tympanic opening of the facial nerve lies just above the oval window. At this point the nerve turns sharply dorsad and takes a straight course through the periotic. Thus, the geniculate ganglion must lie in the tympanic cavity. This is due to the non-development of that portion of the tegmen tympani which in other mammals (as, for instance, man) covers in the facial canal for the latter part of its course in the tympanum. A minute canal for the great superficial nerve passes rostrad between tegmen tympani and periotic, as it has been found by us in *Tursiops* and *Balœnoptera*. Owing to the fact that the periotic lies entirely without the cranial cavity, the great superficial petrosal nerve is entirely without the skull.

There are two points of contact and fusion between the os tympanum and the periotic: the anterior is, in this animal, already a bony union; the posterior consists of an exceedingly firm fibrous union of the tympanic process of the periotic to the dorsal surface of the tympano-mastoid. Except for these points, the bones are not in contact and the intervals are filled in by cavernous tissue.

At three places this tissue wall is broken and here the air space of tympanum communicates with the system of air spaces without. These have been described by Denker for *Phocœna* as lying in three groups: laterad, caudad, and rostrad. We find a like arrangement in *Kogia*. The lateral group opens out through the space between the membrana tympani and the periotic. It here consists of a few small cells. The posterior group communicates with the tympanum by an opening laterad to the facial canal and lies in the space bounded by the tympano-mastoid and the basi-occipital process of occiput. These cells also are of insignificant size. The anterior group, opening through the gutter of the os tympanum, contains only one cell but this is of remarkable dimensions. It is an oval space, 3 cm. by 5 cm., which occupies the whole of the pterygoid fossa. Its mesal wall, as are the walls of all these air sinuses, is made up of a thick pad of cavernous tissue. Its thin outer wall is overlain by the internal pterygoid muscle. Ventrally, in the angle of junction of the mesal and lateral walls, a minute opening allows a probe to pass through the pterygoid notch into the naso-pharynx. Thus, this large space is evidently an expansion of the Eustachian tube. Its communication with the naso-pharynx and the intimate relation to its lateral wall of the pterygoid muscle evidently permit of its distension by air and the expulsion of the same.

If we consider the presence of these air cells in connection with the cavernous nature of their walls, for we must remember that the whole otic complex is surrounded by a mass of cavernous tissue which fills every possible space — we will see that this region may be entirely filled with blood, the air spaces being obliterated, or, on the other hand, with air, the blood spaces being in their turn empty. The purpose of this arrangement is probably hydrostatic, making possible the submergence of the head or its sustension above the surface without effort. Again, we may think that these extensive air spaces, since their walls are trabeculated, afford additional surface for the absorption of oxygen by the blood.

The auditory apparatus of *Kogia,* as in other Cetacea, has thus been modified from an apparatus designed to receive air-borne sounds to one designed to receive water-borne sounds. The external meatus has been practically closed, the drum membrane fixed, and the ossicles rendered immovable by the fusion of the malleus to the os tympanum. Denker has thoroughly demonstrated that vibration of the ossicular chain is impossible. The water-borne sounds are evidently transmitted to the cochlear apparatus through the solid tissues of the head. This method of hearing is all the more efficient on account of the closing off of sounds borne through air, in accordance with the well-known clinical fact that bone conduction is increased where the function of the middle ear is diminished.

The manner in which the sounds are transmitted to the cochlea is disputed. Some authorities maintain that the vibrations are transmitted to the air in the tympanum, and thence to the cochlea through the fenestra ovalis. Others say that the sound waves reach the receptive organs in the cochlea directly through the walls of the periotic bone. In this connection, it is important to recall that the os tympanum and the periotic are nowhere in contact with the other bones of the skull and that they are surrounded by numerous cells capable of distension with air. So it seems necessary to suppose that sound waves must reach the internal ear through a cushion of air immediately related to the periotic, though not necessarily that contained in the tympanum alone.

The large relative size of the cochlear division of the periotic argues an active hearing function. On the other hand, the comparatively small size of the semicircular canals is what we should expect in an animal living in the water where little active balancing would be called for.