

**Article II.—THE EXTERNAL CHARACTERS, SKELETAL  
MUSCLES, AND PERIPHERAL NERVES OF *KOGIA*  
*BREVICEPS* (BLAINVILLE)**

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CONTENTS

	PAGE
Introduction.....	7
Measurements.....	8
External characters.....	8
Myology.....	11
Peripheral nerves.....	60

INTRODUCTION

The foetal *Kogia* [Physeteridæ; Odontoceti] described in this paper was taken from a large female which became stranded at Long Beach, Long Island, the skeleton of which is preserved in the American Museum of Natural History, No. 36595.

The specimen was entrusted to us for study by Dr. J. A. Allen, at the suggestion of Mr. R. C. Andrews. To both of these gentlemen we would express our sincere gratitude. We would also express our appreciation to Mrs. Helen Ziska for her painstaking skill in the preparation of the illustrations.

The foetus, which is a male, was preserved in alcohol and received in good condition. The muscles were rather soft but not to such a degree as seriously to interfere with dissection. The cheeks, however, especially the left, had pressed against the side of the container and had desiccated. On the left side, the underlying muscles could not be studied; on the right, with only partial success. It was also impossible to find on the surface the orifice of the ear and the location of hairs; the situation of these structures was ascertained only during the removal of the blubber.

While the writers have collaborated throughout in the study of this *Kogia*, one of them (Smith) has charged himself especially with the nerves, the other with the muscles, and each would assume in his division of the work the major responsibility for the statements made therein.

## MEASUREMENTS

The dimensions of this specimen are given in the accompanying table:—

	cm.
Total length — notch in flukes to snout.....	109.7
Tip of snout to eye.....	Left, 15 cm.; Right, 16.0
“ “ “ “ blow hole.....	10.5
“ “ “ “ axilla R.....	25.5
“ “ “ “ axilla L.....	27.0
Notch in flukes to anus.....	36.0
“ “ “ “ preputial orifice.....	60.5
“ “ “ “ dorsal hump.....	47.3
“ “ “ “ umbilicus.....	63.3
Flukes — tip to tip.....	21.0
Depth of pedicle just anterior to flukes.....	7.1
“ “ “ midway between flukes and anus.....	12.7
Fin tip to head of humerus, R.....	18.7
“ “ “ “ “ “ L.....	19.3
“ “ to anterior insertion, R.....	19.0
“ “ “ “ “ “ L.....	20.0
“ “ “ posterior “ R.....	14.0
“ “ “ “ “ “ L.....	14.5
Greatest breadth, R.....	6.5
“ “ L.....	6.5
Length of blow hole.....	2.4
Circumference at eye.....	58.0
“ at axilla.....	62.5
“ at umbilicus.....	60.5
“ at anus.....	39.9
“ midway between anus and flukes.....	29.6
“ just anterior to flukes.....	17.0
Length of dorsal fin at base.....	11.5
“ “ “ “ to incisure.....	9.8
Height of dorsal fin.....	5.2

## EXTERNAL CHARACTERS

*Coloration.* The dorsal parts are glossy black; the ventral, a dirty buff color, apparently altered in hue by the preservative. The light area includes the throat, the under side of the flippers, and the venter; extending about half-way up the trunk immediately behind the axillæ and contracting gradually towards the pedicle it is continued as a narrow strip to the flukes, the under parts of which are also light colored. The margins, as well as the

dorsum, of flippers and flukes are dark, and the pigmentation encroaches to a slight degree upon their under sides.

*Contour.* In the illustrations of the adult specimens of *Kogia*, the snout projects strongly beyond the mouth. In le Danois' figure, its contour ascends at an angle of about  $45^{\circ}$  to the level of the eye and then turns at something less than a right angle into the sloping convexity of the head. In his sections, this contour is seen to follow closely the outline of the spermaceti organ. The large size of this structure in the adult would seem, therefore, to determine the difference in the shape of the snout as compared to the foetus, for in the specimen here described the snout ascends with only a slight deviation forward from the vertical. Its tip is separated dorsally by a concavity — probably artificial — from the convexity of the spiracular sac. Beyond this again is a slight incurvation of the outline followed by a second convexity at the insertion of the dorsal muscles into the occipital

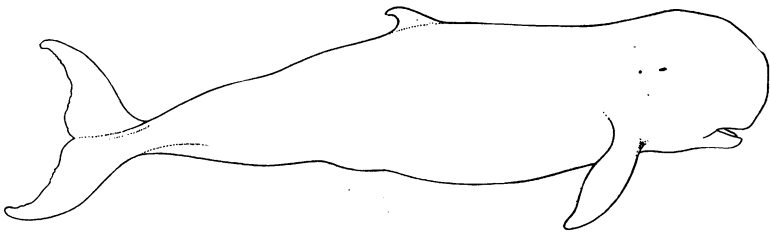


Fig. 1. Contour of foetus at term.

bone. Thence to the pedicle the contour is evenly and slightly arched, the hump occupying the summit of the curve. At the beginning of the pedicle, a shallow concavity is present, beyond which the contour is again slightly arched, finally descending to the flukes with a steep slope. In this respect and indeed in its whole dorsal outline, with the exception of the hump it resembles Krefft's wood cut far more closely than either of Owen's figures. The ventral contour is uniformly and very moderately convex, save for slight concavities at the throat, at the preputial orifice, and at the junction of the pedicle with the trunk. The first two are indicated in Owen's illustrations, but in them the protrusion of belly and chest are much greater. It will be remembered that the specimen from which they were taken was a pregnant female.

*The head.* The head is described by le Danois as conical. In this younger specimen it is rather to be described as wedge-shaped. The sloping sides meet in a line ascending from the mouth like the stem of a boat.

The blow-hole, lunate with caudally directed horns, is situated in the

space between the eyes about as in Owen's figure and not as far rostrad as in le Danois', with which however it corresponds in position with reference to the median line.

The asymmetry of the head is also shown in the position of the eyes, the left being visibly nearer the tip of the snout, as le Danois has pointed out.

To the description of the mouth by this last named writer, our material enables us to add little. The sulcus corresponding to the mandibular teeth is situated at the junction of the lip and rostrum. It is wide and shallow and not yet divided into pits for the teeth — an adult condition recorded first by Wall. Krefft failed to find the pits, but they were again observed by le Danois. The lower teeth are present as a close-set series of elevations but have not yet broken through. They are blunt and rounded, fifteen in number; the largest at the middle of the series; the last three are very small.

In the midline of the palate, at its rostral extremity close to the sulcus of the upper lip, is a distinct ridge 15 mm. in length. No pits were found in its vicinity. It is probable, however, that it represents the papilla incisiva. There is no external evidence of premaxillary teeth, nor were we able to discern their anlagen in the dissection of the contents of the alveolar sulci of the maxilla. Further, we found no trace of Benham's sclerite. The condition of the soft parts is not such as to warrant an absolute statement, but good enough for us to feel that had these structures attained even a moderate size they would have been observable.

*The flipper.* The pectoral limbs are short and broad, with a robust preaxial margin. Their thickness diminishes towards the postaxial border, which is tenuous but even. They are broadest in the metacarpal region and thence diminish rapidly, largely at the expense of the postaxial border, which becomes concave. The tip is obscurely recurved.

*The hump.* The dorsal fin is thick and solid, falcate and prolonged along the back by a low ridge. It is less elevated than in Owen's figure. Krefft represents it as a low irregular ridge.

*The pedicle.* The pedicle is high and compressed. Demarcated from the trunk by slight concavities in its ventral and dorsal contours, it maintains its size to near the flukes where it diminishes rather abruptly.

*The flukes.* The flukes are not symmetrical. The greatest transverse measurement of the right is 11.5 cm.; the greatest sagittal, 10.5 cm. The corresponding measurements on the left are 10.5 cm. and 10.6 cm. The right fluke also projects more transversely. Their inclination from the pedicle could not be determined as they had become bent in the container.

*The vent.* The anus is situated in a depression 18 mm. long by 12 mm. broad, bordered at the sides by thick ridges.

*The preputial orifice.* The preputial orifice is situated 19 mm. caudal to

the umbilicus. It measures 21 mm. in length by 10 mm. in breadth; and, like the vent, is bordered at the sides by heavy ridges. Just caudad of the opening, there is a slight incurvation of the ventral contour which does not correspond to the extremity of the phallus and is perhaps due to the bending of the foetus in its container.

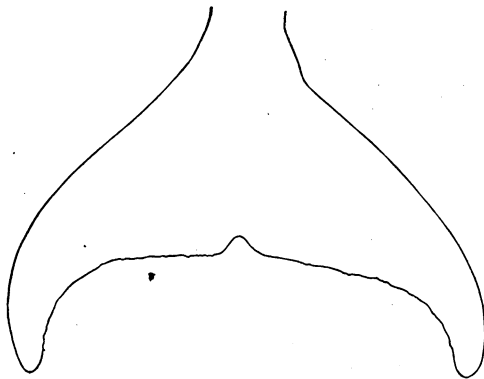


Fig. 2. Contour of flukes viewed from above.

*Hairs.* Four hairs, arranged in an oblique line, were present in front of the eye. The intervals between these hairs were such as to suggest that a fifth had disappeared from the middle of the series. None was observable on the surface, which had dried.

#### MYOLOGY

For the study of the musculature of odontocetes, the fundamental work is that of Stannius upon *Phocaena*,<sup>1</sup> which supersedes the earlier and less detailed study of Rapp,<sup>2</sup> as well as the scattered notes of Cuvier<sup>3</sup> and Meckel.<sup>4</sup> Murie<sup>5</sup> has described and beautifully figured conditions as they obtain in *Globicephalus* and has also notes upon *Grampus* and *Lagenorhynchus*. Leche's<sup>6</sup> compilation is uncritical but useful for reference. A larger number

<sup>1</sup> Stannius, H. Beschreibung der Muskeln des Tümmlers (*Delphinus phocaena*). Müller's Arch., 1849.

<sup>2</sup> Rapp, W. Die Cetaceen. Stuttgart, Tübingen, 1837.

<sup>3</sup> Cuvier, C. Leçons d'anatomie comparée. Paris, 1805.

<sup>4</sup> Meckel, J. F. System der vergleichenden Anatomie. Halle, 1821-1833.

<sup>5</sup> Murie, J. *Grampus rissoanus*. Jour. Anat. and Phys., V, 1871. *Lagenorhynchus albirostris*. Jour. Linn. Soc., 1870. On the organization of the Caaing whale, *Globicephalus melas*. Trans. Zool. Soc. London, VIII, 1874, p. 235.

<sup>6</sup> Leche, W. Mammalia: Bronn's Thier-Reich. Leipzig, 1874-1900.

of workers have concerned themselves with special muscular complexes and they are referred to in connection with the regions they have recorded.

In the following account of the skeletal muscles of *Kogia*, comparison has been made, where possible, with conditions in other odontocetes, occasionally with mystacetes; but it has been chiefly purposed to describe objectively the arrangements obtaining in this little known whale; for, as yet, only the muscles of the genital tract (Benham,<sup>1</sup> le Danois<sup>2</sup>) of the larynx (Benham), and of the respiratory passages, head, and neck (le Danois), the last under unfavorable circumstances, have been examined.

*Panniculus carnosus.* Placed between the superficial and deep layers of blubber, the panniculus forms an extensive investment of the trunk and is continued over the pedicle by a strong aponeurosis. In *Phocæna*, it has been described by Rapp and later by Stannius in much detail. Behind the shoulder, it is clearly differentiated into dorsal and ventral divisions by a fibrous raphe reaching from the flipper to the beginning of the pedicle in the vicinity of the vulva and anus. To this raphe, the fasciculi ascend or descend with an inclination rostrad, and this arrangement apparently obtains generally among odontocetes, *pace* Murie who has described and figured the panniculus of *Globicephalus melas* without a raphe. In the small foetus of that species in our possession, the raphe is present and the panniculus of the trunk conforms strictly to the conditions described by Stannius in *Phocæna* and observed by us in *Kogia* and *Tursiops*. In the post-axillary region, therefore, uniformity prevails in this muscle among the cetaceans hitherto studied, inclusive of the mystacetes *Balænoptera* and *Megaptera*.<sup>3</sup> Ventrally in all, the muscles of the two sides are separated by fibrous tissue as far as the sternum, the fasciculi becoming continuous from side to side in the neck and intermandibular region.

In the region of the pectoral limb and rostrad, the arrangement becomes somewhat complicated from the acquisition on the part of the panniculus of attachments to the flipper, to the maxilla, and to the cranium, and, further, by the development of interruptions in the sheet both ventrally over the pectoralis and dorsally at the shoulder. Because of the differences in detail of these arrangements, it will be convenient to follow the accounts of the several genera separately.

In *Phocæna*, the dorsal division forms a continuous sheet from occiput to the region of the genitalia. Rapp and Stannius describe no disturbance

<sup>1</sup> Benham, W. B. On the larynx of certain whales (*Cogia*, *Balænoptera*, *Ziphius*). Proc. Zool. Soc. London, 1901. On the anatomy of *Cogia breviceps*. Proc. Zool. Soc. London, 1901.

<sup>2</sup> le Danois, E. Recherches sur l'anatomie de la tête de *Kogia breviceps* Blainv. Arch. de Zool. exp. et gen., (5), VI, 1910. Recherches sur les viscères et le squelette de *Kogia breviceps* Blainv. *Idem.*, VI, 1911.

<sup>3</sup> Mem. Amer. Mus. Nat. Hist., N. S., I, part 6, 1916.

of the uniform ventro-rostral course of its fasciculi at the shoulder, except only (Stannius) a moderate concentration over the scapula, and this implicitly rather than explicitly as a necessary consequence of the direction given the bundles of occipital origin. These descend with a caudal inclination to the side of the neck and then sweep transversely into continuity with the ventral division. It is fair to suppose that the inclination of the fasciculi changes from ventral and rostral to directly ventral in the region of the limb girdle, without interruption of the continuity of the sheet, and therefore with some concentration of the bundles acting upon the limb.

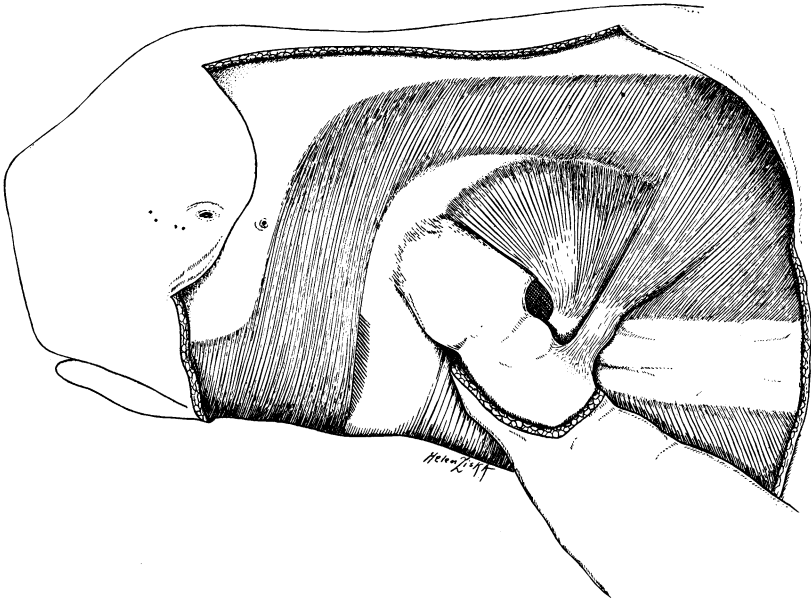


Fig. 3. Panniculus carnosus.

They are inserted into the aponeurosis upon the lateral surface of the flipper and into the corresponding surface of the humerus. The ventral division passes without interruption over the thorax and neck into the intermandibular region. A small area of sternum is exposed between the muscles of the two sides, beyond which their fasciculi are directly continuous across the median line. Those of the chest insert into the fibrous investment of the flipper. Those of the neck are continuous dorsad with the fasciculi of occipital origin previously mentioned; and, finally, those of the intermandibular region stretch transversely between the mandibles. The panniculus extends continuously over the pectoralis major and has no inti-

mate connections with that muscle. We find no justification for Stannius' statement that Rapp designated any portion of panniculus as pectoralis major or that his account differed from Stannius' own save in its omission of details.

In *Tursiops*, the ventral divisions are separated by a broad median aponeurosis except at the vulva where the muscular fasciculi are prolonged to the sides of the vagina and also to the rectum. The fasciculi are directed dorsad and rostrad to the raphe, overlapping to a very slight degree the caudal margin of the pectoralis major. Otherwise, this latter muscle is exposed in its whole extent, the thoracic portion of the panniculus defaulting in the whole region of the greater pectoral. In the neck a triangular aponeurosis is present between the pannicular fasciculi of the two sides. Its base corresponds to the rostral margin of the pectoral; its apex lies in the transverse plane of the auditory orifices. Beyond it, the fasciculi are continuous from side to side. In the intermandibular region, these are attached laterally to the fibrous structures of the lip, sweeping over the ventral margins of the mandibles, only a few of the deeper bundles gaining an insertion into the lateral surfaces of these bones. Caudal to the angulus oris, some of the bundles ascend to be inserted into the fibrous tissue that covers the masseter. The dorsal division extends from occiput to the region of the vulva, here becoming very narrow. In the region of the shoulder, the fasciculi gradually alter their direction, becoming transverse and ultimately inclined slightly caudad. The most rostral fasciculi terminate in the fascia over the masseter and about the external auditory meatus; those next succeeding pass between the meatus and the shoulder in a broad band, concealing the deep muscles and inserting upon the sides of the aponeurotic triangle in front of the ectopectoral. Between these and the next fasciculi going to the shoulder, a narrow fibrous interval has developed and this broadens ventrad, becoming continuous with the ventral aponeurosis just described. Some such interposition as this would seem necessarily to result from the divergent direction of the fasciculi of the neck and of the shoulder, the former being transverse, the latter inclined caudad; and this would hold true of *Phocæna* as well as of *Tursiops*. In the latter genus, the process has apparently advanced, for the caudally inclined fasciculi converge towards the hinder margin of the flipper close to the insertion of the lateral raphe, instead of being diffusely attached to the aponeurosis of its ectal surface. The effect of this arrangement is to enhance the force of adduction exerted by the panniculus and further to elevate the flipper when closely appressed to the side of the thorax, at the sacrifice of some efficiency in abducting and elevating the extended flipper. With the limb extended, the contraction of these fasciculi would tend to elevate its post-



axial margin and only secondarily produce a general elevation of the limb as a whole.

In *Kogia*, the ventral and dorsal divisions are separated by a broad aponeurosis, which contracts to a raphe only as the axilla is approached. In the ventral midline, an aponeurosis of moderate width separates the muscles of the two sides between the vulva and the ectopectoral. The ventral division in the trunk extends from the beginning of the pedicle just caudal to the anus as far as the pectoralis major, overlapping the abdominal fasciculi of that muscle and inserting in part into the aponeurosis which covers its sternal portion. The great majority of bundles insert into the lateral raphe and aponeurosis; all have an oblique rostro-dorsal direction. There is a wide pectoral interval in the panniculus, which in the neck is prolonged by a median aponeurosis as in *Tursiops*, not triangular as in that form but with a curved rostral border. The intermandibular fasciculi have the same arrangement. The dorsal division extends from opposite the anus, here thin and narrow, to the occiput. The most rostral fasciculi are directed ventrad and caudad to the fascia over the masseter. The next, sweeping ventrad in the neck as a broad band of parallel bundles, arrive at the throat and insert upon the ventral aponeurosis or become continuous with those of the opposite side. This aponeurosis lies in the same plane as the intermandibular fasciculi and forms a caudal continuation of the layer. The portion of the dorsal division related to the flipper is highly modified in the direction of concentration at its axillary margin. The aponeurosis of the neck extends far dorsad in front of the shoulder, intervening between it and the band of fasciculi descending on the side of the neck. From its dorsal extremity, a very narrow arched inscription extends to the axilla where it joins the lateral raphe. The bundles of the panniculus arising from the dorsal aponeurosis insert into this fibrous arcade and in front of it into the prolongation of the gular aponeurosis. Those more caudally placed converge to form a band of muscle, which reaches the lateral raphe opposite the point where the lower sternal bundles of the pectoral also join it. Ventral to the arched inscription is a fan of muscle converging to the axilla. These fasciculi arise from the fibrous arcade interdigitating with those of the main sheet of the panniculus. They are directed ventrad and distinctly caudad; and, as they approach the axilla, they assume a deeper position, coming to be partially overlapped by the muscular band described above and, under cover of it, gaining attachment to the lateral raphe. This applies only to the caudad fasciculi of the fan. The remainder, becoming aponeurotic, are attached to the deep surface of the ectopectoral and the postaxial margin of the flipper. In this respect *Kogia* has advanced upon the conditions observed in *Tursiops*, which, in turn, stands somewhat higher than *Phocaena*.

In *Globicephalus*, Murie describes a panniculus with a wide thoracic interruption. As has been already stated, he describes no lateral raphe and in his illustrations gives throughout a very unusual direction to the fasciculi. Our small foetus<sup>1</sup> was, unfortunately, somewhat dried, which rendered the examination of its muscles difficult. It was possible, however, to ascertain the presence of a raphe and the usual course of fasciculi in both ventral and dorsal divisions. Otherwise, conditions were much the same as in *Tursiops*, with possibly even less concentration of the dorsal division at the axillary margin of the flipper.

The arrangement of the panniculus in mystacetes, to judge by conditions obtaining in rorquals *Balænoptera* and *Megaptera*, is in essentials the same but differs in the neck and ventral pouch as secondarily modified in connection with the development of the throat furrows. The redundant ventral integuments are in need of muscular support which is supplied by the panniculus along with the mylohyoid and a derivative of the infrahyoid musculature. The panniculus is continuous over the pectoralis from the trunk to the intermandibular region, and on the side of the neck the ventral and dorsal divisions, elsewhere united by a raphe, overlap extensively so that the ventral division attains fixation upon the skull and the dorsal is prolonged into the intermandibular region as a superficial layer. The result of these changes is to reinforce the ventral pouch, which permits of the enormous distension of the mouth and by the contractibility of its wall assists in the discharge of the engulfed sea water through the baleen fringes, the minute organisms on which the rorqual feeds being in this way filtered out and retained.

In *Kogia*, the intermandibular portion of the panniculus is innervated by a branch of the facial nerve. The cervical portion receives its supply from the ventral division of the second, third, and fourth cervical nerves. All of these nerves give small branches to the dorsal portion of the panniculus, the branches emerging through the lateral intermuscular septum. In addition, a large trunk, formed by the second with contributions from the third and fourth nerves, supplies the bulk of the panniculus between the ear and the aponeurosis at the rostral border of the pectoralis.

The portion of the dorsal division lying in relation to the scapula and thence caudad is supplied by the cervico-brachial plexus through five or six large branches arising from the long thoracic nerve. These branches radiate dorsad on the ental surface of the muscle, the more dorsal curving around the caudal border of the scapula.

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<sup>1</sup> For the privilege of examining this specimen, we would express our appreciation to Mr. R. C. Murphy of the Brooklyn Institute of Arts and Sciences.

The remainder of the panniculus is innervated by a plexus formed of the long thoracic nerve and branches of the thoracic nerves from the first to the eleventh. This plexus is composed of two longitudinal trunks closely connected with each other and lying ental to the lateral raphe of the panniculus. These trunks give off nerves to both dorsal and ventral divisions of the panniculus.

The nerve supply plainly indicates that the panniculus is a superficial derivative of the general trunk musculature to which, in the neck, is added a similar cleavage product of the hyoid bar. In this it agrees with usual mammalian conditions. Quite generally, however, a high development of the panniculus is associated with a corresponding development of epidermal derivatives, hairs or bristles (Weber), and in the Cetacea these are all but totally wanting. Some other explanation of its function must be sought. That it acts powerfully upon the flipper is beyond doubt, but another suggestion lies at hand in its restriction on the trunk to the regions of the body cavities; for it is lacking over the dorsal muscles and in the pedicle. It would seem, therefore, so disposed as to maintain pressure upon these regions and to prevent their distension by the expansion of their air-containing contents as the animal rises from deep water. The same factor may also be of account in connection with the enormous plexuses of the neck. In this connection, passing reference may be made to the great development of the muscles serving as agents of expiration, notably the rectus abdominis and, in the odontocetes, the transversarius superior.

*Accessorius group.* The sterno-mastoid arises from the manubrium sterni between the areas occupied by the sterno-hyoid and the ectopectoral; the latter muscle overlies its origin. At first slender and tendinous on its surface, it lies in a groove in the lateral portion of the sterno-hyoid. Diverging from this muscle, its belly becomes flat and ribbon-like, crosses the neck obliquely, and inserts by a flat tendon into the tympano-mastoid and exoccipital under cover of the masto-humeralis. The latter muscle, also ribbon-like, partially overlaps the sterno-mastoid in the neck. It then passes deeply to the deltoid, under cover of which it is inserted by a cylindrical tendon into the summit of the tuberosity of the humerus. There is no trapezius.

These muscles are supplied by nerves which come directly from the trunk of the vagus, probably containing fibers of accessory origin. No communications with the cervical nerves were found.

These muscles are much as in *Phocæna* and agree with the accounts of Cuvier, Meckel, Rapp and Stannius, save that the accessory slip of the last investigator from the hyoid to the sterno-mastoid is not present. Meckel describes a second, partially independent head of the sterno-mastoid,

which Murie believes represents the cleido-mastoid. In *Globicephalus* the muscle is single. None of these authors describe a trapezius, although both Meckel and Murie consider the possibility of so designating the rhomboideus capitis, an interpretation excluded by its nerve supply.

*Trachelo-costo-scapular muscles.* This sheet is reduced and there is a wide interval between the small levator and the very moderately developed serratus. The levator anguli scapulæ arises from the extremity of the transverse process of the atlas and from the sheath of the scalenus posticus to which it is broadly adherent. The small flat belly turns dorsad around the transversarius capitis and, reaching the basis scapulæ, is inserted under cover of the rhomboideus at some distance from the angle. This muscle has a constant disposition with but trifling variations in other cetaceans (Murie) but the muscle of *Kogia* is peculiar in the displacement of its insertion caudad from the angle of the scapula.

The serratus anticus arises from the first three ribs and the fascia of the intervening spaces. On the right side, there is a broad middle digitation to which much smaller ones are added from the first and third ribs. On the left side, the origin on the first rib is minimal and the fasciculi of this origin are not separable from those of the second rib, so that but two digitations are present. The insertion is into the caudal angle of the scapula on its ental surface. In *Globicephalus*, the sheet seems to be complete from atlas to first rib and thence extend far upon the thorax (Murie). In *Phocæna* the muscle is confined to the thorax but extends to the fourth rib (Rapp) or the fifth (Stannius).

The levator anguli scapulæ receives fibres from the second, third, fourth, fifth, and sixth cervical nerves, through two branches. The first, derived from all of these nerves, supplies also the rhomboideus capitis. The second, derived from the fifth and sixth, enters the distal part of the belly. The serratus anticus receives its nerve supply by a branch derived from the seventh and eighth cervical nerves; this branch pierces the scalenus medius, crosses the first rib, and enters the deep surface of the muscle. Thus these muscles retain, in their nerve supply, evidence of the complete sheet of which they are the reduced representatives.

*Rhomboids.* The rhomboideus is well developed and differentiated into three elements: a rhomboideus capitis, a superficial, and a deep rhomboideus vertebralis. The first two are concentrated at the rostral angle of the scapula; the last inserts along the whole of its base. The rhomboideus capitis arises from the parietal bone close to the supratemporal crest. Its belly is composed of parallel bundles, crosses the splenius capitis superficially, and inserts into the rostral angle of the scapula. From the insertion, tendinous bands are prolonged upon the fascia covering the deltoid. The

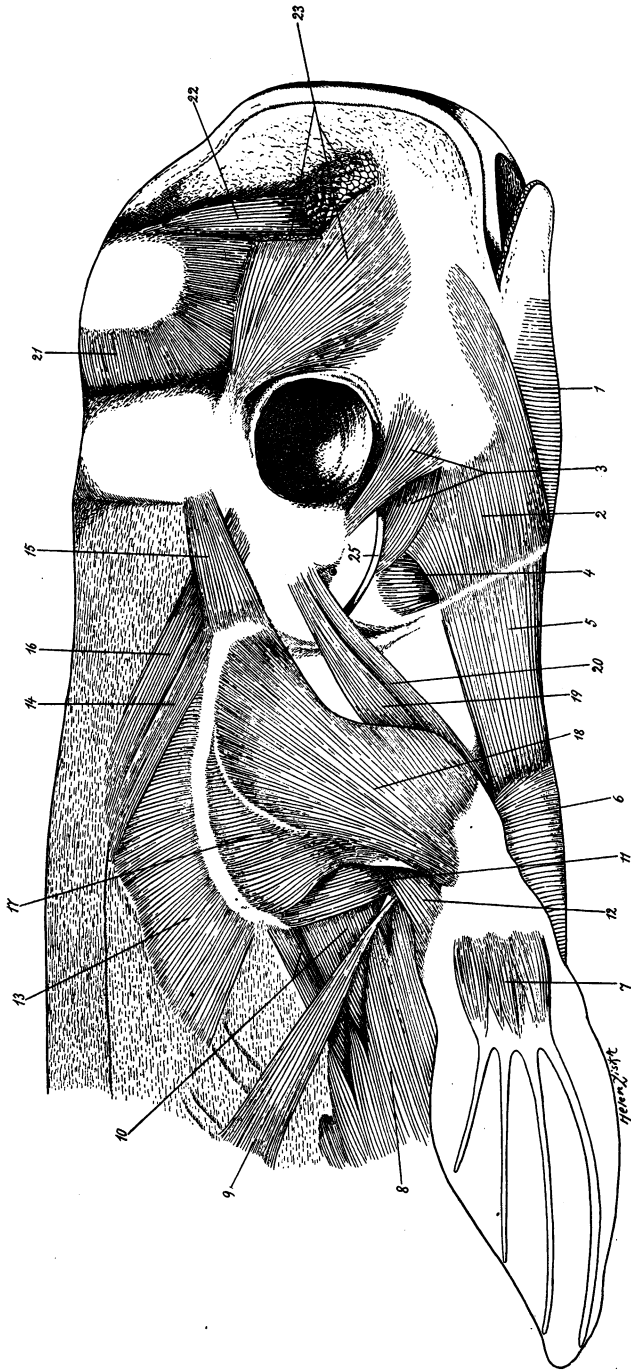


Fig. 4. Muscles of axis and flipper after removal of panniculus.  
 1, Mylohyoid; 2, Hyomandibularis; 3, Muscular slips innervated by the facial nerve; 4, Depressor mandibule; 5, Sternohyoid; 6, Pectoralis major; 7, Extensor communis; 8, External oblique; 9, Latissimus dorsi; 10, Serratus anticus; 11, Teres major; 12, Triceps; 13, Rhomboideus vertebralis, deep layer; 14, Rhomboideus vertebralis, superficial layer; 15, Mastoideus capitis; 16, Splenius; 17, Infraepinatus; 18, Deltoid; 19, Masto-humeralis; 20, Sterno-mastoid; 21, Dilator naris; 22, Retractor; 23, Other facial muscles.

superficial portion of the rhomboideus vertebralis arises from the mid-dorsal intermuscular septum by a strong aponeurosis and inserts into the basis scapulæ close to its rostral angle. Like the rhomboideus capitis, it is prolonged upon the deltoid fascia, but in this case some muscular fasciculi are added to the tendinous bands. The deep layer of the vertebral portion inserts into the whole length of the basis scapulæ, at its rostral angle under cover of the foregoing. Its origin is from the fascia over the transversarius, approaching the lateral intermuscular septum rostrad, where also it is prolonged by tendinous bands in the aponeurosis of the longissimus. On its deep surface, it receives bundles from the third rib over a wide area, less extensively and on a more ventral level from the fourth rib also. Its fasciculi converge to their insertion, the more caudal passing rostro-ventrad, the more rostral nearly transversely. The rhomboideus is subject to variation among odontocetes; or, at least, the accounts of observers differ in important matters. In *Phocæna*, Cuvier, Meckel, and Murie describe a single muscle; Rapp, a superior and inferior coming from the dorsal aponeurosis. Stannius has the origin of the superior extending close to the occipital and its bundles pursuing an oblique caudo-ventral course to the rostral angle of the scapula. The inferior, in addition to its aponeurotic origin, has attachments to the first four ribs. In *Grampus*, Murie noted a rhomboideus capitis "which, indeed, might be a trapezius."

In our *Kogia*, the supply of the rhomboideus superficialis and profundus escaped our observation. The occipital muscle received its supply from the rostral nerve of the levator anguli scapulæ.

*Ventro-appendicular muscles.* The ectopectoral is a heavy sheet of muscle arising from the linea alba and sheath of the rectus to within 5 cm. of the umbilicus, from the midline of the sternum in its whole length, broadly from the manubrium, and from the cervical fascia over the sterno-mastoid and sterno-hyoid muscles. These last fasciculi would seem equivalent to a pars clavicularis and have a slight caudal inclination in their course to the humerus. The sternal portion is the most strongly developed and has a general transverse direction with but slight tendency to concentration towards its insertion. The pars abdominalis is distinctly thinner and its bundles ascend with a rostral inclination towards the axilla. The insertion is into the neck of the humerus on its flexor surface, into the brachial aponeurosis, and into the deep surface of the lateral raphe of the panniculus. At the caudal border of the muscle on the right side was an additional slip arising from the sheath of the rectus over the cartilages of the fourth and fifth ribs but having no attachment to the cartilages themselves. It soon became tendinous and was inserted into the lateral raphe on the deep surface of the rest of the muscle. It is evidently an element of the pars abdominalis.

The entopectoral is a short, but very robust, muscle of triangular form. It arises fleshy from the lateral angle of the manubrium sterni and from the first costal cartilage; narrowing and becoming mixed with tendinous fibres, it is inserted into the ental surface and tip of the coracoid here fusing with the coraco-brachialis. We found no costo-humeralis such as Rapp and Stannius describe in *Phocæna*. Murie observed this muscle in *Lagenorhynchus* but failed to find it in *Globicephalus*.

The latissimus dorsi is of small size. Its origin, largely by tendinous fibers, is from the sixth and to a less extent the fifth rib and the fascia of the intervening space, approximately midway between the angles and the ventral extremities of the ribs. The flat belly directed rostrad and ventrad passes into a slender tendon which, curving round the teres major, is inserted into the flexor aspect of the shaft of the humerus near the postaxial border. In *Phocæna*, the costal origin is broader, the fourth to the sixth rib (Rapp, Stannius), the sixth to the eighth (Murie); in *Lagenorhynchus*, Murie found it arising from the eighth to the twelfth rib.

The pectoralis major has an extensive nerve supply, apparently receiving filaments from all the cervical nerves except the first. Two loops are formed in the cervico-brachial plexus (Fig. 18) from which numerous branches are given to the muscle. The pectoralis minor is supplied by branches of the great brachial trunk and, in addition, receives a twig from the phrenic nerve. The latissimus dorsi is supplied in common with the teres major by a branch from the great brachial trunk.

*Scapulo-humeral muscles.* The deltoid has a very large surface of origin from the dorsum scapulæ and from the lateral surface of the huge acromion. On the dorsum, it extends from the rostral border to the infraspinatus and from the base to the neck, here bordering upon the large subdeltoideus. Its origin is extended rostrad upon the prescapular septum intervening between it and the subscapularis, while caudad it overlies the infraspinatus deriving additional fasciculi from its sheath. The acromial portion of the muscle is thickest, the remainder forming a sheet largely aponeurotic on the surface. At the shoulder, the muscle contracts moderately and becomes superficially entirely tendinous, remaining fleshy in its deep layers to its insertion. This is into the preaxial border of the humerus below the tuberosity and into a transverse area on its extensor surface involving the whole width of the bone between the infraspinatus and the origin of the extensor digitorum. Here a strong layer of transverse fibrous bands is applied to the surface of its tendon. There is, further, an extensive aponeurotic sheet prolonged from the tendon into the fascial investment of both brachium and antebrachium.

The muscle is peculiar only in the convexity of its rostral border

occasioned by the very large size of the acromion. Superficially, its fascia is reinforced by tendinous bands continued from the rhomboideus. In this it agrees with *Tursiops* and apparently with *Globicephalus*, to judge from Murie's illustration — a condition which may be considered allied to the fusion of these muscles in *Megaptera*. On the other hand, *Balænoptera* lacks this fusion, and, in the foetus, the rhomboid and deltoid are separated by a narrow area of scapula.

The subdeltoideus, though of large size, is wholly concealed by the deltoid. Its origin, interposed between that of the last named muscle and the infraspinatus, extends to the glenoid margin. The belly crosses the capsule of the shoulder joint, to which it adheres, in contact with the infraspinatus and is inserted between it and the supraspinatus into the tuberosity of the humerus.

The deltoid is, in great part, innervated by the suprascapular nerve but, in addition, receives branches from the circumflex. The subdeltoideus is innervated by branches of the circumflex nerve.

The supraspinatus is small and triangular. Its origin is from the ventral margin of the acromion and from the whole mesal surface of that process, which it occupies with a thin sheet of bundles. Of these, a superficial stratum converge to be inserted into the tip of the coracoid, forming a coraco-acromial muscle in place of the usual ligament which is here represented only by the very thick fascia on the surface of the muscle. This superficial layer is not wholly separable from the rest of the supraspinatus. The muscle narrows as it descends and passes on the rostral aspect of the shoulder joint to the summit of the tuberosity of the humerus where it is inserted between the subdeltoideus and the coraco-brachialis.

The infraspinatus arises from the caudal half of the dorsum scapulæ from the suprascapula to the glenoid margin. The fasciculi from the greater part of this origin converge to an aponeurosis on the free surface of the muscle. This, in turn, contracts to a tendon opposite the shoulder joint and is finally inserted into the diaphysis of the humerus rather nearer its postaxial than its preaxial border and at about the junction of its upper and middle thirds. The fasciculi arising from the ventral third and neck of the scapula have a slightly different arrangement. They are directed ventrad but less distinctly rostrad than the rest of the muscle. In consequence, many of them gain an insertion upon the deep surface of the tendon, and the remainder reach the tuberosity of the humerus directly rostrad of the tendon. This portion of the infraspinatus is wholly concealed by the deltoid.

The supraspinatus is innervated by a branch of the suprascapular nerve; the infraspinatus also receives a branch from this source.



The subscapularis occupies the venter of the scapula but extends upon the suprascapula only rostrad. Its belly is partially divided into slips. Three of these are well defined and constitute somewhat less than half the muscle. The caudal portion forms a sheet in which, towards the shoulder, numerous narrow septa appear and, broadening, cover the surface with a wide aponeurosis. The muscle adheres to the capsule of the shoulder joint, but, as in other cetacea, there is no bursa. The insertion is effected by mixed tendinous and fleshy fasciculi into the distal part of the tuberosity of the humerus on its flexor aspect. The muscle is supplied by several small branches from the lateral cord, from the lesser brachial trunk, and from the intermediate cord of the brachial plexus.

The teres major arises from the whole length of the caudal border of the capsule. It is a broad, thick muscle of parallel fasciculi directed ventrad and very slightly rostrad to be inserted, in common with the latissimus dorsi, into the flexor aspect of the shaft of the humerus between the subscapularis and the origin of the short head of the triceps. It is innervated by a single large nerve arising from the ectal surface of the great brachial trunk.

*Coraco-humeral muscles.* The coraco-brachialis arises from the mesial surface of the coracoid process, except for a small area at the tip which serves for the insertion of the entopectoral. Its belly is interposed between the supraspinatus and the subscapularis; somewhat adherent to the latter, it is separated from the former by a thick intermuscular septum. This septum, extending from the ventral margin of the coracoid to the tuberosity of the humerus, is firmly attached to the capsule of the shoulder joint, to which it acts as a strengthening band and, in the dissected part at any rate, serves to limit internal rotation of the abducted flipper. The insertion of the coraco-brachialis is into the summit of the tuberosity of the humerus between the subscapularis and the supraspinatus. Its innervation was not found.

The triceps is distinctly more muscular than in *Phocæna* (according to Stannius), although its substance contains an admixture of fibrous tissue. The scapular head is of considerable size and arises from the postglenoid tubercle and adjacent caudal margin of that bone; it is inserted into the olecranon and, in addition, by a fibrous expansion into the aponeurosis of the flipper. A small humeral head is also present. It arises from the postaxial margin of the humerus and inserts upon the olecranon. It is all but wholly embedded in the scapular head, from which it is only imperfectly separable. There is, however, no doubt of the humeral origin of some fasciculi. Murie has recorded the absence of this element in *Phocæna*, *Grampus* and *Lagenorhynchus*; on the other hand, Carte and MacAlister recognized three heads in *Balænoptera*.

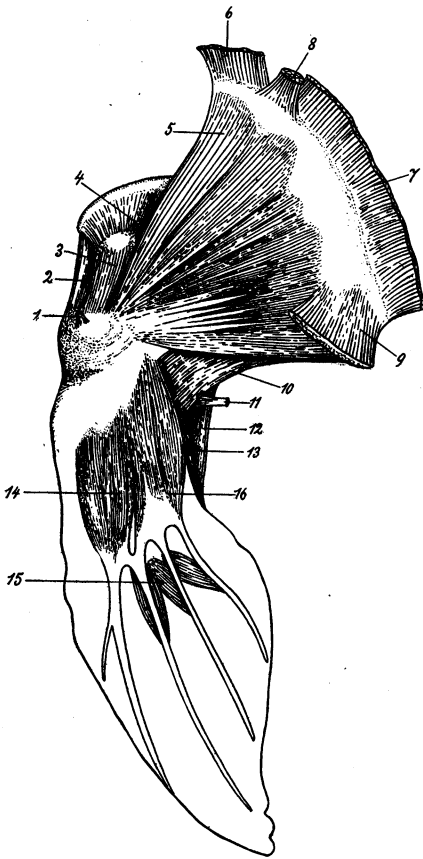


Fig. 5.

Fig. 5. Muscles of right flipper; mesal view.

1, Masto-humeralis; 2, Supraspinatus; 3, Coraco-brachialis; 4, Coraco-acromialis; 5, Subscapularis; 6, Rhomboideus capitis; 7, Rhomboideus vertebralis; 8, Levator scapulæ; 9, Serratus anticus; 10, Teres major; 11, Latissimus dorsi; 12, Triceps; 13, Flexor carpi ulnaris; 14, Flexor digitorum radialis; 15, Interossei; 16, Flexor digitorum ulnaris.

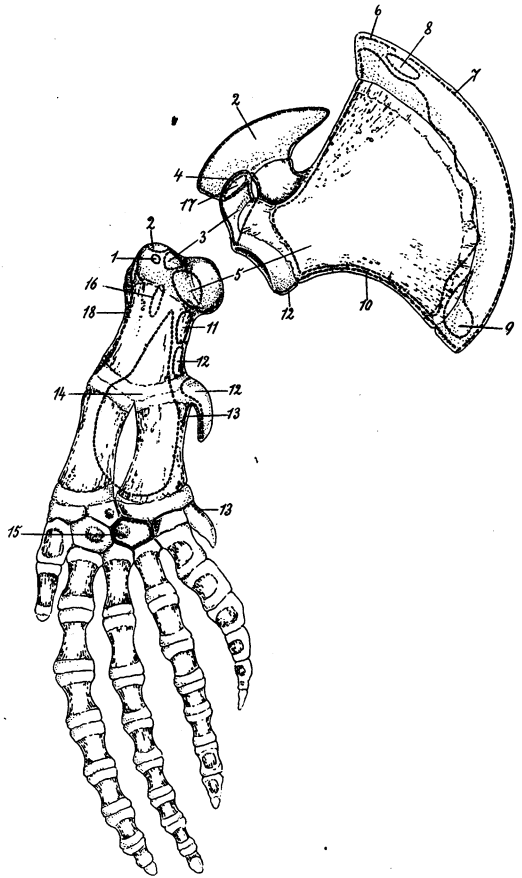


Fig. 6.

Fig. 6. Skeleton of right flipper; mesal view, showing attachments of muscles.

1, Masto-humeralis; 2, Supraspinatus; 3, Coraco-brachialis; 4, Coraco-acromialis; 5, Subscapularis; 6, Rhomboideus capitis; 7, Rhomboideus vertebralis; 8, Levator anguli scapulæ; 9, Serratus anticus; 10, Teres major; 11, T. major and latissimus insertion; 12, Triceps; 13, Flexor carpi ulnaris; 14, Flexor digitorum; 15, Interossei; 16, Pectoralis major; 17, Pectoralis minor; 18, Deltoid.

The triceps receives its nerve supply from the musculospiral nerve as it passes through the substance of the muscle to reach the extensor surface of the flipper.

*Intrinsic muscles of the flipper.* On the extensor aspect, there is only an extensor communis digitorum. This muscle has an extensive origin from both bones of the forearm and extends proximad upon the lower extremity of the humerus and the fibrous tissue about the elbow joint.

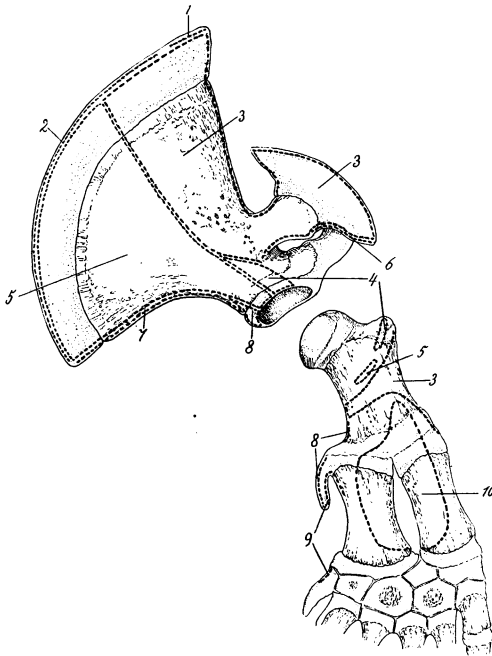


Fig. 7. Skeleton of flipper; lateral view, showing attachments of muscles.

1, Rhomboides capitis; 2, Rhomboides vertebralis; 3, Deltoid; 4, Subdeltoides; 5, Infraspinatus; 6, Supraspinatus; 7, Teres major; 8, Triceps; 9, Flexor carpi ulnaris; 10, Extensor communis digitorum.

On the ulna and radius, the muscle arises from the whole length of the diaphysis, stopping as the distal epiphyses are reached. It also arises from the whole interosseus membrane. In the region of the carpus, four large tendons emerge from the belly and run to the terminal phalanges along the II, III, IV, and V digits. There is no slip to digit I. In their course, they are contained in fibrous sheaths with synovial linings and each tendon follows the axial line of its digit. In the case of the tendon of digit II, this is true only of its proximal portion; distad, it inclines to the

postaxial aspect of its digit sending strong expansions across the phalanges to be inserted into their preaxial borders. These insertions by slips are present also in the other tendons; in the case of digit III, also, they are inserted into the preaxial margins of the phalanges; in digits IV and V, into the postaxial. No slips were found either to carpus or metacarpals. The belly of the muscle is of somewhat complicated structure, being traversed by fibrous septa which partially divide it longitudinally. In this way, the portion of radial origin is separated from the remainder coming from interosseus membrane and ulna. Its fasciculi pass entirely into the tendon of digit II. The fasciculi of ulnar origin are less completely independent and pass to digit V. The remainder of the muscle is partially overlapped by the radial and ulnar portions and sends its fasciculi mainly into two middle tendons with, however, a very considerable muscular contribution to the second digit. Such a muscular slip from the interosseous origin to the tendon of the fifth digit was not found on either side. The extensor muscle is innervated by branches of the musculo-spiral nerve.

The flexor digitorum ulnaris (profundus) is a large muscle, its insertion extending upon the humerus ventral to the insertion of the teres major. It arises further from the fibrous structures about the elbow joint and from the whole length of the diaphysis of the ulna together with the adjacent interosseous membrane. Its belly is imperfectly divided by a longitudinal fibrous septum. The preaxial belly becomes aponeurotic at the level of the carpus and the bundles of the second belly are attached to the postaxial border of its tendon, which then divides into three subequal slips for the third, fourth, and fifth digits. The humeral attachment seems slightly larger than in *Hyperoödon*, where Struthers found it only slightly overlapping the teres.

The flexor digitorum radialis is somewhat smaller than the ulnar flexor, especially in the extension of its origin upon the humerus. It arises from the diaphysis of the radius in its whole length and from the interosseous membrane. The latter portion is coarsely fasciculated by longitudinal, fibrous septa. At the carpus it becomes tendinous and, after giving a slip to the tendon of the third digit, it continues along the axis of the second. As this tendon passes the carpo-metacarpal articulation it gave off a slip of moderate size to the first digit which was inserted upon its metacarpal and its first phalanx. This slip corresponds obviously to the slip in *Hyperoödon*, which has a more distal insertion into the ligament connecting the end of the first digit to the second bone of digit II (Struthers).

The flexor carpi ulnaris is very small and covered by the tendinous expansion of the triceps. It arises from the concave border of the olecranon and, to a corresponding degree, from the shaft of the ulna. It is inserted by mixed tendinous and fleshy fibres into the base of the pisiform.

Beneath the flexor tendons, well developed interossei were found. These were three in number and had a common origin from the lateral carpal and adjacent fibrous tissue of the wrist. Their bellies diverged. The preaxial one followed the axis of the third digit; the middle passed obliquely to the fourth; and the postaxial one, almost transversely to the fifth digit. At the distal extremities of their respective metacarpals they severally become tendinous and were inserted into the ends of the third, fourth, and fifth metacarpals, and the volar aspects of the capsules of these metacarpo-phalangeal joints. These insertions were in the axial lines of their digits under cover of the flexor tendons.

The flexor muscles and the interossei are supplied by the ulnar nerve.

The presence of antebrachial muscles was first recorded in a cetacean by Flower<sup>1</sup> in 1865. Since then they have been recognized and described in *Balænoptera*,<sup>2</sup> *Megaptera*,<sup>3</sup> *Balæna*,<sup>4</sup> *Platanista*,<sup>5</sup> *Mesoplodon*,<sup>6</sup> *Hyperoödon*,<sup>7</sup> and *Globicephalus*.<sup>8</sup>

In the two ziphioids, substantial differences obtain, both in the number of muscles and in the arrangement of their tendons. In *Mesoplodon*, the extensor digitorum is divided into a radialis with tendons for the second and third digits and an ulnaris for the fourth and fifth. The tendon of the index gives off a slip to the margin of the flipper distad of the pollex. The ulnaris tendon of the fourth digit is very peculiar according to Turner's account, dividing into slips which intercommunicate and again subdivide prior to their insertion upon digit IV and the adjacent interdigital connective tissue. On the flexor aspect, there is a flexor carpi ulnaris, and a flexor digitorum ulnaris and radialis. The ulnaris is remarkable for the number of digits which it supplies, for it sends slips to the postaxial four and, in addition,

<sup>1</sup> Flower, W. H. Observations upon a fin-whale (*Physalus antiquorum*, Gray) recently stranded in Pevensey Bay. Proc. Zool. Soc. London, 1865.

<sup>2</sup> Carte, A. and MacAlister, A. On the anatomy of *Balænoptera rostrata*. Phil. Trans. Roy. Soc. London, CLVIII, 1869. Perrin, J. B. Notes on the anatomy of *Balænoptera rostrata*. Proc. Zool. Soc. London, 1870. Struthers, J. On some points in the anatomy of a great fin-whale (*Balænoptera musculus*). Jour. Anat. and Phys., VI, 1871. Schulte, H. von W. Anatomy of a fœtus of *Balænoptera borealis*. Mem. Amer. Mus. Nat. Hist., N. S., I, part 6, 1916.

<sup>3</sup> Struthers, J. On some points in the anatomy of *Megaptera longimana*. Jour. Anat. and Phys., XXII, 1887-8.

<sup>4</sup> Struthers, J. Account of rudimentary finger muscles found in the Greenland right-whale (*Balæna mysticetus*). Jour. Anat. and Phys., XII, 1877.

<sup>5</sup> Anderson, J. Anatomical and Zoological researches, comprising an account of the zoological results of two Expeditions to Western Yunnan in 1868 and 1875, and a monograph of the two cetacean genera, *Platanista* and *Orcella*. London, I, 1878.

<sup>6</sup> Turner, W. The anatomy of a second specimen of Sowerby's whale (*Mesoplodon bidens*) from Shetland. Jour. Anat. and Phys., XX, 1885-6.

<sup>7</sup> Struthers, J. Account of rudimentary finger muscles found in a toothed whale (*Hyperoödon bidens*). Jour. Anat. and Phys., VIII, 1873-5.

<sup>8</sup> Murie, J. On the organization of the Caaing whale, *Globicephalus melas*. Trans. Zool. Soc. London, VIII, 1874.

a slip to the margin of the flipper beyond the end of the first digit. The flexor radialis is correspondingly reduced. Its delicate tendon divides into a slip of communication to the tendon of the second digit, a slip to the terminal phalanx of the first, and a slip to the carpus.

In Struther's *Hyperödon bidens*, there is also a division of the extensor into radial and ulnar muscles. The first has the same disposition as in *Mesoplodon*. The ulnar muscle subdivides into a portion for digit IV and a portion for digit V. The latter, however, gives a slip equal to one-third of its bulk to the tendon of the fourth digit. On the right side, there is an intermediate fleshy slip from the radial muscle, the tendon of which divided to join the tendons of the third and fourth digits. There is also, on this side, a small tendon from the radial belly of the ulnar flexor to the tendon from the ulnar belly to the fourth digit. The flexor digitorum ulnaris and the flexor digitorum radialis are both well developed. The radialis supplies the large tendon for digit II, from which a slip is given to the margin of the flipper beyond the termination of the first digit. The ulnaris is distributed to the third, fourth, and fifth digits. The tendons for the last two have a short, common stem; that for digit III receives a slip from the radialis. The flexor carpi ulnaris, as in *Mesoplodon*, extends simply between the olecranon and pisiform.

There is, then, a substantial agreement between the antebrachial muscles of these ziphioids and *Kogia*, which differs chiefly in the incomplete division of its extensor.

The tendency to retain an independent radial extensor is, however, evident, though less marked than in *Hyperödon* (Struthers) and *Mesoplodon* for its digital distribution here is less. In these two ziphioids, independence of this belly is effected by means of an intermuscular septum serving as a common origin to both radial and ulnar extensors, and, in this respect, *Kogia* partially conforms. In them, however, the tendons of the second and third digits arise from the radial belly, which in *Kogia* supplies the tendon of digit II, and that not completely. On the other hand, the tendency of the remainder of the extensor mass to separate a muscle for the fifth digit though initiated in *Hyperödon* is apparently carried further in *Kogia*, for here the fasciculi of ulnar origin are partially separate and have a direction different from those arising from the interosseous membrane.

In all, the flexor carpi ulnaris is practically identical, and this holds true of the flexor digitorum radialis of *Hyperödon* and *Kogia*, while in respect to the flexor digitorum ulnaris *Mesoplodon* differs more widely from *Hyperödon* than that genus does from *Kogia*. The variations recorded on the right side of *Hyperödon* are indicative of the caution necessary in attempting to find specific characters in details of muscular arrangements, especially

in cases where but few specimens are available for comparison. In *Kogia*, the musculature in question is relatively best developed if not most highly specialized, as is shown by the great breadth of the muscles and their extensive humeral origins. The persistence of interossei may be an expression of the same factor. In *Mesoplodon*, the muscles are, in general, least in size and the peculiarities of that form are possibly instances of the common tendency to vary on the part of rudimentary structures.

In *Platanista*, this musculature is highly peculiar. The extensor communis arises only from the ulna and divides into three tendons for digits III, IV, and V. There is but a single digital flexor which arises from both radius and ulna and is distributed to the second, third, and fourth digits, though Anderson thought it possible that minute tendons may also go to the first and fifth. In addition to the usual carpal flexor, there is an extensor carpi ulnaris. Both arise from the olecranon and their fleshy bellies are prolonged upon the phalanges of the fifth digit.

Regarding conditions in Delphinidæ, our knowledge is far from complete. The majority of investigators are silent or record the absence of digital muscles. In *Globicephalus*, Murie found longitudinal bands in the fascia of the flipper which he believed are representative of tendons, but did not ascertain the presence of muscular fasciculi upon the radius and ulna.

It seems permissible to conclude provisionally that a general, great reduction of this musculature has taken place among the Delphinidæ which distinguish them from other known odontocetes. The Physteridæ seem, in this respect, fairly homogeneous, while *Platanista*, nearer the latter than the former, is yet divergently modified.

Among mystacetes, the Balænopterinæ agree in the presence of a common extensor, ulnar and radial flexors, and an ulnar carpal flexor. The last extends between olecranon and pisiform, as in the Physteridæ, although it may vary in *Balænoptera*, where Carte and MacAlister found it extending to the fourth metacarpal and Perrin records its insertion into the ulna. The extensor is simple and divides into four digital slips. In *Balænoptera*, the flexor ulnaris supplies the third, fourth, and fifth digits, and sends a contributing slip to the radial tendon of the second. In *Megaptera*, the tendons of the two muscles unite and the common expansion supplies four subequal slips to the digits. Contrary to what might be inferred from the great size of the flipper, the muscles are distinctly of less development in *Megaptera*. The palmaris longus attributed to *Balænoptera* by Carte and MacAllister and the flexor sublimis of the same genus observed by Perrin have not been found by subsequent observers.

In *Balæna*, the muscles attain a higher development than in other known cetaceans and an extensor carpi ulnaris is present in addition to the

usual complement. It is less developed than in *Platanista* and its tendon, failing to reach the pisiform, is inserted upon the ulna. The flexor carpi ulnaris is smaller than in *Balænoptera* but otherwise not remarkable (Struthers). The extensor communis is subject to some variation. In an adult, Struthers found it dividing opposite the first row of carpals into four slips. In a young male, the digital tendons were given off at different levels before the carpus was reached, and, on the carpus, there was a communicating slip between the middle tendons. There was, further, a small, deep belly of radial origin, the tendon of which joined that of the third digit. This element is perhaps partially equivalent to the middle portion of the extensor of *Kogia*. The ulnar and radial digital flexors communicate by their tendons so that the ulnar supplies about one-tenth of the tendon of digit II; the radial, about the same amount of digit III. The tendons of the fourth and fifth digits belong exclusively to the ulnaris. The flexor radialis is further remarkable for the division of its belly into deep and superficial layers.

This comparison reveals no fundamental differences between the odontocetes and mystacetes in muscles which, from their rudimentary character and small functional value, might perhaps have been expected to reveal phyletic differences. The evidence, such as it is, serves rather to set the Delphinidæ apart from other cetaceans, and to approximate the other known odontocetes with mystacocetes. The less frequent muscles are present in genera of both suborders, the extensor carpi ulnaris in *Kogia* and *Balæna*; and the interossei, while well developed only in *Kogia*, were recognized on microscopic examination by Leboucq<sup>1</sup> in *Balænoptera*.

*Facial musculature.* For convenience of description, the facial muscles may be divided into an ental group acting upon the blow-hole and an ectal one associated with the cheek and lips. The basis of this division is found in the peculiar modification of the skull, for the ental muscles arise predominately from the great maxillary crest and summit of the tuberosity, encroaching only on the proximal portion of the rostrum, while the ectal group takes origin from the sides of the cranial projections and from the distal portion of the rostrum.

The ental group comprises a dilator naris (*M. nasalis*, Stannius) and a muscle which is probably to be interpreted as a retractor. The dilator invests the spiracular sac and inserts into the blow-hole, in part fleshy, in part by an aponeurosis. In consequence of the asymmetry of the region, the muscles of the two sides differ in some respects and are best described separately.

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<sup>1</sup> Leboucq, H. Recherches sur la morphologie de la main chez les mammifères marins. Arch. de Biol., IX, 1889.



The superficial portion<sup>1</sup> of the right muscle, arising from the maxillary crest and tuberosity in their whole length, is thin, sheet-like, and imperfectly separable into two layers. It receives a strong slip rostrad from the fibrous tissue adjacent to the antorbital notch and from the maxilla immediately in front of the notch. This latter is not divisible into layers but otherwise is perfectly continuous with the rest of the muscle. The most

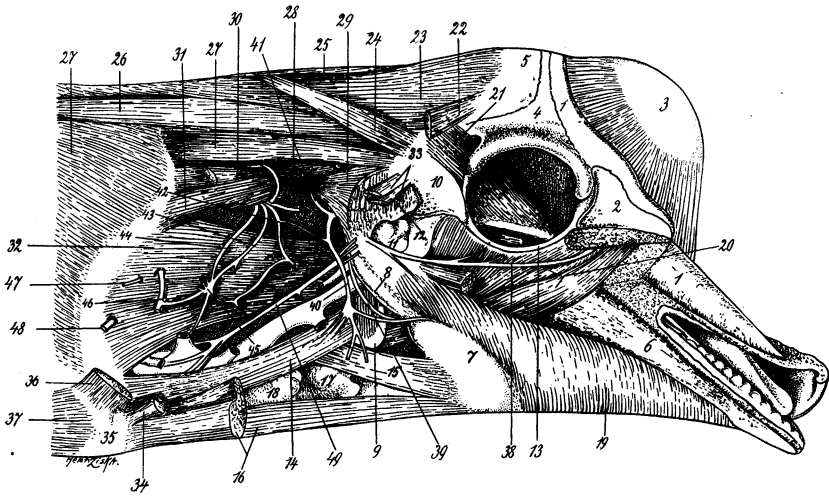


Fig. 8. Deeper muscles of the neck and face.

1, Maxilla; 2, Malar; 3, Spiracular sac; 4, Frontal; 5, Parietal; 6, Mandible; 7, Hyoid body; 8, Stylohyal; 9, Cornu of thyroid; 10, Zygomatic process; 11, Periotic; 12, Tympano-mastoid; 13, Fibrous infraorbital arch; 14, Sternothyroid muscle; 15, Thyrohyoid; 16, Sternohyoid; 17, Thyroid cartilage; 18, Thyroid gland; 19, Mylohyoid; 20, Masseter; 21, Temporal; 22, Rhomboideus capitis; 23, Semispinalis capitis; 24, Splenius; 25, Spinalis dorsi; 26, Longissimus dorsi; 27, Transversarius superior; 28, Obliquus superior; 29, Rectus lateralis; 30, Levator anguli scapulae; 31, Scalenus posticus; 32, Scalenus medius; 33, Sternomastoid and mastohumeral; 34, Sternomastoid origin; 35, Sternum; 36, Pectoralis minor; 37, Rectus abdominis; 38, Facial nerve; 39, Glossopharyngeal nerve; 40, Hypoglossal; 41, First cervical; 42, Second cervical; 43, Cord composed of third and fourth cervical; 44, Cord composed of fifth and sixth cervical; 45, Lesser brachial trunk; 46, Superficial cord of seventh and eighth cervical; 47, Nerve to serratus anticus; 48, Deep cord of seventh and eighth cervical; 49, Vagus.

caudal fasciculi arising from the premaxilla pass sagittally rostrad to be directly inserted into the recurved extremity of the blow-hole; the remainder converge to an aponeurosis which attaches to the extremity and rostral lip of the orifice. The aponeurosis is oval, covering the dorsum of the spiracular sac, and can be split into two layers in the greater part of its

<sup>1</sup> The deep portions of these muscles arising from the concavity of the face are intimately associated with the spiracular sacs; it is planned to report upon them in a subsequent paper dealing with the respiratory passages.

extent. Rostrad, however, where it receives the retractor muscle and the slip from the margin of the antorbital notch, the layers are fused inseparably.

The muscle of the left side has the same origin except that none of its bundles come from the premaxilla, which terminates on this side at the level of the nostril. Its deeper layer is greatly thickened and the muscle, contrary to that of the right side, attains its greatest bulk caudad. The less projection of the spiracular sac on the left affords space for the increase of the muscle. It inserts into the extremity of the blow-hole and the lateral part of its rostral lip directly; the aponeurosis is much reduced and, attached to the mid-region of the lip, involves only the more rostral fasciculi. Here again the topography of the spiracular sacs may be the explanation.

These muscles obviously act as dilators of the blow-hole, drawing forward its rostral lip and fixing its extremities. The greater bulk of the right muscle rostrad and of the left caudad would determine their greatest traction in the line of obliquity of the blow-hole; and the greater thickness of the left muscle is noteworthy, not only as assigning it the major rôle in opening the blow-hole and in consequence of its obliquity acting more favorably than its antimere upon the rostral lip, but also as being, by reason of its greater strength, itself a possible factor in the sinistral displacement of the narial aperture. The form and position of this orifice, its asymmetry, obliquity, and recurved extremities are precisely such as might seem to result from the disposition of these muscles the differences in which, associated with the topography of the spiracular sacs, depend ultimately upon the displacement of the larynx and the enlargement of the left, the reduction and secondary extreme modification of the right narial passage.

The second muscle of the ental group has a transverse origin at the base of the rostrum extending from the septal cartilage across the premaxilla and maxilla to the lateral margin of the latter bone. Here it lies immediately in front of the dilator. The muscle ascends dorsad, nearly vertically on the right, with more obliquity on the left, to the aponeurosis of the dilator. It broadens towards its insertion and becomes mixed with much fibro-areolar tissue, which gives it a tough consistency and pale color, and distinguishes it sharply from the dilator.

The muscles of the lateral group are similarly infiltrated with fibro-areolar tissue and break up into complicated interlacements in the cheek and lip that rendered their complete analysis in this fœtus impossible. The most superficial stratum corresponds to the supraorbital bundle of the mystacocete, and is apparently the sole representative of the occipito-frontalis. At least, we could find no fasciculi of this layer arising from occipital and certainly none inserted into the margins of the blow-hole

superficial to the dilator. The supraorbital bundle is of considerable size. It arises broadly from the lateral surface of frontal, extending upon its orbital plate but not reaching the margin, and also upon the lateral surface of the maxillary. Here it is imperfectly separate from the origin of other fasciculi of differing course and deeper position. The supraorbital muscle then forms a band on the lateral surface of the dilator and, crossing the retractor, breaks up in the fibro-areolar tissue of the snout. Its fasciculi are dispersed in a radiation from its origin, ascending superficial to the dilator, turning mesad in front of the retractor, and descending in the cheek towards the lip and angulus oris, here becoming inextricably blended with the deeper bundles mentioned above. They are, in general, superficial to the other muscles of the region and all terminate in the blubber layer.

A deeper muscle has an extensive origin from the lateral surface of the maxillary tuberosity and malar and from the antorbital process of the frontal. Its numerous fasciculi extend rostrad through the cheek to the upper lip, or are lost near the angle of the mouth, or turning ventrad break up in the dense fibrous blubber of the cheek and over the mandible. They are blended with the bundles of the supraorbital muscle and further interlaced with fasciculi coming from the zygomatic process of the squamosal and from the proximal extremity of the mandible.

The mandibular slip has a mixed tendinous and fleshy origin from the angle of the lower jaw. Passing rostrad, it expands under cover of the slip from squamosal and its superficial bundles are lost in the cheek; its deeper fasciculi ascend towards the malar and the maxilla, some of them gaining an insertion in the vicinity of the antorbital notch. While having the same direction as the masseter, they are distinguished from it by their position superficial to the facial nerve.

From the zygomatic process and the fibrous infraorbital margin arises a fan-shaped muscle of superficial position which radiates into the cheek.

The buccinator is represented by fasciculi on the oral surface of the cheek close to the mucous membrane which are attached to the mandible behind the teeth and to the ventral surface of the maxilla. Extensions from this stratum pass into both upper and lower lips. The whole system is intimately united and blended with the deeper fasciculi of malar and maxillary origin.

The dorsal surface of the rostrum in front of the retractor gives rise to a thick muscle, which, radiating towards the surface, is lost in the thick blubber of the snout.

The orbicularis palpebrarum is well developed. It has an origin at both the pre- and postorbital process, the former being especially large. We were unable to define the auricular muscles.

As a whole, the facial musculature is characterized by its great size and extent, but, with the exception of the dilator naris, none of its elements were clearly differentiated. At sites of bony attachment, it was possible to define elements which, in their further course, became inextricably interwoven with other fasciculi in the dense fibro-areolar tissue of the region. In places where the latter was scanty, the tissue on section had much the structure of tongue.

*Muscles of mastication.* The masseter, in contrast to conditions

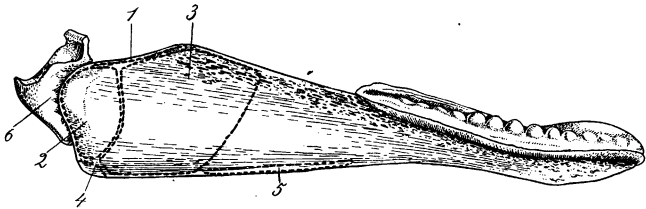


Fig. 9. Lateral surface of mandible; the rudiments of the teeth and surrounding gums are left in place. Half natural size.

1, Temporal muscle; 2, Masseter, superficial portion; 3, Masseter, deep portion; 4, Slip of facial muscle; 5, Hyomandibularis; 6, Temporo-maxillary fibro-cartilage.

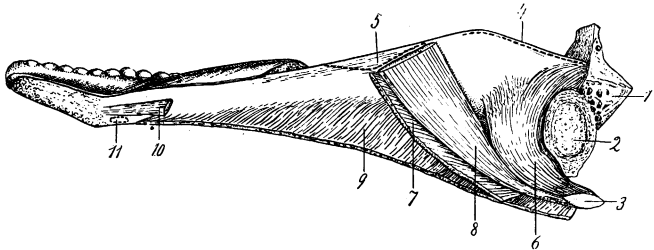


Fig. 10. Mesal view of mandible and attached muscles. Half natural size.

1, Temporo-maxillary fibro-cartilage; 2, Meckel's cartilage; 3, Stylo-mandibular ligament; 4, Temporal muscle; 5, Buccinator; 6, External pterygoid; 7, Internal pterygoid; 8, The same, deep portion; 9, Mylohyoid; 10, Genioglossus; 11, Geniohyoid.

described in *Phocæna* and *Globicephalus*, is a large muscle, divided also into two portions. Our dissection of the superficial portion was imperfect, but this much was ascertained. It arose from the rostral border and tip of the malar and from the fibrous infraorbital arcade. At the origin we could not disentangle it from the massive facial muscle of the region, but very soon the great trunk of the facial nerve was interposed, and from that point to the insertion the muscle could be satisfactorily isolated, except at its rostral margin which could be located only approximately. The same

is true of the deep portion also. The great fibro-muscular interlacement of the cheek seems to involve both of them, together with overlying facial muscles and the deeper buccinator, in a mass that we failed to analyze. From the origin above described, the bundles of the pars superficialis expand to an extensive insertion upon the mandible occupying its whole proximal portion, except the angle which gives origin to a slip of facial innervation and an area near the dorsal margin occupied by the pars profunda. This also arises from the malar, extending upon its mesal surface. The belly expands fan-wise to its insertion. This is, in general, dorsal and rostral to the superficial portion. It includes the border between the condylar process and the superior angle and the dorsal border thence for about two-thirds the length of the pars papyracea, extending ventrad to the insertion of the deep portion and in front of it reaching the ventral margin of the bone for a short distance. The obliquity of the bundles in both portions is such that their contraction must protrude, as well as approximate, the mandible to the maxilla.

The temporal muscle is rather small, but thick. It arises from the whole of the temporal fossa and the ental surface of the zygomatic process. Additional fasciculi are derived from its covering aponeurosis. There is little convergence of its bundles. The insertion is into the dorsal border of the mandible from a little above the condyle to the superior angle (coronoid process) and into the adjacent mesial surface to a moderate degree.

The pterygoideus internus is essentially like that of *Phocæna*, as described by Stannius. The superficial layer arises from the margin of the pterygoid bone from its caudal extremity to the beginning of the infrapalatine process, here becoming thin and aponeurotic. At the pterygoid notch, the muscle is not interrupted but arises from a ligament which spans the notch. The bundles, directed caudad and laterad, form a thin narrow sheet which invests the air-sinus ventrally. The insertion is into an oblique line on the mandible and the fibrous tissue enclosing the deltoid foramen, from the rostral end of the temporal insertion to the angle of the jaw, and slightly into the strong ligament between the angle of the mandible and the styloid process. The deep portion is narrower and applied to the superficial close to its insertion. It arises from the infrapalatine process of the pterygoid. In the adult skull, the muscular impression extends upon the maxilla, but, in the fœtus, we could not follow the tenuous sheet so far. The muscle descends obliquely, contracting to a narrow belly which inserts at the angle of the jaw and into the ligament extending thence to the styloid process.

The external pterygoid is greatly modified by the presence of the air-sinus and partially blended with the deep stratum of the internal. It arises from the mandibulo-styloid ligament and spreads out fan-wise as it ascends

upon the lateral wall of the air-sinus, here resting against the huge remnant of Meckel's cartilage. Arrived at its dorsal border, it is in part inserted into the fibrous wall of the sinus but a very considerable number of its caudal fasciculi pass laterad above Meckel's cartilage and converge to an insertion into the condylar process of the mandible and into the mesial aspect of the interarticular fibro-cartilage.

The suspension of the mandible is effected by means of a large pyramidal cartilage. The base of this is saddle-shaped and attached to the periosteum of the extremity and ental surface of the zygomatic process of the squamosal. The rostral border is applied in a similar way to the mandible from the condyle almost to the angle of the bone. Superficially, the cartilage is covered by a dense membrane which extends from the mandible to the tympano-mastoid and ventrally thickens to form the very strong stylo-mandibular ligament. The membrane serves as origin to the depressor mandibulæ and by its deep surface covers a mass of vascular or really cavernous tissue which surrounds Meckel's cartilage and fills the interval between the jaw and osseous bulla tympani. Against this tissue, the interarticular fibro-cartilage rests its deep surface. The joint is peculiar in the total absence of a cavity, a condition obtaining also in *Balænoptera*.<sup>1</sup> In this connection it may be noted that in other joints of this foetus, the occipito-atlantal and the scapulo-humeral, the surfaces of the articular cartilages were covered by a moderately thick layer of perichondrium continuous with the periosteum of the bones.

*Suprahyoid muscles.* The most superficial muscle of the intermandibular region is a broad, longitudinal sheet of fasciculi arising from the hyoid close to the insertion of the sterno-hyoid and continuing the direction of that muscle to the jaw and cheek. No bundles were found continuous between these muscles. Rostrad, the muscle divides into two layers: a deep layer inserts into the ventral margin of the mandible in its middle third; a superficial stratum is lost in the interlacement of the cheek. The most rostral fasciculi of this layer are prolonged in a well defined slip beyond the angulus oris to the upper lip. The muscle here described rests upon the mylohyoid and is innervated by the mylohyoid branch of the fifth nerve as it lies between them. The muscle is, then, the hyomandibularis, often modified in other forms into the anterior belly of the digastric. Le Danois seems to have mistaken this muscle for the mylohyoid, which he describes and figures with sagittally directed bundles.

The mylohyoid in this specimen has the usual transverse orientation and

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<sup>1</sup> Beauregard, H. Étude de l'articulation temporo-maxillaire chez les Balænoptères. Jour. de l'Anat. et de la Physiol., An. 18, 1882.

is a strong and well developed muscle. It arises under cover of the hyomandibularis from the margin of the hyoid from its tip to the median line along which its origin is continued to the symphysis by a feebly developed

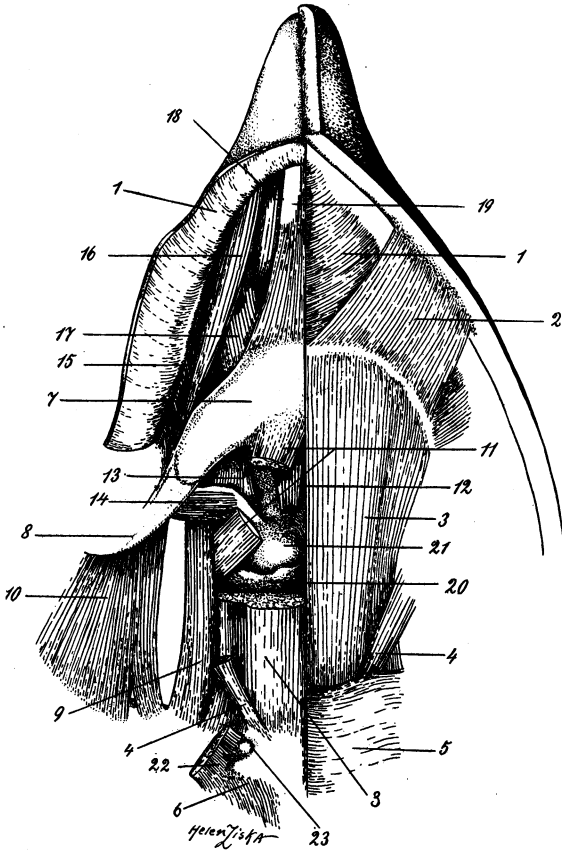


Fig. 11. Muscles of the intermandibular region and throat.

1, Mylohyoid; 2, Hyomandibularis; 3, Sternohyoid; 4, Sternomastoid; 5, Ectopectoral; 6, Rectus abdominis; 7, Hyoid; 8, Stylohyal; 9, Sternothyroid; 10, Scalenus medius; 11, Thyrohyoid; 12, Hyo-epiglotticus; 13, Pterygo-pharyngeus; 14, Inferior constrictor; 15, Internal pterygoid; 16, Styloglossus; 17, Hyoglossus; 18, Genioglossus; 19, Geniohyoid; 20, Thyroid gland; 21, Thyroid cartilage; 22, Entopectoral; 23, Episternal ossicle.

raphe. The fasciculi pass transversely to be inserted into the oral surface of the mandible along a line which ascends to the attachment of the buccinator and then descends to the angle of the jaw.

At the caudal margin of the mylohyoid and continuing its sheet is a

small flat muscle distinguishable from it only by its origin and its innervation. It arises from the hyomandibular ligament and the dense fibrous tissue stretching between the mandible and the tympano-mastoid. It is inserted into the tip of the hyoid continuously with the mylohyoid. Its nerve is a branch of the facial. The last fact serves to identify it as the depressor mandibulæ, the equivalent of the posterior belly of the digastric. In *Phocæna*, the homologue of this muscle, the occipito-hyoideus of Rapp and Stannius, has retained a more primitive position as regards its origin. In *Tursiops*, Chaine<sup>1</sup> found no homologue of the posterior belly of the digastric.

The hyoglossus is a ribbon-shaped muscle of moderate size. It arises from the ventral surface of the ceratohyal and from the adjacent margin of the body and is directed obliquely laterad, dorsad, and rostrad to the side of the tongue, where it disappears under cover of the styloglossus. It is crossed superficially by the hypoglossal nerve, from which it receives a branch, and beneath it lie the plexiform lingual vessels.

The geniohyoid arises from the symphysis and the adjacent portion of the ventral margins of the mandibles, and is inserted into the mesal half of the margin of the hyoid between the mylohyoid and hypoglossus. It is a well-developed, triangular muscle, the lateral portion of which, near its origin, is tendinous.

The genioglossus has lost its attachment to the hyoid, as in *Phocæna* (according to Rapp and Stannius). It has a pointed origin from the symphysis dorsal to the geniohyoid. Its fasciculi radiate in the usual manner into the dorsum of the tongue from the tip caudad. Some of the most ventral bundles are continued dorsal to the hyoid to the oropharyngeal passage. These two muscles are innervated by the hypoglossal nerve.

The styloglossus arises from about the middle of the stylohyal and is directed rostrad, expanding to its insertion into the side of the tongue superficial to the hyoglossus. It is not rudimentary, as in *Phocæna* (according to Stannius), but is of good size.

The interval between the thyrohyal, the stylohyal, the ceratohyal, and body of the hyoid is filled by a muscle, the fasciculi of which run ventrad from the stylohyal expanding to occupy a large area on the dorsum of the thyrohyal and body from the tip of the former to near the median line. This is the ceratohyal or hyoideus latus. It is supplied by the glosso-pharyngeal nerve.

The stylopharyngeus is of moderate size, arising from the stylohyal

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<sup>1</sup> Chaine, J. Le digastrique (Abaisseur de la mandibule des mammifères). Jour. de l'Anat. et de la Physiol., 1914.



dorsal to the foregoing. From the mesal aspect of the cartilage its bundles run mesad and rostrad to the interval between the pterygo-pharyngeus and palato-pharyngeus, where it reaches the wall of the pharynx.

*Infrahyoid muscles.* The sterno-hyoid is a very large muscle. It arises from the rostral border of the sternum in nearly its whole breadth, and mesially its origin extends upon the venter of the manubrium between the origins of the ectopectoral and the sterno-mastoid. The belly of the latter muscle rests in a groove in the sterno-hyoid, partially separating the deeper fasciculi of lateral origin from those just mentioned as arising from the venter

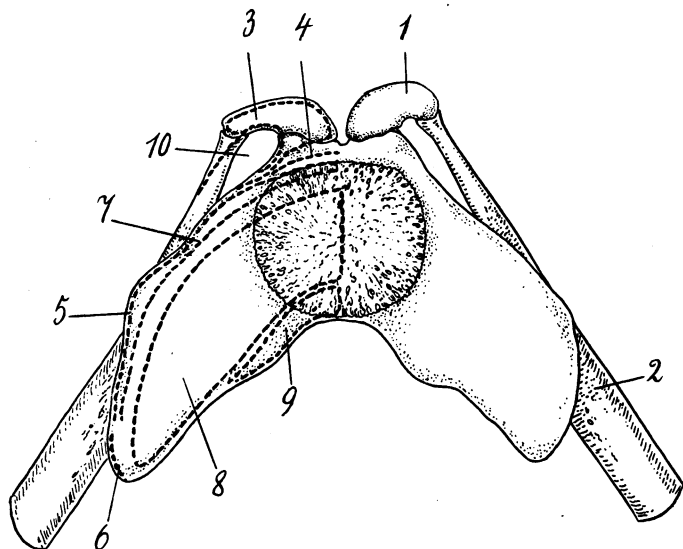


Fig. 12. Ventral view of hyoid, showing attachments of muscles. Half natural size.  
1, Ceratohyal; 2, Stylohyal; 3, Hyoglossus; 4, Genioglossus; 5, Mylohyoid; 6, Depressor mandibulae; 7, Hyomandibularis; 8, Sternohyoid; 9, Thyrohyoid; 10, Hyoideus latus.

of the sternum. Higher in the neck, these bundles spread out and completely cover those coming from the sternal margin. The muscle, as a whole, broadens to its large insertion into the rostral margin and adjacent ventral surface of the hyoid, only a small area being left for the thyrohyoid mesad and caudad.

The sterno-hyoid is a much smaller muscle though of considerable development. It arises from the sternal margin, the cartilage of the first rib, and the capsule of the intervening joint. Mesially, it is in close contact with and partly overlapped by the sterno-hyoid. Its belly runs rostrad and slightly dorsad contracting somewhat to its insertion upon the thyroid cartilage between the thyro-hyoid and the inferior constrictor of the pharynx.

The thyro-hyoid is a thin, flat muscle arising under cover of the fore-going from the thyroid cartilage, directed ventrad and rostrad, and widening and becoming thinner as it approaches its insertion into the venter of the body of the hyoid near the median line and caudal margin of that element.

There is no omo-hyoid on either side. Rapp and Stannius have previously recorded its absence in *Phocæna*.

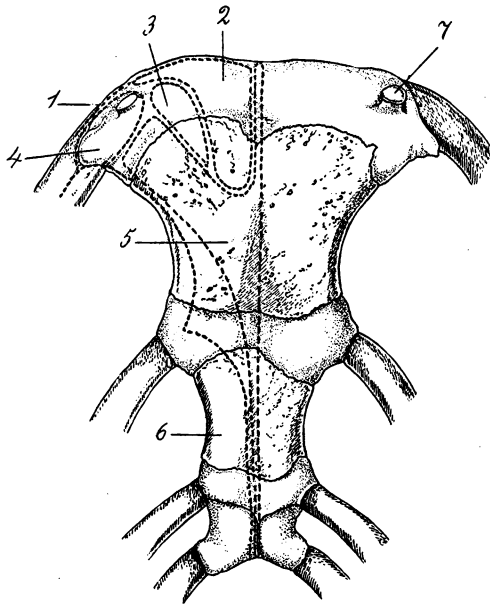


Fig. 13. Sternum, showing attachment of muscles. In the cartilaginous portion of the manubrium on each side is a small elevated facette which articulates with a nodule of cartilage (suprasternale) embedded in the origin of the entopectoral. Two-thirds natural size.

1, Sternothyroid; 2, Sternohyoid; 3, Sternomastoid; 4, Entopectoral; 5, Ectopectoral; 6, Rectus abdominis; 7, Suprasternal cartilage.

*Costal muscles.* Levatores costarum are present from the first to the eleventh thoracic vertebra. That of the first rib could not be distinguished from the mass of the scalenus posticus. They are best developed and most distinct from the external intercostal in the upper thorax; caudad they are reduced to a few fasciculi from the tip of the transverse process to the mesal margin of the intercostal. All are of the short variety, spreading out fan-like from the transverse process to the rostral margin of the next following rib. Their mesal fasciculi are sagittal and in many cases largely fibrous; their lateral ones have the inclination of the external intercostal.

The intercostals are well developed, especially the external. Its fasciculi are markedly oblique caudad and ventrad. Its fleshy bundles, as usual, are shorter than the distance between the ribs and are lengthened by tendons. These are associated with the insertion near the angles of the ribs, with the origin farther ventrad, though on the deep surface of the sheet there are fasciculi which are fleshy throughout. The muscles extend from the levatores costarum to the extremities of the ribs but are lacking upon the cartilages. The internal intercostal has an opposite inclination but is less oblique. In the ventral half of the rib, it is aponeurotic at its origin; the whole insertion and the dorsal part of the origin are fleshy. These muscles extend from the angles of the ribs to the sternum, connecting the cartilages as well as the bones. No interval was found segregating the intercartilaginous portions to form, as in *Phocæna*, the mm. ossium sterno-costalium of Stannius, and there seemed to be no lamination of the intercostal, such as recent students of human anatomy describe — the intercostalis intermedium of Eisler.

The sterno-costalis, described by Stannius in *Phocæna*, we failed to find.

The scalenus anticus is absent, the subclavian artery crossing the first rib entirely ventral to the muscles of this group. The scalenus medius is very large. It arises from the caudal portion and ental surface of the otocranial flange of the basi-occipital and, passing caudad through the neck, is inserted into the margin and ectal surface of the first rib from its extremity dorsad to the insertion of the scalenus posticus. The scalenus posticus though much smaller is yet of good development. It arises from the transverse process of the atlas and the succeeding cervical vertebræ and expands towards its insertion into the ectal surface and border of the first rib in the vicinity of the angle. Of these two muscles, the medius is by far the larger and, the origin being displaced ventrad by the projection of the otocranial flange, its course is almost sagittal. It must, therefore, act with maximum efficiency as an elevator of the first rib. In consequence of the displacement of the origin of the medius, the two muscles are widely separated except at their insertions and a large interval is left in which emerge branches of the cervical plexus; others make their way through the substance of the medius.

*The diaphragm.* The highest point of the diaphragm corresponds, as nearly as can be ascertained in the relaxed condition of the viscera, to the space between the third and fourth ribs. From this point it descends slightly ventrad to the lower end of the sternum, the deep sheath of the rectus, and the cartilages of the fifth ribs. Dorsally the slope is steep and prolonged to the sheath of the hypaxial muscle, here extending as far caudad as the third lumbar vertebra.

As in odontocetes in general (O. Müller<sup>1</sup>), the centrum tendineum is greatly reduced. In this specimen, a small triangular area of the aponeurosis persists on the caudal aspect of the foramen for the postcava. Elsewhere there are scattered fibrous bands on the abdominal surface along the junction of the sternocostal portion with the lumbar. The crura also are largely fibrous and, after joining ventrad of the aortic orifice, are prolonged by a strand of connective tissue to the oesophageal foramen. Caudad, the crura expand into a fibrous sheet which stretches across the hypaxial muscle to the tip of the last rib and is intimately united to the

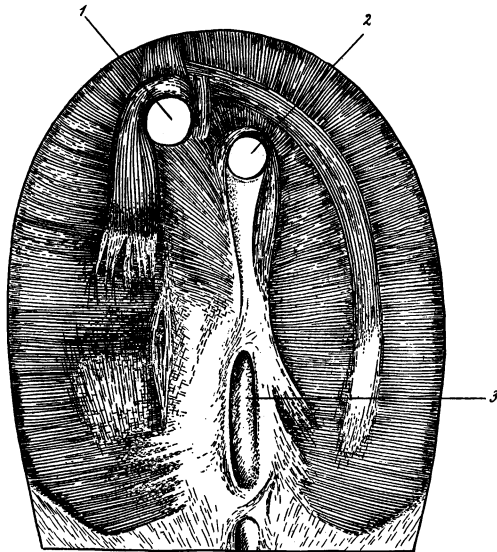


Fig. 14. Abdominal surface of diaphragm.  
1, Foramen for postcava; 2, Foramen for oesophagus; 3, Aortic aperture.

sheath of the muscle and the transversalis fascia. From this no muscular bundles are derived. It serves simply to fill the interval caudad between the last costal digitation and the fasciculi arising from the crus mediale. While the crus laterale thus fails of reaching the ligamentum arcuatum, it is not entirely lacking, if we are right in taking as its equivalent the superficial longitudinal bundles which, following the line of junction of the pars sternocostalis with the crura mediale, converge to the foramen venæ cavæ.

<sup>1</sup> Müller, O. Untersuchungen über die Veränderungen welche die Respirationsorgane der Säugetiere durch Anpassung an das Leben in Wasser erlitten haben. *Jenaische Zeitsch. f. Naturwiss.* XXXII, 1898.

The sternocostal portion forms a continuous sheet of a horseshoe shape, its bundles converging to meet the ental region derived from the crura. The pars sternalis arises from the caudal piece of the sternum and from the sheath of the rectus; at the sides it is perfectly continuous with the costal portion. This arises from the ends of the ribs and their cartilages, from the fourth to the twelfth, interdigitating with the transversalis. The lowermost fasciculi insert into the fibrous expansion of the medial crus above mentioned. The remainder meet the deeper bundles of the crus along a linear junction, which is U-shaped, the arms converging to the foramen venæ cavæ. In much of its course this is concealed by longitudinal fasciculi arising on each side from superficial, tendinous bands, lateral to the crus mediale and converging in a wide arch to the venous foramen where they are interwoven with bundles of the other portions of the muscle.

The crura medialis arise fibrous from the bodies of the first three lumbar vertebræ. Near their origin, they are associated with lateral expansions which are continued into the arcuate ligaments and, higher up, receive the lowest fasciculi of costal origin. The two crura unite ventral to the aorta in an arch, from which a fibrous raphe is prolonged to the œsophageal orifice. To this raphe, on its thoracic surface, is attached the strong fold that in the lower thorax bridges between the aorta and œsophagus. The muscle originating from the crura and raphe is partially divided into a deep and a superficial stratum. The superficial stratum forms a loop about the œsophageal foramen. On the left side, this is sharply defined against the deeper fibers, but on the right, in the interval between the œsophageal and venous foramina, the two layers merge, a small muscular ridge immediately adjacent to the former orifice alone remaining independent and continuing caudal beside the raphe reaches the point of union of the two crura. The deep layer is composed of bundles of a transverse to latero-rostral direction, which pass from the upper parts of the crura and their raphe to meet the sternocostal portion in a U-shaped line.

*Abdominal muscles.* The obliquus externus is a thin and rather narrow sheet of muscle upon the side of the thorax and abdomen. It arises by a somewhat irregular series of slips from all the ribs and, caudal to the twelfth, from an aponeurosis covering the hyaxial muscles and attached by means of the lateral intermuscular septum to the transverse processes of the lumbar vertebræ. The first slip is the largest and arises from the caudal margin of the first rib close to its cartilage. It is directed obliquely caudad and ventrad, skirting the origin of the first slip of the serratus anticus. The second slip arises from the caudal margin of the second rib and passes between the slips of the serratus. The third slip and all the more caudal ones are attached not only to the margins but to the lateral surfaces as well

of their respective ribs, immediately ventral to the insertions of the transversarius superior. The line of this interdigitation ascends caudad as the transversarius narrows. The remainder of the muscle arising from the lumbar aponeurosis is very thin. Its origin ceases about midway between the preputial orifice and the vent. All of the costal slips have an admixture of aponeurotic fibers at their origin. The third digitation on both sides is peculiar in the expansion of the dorsal part of its origin by a tendinous slip to the caudad margin of the second rib. A similar extension is present on the part of the second digitation of the right side, which falls short of the first rib and is attached to the fascia of the first intercostal space. The several slips unite to form a muscular sheet of parallel bundles, which continue to the edge of the rectus where they abruptly become aponeurotic and invest that muscle with a thin but very strong covering as far as its median border. Rostrad to the preputial orifice, they interlace with their antimere. Caudad, where the recti are partially separated by the penis, they are less distinct and are lost upon the surface of the muscle or merged in the thick connective tissue that ensheaths the penis. The relation of the external oblique to the margin of the rectus requires some further comment. While the superficial bundles are continued as is usual into a superficial aponeurosis of the rectus sheath, deep bundles remaining fleshy are interwoven with the lateral fasciculi of the rectus itself and, in the caudal half of the muscle, also with bundles of the obliquus internus, which pass between them to gain the superficial aponeurosis of that muscle or, on the other hand, take a deeper course into the lateral portion of the rectus.

The internal oblique extends farther caudad than the external, arising from the lumbar aponeurosis from a point opposite the anus; rostrad, the origin extends to the last rib. The fasciculi form a thin sheet of very oblique direction. Those of most caudal origin are parallel to the aponeurosis of insertion of the rectus and as they are followed rostrad add themselves to the lateral portion of that muscle. Those of intermediate origin divide at the margin of the rectus and, becoming aponeurotic, form superficial and deep laminae which participate in the usual way in the formation of the sheath. Those of the superficial lamella, however, are interlaced with fasciculi of the external oblique in the manner described above. Between these superficial and deep layers there are additional fleshy bundles which become incorporated into the lateral portion of the rectus. The most rostral portion of the obliquus internus forms a broad layer covering the ventral ends of the free ribs and their cartilages, from the twelfth to the fourth inclusive. The insertions are into the caudal margins of the ribs and into their lateral surfaces, which they occupy in their whole breadth ventral to the obliquus externus as far as the extremities of the cartilages. In the reflection of this

portion of the muscle, many deep fasciculi were found which, arising from the rostral margin of one rib, inserted upon the caudal border of the next in front.

The transversalis is well developed and common to both thorax and abdomen. It arises from the hypaxial aponeurosis, extending not quite as far caudad as the internal oblique. It further arises from the ental surface of the ribs and costal cartilages, from the twelfth to the first inclusive. It forms a thick sheet coarsely fasciculate and of transverse direction, and is inserted into the sternum, the linea alba, and its caudal expansion. The transversalis thoracis is perfectly continuous with the muscle of the abdomen. It comprises the slips from the first four ribs which insert upon the dorsum of the sternum. These are well developed, but I could not separate them into two layers. Their insertion by mixed fleshy and tendinous bundles occupies the whole breadth of the sternum from the lower half of the manubrium to its extremity. The muscle is, in its whole abdominal extent, separable into two lamellæ separated by a distinct, though thin, fascia and further distinguished by a difference in the direction of their fasciculi, those of the deeper stratum being inclined a little caudad. The superficial lamella shows distinct digitations in its thoracic portion; these become tendinous ventrad and are inserted into the sheath of the rectus a little farther from the midline than the deeper stratum. The aponeurotic termination and lateral insertion characterizes the whole lamella; caudad also, where it takes origin from the hypaxial aponeurosis, it is sometimes divided into slips. The deeper layer forms a continuous sheet and is of greater thickness than the superficial. Its costal portion is fleshy to its insertion into the linea alba. Caudad, where the linea alba expands, it also becomes aponeurotic and fuses with the deep surface of the rectus sheath.

Such a reduplication of the transversalis, although occurring in reptiles,<sup>1</sup> is not often recorded in mammals and is not mentioned by Leche.<sup>2</sup> A partial reduplication, however, occurs in man,<sup>3</sup> and frequently in the dog<sup>4</sup>; and, therefore, the condition here recorded ought not to be taken as suggestive of any peculiarly sauropsid affinities on the part of cetaceans, among which, in general, it seems not to occur.

The rectus abdominis is massive. It arises from the lateral margin of the manubrium, from the ventral surface of the following sternobræ, and from the cartilages of the first four ribs. Of the costal digitations, the first

<sup>1</sup> Maurer, L. Die ventrale Rumpfmuskulatur einiger Reptilien.

<sup>2</sup> Leche, W. Die Säugethiere in Braun's Thier-Reich. Bd. VI, Th. I. Leipzig, 1874-1900.

<sup>3</sup> Eisler, P. Die Muskeln des Stammes. Jena, 1912.

<sup>4</sup> Personal communication of Dr. A. J. Brown.

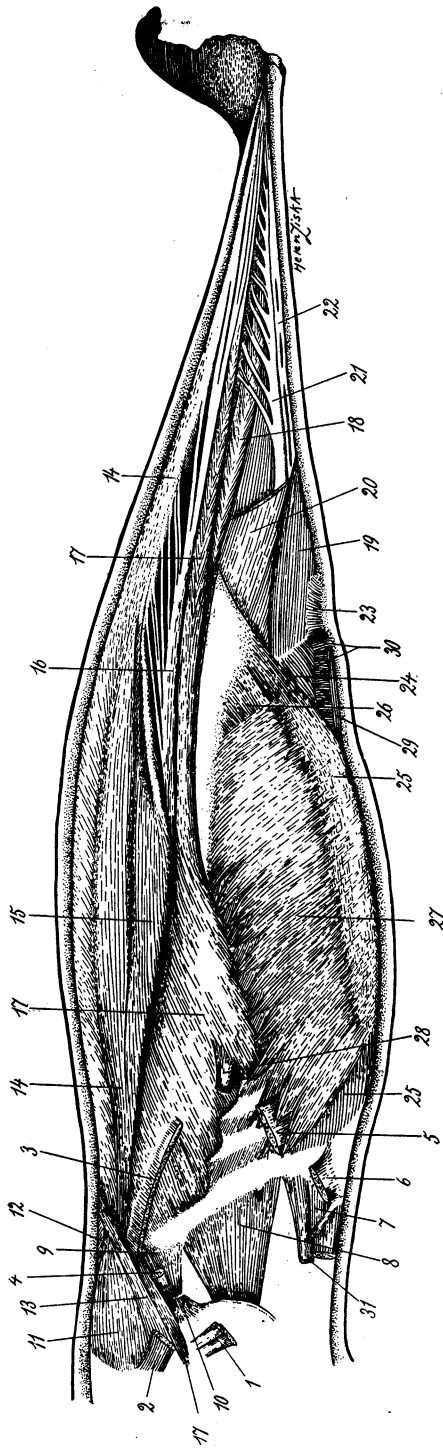


Fig. 15. Muscles of trunk; superficial dissection. The longissimus is partially turned up at the margin to show tendons to the ilio-costalis. 1, Sternomastoid and mastohumeral; 2, Rhomboideus vertebralis; 3, Rhomboideus capitis; 4, Levator anguli scapulae; 5, Serratus anticus; 6, Pectoralis minor; 7, Sternohyoid; 8, Scalenus medius; 9, Scalenus posticus; 10, Rectus capitis lateralis; 11, Semispinalis capitis; 12, Spinalis dorsi; 13, Splenius; 14, Longissimus; 15, Iliocostalis thoracis; 16, Iliocostalis lumborum; 17, Transversarius superior; 18, Transversarius inferior; 19, Ischio-caudalis; 20, Hypaxial muscle, superficial portion; 21, The same, lateral portion; 22, Levator ani; 23, Ischio-cavernosus; 24, Ischio-cavernosus; 25, Rectus abdominis; 26, Rectus abdominis, superficial portion; 27, Obliquus externus; 28, Latissimus dorsi; 29, Retractor penis; 30, Bulbo-cavernosus; 31, Sterno-thyroid.



is the largest. The others join the deep surface of the muscle and are not seen until it is reflected. The belly extends sagittally the whole length of the abdomen and is devoid of tendinous inscriptions. Arrived at the pelvic ligament to which it has a small tendinous attachment, it expands into an aponeurosis which, merged with that covering the hypaxial muscles, is attached to the transverse processes of the lumbo-caudal vertebræ. Between the pelvic tendon and this aponeurosis is an interval of areolar tissue through which the vessels and nerves pass to the venter of the pedicle. The muscles of the two sides are in apposition as far as the umbilicus and united by a *linea alba*. To accommodate the large penis, they then diverge and their mesal borders are united by a very strong aponeurosis, which is equivalent to an expanded *linea alba*. This extends between the muscles to the pelvic region and there, laterally, is continuous with the deep tendon of the rectus. The fibrous interval is reinforced entally by the united aponeuroses of the internal oblique and transversalis, which here become very thick and strong. This area serves as an attachment for many of the bundles of the rectus, and, in consequence, the muscle rapidly diminishes in size, its continuation into the hypaxial aponeurosis representing only about one-third of its cross-section. The sheath of the rectus has the usual composition: its ventral layer formed of external oblique and the ventral aponeurosis of the internal oblique; its dorsal, of the dorsal lamina of the latter muscle and the transversalis. Everywhere the rectus adheres closely to the ventral sheath, which is composed of intersecting fibrous bands corresponding to the direction of the two component muscles. Rostrad of the first digitation of the external oblique the sheath is tenuous. Entally the belly of the rectus is easily separable from its sheath, especially the transversalis layer as far as the preputial orifice. Thence caudad it gradually becomes broadly adherent as its fasciculi terminate in the manner indicated above, and gradually the transversalis layer becomes more broadly and intimately adherent. The fixation of the rectus and the integrity of the abdominal wall is further secured by the connections of the margins with the interlacing fasciculi of the oblique. As the rectus turns laterad to its superficial insertion, its fasciculi are parallel and lie in the same sheet with those of the internal oblique. Indeed, the two muscles are not wholly separable. Farther rostrad, where the oblique splits to enclose the rectus, the cleft occurs in the flesh of the muscle (as in *Phocæna*, according to Stannius), and intermediate bundles, failing to reach either layer of the sheath, add themselves to the margin of the rectus.

*Pelvic muscles.* Benham, after careful search, was able to find no pelvis in a male *Kogia*. Le Danois does not mention it; and we, on dissection, are also unable to ascertain its presence. Its place is occupied by a very

dense lamella of white fibrous tissue which unites the ischiocavernosus to the bulbocavernosus. Caudad, this is continuous with the strong aponeurosis on the dorsum and the venter of the ischiocaudalis. As the former receives the deep tendon of the rectus abdominis and the latter gives attachment to the levator ani and retractor penis, the musculature of this region is as well secured as it could be by the presence of a rudimentary pelvis.

The ischiocaudalis is of moderate size. Its fasciculi arise mainly from its dorsal aponeurosis, which serves as an intermuscular septum between it and the hypaxial muscle and mesally joins its fellow of the opposite side. Bundles are also derived from the caudal end of the pelvic raphe between the ischio- and bulbocavernosus. The fasciculi pursue a sagittal course with a slight mesal inclination and are inserted into the sides of the first six chevron-bones, the fibrous tissue between them and, more ventrally, into the narrow but strong intermuscular septum between the ischiocaudales of the two sides.

The levator ani is well developed and of considerable thickness. It takes origin from the ventral fascia of the ischiocaudalis. Its fasciculi converge in a simple sheet towards the anal orifice, where they are blended with the wall of the anal canal, the bundles of the sphincter, and the panniculus.

The muscles of the penis have been described and figured by Benham and by Le Danois, and conditions in this foetus are in substantial agreement with their findings. The bulbocavernosus arises from the septum between it and the ischiocavernosus and, in front of that, form the sheath of the corpus cavernosum. It unites with its fellow below the corpus spongiosum in a narrow raphe. A loop of its caudal fasciculi passes ventral to the retractor to unite in a similar way with its antimere. This loop, which is narrow, rests against the levator ani. The retractor arises from the fibrous plane interposed between the levator ani and ischiocaudalis, which gives passage to the urethra and corresponds in a general way to the triangular ligament. The retractores then pass through the loop of the caudal bundles of the bulbocavernosus and pass side by side ventral to the rest of the bulb and corpus spongiosum to be inserted into the tunica propria at the level of the preputial sheath. The ischiocavernosi are well developed. They arise from the ventral aponeurosis of the ischiocaudalis and farther rostrad from the sheath of the hypaxial muscle. The fasciculi, which are nearly parallel, pass ventrad and rostrad to the septum between the ischio- and bulbocavernosus and also into the sheath of the corpus spongiosum.

*Dorsal musculature.* It is convenient for descriptive purposes to follow as closely as conditions permit the procedure of human anatomists in the classification and terminology of this very complex region. I have, there-

fore, made the magnificent study of Eisler<sup>1</sup> the basis of the following memoranda in these respects and have indicated where his usage departs from that of Stannius — with whose account of *Phocæna* the arrangement of *Kogia* conforms closely, especially when the variability of this region is taken into account. Leaving aside the transversarii which attain a peculiar development in Cetacea, the deep muscles of the back are divided into two layers: the first comprises the serrati postici; the second is subdivided into a lateral tract, a mesal tract, and the suboccipital muscles. The lateral tract includes the splenius, sacrolumbalis, and dorsal intertransversarii. The mesal tract is made up by the spinales, transverso-spinales (semi-spinales, multifidus, submultifidus), and the interspinales.

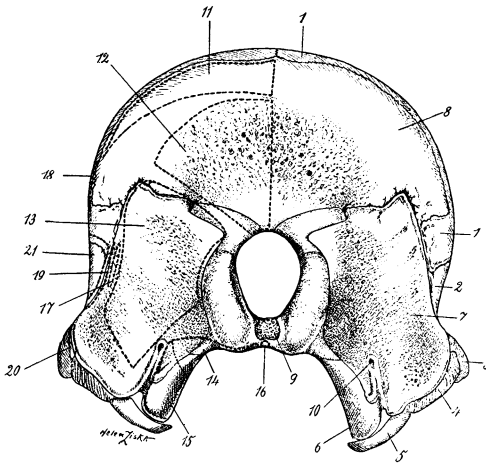


Fig. 16. Norma occipitalis, showing attachments of muscles. Two-thirds natural size.

1, Parietal; 2, Squamosal; 3, Zygoma; 4, Tympano-mastoid; 5, Stylohyal; 6, Otorcranial flange; 7, Exoccipital; 8, Supraoccipital; 9, Caudal ossification center of basi-occipital; 10, Hypoglossal canal; 11, Semispinalis capitis; 12, Rectus posticus; 13, Rectus lateralis; 14, Rectus anticus; 15, Scalenus medius; 16, Longus colli; 17, Obliquus superior; 18, Rhomboideus capitis; 19, Splenius, longissimus, and transversarius; 20, Sternomastoid and mastohumeral; 21, Temporal.

These muscles, throughout pedicle and trunk, are segregated by a strong aponeurosis, a dorsal and a lateral septum. The dorsal septum extends between the spines; the lateral is attached to the transverse processes separating the dorsal muscles from the transversarius superior; the aponeurosis is attached to the tips of the spines and to the intermuscular septa, thus completing the compartment by a superficial investment. In the neck these fibrous structures, the dorsal septum excepted, become thinner and the lateral septum disappears altogether permitting a union between the

<sup>1</sup> Eisler, P. Die Muskeln des Stammes. Jena, 1912.

lateral tract and the transversarius. The shortening of the neck and in particular the reduction of the spines of the cervical vertebræ are associated with a diminution of the insertions upon this segment of the spine. In the case of several of the superficial elements these insertions are absent and muscles are prolonged to the occiput (transversarius superior) which do not usually in mammals reach the skull.

The serrati postici are absent as in other odontocetes (Rapp, Stannius, Murie).

The splenius is a rather small flat muscle arising from the dorsal intermuscular septum by an aponeurosis intimately adherent to that of the longissimus dorsi. Becoming muscular as it passes the lateral septum, it runs obliquely ventrad and rostrad parallel to the superficial rhomboideus vertebralis and beneath the rhomboideus capitis to the lateral border of the exoccipital, contracting slightly to its insertion by mixed fleshy and tendinous fibers. It is innervated by a branch derived from dorsal rami of the upper cervical nerve. At its insertion it is fused with the iliocostalis capitis and transversarius superior.

The sacrospinalis is composed of a lateral portion or iliocostalis corresponding to the caudalis superior and sacro-lumbalis of Stannius and a mesial portion, the longissimus. Both of these elements extend from the tip of the tail to the occiput and nowhere can they be completely separated. They are most independent in the pedicle where they are connected only by tendons of origin. As regards the lateral portion, the iliocostalis lumborum (caudalis superior) is almost a separate muscle; the iliocostalis thoracis is directly continued into the capitis; there is no connection with the cervical vertebræ. The last is true also of the longissimus. In its thoracic course, the latter muscle is separated partially from the iliocostalis by a thin septum which is visible on the surface but difficult to follow in the deeper parts. In the neck, it disappears and, towards the occipital insertion the separation of the two muscles, is artificial.

The iliocostalis lumborum extends from the last caudal to the sixth lumbar vertebra. It arises from the last caudal vertebræ by a tendon interposed between that of the transversarius superior and that of the longissimus dorsi. This tendon is reinforced by accretions from the vertebral centra as far as the fifteenth from the end of the series. Here the tendon begins to give rise to fleshy fasciculi and is soon concealed in the belly, which increases in size to the eleventh or twelfth lumbar vertebra and then diminishes to its termination at the sixth. At this point, only its deeper bundles are continued into the iliocostalis of the thorax; on the surface, the two portions are separated by a septum. The belly is increased by a series of tendons, eight in number, which come from the longissimus,

run in synovial sheaths through the intermuscular septum, and, entering the belly of the iliocostalis, are the source of incremental muscular fasciculi. This arrangement seems to be general among the Cetacea. The more caudal tendons are superficial and increase in size to the fourth. Rostrad, they diminish in size and are more deeply placed. The superficial fasciculi of the belly are sagittally directed, with an inclination ventrad, and are inserted into the septum intervening between the iliocostalis and the transversarius superior. The deeper bundles have fleshy attachments into the bodies and transverse processes beginning at the nineteenth lumbo-caudal vertebra. The breadth of the insertion broadens rostrad, on the one hand extending to the tip of the transverse processes as the transversarius superior narrows, and on the other hand extending mesad beneath the longissimus and iliocostalis thoracis to the accessory processes. It thus comes to be overlain in its whole breadth by the iliocostalis thoracis and, at the surface of apposition, is broadly continuous with it, the intermuscular septum disappearing. The region of fusion is just rostrad of the reception of the eight tendon from the longissimus and caudal by the length of four vertebræ from the pointed termination of the lumbar muscle on the surface.

The iliocostalis thoracis is far more intimately united to the longissimus than the foregoing portion of this tract. On the surface, a narrow septum can be followed from the level of the fourth lumbar vertebra to the neck, where it disappears allowing the prolongations of the iliocostalis and longissimus to reach the exoccipital in a common insertion. This septum can not be followed deeply into the muscle, except as scanty connective tissue about the entering branches of the segmental nerves, so that many bundles are continuous from the longissimus into the lateral tract. If these nerves are taken as marking the arbitrary line of division, the iliocostalis may be said to correspond to the transverse processes; the longissimus, to the neural arches and accessory processes; and, save where separated by the spinalis, to the spines of the vertebræ. Its bundles are derived from the continuation of the iliocostalis lumborum at its start and from the longissimus in its whole length, the more lateral of the obliquely inclined fasciculi passing over uninterruptedly into the lateral tract. The insertions are fleshy into the upper lumbar transverse processes and the intervening fascia, into the transverse processes of the thoracic vertebræ, and into the ribs as far laterad as their angles, where they abut upon those of the transversarius superior. In the neck, the iliocostalis has no bony attachments but is continuous between the transversarius and longissimus to insert upon the exoccipital under cover of the splenius.

The longissimus extends the whole length of the axis from the last caudal vertebra to the exoccipital. It occupies the region beside the spinous

process as far as the middle of the thorax. Here the spinalis dorsi becomes independent and preempts the juxtaspinous position, and the semi-spinalis capitis, expanding rostrad, displaces the longissimus far to the side. In the pedicle, the muscle is best delimited; elsewhere it is blended laterad with the iliocostalis and mesad with the spinalis, which is recognizable only as fasciculi of more sagittal course and inserting upon the spinous processes, except rostrad where a septum is developed between the two muscles. As far as the mid-thorax, the longissimus is covered by a very dense aponeurosis of origin in its mesal portion. This is composed of oblique fibrous bands running rostrad and laterad from the tips of the spinous processes and the dorsal septum. After covering the muscle for a breadth of about an inch, it dips into its depth and can be followed nearly, but not quite, through its thickness. In *Phocæna*, Stannius found this septum dividing the longissimus from the iliocostalis (sacrolumbalis), but here it was embedded in the substance of the longissimus and is distinctly median to, and at some distance from, the superficial septum which we have taken as marking the boundary between these muscles in so far as it can be defined in *Kogia*. Caudal only at the beginning of the pedicle, just as the aponeurosis ceases to cover the whole surface of the muscle can it be said to effect such a separation, for here the fasciculi arising from its lateral surface are continued into the iliocostalis and reach insertions upon the ribs and transverse processes. Farther rostrad, fasciculi of similar origin constitute a broad tract between the lateral septum and the aponeurosis and are inserted into the neural arches and accessory processes. Fasciculi arise from the median side of the septum also and form a thick column, covered superficially by the aponeurosis; this is, in the greater part of the trunk, inseparable from the spinalis dorsi, but in the upper thorax defines itself by the lateral inclination of the bundles, some of them joining the more lateral portion of the longissimus while others are continued into the semispinalis capitis. Nowhere is a clean dissection possible.

The origin of the longissimus is by a series of tendons from the dorsal parts of the rudimentary caudal vertebræ, from the vertebral spines, directly and by means of the extensive aponeurosis on its surface, and by a series of tendons from the accessory processes. A large tendon is formed in the region of the last fifteen vertebræ by the union of successive tendinous slips. This then gives rise to fleshy bundles and the belly of the muscle rapidly increases in size by the addition of fasciculi from the deep surface of the investing aponeurosis. When the small spinous processes appear towards the middle of the pedicle, a series of tendons arise from their summits and from them bundles are added to the deeper parts of the muscle, which here rises high above the vertebræ. As the spines increase in size their sides

give rise to fleshy fasciculi and the tendons are transferred to the accessory processes. As has been said, the aponeurosis of origin dips deeply into the belly and fasciculi are derived from both its sides. This septum is directed from the surface towards the accessory processes and immediately below it are the tendons attached to these processes. Each tendon divides, and one division passes lateral, the other mesal, to the septum, so that the muscular derivatives of each tendon pass to both portions of the longissimus. In the middle third of the thorax, where the spinalis dorsi becomes defined and the semispinalis a little farther rostrad, the mesal arms of the tendons pass to these muscles, the lateral ones to the longissimus, and, as the spinalis increases in bulk, it gradually displaces the longissimus from the transverse processes — at first from their bases, later from their whole surface — so that it gives up all of its attachment to them, save for the aponeurosis from their tips and even this ceases in the upper third of the thorax.

The fasciculi have a nearly sagittal direction, the majority with a slight lateral inclination; thus they come to have a very long course between origin and insertion. Very many of them, as has been said, pass over into the iliocostalis or are carried into the deeper parts of the semispinalis capitis. Others, from the middle of the pedicle rostrad, have a sagittal direction and, inserting into the spinous processes, are representative of the spinalis dorsi, which becomes separable without injury of fasciculi only in the upper thorax and neck. Others, intermediate in position, form a tract which reaches the exoccipital in common with the iliocostalis. Of this tract, some of the deeper bundles are inserted into the bases of the transverse processes and the accessory processes of the rostral thoracic vertebræ, the iliocostalis being displaced laterad, for the tract diminishes in size to very moderate dimensions as it approaches the neck.

The spinalis dorsi is of small size in the pedicle and lower thorax and is inextricable from the mass of the longissimus. It appears on the surface in the upper thorax and is of considerable breadth when the aponeurosis of the longissimus ceases. Rostrad, it tapers to its termination on the dorsal tubercle of the atlas. Its fasciculi are derived from the longissimus, of which it constitutes a median tract. In addition to those coming from the belly and aponeurosis of that muscle, increments are derived from the tendons attached to the accessory processes. When it has attained sufficient size to displace the longissimus, it arises from the sides of the spinous processes, first at their bases and then in nearly their whole extent. The insertions are into the spinous processes and the equivalent tubercles of the cervical vertebræ. Deeply, the spinalis is intimately joined to the multifidus.

The semispinalis capitis is a large muscle. The pointed extremity of its

belly appears at the level of the seventh thoracic vertebra between the longissimus and the spinalis dorsi. Thence it expands rapidly to its insertion into the crest of the supraoccipital, which it occupies from the median line nearly in its whole breadth extending laterad to the insertion of the longissimus and splenius. Its fasciculi are, many of them, continued into it from the longissimus, but in addition it arises extensively from the aponeurosis of that muscle and receives large slips from the spinous processes of the upper thoracic vertebræ. In the neck, it has no attachments and is entirely free from the rectus posticus, in this respect differing from the homologue in *Phocæna* (according to Stannius).

The multifidus is represented by a series of oblique bundles arising from accessory processes and inserting upon the sides of the spines. In their course these elements pass over several vertebræ. Superficially, they are blended with the spinalis dorsi; deeply, with the submultifidus. The system is well developed from the upper lumbar region to the atlas; in the cervical region, its superficial bundles have a sagittal course and pass uninterruptedly from the first thoracic vertebra to the atlas; in the pedicle, it gradually diminished and was lost.

The submultifidus has about the same extent. It is composed of shorter bundles passing from accessory processes to the caudal margins of the spines and neural arches. The interspinales are well developed, especially between the large spines of the thorax.

These deep dorsal muscles conform closely to the account of conditions in *Phocæna* by Stannius.

The rectus capitis posticus is not resolvable into major and minor, or, more correctly, the minor alone is present, for the origin is confined to the dorsal arch of the atlas and no bundles are prolonged into the belly from the epistrophæus. It is a broad thick sheet of muscle, sagittally directed from its wide origin and inserted into the supraoccipital from the median line transversely to the suture of the exoccipital immediately ventral to the attachment of the semispinalis capitis. From this muscle it is entirely discrete, differing in this respect from conditions in *Phocæna* (according to Stannius) and in *Balænoptera*. In *Globicephalus*, Murie records both major and minor but intimately woven together.

The obliquus capitis superior lies at the lateral margin of the foregoing. In common with the rectus capitis lateralis, it arises from the transverse process of the atlas. Its belly is sagittally directed and in its proximal portion the surface is aponeurotic. It is inserted into the exoccipital beside the rectus posticus and, like it, is covered by the semispinalis.

The rectus capitis lateralis is short and triangular. Arising in common with the obliquus, it expands to a wide insertion upon the exoccipital,



occupying the area between the condyle and the lateral margin and extending ventrad to the level of the hypoglossal canal.

These three short muscles are supplied by the suboccipital nerve.

The transversarius superior is the most laterally placed of the dorsal muscles, following the line of the transverse processes and the costal angles throughout the length of the vertebral column. Its mesal border is separated by a strong septum from the members of the erector spinæ group and through this septum emerge the dorsal divisions of the segmental nerves. Superficially, the muscle and its tendons of origin are covered by a very dense sheath which extends rostrad as far as the last rib, beyond which it becomes tenuous. Ventrally, the sheath is attached to the sides of the centra and, where they are present, to the tips of the transverse processes which separate it from the transversarius inferior; dorsally, the sheath joins the lateral intermuscular septum. The muscle is thus well circumscribed as far as the last rib. Its lumbo-sacral portion is narrow; caudad, it is flattened against the sides of the centra; but, when transverse processes put in their appearance, it narrows slightly and becomes thicker, though not markedly. In this segment of its course, it is applied to the tips of the transverse processes and does not encroach upon their dorsal surface extensively, differing here in degree only from *Phocæna* (according to Stannius), which otherwise it closely resembles. Beneath its sheath, this portion of the muscle is covered by strong aponeurotic bands arranged in a herring-bone pattern with the angles pointing rostrad. This extends as far as the vent, proximad of which the fleshy fasciculi come to the surface. These are nearly sagittal in direction with only the slightest inclination ventrad as they pass from their origin upon the transverse process to their insertion on the last rib and on the septum between the transversarius and the great hypaxial muscle. The costal portion expands into a broad sheet, covering the side of the thorax and interdigitating with the external oblique. Stannius distinguishes (for the purpose of description only for the two portions are inseparable) between a mesal portion associated with the angles of the ribs and the expanded sheet upon the thorax. The mesal part is thicker and is further characterized by its tendinous insertion into the angles and more mesial portions of the ribs, the fasciculi turning mesad under cover of the longissimus to reach these insertions. In the remainder of the muscle, the bundles are oblique ventrad and rostrad and, on the surface, present an uninterrupted course. There are no inscriptions. They appear as a continuation of the bundles of the lumbo-caudal segment, reinforced laterally by a series of digitations from the caudal margins and lateral surfaces of the ribs. The sheet attains its greatest breadth on the fourth rib and narrows by a series of steps to the first. From the first rib, the muscle is carried

rostrad by a thick rounded prolongation to the exoccipital, where it is inserted in close apposition to a slip of the longissimus. This cervical segment, which is not described by Stannius, arises from the angle of the first rib dorsal to the scalenus posticus. On the right side, it is separated from the thoracic portion by an inscription; but, on the left, this was lacking and the fasciculi of the thoracic segment continued into it. At first clearly separated from the longissimus by a prolongation of the intermuscular septum and by emerging dorsal divisions of cervical nerves, it is barely separable towards the occiput from the longissimus slip which inserts upon the exoccipital. Its relation to septum and nerves, however, seem to establish its homodynamity with the transversarius. It is entirely free; indeed, widely separated from the cervical transverse processes, a massive vascular plexus intervening.

Stannius describes the origin as beginning by a tendon from the last caudal vertebra reinforced by a series of tendinous slips from the next succeeding centra. Unfortunately this region dried during the process of dissection, and we could follow the main tendon only to the thirteenth from the last of the series. From the vertebra in front of this, the origin became fleshy and the tendon was quickly concealed by muscle bundles arising from it and from the sides of the centra, subsequently from the tips of the transverse processes, and to a small extent from the septum separating it from the dorsal muscles proper. Where it rests upon the hypaxial muscle it receives but scanty accretion of new bundles and these from the septum, and the extreme tips of the transverse processes. In the thorax the origins are extensive from the caudal margins and lateral surfaces of the ribs as far as the second. The first rib at its angle gives rise to the bulk of the cervical prolongation. The insertions begin at the twelfth rib and thence rostrad are into the caudal margins and lateral surfaces of the ribs from a point mesal to their angles for a variable distance laterad, the extent of the attachments increasing as far as the fourth rib and thence decreasing to the first. The cervical prolongation is inserted into the exoccipital in conjunction with the longissimus and the splenius.

The transversarius inferior extends over the last thirty lumbo-caudal vertebrae and is placed against the ventral halves of the centra and on the ventral aspect of the transverse processes; in other respects it resembles closely the corresponding portion of the transversarius superior. A large tendon arises from the ultimate caudal vertebrae and is reinforced by tendinous slips as far as the sixteenth from the end of the series. Thence to the twentieth the origin is by fleshy fasciculi. The surface of the belly for more than half its length is covered by V-shaped aponeurotic bands. From the deep surface of these, fleshy fasciculi are derived, those from the dorsal

arms passing obliquely to the more caudal transverse processes, those from the ventral pursuing a more nearly sagittal course to more rostral transverse processes. The insertion is by a series of slips into the tips of the transverse processes from their first appearance to that of the twenty-ninth or thirtieth vertebra from the tail. We could not find a continuity on the part of this muscle with the transversarius superior, such as Stannius describes, but otherwise it closely resembles his account of conditions in *Phocæna*. The ends of the origin are crossed by those of the great hypaxial muscle from which they are separated by very dense fibrous tissue. When the bellies appear they are separated by a strong septum, which is connected with the deep fascia ensheathing them on the surface. The septum, deeply, is attached to the chevron bones.

The intertransversarii are well developed flat muscles stretching between the transverse processes. They are separated from the transversarius superior by its very strong aponeurotic sheath. The fascial separation from the transversarius inferior and rostrad to the termination of that muscle from the hypaxial mass is less robust, but the muscles are everywhere perfectly distinct and there is no continuity of bundles. The small muscles are immediately ventral to the dorsal division of the segmental nerves from which they receive branches.

*The hypaxial muscles.* In the muscles of this system, in the neck *Kogia* differs materially from the known members of the Delphinidæ in the absence of the rectus capitis anticus major, a large muscle in both *Phocæna* and *Globicephalus*. The rectus capitis anticus minor is of good size, arising from the arch and transverse process of the atlas and inserting broadly into the exoccipital and basioccipital, extending from the attachment of the rectus capitis lateralis to the median line. The muscles of the two sides are separated by a triangle of connective tissue at their origin but converge to their insertions, where they are to a slight degree blended with the scalenus medius. In all respects, it is very similar to its homologue in *Phocæna*. The longus colli is represented by a moderately developed inferior oblique portion and a weak superior oblique, while the longitudinal bundles are apparently wanting. The inferior oblique portion arises from the centra of the first five thoracic vertebræ; occupying, with its antimere, the whole ventral surface of the spine so that the bellies are in contact save for an intermuscular septum. The fasciculi pass rostrad and laterad, and are inserted upon the venter of the mass of fused cervical vertebræ at about its middle, the insertion beginning at some distance from the midline and extending obliquely to the capitular process for the first rib. The superior oblique portion is weak. It arises from the venter of the cervical mass immediately rostrad of the foregoing insertion. Its bundles converge to join those of its

antimere in a small insertion into the basioccipital between the ventral ends of the condyles and into the anterior atlanto-occipital ligament.

The hypaxial muscle of the lumbar region and pedicle is of great size, extending from the lower ribs to the extremity of the tail. Rapp, who has given a careful description of the muscle in *Phocæna*, has designated it the psoas magnus, to which it corresponds partially but with the inclusion of other elements (Stannius). In *Kogia* the mass is incompletely separable into three parts as in *Balanoptera*. Two sets of tendons appear caudad; one ventral, one lateral in position. The ventral tendons are continued into a belly deeply placed against the centra and the bases of the transverse processes. This is covered and concealed in the natural position of the parts by the belly arising from the lateral tendons. The two portions are separated by a very strong septum in the pedicle and in this septum are contained the two sets of tendons and their synovial sheaths. In the lumbar region, the septum defaults and the two bellies fuse into a common mass. Superficially a strong sheath invests the muscle. This, in its proximal two-thirds, is the source of muscular bundles which pass rostrad and dorsad to the tips of the transverse processes, so constituting a third portion of the hypaxial mass.

Rapp and Stannius have described the strong fibrous sheath. Laterally it is attached to the sides of the centra and forms an intermuscular septum between the hypaxial muscle and the transversarius inferior. Where the latter terminates, the sheath gains an attachment to the tips of the transverse processes. Ventrally the attachment is to the tip of the chevrons and farther rostrad to the centra of the vertebræ. It forms a septum between the hypaxial mass and the ischiocaudalis and, in the abdominal region, becomes blended with the strong transversalis fascia.

The superficial investing portion of the muscle requires but little additional description. It arises from the proximal chevron bones by means of the septum above described and, more rostrally, from the fusion area of the sheath with the transversalis fascia. The insertion is into the last rib and the transverse processes of the lumbar vertebræ as far caudad as the eleventh. Deeply, its bundles fuse with the next portion of the muscle.

This, the derivative of the lateral set of tendons, is independent as far rostrad as the eighth lumbar vertebra. The great tendon arises from the centra of the caudal vertebræ in their latero-ventral portion and is reinforced by a series of slips from the sides of the more proximal vertebræ. These cross the transversarius inferior superficially. Ventrally, another set of segmental tendons are derived from the septum attached to the chevron-bones. Thus is formed a great tendon which divides before enter-

ing the belly into seven subsidiary tendons. These run, as has been said, in synovial sheaths in the septum on the deep surface of the muscle and successively enter its ventral margin. The insertion takes place, in common with the deepest part of the hypaxial mass, into the last ribs and the transverse processes of the first eight lumbar vertebræ. Caudal to this point, the muscle is independent and its fasciculi insert fleshy into the ventral surfaces of the transverse processes of the ninth, tenth, and eleventh vertebræ. Beyond the last named, the transversarius inferior intervenes and separates the hypaxial mass from the processes; its fasciculi then insert into the septum between the two muscles as far caudad as the twentieth lumbo-caudal vertebra.

The deepest portion of the hypaxial mass originates by a tendon arising from the venter of the last centrum and receiving accessory slips from the succeeding vertebræ as far as the twenty-fifth lumbo-caudal vertebra. The belly begins at the nineteenth vertebra, arising from the most dorsal of the slips into which the tendon divides; this is followed by nine others, the more ventral having increasingly long courses in the synovial sheaths of the intramuscular septum. The most ventral tendon can be followed as far as the eighth lumbo-sacral vertebra before entering the belly. This has, in general, a bipenniform arrangement, its fasciculi diverging from an axial fibrous line along which the tendons enter and themselves give rise to diverging fasciculi, which at first are independent but soon merge in the general mass. Thus the belly is partially resolvable into a series of superimposed parts, those coming from the more ventral tendons having a more superficial and rostral position. From the eighth lumbo-caudal vertebra this portion is fused with the more superficial parts of the muscle. The insertions are into the sides of the centra of the lumbo-caudal vertebræ from the twentieth rostrad and into the bases of the transverse processes. The fused proximal portion of the mass inserts into the whole venter of the transverse processes and the centra, the muscles of the two sides approaching one another so that they are only separated by a narrow cleft in which are lodged the aorta and venæ cavæ. On reaching the thorax, the muscle inserts into the whole length of the last rib and its cartilage on its ental surface. Ventrally, a small component is continued to the eleventh rib beyond the extremity of the twelfth; and, dorsally, in the region of the angles a large portion extends to the tenth and eleventh ribs.

## PERIPHERAL NERVES

The condition of the superficial parts of the head interfered seriously with the dissection of the nerves, and our account of them is accordingly incomplete. Especially was this the case with the orbital contents. Of the oculomotor and patheticus we have nothing to record.

The trochlearis leaves the cranial cavity by passing through the posterior and upper part of the sphenoidal fissure. Its course is rostrad and laterad, and it crosses dorsal to the eye muscles to enter the substance of the superior oblique.

The ophthalmic division of the fifth nerve leaves the skull through the sphenoidal foramen. It crosses the orbit lying in relation to the roof and turns dorsad through the notch in the orbital margin of the frontal bone. The nasal portion reënters the skull through the sphenoidal fissure, passes mesad lying in a groove in the frontal bone, and finally leaves the skull through a small foramen in the ethmoid to enter the nasal fossa.<sup>1</sup>

The second division of the trigeminal nerve emerges from the brain-case through the sphenoidal fissure. Its course is rostrad, crossing ventral to the attachment of the eye muscles to reach the canal in the superior maxilla corresponding to the infra-orbital canal. Just before entering this a branch is given off which probably goes to the sphenopalatine ganglion. Traversing the main canal in the maxilla, the trunk appears on the dorsal surface of that bone and continues rostrad lying in a groove on the maxilla. Branches are given off to surrounding structures but could not definitely be traced. There is a small branch which unites with a ganglion-like formation. This small mass of nerve tissue lies on the dorsum of the rostrum between the antorbital notch and the infra-orbital canal and receives branches from both fifth and seventh nerves.

The third division of the trigeminal nerve leaves the skull through the foramen ovale. Its course is at first directly laterad. Nearing the mandible, it gives branches supplying the temporalis muscle. It then turns at right angles to its former course and proceeds rostrad, paralleling the upper border of the mandible and lying dorsal to the large and degenerate remanent of Mechel's cartilage. It soon divides into two portions. The main division passes rostrad, giving off branches to the pterygoid muscles and branches which turn rostrad and dorsad to cross the upper border of the mandible probably to supply the masseter. It also gives numerous branches

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<sup>1</sup> Cf. Schulte, The Skull of *Kogia breviceps* Blainv. Bull. Amer. Mus. Nat. History, XXXVII, Art. xvii, Pl. xlii.

to the mucus membrane of the alveolingual region and continues as the lingual nerve into the tongue.

The other division, corresponding to the inferior dental, curves ventrad, giving off a branch which passes caudad to reach the region of the ear.

The mylohyoid branch is given off as the nerve enters the inferior dental foramen. This pierces the fat and connective tissue near the border of the mylohyoid and then passes forward, paralleling the lower border of the jaw and lying superficial to the muscle, which it supplies together with the overlying hyomandibularis.

The facial nerve leaves the cranial cavity through the jugulo-acoustic foramen in company with the auditory nerve. It lies rostral to the auditory

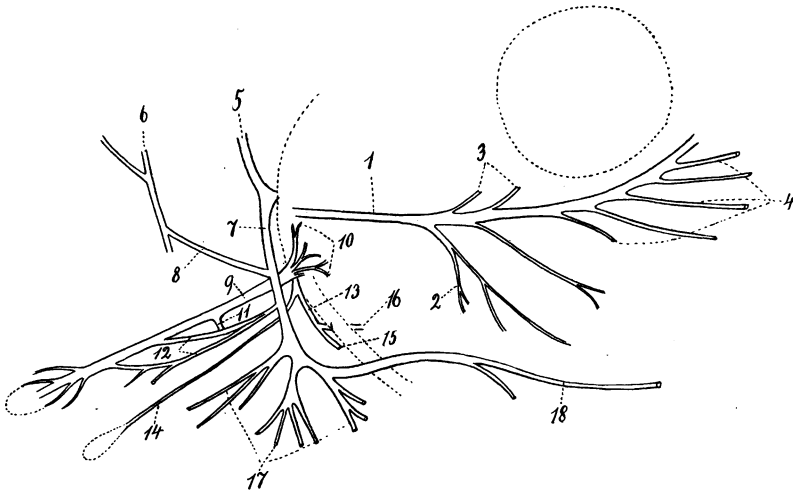


Fig. 17. Schema of the caudal cranial nerves of the right side.

1, Facial nerve; 2, Branch to depressor mandibuli; 3, Branches to obicularis orbitalis; 4, Branches to facial musculature; 5, First cervical nerve; 6, Second cervical nerve; 7, Hypoglossal; 8, Anastomotic branch between second cervical and hypoglossal; 9, Vagus; 10, Accessory branches of vagus to sternomastoid and cephalohumeralis; 11, Superior laryngeal branch of vagus; 12, Anastomotic branches between vagus and hypoglossal; 13, Glossopharyngeal; 14, Branch to innominate artery; 15, Branch to hyoideus latus; 16, Branch to stylopharyngeus and mucous membrane; 17, Branches to infrahyoid muscles; 18, Branches to geniohyoid and genioglossus and hyoglossus muscles.

nerve and is enclosed in the same dural sheath. The two separate on entering the periotic; the facial to enter the facial canal, and the eighth to enter the internal auditory meatus. The eighth ends by dividing into branches which pierce the small foramina in the end of the internal auditory meatus. The seventh, after entering the facial canal in the periotic, following the course of the canal curves slightly caudad, and then, leaving the periotic, comes to lie between the tympano-mastoid and the exoccipital

and emerges upon the surface of the skull through a foramen formed by these two bones, mesial to the attachment of the stylohyal to the skull. It passes rostrad close to the skull, at first ental to the sternomastoid and cephalo-humeralis, and then beneath the mass of fat and connective tissue underlying the panniculus. It continues forward ventrad to the orbit and ental to the superficial facial muscles. There it turns dorsad and mesad to enter the region of the spiracular sac through the antorbital notch and ends by breaking up into branches supplying the musculature of this region.

It sends a branch to the panniculus in the region of the lower jaw. A small branch supplies the depressor mandibuli. Branches are given off to the facial muscles and the obicularis palpebrarum, and terminal branches supply the musculature of the spiracular sac.

An inspection of Le Danois' figures makes it evident that it is the trunk of the facial nerve which he has described as the fibrous zygomatic process.

The glossopharyngeal and the vagus nerves leave the cranial cavity through the posterior part of the jugulo-acoustic foramen. They pass ventrad, lying in a groove, or better a canal, formed by the otocranial process of Owen, the exoccipital, and the periotic. Reaching the notch between the ventral borders of the first two of the above mentioned bones, the nerves turn sharply caudad and appear in the cervical region.

The glossopharyngeal lies ventral and a little mesial to the vagus. It passes ventrad close to the stylohyal cartilage and gives off a branch which passes caudad lying ventral to the great vessels of the neck. This branch ends by breaking up into a plexus on the surface of the innominate artery. The main trunk curves rostrad, giving off a branch to the hyoideus latus, and passes deep to the stylohyal. Here it gives off a branch to the stylopharyngeus. It then continues forward, lying deep to the palate muscles, and ends by supplying the mucus membrane of the soft palate and fauces, and also the posterior portion of the tongue.

As in *Balanoptera*, the vagus is intimately associated with the sympathetic. It appears in the neck ventral to the attachment of the styloid process and gives off branches to the sternomastoid and mastohumeralis. These are no doubt equivalent to the spinal accessory of other animals. Close to this, the vagus is crossed by and is adherent to the hypoglossal. In its course caudad, the nerve lies close to the ventral border of the middle scalene and dorsal to the great arteries. The superior laryngeal nerve arises near the junction with the hypoglossal, passes mesad until it reaches the fascial plane deep to the great vessels, and there turns ventrad to reach the larynx.

In its course the vago-sympathetic trunk received two fine branches from the hypoglossal. Just before reaching the subclavian artery it sepa-



rates into its vagal and sympathetic components. On the right side, the vagus crosses the vessels in several separate strands. Small anastomotic connections unite these with the plexus formed by the glossopharyngeal. The smaller strands pass down along the aorta. The largest division, after sending several cardiac branches to the aorta, turns mesad and dorsad behind the tracheal bronchus to reach the root of the lung, where it forms the posterior pulmonary plexus. Before this it gives off a branch which passes in front of the bronchus, forming the anterior pulmonary plexus and anastomosing with the cardiac plexus. The strands of the posterior pulmonary plexus unite upon the œsophagus and pass caudad upon its dorsal surface.

The left vagus differs from the right in that its sympathetic element is more distinct. The first branch after the separation of the sympathetic element is much larger than on the right side and passes to the ventral surface of the aorta, forming with the branches from the right side and some fibers from the sympathetic the cardiac plexus. The main vagal trunk gives off an anterior pulmonary branch, as on the right side, and then, as it passes the ductus in its dorsal course, it sends a small nerve cephalad behind the aorta toward the larynx. This probably is the recurrent laryngeal. It was not found on the right side. The posterior pulmonary plexus was formed as on the right side.

The hypoglossal nerve emerges from the hypoglossal canal. This is widely separated from the jugular foramen and opens upon the caudal surface of the skull. On exit, the nerve receives a large anastomotic branch from the first cervical. The resultant trunk passes ventrad, lying at first in relation to the exoccipital and then to the stylohyal. The scalemus medius lies ental, the sternomastoid and mastohumeralis ectal, to it. A short distance from the point of emergence, it receives an anastomotic branch from the second cervical. Then it crosses the vagus, lying ectal and closely adherent to the latter. Slightly further ventrad, it crosses the great vessels and leaves the stylohyal. It is covered in this region by deep fascia and panniculus. Here two small branches pass caudad to anastomose with the vagus. The next branches are given off to the sternothyroid and the sternohyoid muscles. The trunk then arches rostrad along the dorsal border of the sternohyoid, giving off large branches to the deep surface of this muscle and to the thyrohyoid. Crossing the border of the thyrohyal cartilage, it turns rostrad and mesad, and, for a short distance, lies between the stylohyal and the thyrohyal cartilage upon the ceratohyal muscle. It then ramifies upon the hyoglossus muscle. The mylohyoid is at this point superficial to the nerve. The hypoglossal ends by breaking up into branches supplying the geniohyoid, the hyoglossus, and the genio-glossus muscles.

The plexus formed by the cervical nerves in *Kogia* is characterized by the formation of two large masses of nerve fibers. These, for purposes of convenience, have been termed the lesser brachial trunk and the greater brachial trunk. The former is produced by the union of two cords comprised of the third and fourth, and fifth and sixth cervical nerves respectively. The latter is formed by a large band of fibers from the lesser brachial trunk and two cords from the seventh and eighth cervical nerves, assisted by the first thoracic.

This condition has not before been described and it is very different from the arrangement pictured by Cunningham<sup>1</sup> in *Phocæna*. In that animal, the innervation of the flipper takes place through a single trunk formed from the last five cervical and the first thoracic nerves, but the conspicuous division of the cervico-brachial trunk above mentioned is absent. The plexus of *Balaenoptera* suggests the condition but is by no means as definite.

The arrangement, so far as it goes, would tend to place *Kogia* somewhat nearer to the mystacocetes than to the Delphinidæ — an inference which receives further support from the arrangement of the antebrachial musculature.

The cervical nerves, with the exception of the first, possess ventral and dorsal divisions, the separation occurring in the vertebral foramina. The dorsal divisions will be considered separately. The first cervical nerve emerges from the spinal canal, between the atlas and the occiput. Its point of exit is separated from the other cervical nerves by a considerable interval and is dorsal to the lateral mass of the atlas. In its course ventrad and slightly rostrad, it gives innervation to the rectus posticus, rectus lateralis, rectus anticus, and superior oblique muscles. It ends by anastomosing with the hypoglossal near the point of emergence of the latter nerve. The other cervical nerves leave the spinal canal very close together. The second cervical nerve emerges singly and gives off a small branch which passes rostrad, lying upon the rectus anticus, and unites with a branch of the first cervical upon the surface of that muscle. The nerve continuing soon unites with the third and fourth. These latter emerge closely approximated and fuse almost immediately into a single trunk. The connection between this trunk and the second cervical is only temporary; for the resultant nerve mass, after giving off a branch to innervate the scalenus medius, separates into two large nerves which pass ectad between the scalenus posticus and medius.

The first of these two nerves is probably derived mainly from the second cervical. It passes ventrad and rostrad, ectal to the scalenus medius, and

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<sup>1</sup> Cunningham, D. J. Jour. Anat. & Phys., XI, 1876-77.

breaks up to supply the tissues of the neck, the cervical panniculus, and the overlying skin. In its course, it gives off a branch which, by uniting with twigs from the third, fourth, fifth, and sixth, forms a nerve to innervate the levator anguli scapulæ and the rhomboideus capitis. There is a large anastomotic branch which connects with the hypoglossal and represents the ansa hypoglossi. Just before the nerve breaks up, it sends a division to anastomose with a branch from the lesser brachial trunk, the combination serving to innervate the upper portion of the pectoralis major.

The portion composed for the most part of the third and fourth cervical nerves passes ventrad and slightly caudad, giving off branches to the middle scalene muscle, and ends by fusing with a cord formed by the fifth and sixth cervical to produce what is termed the lesser brachial trunk. The fifth and sixth cervical unite very soon after emergence from the vertebral canal. They probably receive sympathetic branches before fusion, but this was not definitely ascertained. The resulting cord passes ventrad and caudad, lying ectal to the scalenus medius. This cord gives twigs as above noted which assist in innervating the levator anguli scapulæ and finally, ental to the scapula, unites with the cord composed of the third and fourth. The resultant brachial trunk gives off a branch (*vide supra*) which assists in the innervation of the pectoralis major. The next branch is the suprascapular nerve. This is large and proceeds to the ectal surface of the scapula. Here it ramifies upon the deep surface of the deltoid, supplying it together with the subdeltoideus, the infraspinatus, and the supraspinatus. It anastomoses with branches of the circumflex nerve. The phrenic nerve arises from the lesser brachial trunk near the foregoing. It passes ventrad and then, as it reaches the border of the scalenus medius, it turns caudad to accompany the great vessels into the thorax. At this point it gives off a branch to the pectoralis minor. From the ectal surface of the lesser brachial trunk there are given off four or five small branches which enter the subscapularis muscle to supply it. Lastly, the major portion of the lesser brachial trunk passes caudad and ventrad to unite with the cords of the seventh and eighth cervical to produce the greater brachial trunk.

The seventh and eighth cervical communicate with the sympathetic and give off branches supplying the scalenus posticus muscle. The seventh cervical sends a branch to supply the longus colli. The two nerves unite after this and form a single cord. This, lying ental to the scalenus medius, divides into two parts. The most superficial portion gives off a branch which pierces the muscle and passes caudad to supply the serratus anticus. Then it pierces the scalenus medius itself and unites with the continuation of the lesser brachial trunk. The deeper portion receives a large addition from the first thoracic nerve and then, near the ventral border of the scale-

nus medius and just cephalad to the first rib, pierces the muscle and unites with the anastomosis between the superficial portion and a branch from the lesser brachial trunk (Fig. 18.38). This is broad and flat, and lies ental to the scapula near the scapulo-humeral articulation.

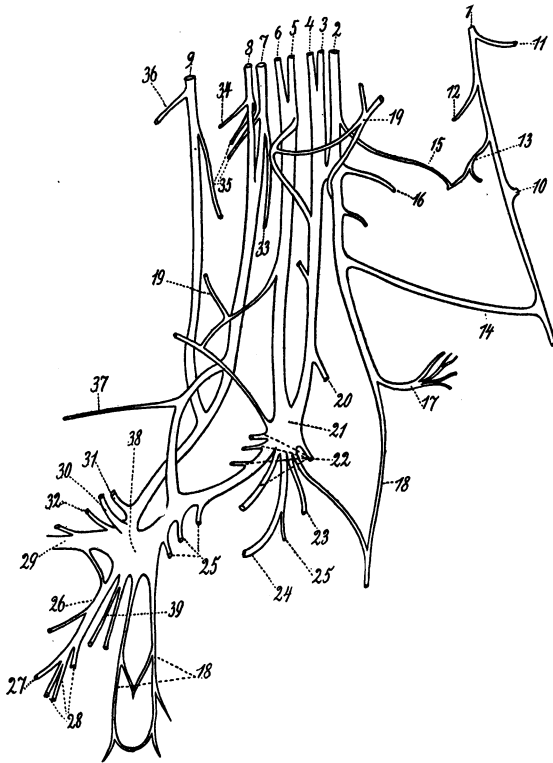


Fig. 18. Cervico-brachial plexus, ventral divisions.

1, First cervical nerve; 2, Second cervical nerve; 3, Third cervical nerve; 4, Fourth cervical nerve; 5, Fifth cervical nerve; 6, Sixth cervical nerve; 7, Seventh cervical nerve; 8, Eighth cervical nerve; 9, First thoracic nerve; 10, Hypoglossal nerve; 11, Branch to rectus posticus; 12, Branch to rectus lateralis; 13, Branch to rectus anticus; 14, Anastomotic branch to hypoglossal; 15, Branch to rectus anticus; 16, Branch to scalenus medius; 17, Branch to panniculus; 18, Branch to pectoralis major; 19, Loop supplying levator anguli scapulae and rhomboideus; 20, Branch to panniculus; 21, Lesser brachial trunk; 22, Branches to subscapularis; 23, Suprascapular nerve; 24, Phrenic nerve; 25, Branch to pectoralis minor; 26, Ulno-median nerve; 27, Musculo-spinal nerve; 28, Ulnar nerve; 29, Long thoracic nerve; 30, Circumflex nerve; 31, Nerve to teres major; 32, Branch to panniculus overlying scapula; 33, Nerve to longus colli; 34, Scalenus posticus; 35, Connections between sympathetic, seventh and eighth cervical, and first thoracic; 36, Intercostal portion of first thoracic; 37, Nerve to serratus anticus; 38, Greater brachial trunk; 39, Cutaneous nerves to radial margin of flipper.

From the anterior part of this trunk three or four small nerves (25) arise which supply the pectoralis minor. Next to these there is a double

loop (18), as shown in the diagram, which innervates the greater portion of the pectoralis major. In conjunction with the origin of the loop, a nerve passes (39) distad, crossing the ental surface of the flipper just below the tuberosity of the humerus to reach the radial border. More distal to, paralleling, and connected with the above is another rather larger nerve which disappears under the dense tissue forming the origin of the flexor muscles. Near the origin of these two nerves, the circumflex nerve (30) arises and passes ectad in the space between the teres and the scapulo-humeral articulation, and ends by anastomosing with the suprascapular nerve to take part in the supply of the deltoid. Next in order, a single large nerve (26) arises from the distal portion of the trunk and continues along the postaxial border of the flipper upon the flexor surface. Near its origin, it gives off an anastomotic branch to the long thoracic. Just distal to this, there is a large branch (27) which pierces the triceps, innervating that muscle, and then curves around the postaxial border just proximal to the olecranon to reach the extensor surface of the flipper. Here it ramifies on the ental surface of the extensor digitorum, supplying this muscle. This corresponds to the musculo-spiral nerve.

The main nerve passes distad on the flexor surface of the flipper, dividing into five or six branches (28) which ramify underneath the flexor muscle and supply it. The two branches near the postaxial border supply the interossei. This nerve probably represents the combined ulnar and median.

From the caudal extremity of the greater brachial nerve arises the long thoracic nerve (29). It passes caudad, lying at first in relation to the subscapularis muscle and receiving anastomotic branches from the ulnar median complex. Near its origin, it gives off a large branch (23) which curves around the border of the scapularis and then ramifies in five or six divisions upon the ental surface of the panniculus, supplying the dorsal portion of that muscle from the scapular region almost to the caudal extremity.

The long thoracic is continued caudad beneath the fibrous raphe of the panniculus and forms a plexus with branches of the segmental nerves from the first to the eleventh thoracic. This plexus is composed of from two to four parallel nerves, connected by anastomoses and giving off branches supplying both dorsal and ventral portions of the panniculus. This plexus ends with the panniculus.

From the ectal surface of the greater brachial trunk, the nerve (31) to supply the teres major arises. Near its ending in that muscle it sends a branch caudad to supply the latissimus dorsi.

The dorsal divisions of the cervical nerves separate from the ventral divisions in the vertebral foramina and emerge so close together that it is

practically impossible to distinguish them from one another. They pass dorsad between the atlas and the transverse process of the first thoracic vertebra and ramify in tree-like arborizations to supply the dorsal musculature. The various branches anastomose with one another. Some medial branches to the semispinalis capitis extend caudad in the substance of that muscle as far as the fourth and fifth thoracic vertebra. A branch from one of the lower members of the plexus connects it with the dorsal division of the first thoracic nerve across the transverse process.

The thoracic nerves emerge from the intervertebral foramina as single

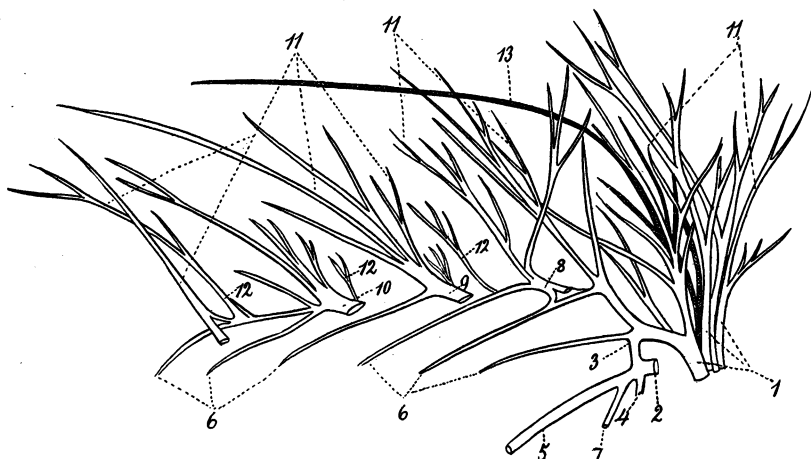


Fig. 19. Dorsal divisions of cervical and upper thoracic nerves.

1, Dorsal branches of last seven cervical nerves; 2, First thoracic nerve; 3, Dorsal division of first thoracic nerve; 4, Branch to cervico-brachial plexus; 5, Intercostal branch of first thoracic; 6, Branches of dorsal divisions to transversarius; 7, Branch of first thoracic to sympathetic; 8, Dorsal division of second thoracic; 9, Dorsal division of third thoracic; 10, Dorsal division of fourth thoracic; 11, Branches to longissimus; 12, Branches to multifidus and erector spinae; 13, Branches to semi-spinalis capitis.

trunks and separate into dorsal and ventral divisions between the transverse processes. The ventral portion lies, throughout the greater part of its course, between the pleura and the intercostal muscles, at first lying near the rib next below but soon crossing the intercostal space to lie near the rib just above. Near its origin, it sends off a collateral branch which ramifies between the two layers of intercostal muscles supplying them. As the nerve nears the level of the lateral raphe of the panniculus, it sends a branch which pierces the intercostal muscles to unite with the long thoracic of the brachial plexus to form the plexus supplying the panniculus. The ventral division ends by ramifying in and supplying the rectus abdominis.

The ventral division of the first thoracic nerve differs from the other members in that it gives off, at the region of its first or intercostal branch, two other branches. The larger of these pass cephalad and ventrad beneath the first rib to join the deep cord of the seventh and eighth cervical and enter into the formation of the brachial plexus. The smaller branch crosses the dome of the pleura to reach the tip of the second ganglion of the cervical sympathetic system.

The dorsal divisions pass between the transverse processes and separate into three main divisions. The most mesial of these pass caudad and dorsad to the interspinous space next below to supply the multifidus. In the mid-thoracic region the spinalis dorsi also receives branches from this set. The second set are more numerous and much larger and ramify in the substance of the longissimus, supplying it, and the iliocostalis. The third set are distributed to the transversarius, their cutaneous branches emerging through the lateral intermuscular septum.



Fig. 20. Schema of lumbosacral nerves.

1 to 9, Lumbo-sacral nerves, in order; 10, Last thoracic nerve; 11, Nerves from dorsal divisions supplying longissimus and iliocostalis muscles; 12, Nerves from dorsal divisions supplying multifidus and interspinalis muscles; 13, Nerves from dorsal divisions supplying transversarius; 14, Dorsal longitudinal trunk; 15, Ventral divisions; 16, Branches of abdominal muscles; 17, Anastomotic branch from fifth to sixth lumbo-sacral nerve; 18, Internal pudic nerve; 19, Ventral longitudinal trunk.

The lumbo-caudal plexus is characterized by the formation of two longitudinal trunks which lie respectively above and below the transverse processes of the vertebræ. This condition obtains in *Phocæna*, according to Cunningham, in a more marked degree, and is probably a result of the arrangement of the muscles going to the pedicle. These trunks are formed by the middle and lower members of the plexus.

Like the thoracic nerves, the lumbo-caudal nerves divide into dorsal

and ventral divisions between the transverse processes of the vertebræ. The dorsal divisions, in arrangement, resemble those of the thoracic nerves. There is present the same separation into three branches. The most internal crosses the adjacent vertebra and the intervertebral space to supply the multifidus and interspinalis, the middle branch enters the longissimus and iliocostalis muscles and the external branch crosses the transverse processes caudad to supply the transversarius.

From the dorsal division of the second nerve of the series, a branch arises which anastomoses with the dorsal division of the next segment. From this, a still larger anastomotic branch passes to the fourth and, increasing in size by successive segmental increments, continues caudad. At first only a portion but further caudad the whole dorsal division enters into the cord, and the three sets of branches already noted arise from this and not from the dorsal nerve before its entrance into the trunk. This trunk was traced as far as the base of the flukes where it was lost.

The ventral divisions pass ectad between the transverse processes and enter into the substance of the hypaxial muscle, first giving off small branches which may be sympathetic in character. The first four pass ventrad, giving off branches to the superficial layer of the hypaxial muscle. These branches turn dorsad in the substance of the muscle. Branches are also given off to supply the internal and external oblique muscles. The nerve ends by supplying the rectus abdominis.

The fifth lumbar nerve, in addition to the usual arrangement, in the substance of the hypaxial muscle sends a large anastomotic branch to join the sixth. The latter, thus reinforced, unites with the seventh of the series and forms the nerve termed by Cunningham the internal pudic. This passes ventrad between the muscle layers to the venter of the animal and ends by breaking up into two main divisions. The anterior of these ramifies and forms a plexus supplying the genital muscles. The posterior branch supplies the anal musculature.

From the ventral divisions of the seventh, before the formation of the internal pudic nerve, a large anastomotic branch passes caudad to unite with the ventral division of the eighth. This is continued as a trunk, lying below the transverse processes, and is joined by the ventral divisions of the succeeding nerves. At the points of junction, branches are given off to the adjacent muscles. This trunk was traced along the ventro-lateral surface of the vertebræ to the base of the flukes. This sustains Cunningham's findings in *Phocæna* and strengthens his argument as to the probable sensibility of the whale's tail as against Swann, who thought there was but little sensation in the flukes.

The sympathetic system is represented in the neck by three ganglia and their connections.



The most rostrad and ventrad of these ganglia is intimately associated with the vagus. On the right, the two are fused. The cephalic connections of the ganglion are represented by a small strand on the surface of the main vagus trunk. On the left side, the ganglion is united with the vagus only by several fibers crossing directly from the body of the ganglion to the nerve. From the superior pole, a large branch connects with the vagus in the region of the superior laryngeal nerve. From the caudal pole, a large nerve connects it with the second ganglion of the series.

The second ganglion is situated cephalad to the apex of the lung. It is

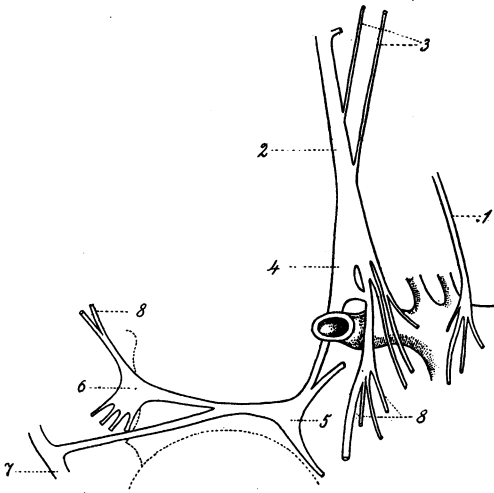


Fig. 21. Cervical sympathetic ganglia.

1, Branch of glossopharyngeal; 2, Vagus; 3, Anastomotic branches from hypoglossal; 4, First sympathetic ganglion; 5, Second sympathetic ganglion; 6, Third sympathetic ganglion; 7, First thoracic nerve; 8, Branches connecting with seventh and eighth cervical.

connected by large trunks with the ganglion just described, and the third of the series. It receives a large contribution from the first dorsal nerve and gives off several small nerves which pass mesad to anastomose in front of the aorta, and assist in the formation of the cardiac plexus.

The third ganglion of the series lies close to the 1st thoracic vertebra. In addition to the connection mentioned above, it receives rami from the various cervical nerves and sends three or four branches rostrad along the vertebral column.

The ganglionic cord lies upon the lateral surface of the vertebral column. It is connected with the cervical sympathetic, as described above, by means of several small strands. It becomes definite at the upper level of the fifth

thoracic vertebra and receives branches from each segmental nerve from the fifth thoracic to the eleventh. Augmented by these branches, it increases in size to the level of the tenth thoracic vertebra where a large nerve is given off. This passes to the root of the mesentry which it enters and represents the splanchnic nerves. The cord from this point on becomes less of a trunk and more of a true ganglionated cord, and lies embedded in the hypaxial musculature.