A CONTRIBUTION TO THE ANATOMY OF THE PILOT WHALE (*Globiocephalus Svineval*, Lacépede). By PROFESSOR TURNER.

IN the spring of the present year a shoal of Pilot Whales entered the Firth of Forth,—one of these, a young female, about 8 feet long, I obtained for the Anatomical Museum of the University, and as the anatomy of the soft parts of this cetacean has not received much attention, I have drawn up a brief account of some of the most interesting facts observed in the course of the dissection.

ARCH OF AORTA AND GREAT ARTERIES.—The arrangement of the aortic arch and great vessels proceeding from it in the cetacea has been chiefly studied in Delphinus phocæna, in which animal two innominate arteries are found arising from the transverse part of the arch. But whilst Cuvier and Meckel state that each innominate artery divides into a carotid, subclavian, and vertebral branch, Stannius has pointed out[1] that the common carotid trunk is completely wanting and that the internal and external carotids arise directly from the innominate artery. This description of Stannius has been confirmed by Barkow, Rathke and myself[2].

In the pilot whale the aorta *A* arched to the left, and at the place of junction with the ductus arteriosus *D* suddenly diminished in size. The right and left coronary arteries arose from its sides close to its origin. From the transverse part of the arch two large innominate arteries proceeded. The right ascended for about an inch and then divided into two branches. The anterior, somewhat the larger, gave off: *a.* carotis cerebralis, which ran forwards without branching as far as the basis cranii, where it passed through the carotid canal into the cranial cavity. *b.* carotis facialis, which ran forwards to supply the tongue, face &c. and for the most part represents in its distribution the external carotid artery. *c.* art. subclavia, which arched outwards to the anterior limb and gave origin to a small

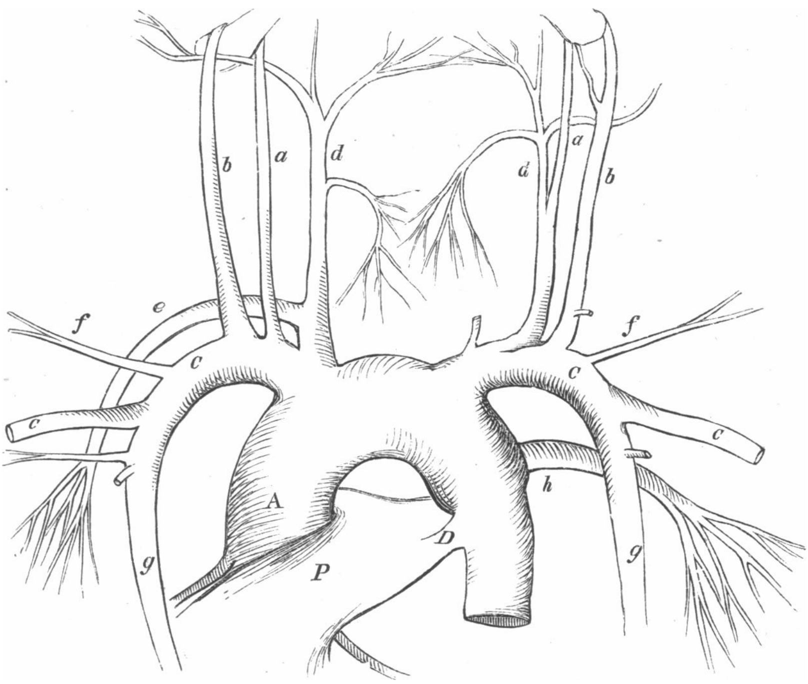
[1] Müller's *Archiv.* 1841, p. 379.

[2] *British and Foreign Medico-Chirurgical Review*, October 1862, p. 479.

transversalis colli *f*, and a large internal mammary branch *g*, the last-named being indeed of greater calibre than the continuation of the subclavian which passed to the anterior limb.

The posterior branch of the innominate artery after a course of ¾ inch divided into two branches: *d*. cervico-occipitalis passed forwards deeply in the neck parallel to the windpipe, gave off small branches to form a network between the bodies of the cervical vertebræ and the pharynx, and then turned outwards on the inferior aspect of the scalene muscle to the posterior

Fig. 1.



The arch and great arteries of the Pilot Whale. *A*, aorta. *P*, pulmonary artery. *D*, ductus arteriosus. *a*, carotis cerebralis: the diminution in calibre of this artery in the course of its ascent is not sufficiently represented in the figure. *b*, carotis facialis. *c*, subclavia. *d*, cervico-occipitalis. *e*, thoracica posterior dextra. *f*, transversalis colli. *g*, mammaria interna. *h*, thoracica posterior sinistra. For the drawing of this and the succeeding figures I am indebted to Dr J. W. Moir.

part of the cranium. *e.* art. thoracica posterior dextra passed behind the right pleural membrane to break up into branches for the large thoracic rete. In the porpoise, according to Stannius, the right innominate artery does not subdivide into two branches but gives off each vessel independently in the following order, right posterior thoracic, cerebral carotid, facial carotid, occipito-cervical and subclavian. In a specimen which I dissected not only did these vessels spring from the right innominate, but, between the origins of the facial carotid and occipito-cervical, a branch arose, which passed inwards behind the pharynx, to assist a corresponding vessel from the opposite side, in the formation of the large prevertebral cervical rete.

The left innominate artery gave off close to its origin a small branch to the thyroid gland and windpipe, and then ascended for about half an inch, when it also bifurcated into an anterior and posterior branch. The anterior branch divided into *b* the carotis facialis and *c* the subclavia sinistra, from the latter of which arose the transversalis colli *f*, and internal mammary *g*, arteries before it entered the anterior limb. The posterior branch ascended for somewhat more than an inch, and then divided into *a* the carotis cerebralis and *d* the cervico-occipitalis. The art. thoracica posterior sinistra *h*, arose from the back of the arch just before it was joined by the ductus arteriosus.

Stannius describes the left innominate artery in the porpoise as giving origin to the following separate branches, cerebral carotid, facial carotid, occipito-cervical and subclavian. The place of origin of the left posterior thoracic artery is not however constant in the porpoise. In Stannius' description, and in a specimen which I dissected, it arose from the arch, but in a second specimen (153), in the Anatomical Museum of the University of Edinburgh, it proceeded from the descending thoracic aorta nearly ½ inch below the ductus arteriosus.

The distribution of the posterior thoracic rete on each side in the pilot whale was most extensive, and the intercostal arteries participated very largely in its formation. The retia on opposite sides freely communicated across the middle line, and with a rich arterial network within the spinal canal, to which they sent numerous offshoots through the intervertebral foramina. As the more minute arrangement of the great thoracic rete in the cetacea, first discovered by Tyson, has been so carefully described by Hunter, Breschet and Von Baer, I need not further refer to it.

The cerebral or internal carotid arteries appeared to be the only arteries of supply for the brain, and it is important to note that as they ascended to the skull they underwent a very considerable diminution in calibre, without giving off any branches in the neck. Dr Sharpey[1] and Von Baer[2] have also directed attention to the great diminution in size of the internal carotid arteries in the porpoise before they enter the cranium. This is a fact of very considerable interest, as bearing on the question of the rapidity with which nutritive changes may take place in the very important organ to which these vessels convey a supply of blood. In this young pilot whale the brain was of large size, and weighed, after having been immersed for some weeks in spirits of wine, 58 oz., which is several ounces greater than the average weight of the adult human brain; but as the amount of blood, which its arteries of supply could transmit to it, is very much less than the quantity transmitted to the human brain through its vessels, it may fairly be assumed that the functional activity of the brain in the cetacean is very considerably slower, notwithstanding its greater size, than that of the brain of man. Hence, in comparing brains with each other, it is not sufficient to consider merely, the differences in their absolute weight, or in their weight, as compared with the weight of the body, but their relative vascularity should be determined.

Each cerebral carotid artery, after it had entered the cranial cavity, gave off branches, which passed not only forwards and outwards to the lobes of the cerebrum and the tentorial aspect of the cerebellum, but backwards to the occipital surface of the cerebellum, the pons and the medulla. One posterior branch ran inwards to the middle line, where it joined a corresponding branch from the opposite artery to form a median vessel, which

[1] *Reports of British Association*, 1834, p. 683.
[2] *Nova acta Phys. Med.* Vol. XVII. 1835.

extended backwards as far as the commencement of the spinal cord and gave off in its course branches to the occipital surface of the cerebellum.

Both the foramen ovale and ductus arteriosus were closed. In comparing the branches which arose from the two innominate arteries it will be seen that the arrangement was far from being symmetrical on the two sides, for not only had the posterior thoracic arteries very different origins, but whilst on the right side the cerebral and facial carotids and occipito-cervical arteries arose independently, so that no vestige of a common carotid existed, on the left the cerebral carotid and cervico-occipital arose by a common trunk, which may perhaps be regarded as in part representing the left common carotid artery.

THE PANCREAS, covered with peritoneum on its inferior surface, was situated in the anterior curvature of the stomach almost parallel to the 5th compartment, and lay therefore across the abdominal cavity. It was upwards of 6 inches long by $2\frac{1}{2}$ inches at its broadest part. It was succulent, and its lobules were, owing to the small amount of interlobular connective tissue, more closely aggregated together than is seen, for example, in the human pancreas. There was no gall-bladder, but entering the substance of the pancreas, close to its right extremity, were two wide and distinct bile ducts, which almost immediately joined to form a common tube, which, after a course of half an inch, was joined, whilst still enclosed by the lobules of the gland, by a large, strong-walled, pancreatic duct.

STOMACH. The stomach in the cetacea is a complex organ, and is subdivided into several compartments, the number and size of which is by no means uniform in the different genera. In the genus Hyperoodon seven compartments have been described, whilst in other genera, three, four, or five are said to exist. Anatomists, however, not unfrequently differ in their statements of the number of subdivisions of the stomach even in the same animal, the difference arising from the circumstance that a part, which some consider to be a distinct, though perhaps small compartment, is by others regarded only as a channel, or tubular passage, connecting larger subdivisions of the organ.

The stomach of the common porpoise has been most frequently examined, and it may assist in making clear the construction of the organ in the pilot whale, if I compare it with the stomach of the porpoise, two specimens of which I have at the same time studied, but in making the comparison, it should be kept in mind that the stomach of the porpoise was from an older animal than that of the pilot whale.

In this young pilot whale the 1st compartment (1) was 6 inches long, somewhat ovoid in form and opened into the bottom of the esophagus by an aperture, which admitted only two fingers, and which was neither so large nor so direct as the corresponding opening in the stomach of the porpoise. Its mucous membrane had the same general appearance as that of the esophagus, and was covered by a thick, laminated, squamous epithelium, but the membrane was not so rugose as in the corresponding compartment in the porpoise. From the character of its epithelium this compartment might indeed rather be regarded as an esophageal pouch than as a true digestive chamber.

The 2nd compartment (2) formed a large globular bag. It communicated directly by an aperture, which readily admitted four fingers, with the lower end of the esophagus, and which indeed, in this young specimen, was more direct than that of the 1st compartment with that tube[1]. Its mucous membrane presented however a very different appearance from that of the first, for large folds, laterally connected, wound spirally round the interior of the bag, and on the free surface of the membrane the mouths of numerous glands were visible. The line of separation between the esophageal and gastric mucous membrane was sharply marked by a circular fold, covered with thick esophageal epithelium, which surrounded the orifice of the 2nd compartment. In its general form, and the appearance of its mucous membrane, it closely resembled the corresponding com-

[1] After this description was written, I had the opportunity, through the courtesy of Dr Murie, of seeing a much larger stomach, from an older specimen of this species of whale, in which the relative size of the openings into the first and second compartments was reversed, that into the first being larger than the opening into the second.

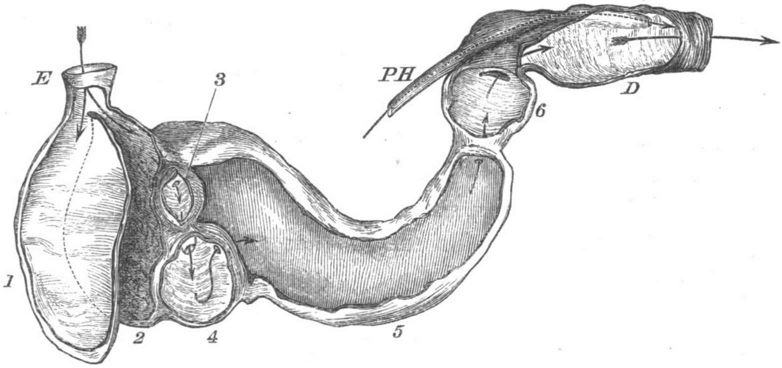
partment in the porpoise, but in the latter the opening was not into the esophagus, but into the 1st compartment, and luxuriant folds of the mucous membrane projected around the orifice.

Anatomists are in the habit, when comparing the complex ruminant stomach with that of the cetacean, of pointing out that in the former, two, if not three, compartments, communicate directly with the bottom of the esophagus, so as to permit of the passage of the food directly from the esophagus into one or other of the subdivisions of the stomach; whilst in the cetacean all the food must pass into the first compartment before it can be transmitted into the second. This statement, though undoubtedly correct as regards the porpoise and many other cetacea, could not be applied to the stomach of this pilot whale, in which the esophagus, when the eye was directed down the tube, could be seen freely to communicate at its lower end both with the 1st and 2nd compartments; so that a provision would seem to exist in this animal for permitting a process of rumination as far as regards the contents of these two compartments, and an additional link is established between the ruminant and cetacean stomach.

The aperture of communication between the 2nd and 3rd compartments was situated at the upper part of the intervening septum, and was only $\frac{1}{4}$ inch in diameter. The 3rd compartment (3) was the smallest of all the subdivisions of the organ, and, from its size, form, and position, evidently corresponded to the 3rd stomach of the porpoise. Before being opened into, it seemed to be only a tubular passage, or channel of communication, between the 2nd and 4th compartments; but, when the wall was cut through, a distinctly dilated sac-like cavity, of the size and shape of a large walnut, was recognised. The mucous membrane had the same colour as that of the 2nd compartment, and presented a few faintly marked folds and gland orifices. At its lower part the 3rd compartment communicated by an orifice, $\frac{3}{8}$ths inch in diameter, with the 4th subdivision of the stomach.

The 4th compartment (4) reached the lower border of the stomach. It was globular in form and as big as a medium-sized orange. Its muscular coat was much thinner than that of

Fig. 2.



Dissected stomach of young pilot whale arranged to show the communications between the compartments. *E*, esophagus. 1 to 5 inclusive, the five subdivisions of the stomach. 6, the dilatation immediately preceding the cylindrical duodenum. *D*, duodenum. *PH*, the conjoined pancreatico-hepatic duct.

the 1st and 2nd compartments, and its mucous membrane was almost smooth, but showed the mouths of numerous glands. No corresponding compartment is differentiated in the stomach of the porpoise[1]. It communicated with the 5th compartment by an opening somewhat smaller than the aperture of inlet.

The 5th compartment (5), homologous with the 4th or sigmoid stomach of the porpoise, was about 10 inches long, curved in its direction, and approached the cylindrical in form. It lay across the abdomen, and its left extremity extended beyond the 3rd and 4th compartments, so as to come into relation with the 2nd, where it formed a somewhat dilated cul-de-sac. Its muscular coat was comparatively thin; its mucous membrane was smooth, and numerous gland orifices were seen on its surface. It was evidently an important digestive chamber. A thick septum, pierced by an orifice in the centre, large enough to admit a quill, was situated at its right extremity. It resembled the septum at the intestinal end of the 4th compart-

[1] If the part of the left end of the sigmoid stomach of the porpoise, which forms a cul-de-sac below the opening into the 3rd compartment, were cut off from the rest of the sigmoid stomach by a septum, having an orifice in its centre, it would represent the 4th compartment of the pilot whale.

ment of the porpoise's stomach, and had the appearance of a pyloric valve. Through this orifice the 5th compartment communicated with a dilatation (6), as to the nature of which it is not easy to decide. In its general form it was not unlike that dilated portion of the alimentary canal in the porpoise, which John Hunter described as a 5th stomach, but which Professor Owen, on account of the conjoined biliary and pancreatic ducts opening into it, has more correctly regarded as the dilated commencement of the duodenum in that animal. In the pilot whale, however, the hepatico-pancreatic duct did not open into the dilatation, but on the summit of a papilla situated in the cylindrical tube of the duodenum. At the line of junction of this dilatation with the cylindrical part of the gut the canal was bent at a very decided angle, and a fold of mucous membrane projected for some distance across, so as materially to diminish the size of the passage. The mucous lining of this dilatation was almost smooth. Attempts have occasionally been made to show that the number of subdivisions of the stomach is uniform in the various genera of the cetacea. Meckel (*Vergleich Anat.* Vol. IV. p. 525) is of opinion that only three subdivisions exist, whilst the author of the article Cetacea in the *Cyclopædia of Anatomy and Physiology* considers it probable that five is the typical number of compartments. From the comparison which I have instituted between the stomachs of the porpoise and pilot whale, I do not think we are in a position to lay down any such general proposition; for, leaving out of consideration the dilatation marked 6 in the drawing, fig. 2, as to the nature of which there is room for a difference of opinion, we find that there are five distinct compartments in the stomach of globio-cephalus, whilst only four can be recognized in the porpoise, the compartment, marked 4 in the former, not being differentiated in the stomach of the latter.

In the cylindrical duodenum the valvulæ conniventes, somewhat faintly marked at first, gradually increased in size and number, and 2¾ inches beyond the projecting fold of mucous membrane, which marked the commencement of this part of the gut, the conjoined pancreatico-hepatic duct opened by a single orifice at the summit of a papilla. This duct after leaving the pancreas joined the wall of the dilatation beyond the 5th stomach, and became so closely blended with it, that they were invested by the same serous membrane. It acquired also a very powerful muscular coat, and continued in intimate connection with the duodenum, its position being marked by a slight ridge on the surface, and then passed very obliquely through the duodenal wall to open on the summit of the papilla already described.

KIDNEY.—Each kidney was 7 inches long and, as in the porpoise, was subdivided into a large number of small pyramidal lobes, to the apex of each of which the lobular branches of the renal vessels and the calyx were attached. The calyces from the different lobules united to form an elongated tubular ureter, which, without dilating into a pelvis, left the kidney close to its posterior end. The renal vessels, on the other hand, lying close together, entered the kidney near its anterior extremity. The cortical substance of each lobe was very vascular, and contained numerous Malpighian tufts and convoluted uriniferous tubules. The pyramidal substance was almost non-vascular, and in the injected kidney its white appearance presented a striking contrast to the red cortex. It was not possible to inject the tubuli uriniferi from the ureter, the elongated form of the papilla on which they open and the small size of their orifices interfering with the admission of the injection.

THE BLADDER was almost cylindrical in form and remarkably small for so large an animal. It ended in a funnel-shaped urethra, which lay for 4 inches in close contact with the inferior wall of the vagina. The ureters opened into the bladder, close to the urethral orifice, and from their position, as well as the small size of the bladder, it is probable that but a small quantity of urine could collect in that organ prior to its excretion.

THE VAGINA, 6 inches long, was comparatively smooth internally close to its orifice, but its mucous membrane gradually became rugose, and at its deeper end was thrown into strong transverse folds, between which a quantity of thick mucus was collected. The cervix uteri, 1 inch long, opened by a narrow orifice, the lips of which were liable to be confounded with the upper transverse mucous fold of the vagina. Into the summit of the cervix the mouths of the two uterine cornua opened.

THE THYROID GLAND.—As considerable difference of opinion existed amongst anatomists regarding the presence of a thyroid gland in the cetacea, I undertook some years ago an inquiry into the subject, and examined and described the gland in the Porpoise (*Trans. Roy. Soc.* Edinb. 1860). In the pilot whale also this gland was found situated on the inferior aspect of the cricoid cartilage, and extending forwards and upwards towards the sides of the thyroid cartilage. The lymphatic glands of the neck, more especially on the left side, were well developed.

SPLEEN.—Only 4½ inches long, consisted of one principal mass, with five more or less perfectly separated lobes, which varied in size from a fig to a kidney-bean.

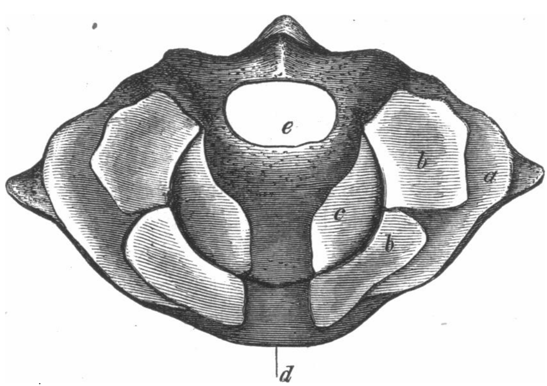
LACTEAL VESSELS AND MESENTERIC GLANDS.—When the abdominal cavity was opened, and the intestines spread out, the lacteal vessels, distended with chyle, could be seen traversing the mesentery from its intestinal towards its vertebral border, some lying along with, others between, the branches of the mesenteric artery and vein. By the union of two, three, or more of the smaller lacteals larger vessels were formed, which sparingly anastomosed with each other through lateral communications. At the root of the mesentery many lymphatic glands were situated, one of which, especially large, was 2¾ inches long. To these glands the lacteals converged in large numbers, and though many entered their interior, yet a very considerable number ramified *on the outer surface of the glands*, and covered them so closely that the gland substance was almost entirely concealed. It is quite possible that the lacteals which invested one gland might, in their onward course, enter the interior of another somewhat nearer the spine. When the glands were bisected the surface of section presented a creamy aspect, doubtless from the quantity of chyle which they contained. In the *Philosophical Transactions for* 1796 Mr Abernethy describes, in a male balæna, the lymphatic glands as hollowed out internally into bags, with which a number of the lacteal vessels communicated; but the glands of the pilot whale presented no cavities in their interior, and, even after a stream of water had been directed on the surface of the section for some minutes, so as to wash away the chyle, the only openings which could be seen were the mouths of divided vessels. An injecting pipe was passed by my assistant Mr Stirling into several of the larger lacteals proceeding to one of the glands, and a carmine and gelatine injection forced along it, many of the lacteals on the surface of the gland were filled, and a portion also passed into its interior. On section patches of red injection were seen, which at first sight might have been regarded as lying in cavities; but careful examination showed that the appearance was due to extravasation of the coloured injection amidst the textures of the gland. The bag-like cavities, described by Mr Abernethy, may have been and probably were artificially produced in his preparations by the breaking down of the gland structure in the act of injecting. The death of this animal, at a time when absorption was actively going on, and the lacteals filled with chyle, has enabled me to show, even more conclusively than was done by Dr Knox in his experiments[1], that in the cetacea, as in other mammals, the chyle is conveyed to the blood by a special system of vessels, which in their course become connected with the glands situated at the root of the mesentery. The intestinal mucous membrane presented numerous transverse valvulæ conniventes. Its free surface to the naked eye seemed perfectly smooth, as if destitute of villi. When an inverted portion of the gut was held up to the light, and examined by a simple lens, a slightly flocculent appearance was recognised; and when these flocculi were looked at with higher powers they were found to be elongated narrow processes, connected by their bases with the narrow bands of mucous membrane which separated the circular, or oval, mouths of the large Lieberkühnian glands from each other. These processes were by no means scattered over the whole surface of the membrane, and the duodenal portion seemed to be without them. This

[1] *Edinburgh Medical and Surgical Journal*, p. 28. 1824.

part of the gut indeed, with the numerous, closely-set mouths of its Lieberkühnian glands, resembled in its appearance much more the mucous membrane of the large intestine in an ordinary mammal, than that of the small. From their comparatively scanty numbers, their irregular distribution, and attenuated aspect, these processes did not seem to be structures of primary importance; and evidently played but a small part, if any, in the absorption of the chyle. A rich net-work of fine chyle-filled lacteals could be readily seen immediately beneath the free surface of the membrane. In connection with the distribution of the lymphatic glands it may be noted that a large cluster lay close to the lower end of the rectum.

CERVICAL VERTEBRÆ.—It was possible in this young animal to trace the order of ossification of the stunted cervical vertebræ with each other. The ventral part of the ring of the atlas was blended with the corresponding portion of the 2nd vertebra, and sent backwards a median process below the bodies of the 3rd and 4th vertebræ. The lateral portions and transverse processes of these bones were separated by cartilage, and the tips of the transverse processes were still cartilaginous. Owing

Fig. 3.



a, *b*, *b*, condylo-articular surface of atlas, the part *a* is yet cartilaginous. *c*, condylo-articular surface of axis. *d*, non-articular part of atlas. *e*, non-articular part of axis.

to the shallowness of the anterior articular surface of the atlas, the anterior surface of the body of the axis was in part also encrusted with articular cartilage, came into relation with the occipital condyles, and assisted in the formation of the cranio-vertebral joint. In and immediately on each side of the middle line the anterior surface of the atlas was non-articular, was continuous by ossific union with a similar non-articular portion of the axis, and corresponded to the interval between the occipital condyles. The bodies of the 3rd, 4th, and 5th vertebræ were ossified with each other and with the 2nd, but it was possible to see in a longitudinal section through the bodies, by a difference in the texture of the bone, where the original line of demarcation between the bodies had been, and a narrow ring of unossified fibro-cartilage marked externally the position of the inter-articular disk. The bodies of the 6th and 7th vertebræ had complete fibro-cartilaginous disks between each other and the vertebræ above and below. The spines and laminæ of the 1st and 2nd were blended with the left but not with the right lamina of the 3rd vertebra. The spines of the 4th, 5th, and 6th vertebræ were ossified into one mass, but the 7th was free in its entire extent. The transverse processes had no foramina at their roots.

The description of the Brain will form the subject of a future communication.