ON THE ANATOMICAL STRUCTURE OF THE VAGUS NERVE.

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WHILE recently engaged in investigating the condition of the vagus nerve in general paralysis of the insane and in beriberi, I undertook, at the suggestion of Dr Mott, in order to facilitate this examination, a further investigation into the normal anatomy of this nerve, and in this way many facts were ascertained which have not, so far as I can discover, been hitherto described. These details of structure are of interest to the physiologist, and a knowledge of them is indispensable when a complete examination of the vagus in pathological states is attempted.

Ten vagus nerves were examined in their course from the jugular foramen above to the root of the lung below. Transverse sections of the nerves were made in different situations, namely, where the superior laryngeal branch leaves the main trunk, and at various points above this level; at the point of divergence of the inferior laryngeal, and below this level; as well as at a point between these two levels. Sketches of the appearances presented by the transverse sections (figs. 1, 2, 3, and 4) were made accurately to scale, and were arranged side by side in a descending series, for the sake of ready comparison. Transverse sections of the laryngeal and other branches were also made separately at the above-mentioned levels, in order to check the conclusions arrived at as to the position of these branches in the main trunk. In addition, longitudinal sections were made, corresponding to the transverse ones. The stains found most useful were osmic acid, methylene blue, and safranin. Immediately after death the cadavera were, in accordance with the usual mortuary routine, placed in a chamber maintained at 28° F. to 30° F. until the post-mortem examination took place.

By a study of transverse sections made as above described, the

following facts respecting the constitution of the vagus nerve were elicited. The vagus was found to be made up of bundles of nerve-fibres which present the peculiarity of being repeatedly rearranged as the nerve travels onward, so that the appearance of transverse sections (cp. figs. 1 and 2, C to F) is constantly altering, even at closely contiguous levels; that is, at levels which above the inferior ganglion are only a few millimetres apart, and in the neck are separated by a few centimetres. This rearrangement may be compared to that which occurs in the plexuses formed by the spinal nerves; for instance, the brachial plexus. And inasmuch as the appearance presented by sections at the same level (figs. 1 to 4) varies considerably in different nerves, particularly as to the size, number, and arrangement of the nerve-bundles, and the extent to which these coalesce with, or remain separate from, each other, it would appear that the arrangement of the nerve-bundles is not confined to a single type, but that several modes of arrangement are possible, as in the case of the brachial plexus already referred to.

At the level at which the superior laryngeal nerve (*sup. lar. n.*) leaves the main trunk (C, figs. 1 to 4), the inferior laryngeal nerve (*rec. lar. n.*) can also be recognised. The identification of the laryngeal nerves (and the same applies to other nerves whose position in the main trunk it may be desired to recognise) is made by a comparison of the mixed nerve with sections of the laryngeal nerves made separately, especial attention being paid to the size of the nerve-bundles, the thickness of their nerve-sheaths, and the character and arrangement of the septa within; and to the relative preponderance of medullated fibres in these nerves. If the inferior laryngeal breaks up early into smaller bundles, it may also be necessary to cut sections of the main trunk at levels intermediate between those of the divergence of the superior and inferior laryngeal nerves respectively, so as to follow the latter nerve upwards in the trunk of the vagus. The fact that the two laryngeal nerves can be recognised at the same high level is important, in view of the distribution of both to the same region.[1]

The vagus nerve varies in sectional area in different cases.

[1] Both nerves, however, contain cardiac branches. In the superior laryngeal a small collection of non-medullated fibres runs in the crico-thyroid nerve (this

Sometimes, when two vagus nerves from different subjects are contrasted in transverse section, the one may show at every level a distinctly smaller sectional area as compared with the other. The explanation of this difference is, perhaps, to be found in the circumstance that the vagus is readily stretched during removal, or in hardening if small weights are attached to the nerve.

The nerve-fibres of the vagus have been classified by Gaskell[1] into large medullated, which are about 10·8μ in diameter, small medullated, and non-medullated. My own observations (cp. figs. 5, 6, and 7) give similar results, the size of the large medullated varying from 8·7μ to 12μ, that of the small medullated being 3·5μ to 7μ, or even 8μ, and the non-medullated ranging from 1μ or 2μ to 4μ. The large medullated fibres contain relatively more myelin than the small medullated fibres, which thus appear to be constructed on a different type. The small medullated fibres, also, like the non-medullated, are very apt to exhibit varicosities, while the neighbouring large medullated fibres, though their outlines may here and there be wavy or irregular, yet remain, on the whole, much more free from distortion than the smaller fibres.

A study of transverse sections shows that the relative proportion of medullated and non-medullated fibres varies in different parts of the vagus. In the pharyngeal and also the laryngeal branches (particularly the superior laryngeal, cp. fig. 5) large medullated fibres are conspicuous;[2] in the main trunk of the vagus (fig. 6) small medullated and non-medullated fibres are abundant; the thoracic cardiac (fig. 7) and pulmonary nerves not unfrequently consist of non-medullated nerves, either pure or mixed with a very few small medullated fibres. Collections of non-medullated nerve-fibres are not uncommon in the main trunk

nerve is seen on the left imperfectly separated from the main trunk of the superior laryngeal nerve in C, fig. 2), and goes to join the cardiac branch given off from the upper cervical ganglion of the sympathetic. The cardiac nerves in the inferior laryngeal are much more numerous: they separate from the inferior laryngeal soon after its divergence from the main trunk, as shown in the diagram of the vagus accompanying figs. 1 to 4.

[1] "On the Relation between the Structure, Functions, Distribution and Origin of the Cranial Nerves; together with a Theory of the Nervous System of Vertebrata," *Jour. of Physiol.*, vol. x., 1889, pp. 153–212.

[2] The same is true of the branches of distribution of the glosso-pharyngeal, spinal accessory, and the hypoglossal.

at all levels, and sometimes in its larger branches, particularly the inferior laryngeal. These fibres of Remak are usually situated on the periphery, but are occasionally surrounded by mixed fibres (E, fig. 4). They seem generally to be on the point of leaving the nerve, to proceed to their area of distribution.

The appearance of the inferior ganglion of the vagus varies in different nerves. Transverse sections of the vagus at the level of this ganglion (figs. 1 to 4 at level B) sometimes exhibit a large main trunk containing nerve-cells surrounded by a few smaller bundles of nerve-fibres, as in fig. 3, B; sometimes the main trunk is small, and the surrounding nerve-bundles are of correspondingly larger size, as in fig. 2, B. In the former case the ganglionic mass is seen to occupy only a portion of the main trunk; in the latter case the nerve-cells are more evenly diffused through the whole, but in each case only a portion of the nerve-fibres goes through the ganglion, the remainder passing by the side of the ganglion. Nevertheless, in transverse sections of the vagus, nerve-cells are seen occasionally in the outlying bundles of nerve-fibres; and as these are repeated in successive sections, it follows that they are arranged in slender columns. From the main mass of ganglion-cells also sometimes one or several small columns of cells descend for some distance in the main trunk of the nerve, below the level at which the superior laryngeal diverges. Our conception of the inferior ganglion of the vagus is therefore not a simple one. It sometimes consists of an elongated mass of cells in the upper part of the main trunk of the vagus, while at other times it includes in addition separate slender cell-columns in outlying nerve-bundles, at the same level (*e.g.*, the superior and inferior laryngeal nerves), and a downward continuation in the trunk of the vagus, in the form of one or more cell-columns, for some distance below the divergence of the superior laryngeal.

The inferior ganglion of the vagus is regarded by Gaskell[1] as a vagrant ganglion or anterior-root ganglion, and of the nature of a sympathetic ganglion. By Van Gehuchten[2] it is regarded as analogous to the ganglia on the posterior roots of the spinal nerves. In the circumstance, referred to above, that only a por-

[1] *Loc. cit*, pp. 178–9.

[2] *Anatomie du système nerveux de l'homme*, Louvain, 1897, pp. 480, 481.

tion of the nerve-fibres, with which it is in relation, passes through the ganglion, it presents a striking resemblance to a posterior root ganglion, and a section through the vagus at the level of the inferior ganglion corresponds very closely to a section of a mixed spinal nerve taken through the ganglion on the posterior root.

The nerve-cells in the inferior ganglion of the vagus (fig. 8) also closely resemble in appearance the cells of the ganglia on the posterior roots of the spinal nerves. They are surrounded by multi-nucleated capsules; and though it is generally difficult to recognise any nerve-processes, yet a few cells can be seen to exhibit a single thick process which curves over the cell, surrounded by a prolongation of the capsule. The cells vary considerably in size (from 18μ to 36μ), staining power, degree of pigmentation, and the presence or absence of a nucleus. They are frequently retracted from their capsules, when their outline may be sharp or rugged. In all these points the inferior ganglion of the vagus bears so close a resemblance to the ganglia on the posterior roots of the spinal nerves that it is difficult to believe that it is not homologous with the latter.

In one case the skull was opened from behind, the vagus dissected out, and transverse sections of it examined at intervals of $\frac{1}{2}$ mm. down to the level of the inferior ganglion. They showed that the two ganglia were separated by an interval of 3 mm. The upper ganglion was $1\frac{1}{2}$ mm. long, and the cells of the two ganglia were not obviously distinct in character.

This work has been done in the pathological laboratory at Claybury Asylum, and my warmest thanks are due to Dr Mott for his invaluable assistance throughout.

DESCRIPTION OF PLATES VIII.–XII.

Fig. 1. On the right is seen a diagram of the vagus nerve, from the base of the skull to the root of the lung, with its principal branches—namely, the pharyngeal nerve (*phar. br.*); the superior laryngeal nerve (*sup. lar. n.*); the inferior cervical cardiac nerve (*inf. cerv. card. n.*); the recurrent laryngeal nerve (*rec. lar. n.*); and the thoracic cardiac and pulmonary nerves (*card.* and *pulm. brs.*). Above, the glosso-pharyngeal nerve (*gl. ph. n.*), the spinal accessory nerve (*sp. acc. n.*), and the hypoglossal nerve (*hypogl. n.*) are indi-

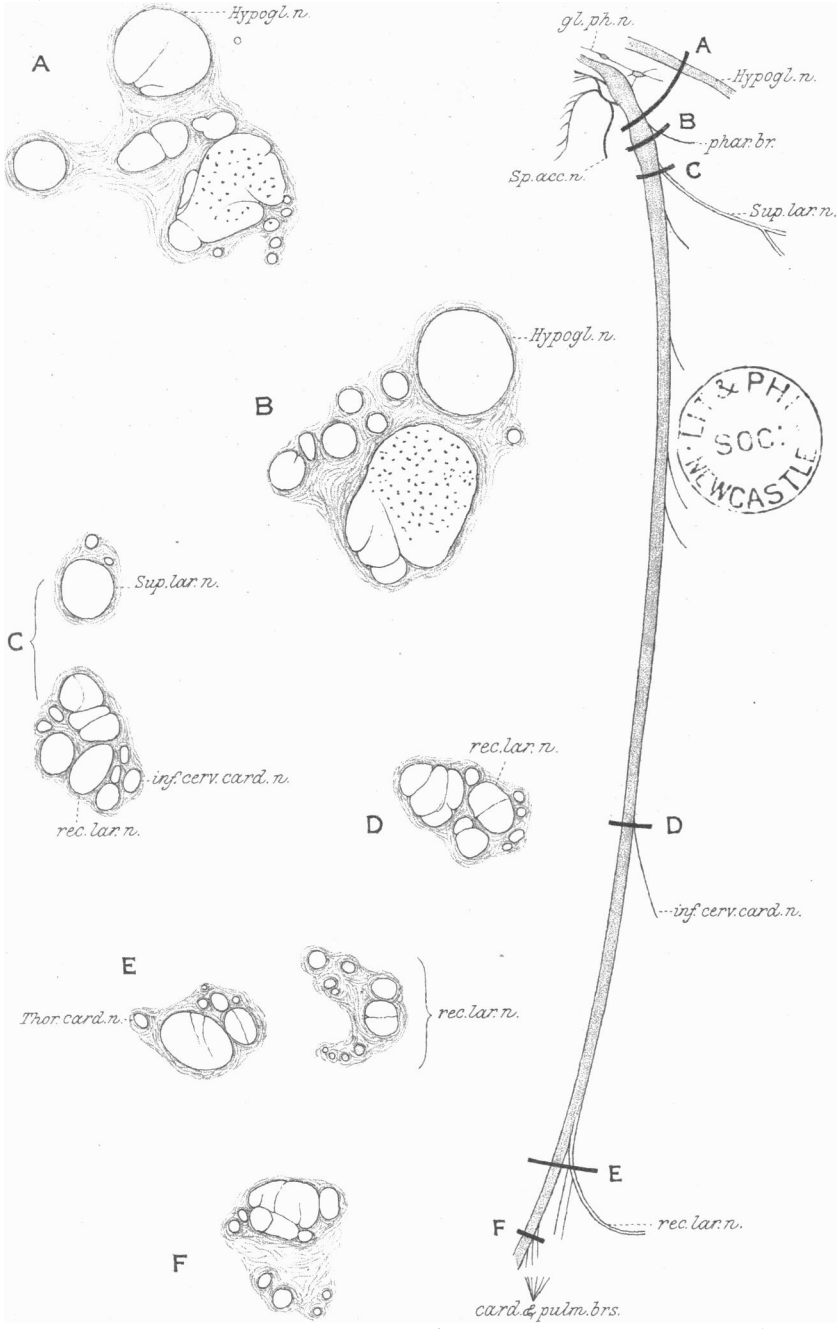
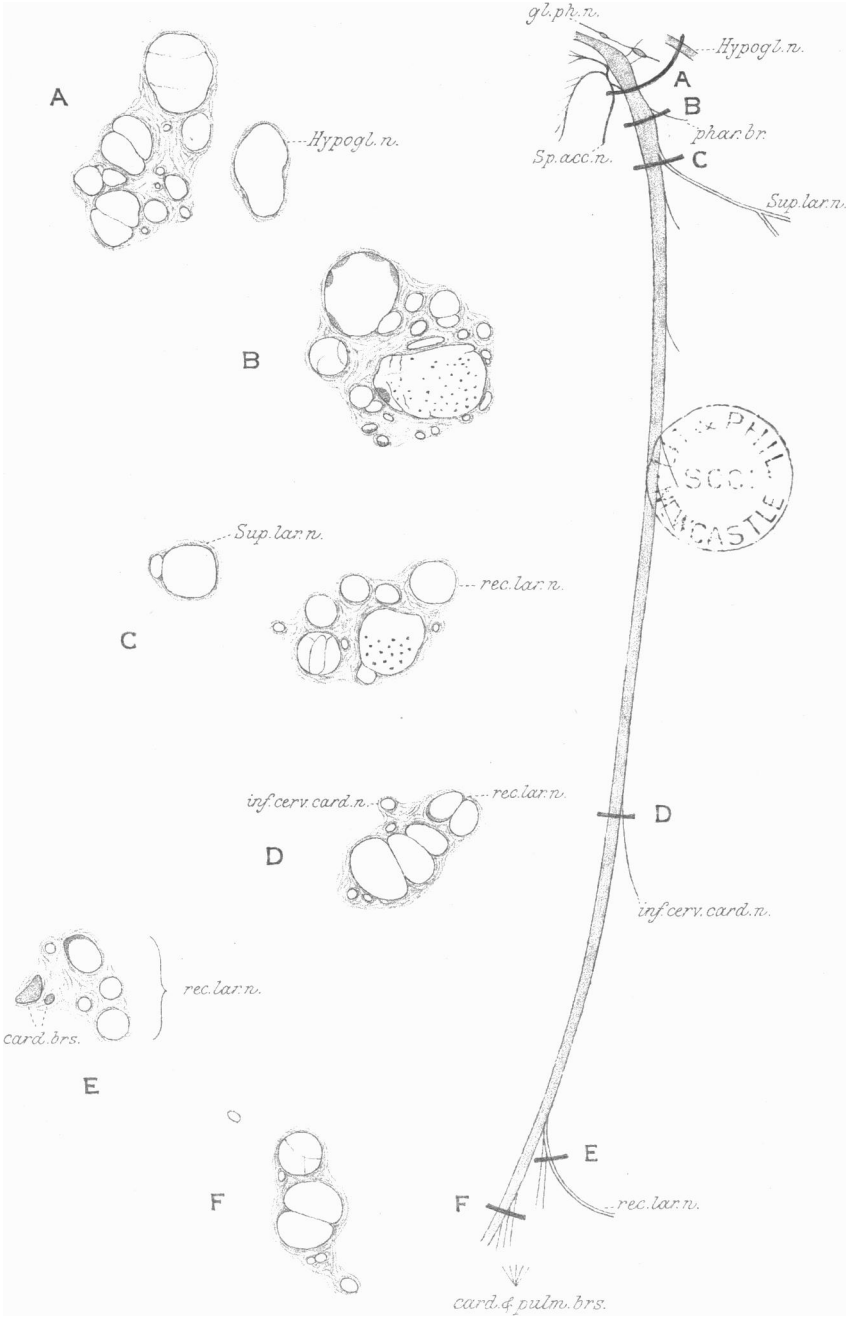


Fig. I.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C
inf.cerv.card.n.
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D
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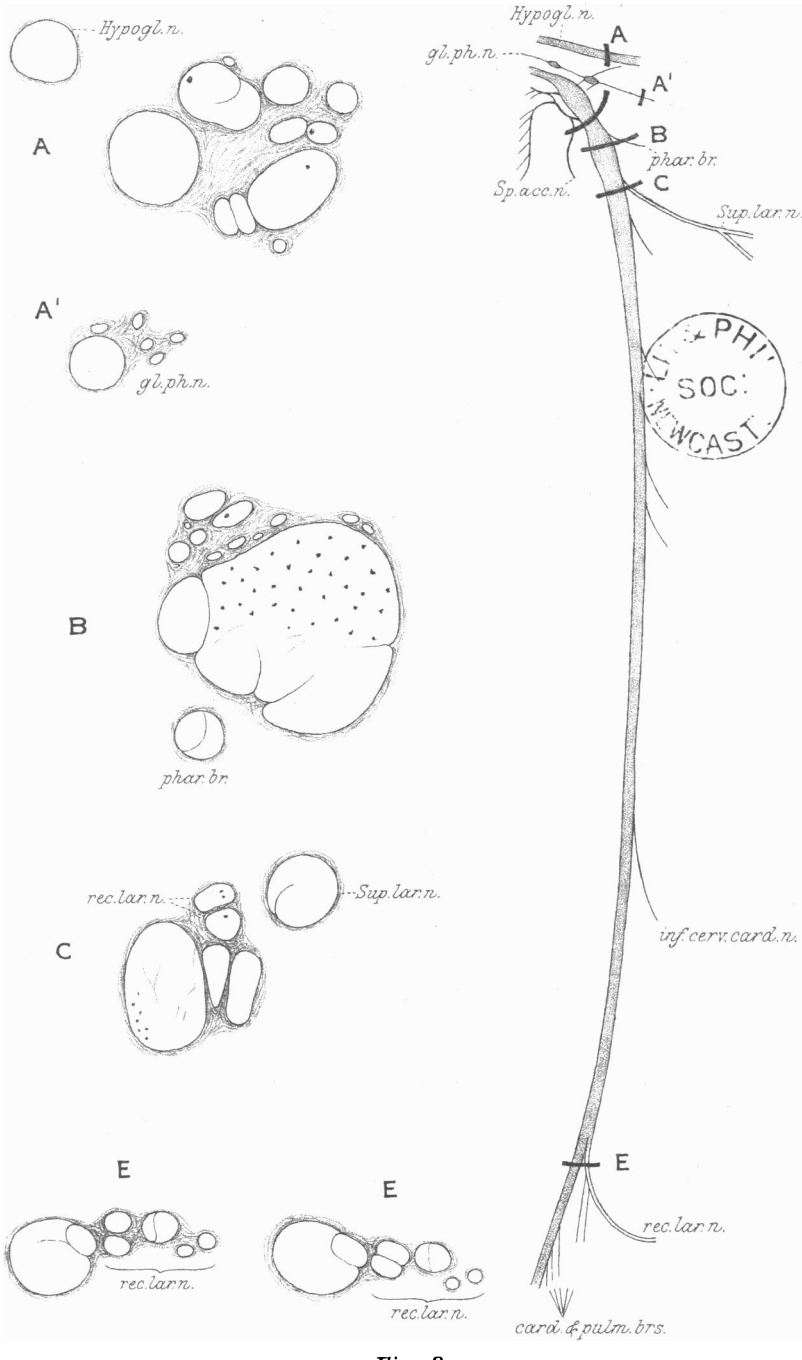
Fig. 2.


Hypogl. n.
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Hypogl. n.
gl. ph. n.
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A'
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phar. br.
C
Sp. acc. n.
Sup. lar. n.
A'
gl. ph. n.
B
phar. br.
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C
rec. lar. n.
Sup. lar. n.
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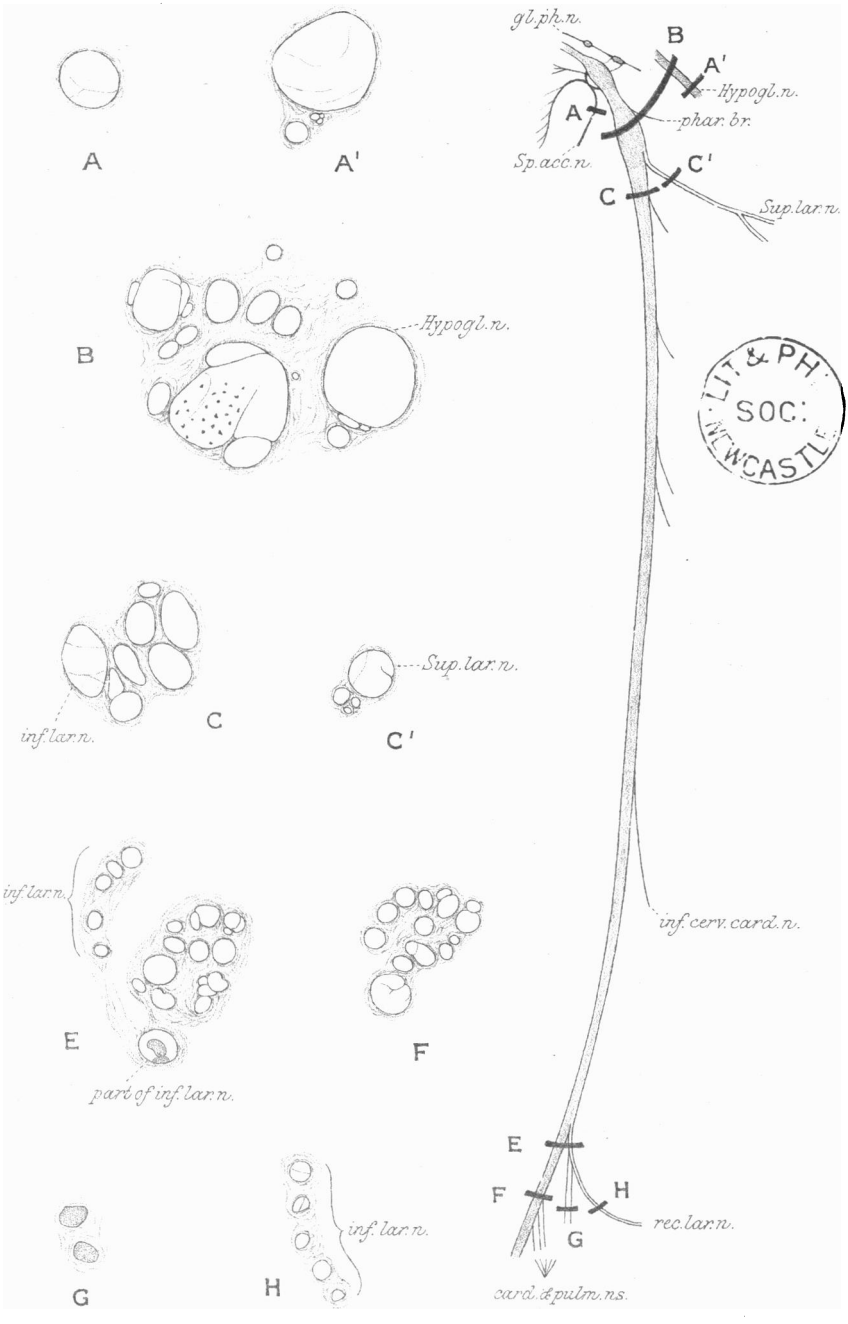
Fig. 3.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inf.lar.n.
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C'
inf.lar.n.
inf.cerv.card.n.
E
F
part of inf.lar.n.
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card. & pulm.ns.
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Fig. 4.

Fig. 5.

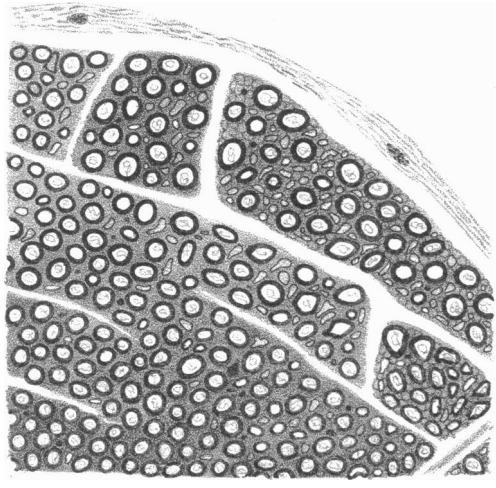
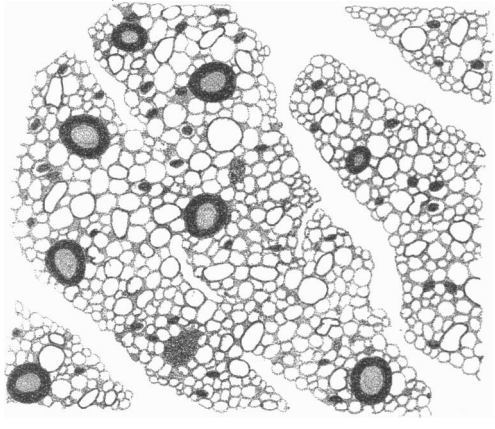


Fig. 6.



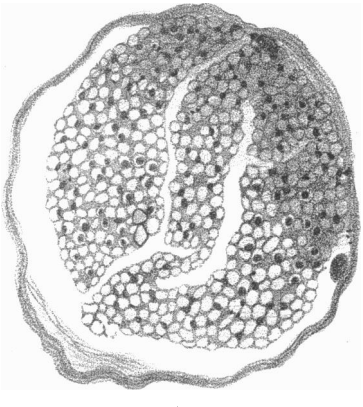


Fig. 7.

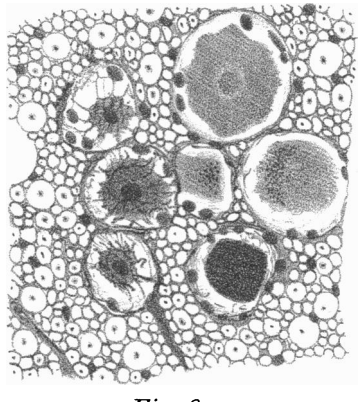


Fig. 8.

cated. The levels at which the transverse sections of the vagus are made are denoted by the thick black lines: A, above the inferior ganglion; B, through the middle of the inferior ganglion; C, at the point of divergence of the superior laryngeal nerve from the main trunk; D, at the point of divergence of the inferior cervical cardiac nerve; E at, and F below, the point of divergence of the inferior laryngeal nerve. This diagram is nearly of the natural size.

On the left are seen transverse sections of the vagus at the levels A, B, etc., all drawn to the same magnification, with such of the more important nerve-bundles as can be identified, indicated by the same lettering which is used in the diagram to the right. The nerve-cells of the inferior ganglion are shown in A and B. × 9.

Fig. 2 is similar to the above. The shaded areas in B, D, and E indicate collections of non-medullated fibres, those in D and E going to the cardiac plexus. Nerve-cells in the main trunk are seen at C.

Fig. 3 is similar to the preceding. In the transverse sections at A, B, and C, single nerve-cells, representing cell-columns cut across, are seen in the outlying bundles of nerve-fibres; and at C, nerve-cells are again present in the main trunk, as in the preceding fig. There is less division of the main trunk into separated bundles than in the preceding figs., particularly at C and E.

Fig. 4 is similar to the preceding. At E, the trunk is divided into a large number of bundles. At E and G, collections of non-medullated fibres are indicated by the light shading,—one such collection at the lower part of E (below the main trunk) being placed centrally.

Fig. 5. Transverse section of part of the inferior laryngeal nerve. Large and small medullated nerves are seen—the former preponderating. Above and to the right some non-medullated nerves are seen, though somewhat indistinctly; elsewhere these fibres are not recognisable, having been obliterated during the preparation of the section. × 375. Osmic acid. Safranin.

Fig. 6. Transverse section of the main trunk of the vagus at D (figs. 1 and 2). Large and small medullated, and non-medullated fibres are seen, the last predominating. The nuclei of the primitive sheaths of the non-medullated fibres are also seen. × 475. Osmic acid. Safranin.

Fig. 7. Transverse section of a small thoracic cardiac nerve. The nerve is made up of non-medullated fibres, the nuclei of which are readily distinguishable; two small medullated fibres are shown near the centre. × 375. Osmic acid. Safranin.

Fig. 8. Portion of a transverse section of the inferior ganglion of the vagus. Seven ganglion-cells are seen, varying considerably in their staining power, and exhibiting, with two exceptions, more or less faintly outlined nuclei. Three of the cells exhibit pigment-masses. The upper cells present an appearance of processes running between the body of the cell and the capsule. The capsules are multi-nucleated (the nuclei are not, however, so numerous as in the ganglia on the posterior spinal roots). Surrounding and separating the nerve-cells are numerous nerve-fibres, cut across transversely, most of which exhibit axis-cylinders. × 275. Aniline-blue.