The Journal of
Laryngology and Otology

(*Founded in* 1887 *by* MORELL MACKENZIE *and* NORRIS WOLFENDEN)

August 1954

THE AUTONOMIC NERVE SUPPLY OF THE THROAT, NOSE AND EAR*

By G. A. G. MITCHELL (Manchester)

THE general arrangement of the autonomic nervous system should be discussed before describing the innervation of particular structures, but as most readers of specialist journals possess this knowledge, preliminary information of a basic character will be confined to a few special points that are sometimes incompletely appreciated and to several others that are generally applicable.

First: the division of the nervous system into somatic and autonomic components is artificial, although it is convenient for descriptive purposes. These parts of the nervous system are neither separate nor distinct entities. They originate from common primordial cells, they develop together, they are built up from the same basic units or neurons associated in similar reflex arcs, they comprise central and peripheral parts, and structurally they are always related and often closely connected.

Second: the narrow belief that the autonomic part of the nervous system is merely a peripheral efferent mechanism should be discarded, for it is represented at every level in the central nervous system, a conception foreshadowed by Thomas Willis almost three centuries ago and formulated clearly by Hughlings Jackson about eighty years ago, but still not widely recognized. This basic fact explains why visceral and vascular disturbances may follow cerebral lesions or emotional upsets. We are all familiar with the violent palpitation, the ghastly pallor, the becoming

* A lecture arranged by the Joint Committee of the Institute of Laryngology and Otology and the Royal College of Surgeons and delivered at the College on May 6th, 1954.

NEURENT 1064

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

blush, the sympathetic tears, the laboured breathing, the rebellious stomach, the impatient bladder and so on that may be associated with such lesions or upsets, but we sometimes forget that other structures are involved in such disturbances. Thus the increased nasal secretion in conditions such as "honeymoon colds" or the dry nose and mouth of fever are the result of vasomotor and secretomotor effects produced through the autonomic nerves supplying the vessels and glands in the nose and mouth. And the nausea and vertigo occasionally associated with horrific sights or loathsome smells may not be purely psychological. Possibly the intense and unpleasant afferent impulses reaching the brain evoke exaggerated efferent impulses which may produce, amongst other things, vasomotor changes in the labyrinthine apparatus. Thus some processes commonly regarded as psychological or emotional, and due to abstract mental processes, may be the result of abnormal efferent autonomic impulses on visceral and vascular structures which in their turn produce disordered motor or sensory effects.

Third: the *parasympathetic* pre-ganglionic fibres supplying all structures in the head end of the body have their nuclei of origin in the brain and brain stem, and they form synapses with more than one neuron in peripheral ganglia located in or near the structures innervated (Fig. 1). Each parasympathetic pre-ganglionic fibre forms synapses with two or three ganglionic cells, but in sympathetic ganglia, which are generally located further away from the structure supplied, the disproportion between pre-ganglionic and ganglionic neurons (the latter give rise to the post-ganglionic fibres) may be as great as 1:17. This is one reason why parasympathetic effects are more limited than sympathetic, and there are others; the parasympathetic post-ganglionic fibres are short and have a more circumscribed distribution; and acetylcholine, which is the reputed mediator in the parasympathetic system, is more readily destroyed than nor-adrenaline.

The *sympathetic* pre-ganglionic fibres supplying structures in the head region are the axons of cells lying in the lateral (intermedio-lateral) columns of the upper thoracic cord segments. They emerge in the corresponding ventral spinal nerve roots and pass to the sympathetic ganglionated trunks in white rami communicantes. They relay in the stellate ganglion or ascend to form synapses in the middle and superior cervical ganglion, or in ganglia associated with the vertebral or carotid arteries. Thus some of the ear, nose and throat fibres may relay in ganglia on the internal carotid nerves, which may represent the cranial portions of the sympathetic trunks (Mitchell, 1953), while some of the other fibres supplying the nose and throat may relay in a ganglion located on the external carotid artery near the origin of its facial branch. Therefore, if for any reason it is desired to interrupt the entire sympathetic supply to the ear, nose and throat, and if it is immaterial whether the interruption

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

is pre-ganglionic or post-ganglionic, the simplest way to do this is to attack the stellate ganglion by surgical or injection techniques. If pre-ganglionic interruption is essential, the only certain way to effect this is to divide the upper thoracic white rami communicantes and the sympathetic trunks below the stellate ganglia, but in practice the first

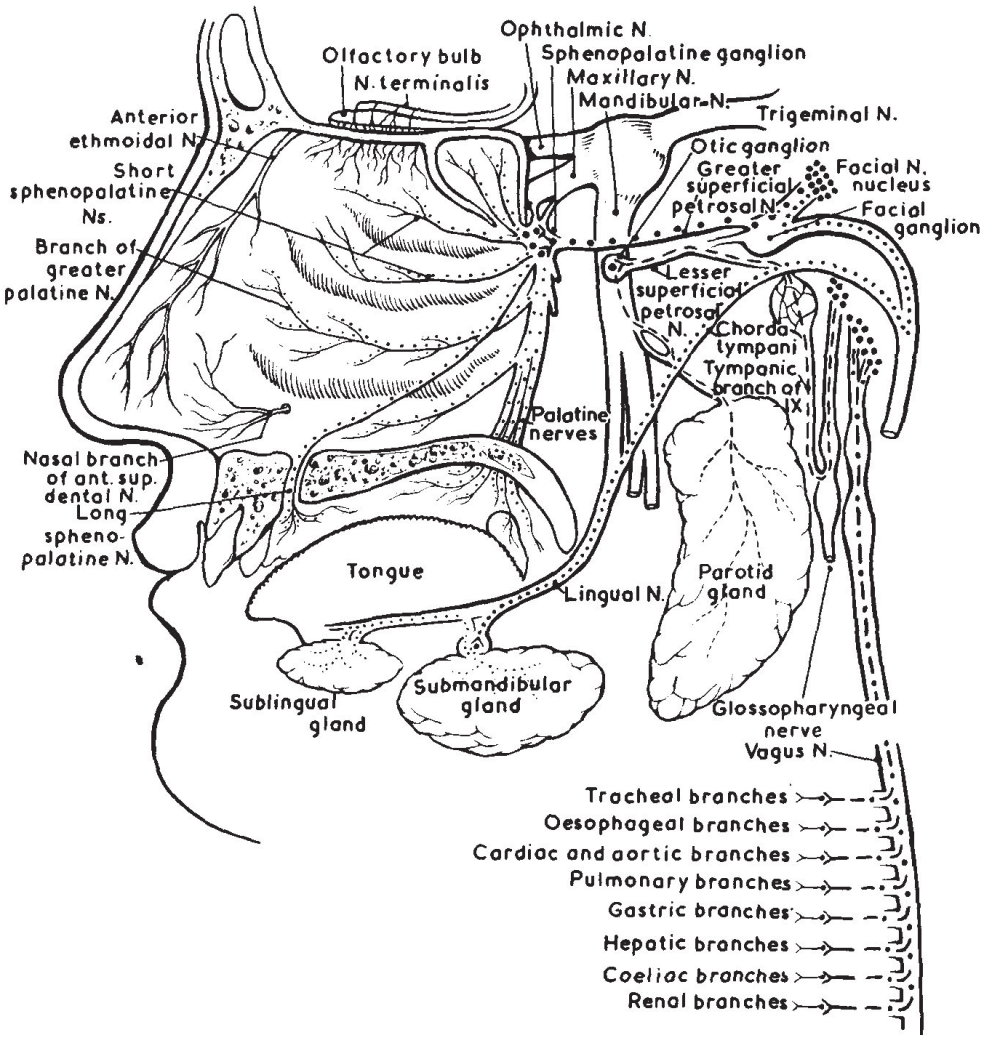


FIG. 1.

A diagram showing the pathways of parasympathetic fibres supplying most of the glands and vessels in the nose, nasopharynx and palate. To avoid confusion the sympathetic pathways are not shown. The pre-ganglionic pathways are shown by bolder dots or lines than the post-ganglionic.

thoracic rami are usually spared to avoid producing Horner's syndrome and vasodilatation and congestion of the nasal mucosa.

Fourth: the most evident effect of sympathetic activity is vaso-constriction and of parasympathetic activity vasodilatation and glandular

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

secretion. By virtue of their effects on vessels and glands they exercise a trophic influence on the structures they supply.

Fifth: although in general innervation is segmental there are exceptions to this rule. Thus the vagus and chorda tympani nerves cross segmental barriers and this indifference to developmental boundaries is also evinced by other nerves. Therefore a study of embryology, ontogeny or phylogeny will not provide indisputable evidence about the origin or innervation of certain parts such as the internal ear.

Sixth: at present wide credence is given to the theory that certain chemicals act as mediators in the transmission of nerve impulses across synapses and between efferent nerve endings and the structures they innervate. The evidence for this view is in some respects impressive, but it presupposes the existence of definite nerve endings, with junctional zones between them and the visceral structures innervated, yet there is no absolute proof they do exist and the evidence is much weaker in the case of autonomic than somatic nerves. It is true that such endings have been described both in viscera and vessels, but it is perhaps significant that the only convincing illustrations of these are drawings and not photomicrographs. A number of anatomists believe that true efferent nerve endings do not exist in visceral and vascular structures and maintain that the autonomic efferent fibres and fibrillae unite to form a very delicate *terminal reticulum* (Fig. 2) in or upon the structures innervated. A few go further and suggest there is syncitial continuity between the nerve fibrillae and the protoplasm of the effector cells. Others believe that the terminal reticula are really formed by the interlacing processes of small *interstitial nerve cells* which intervene between the terminations of the efferent fibres and the effector visceral cells: critics of this view claim that these autonomic interstitial cells are connective tissue elements, but there is good evidence that they are nervous (Meyling, 1953).

The Throat

The throat comprises the oropharyngeal isthmus, the pharynx and the larynx and these are innervated mainly from parasympathetic and sympathetic sources. The nasal part of the pharynx is a part of the nose, and the soft palate therefore separates the nasal chambers from the pharynx and shares in the innervation of both.

The Soft Palate.

The sensory supply is carried mainly in the palatine and glossopharyngeal nerves. The latter carries special visceral afferents from the few taste buds in the soft palate. The greater and lesser palatine nerves arise from the sphenopalatine ganglion, but the majority of their fibres really come from the maxillary division of the trigeminal nerve which is

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press



FIG. 2.

Terminal nerve reticulum around small arteriole (×420) revealed by combined intravital and supravital staining with methylene blue. Owing to the thickness of the section the whole plexus cannot all be brought into sharp focus at once. The connections, however, with the adjacent larger bundles of nerve fibres are clearly seen and the beaded or varicose appearance of most of the constituent fibrillae in the terminal network. (Reproduced by courtesy of E. & S. Livingstone from *Basic Anatomy* by Mitchell and Patterson 1954.)

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

connected to the ganglion by two or three branches (Figs. 1 and 7). A small proportion of the fibres in the palatine nerves, however, are *parasympathetic* efferents which reach the sphenopalatine ganglion in the greater superficial petrosal branch of the facial nerve and, after relaying in the ganglion, the post-ganglionic fibres are carried with its various branches to the nose, orbit, palate and pharynx. A number of *sympathetic* fibres are distributed with the same nerves, and they reach the sphenopalatine ganglion through the deep petrosal offshoot from the internal carotid plexus. Other sympathetic fibres reach the palate in the paravascular plexuses accompanying the palatine branches of the facial, maxillary and ascending pharygeal arteries, which are ultimately derived from the external carotid plexus.

The muscles of the soft palate (with the exception of the Tensor palati which receives twigs from the nerve to Pterygoideus internus) are supplied through the pharyngeal plexus by the cranial part of the accessory nerve, which is part of the vagal parasympathetic complex.

THE TONSIL.

The tonsil receives nerve filaments from the lesser palatine (Figs. 1 and 7) and glossopharyngeal nerves, besides a few direct nerve filaments from the pharyngeal plexus. Sympathetic fibres reach it *vîa* paravascular plexuses on the tonsillar branch of the facial artery, the dorsalis linguae of the lingual artery, and the palatine branches of the facial, ascending pharyngeal and maxillary arteries, which contribute to the blood supply of the tonsil.

These nerves are mixtures of fibres derived from several sources—sensory from the trigeminal nerve, parasympathetic from the facial and glossopharyngeal nerves, and sympathetic from the internal and external carotid plexuses.

THE PHARYNX.

Throughout most of the alimentary tract the sympathetic and parasympathetic nerves unite to form the *enteric plexuses*, which lie partly between the muscular coats (myenteric plexus) and partly deep to the mucosa (submucous plexus). In the pharynx, however, the myenteric part of the plexus is located on the surface of the striated (voluntary) constrictor muscles (Figs. 3 and 4) and filaments penetrate them to form a modified submucous plexus (Fig. 5).

The parasympathetic contribution comes through pharyngeal branches of the glossopharyngeal and vagus nerves, and they unite in a plexiform fashion with sympathetic pharyngeal branches of the superior cervical ganglia and with others derived from the plexuses accompanying the ascending pharyngeal, palatine and tonsillar arteries. The vagal fibres are the principal motor supply and originate in the nucleus ambiguus. They

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

Autonomic Nerve Supply of Throat, Nose and Ear

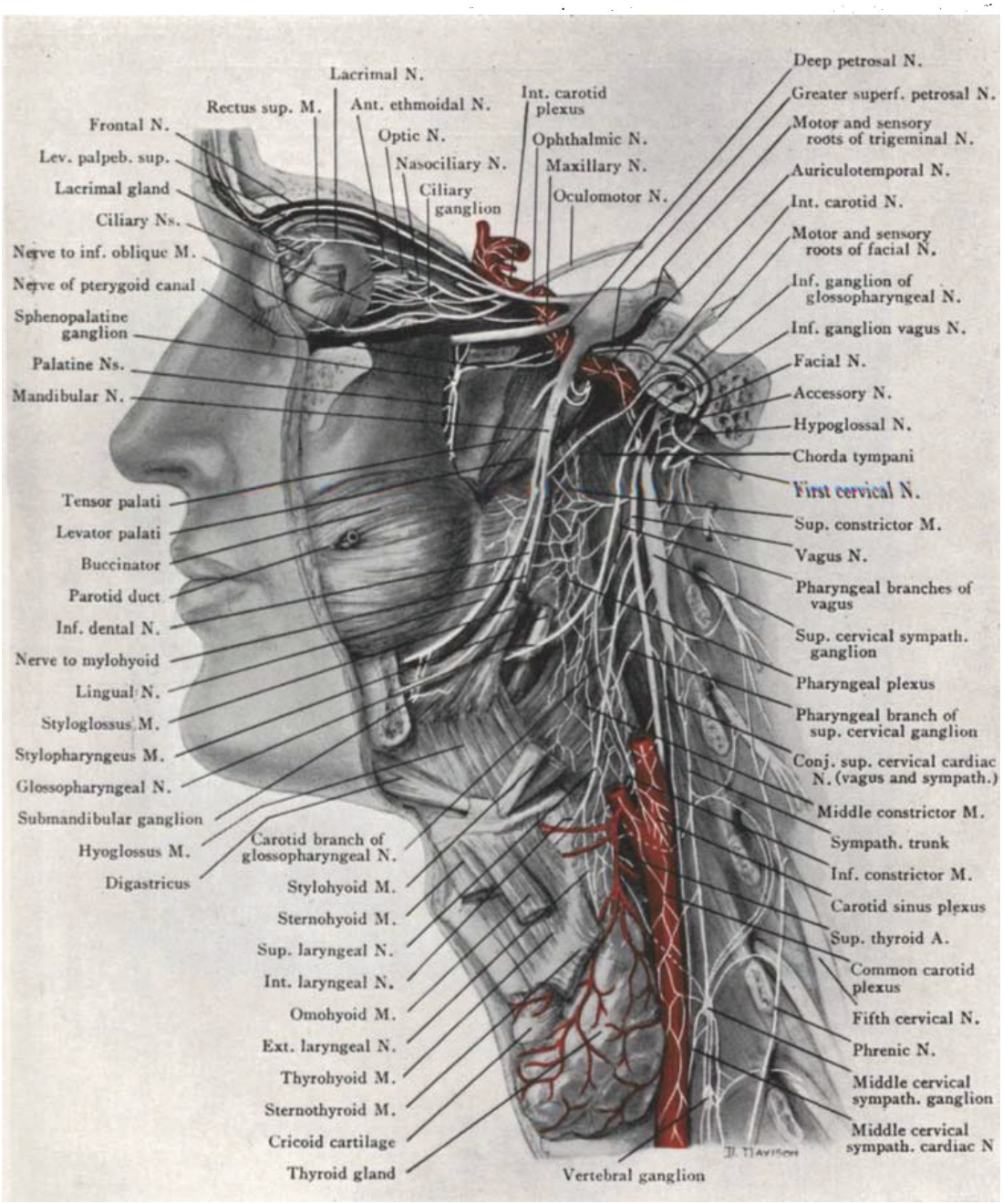


FIG. 3.

Lateral view of head and neck showing parts of the cranial parasympathetic nerves and the cervical portion of the sympathetic system. The pharyngeal plexus is seen spread out over the constrictor muscles. (Reproduced by courtesy of E. & S. Livingstone from Mitchell's *Anatomy of the Autonomic Nervous System* 1953.)

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

emerge from the brain stem in the cranial part of the accessory nerve, the part which joins and is distributed with the vagus, and they innervate all the pharyngeal muscles, except stylopharyngeus, which receives a direct supply from the glossopharyngeal nerve.

The glossopharyngeal and vagus nerves are also the main sensory nerves of the pharynx through the pharyngeal plexus, although the mucosa over the back of the larynx is supplied by the "loop of Galen" which is described later.

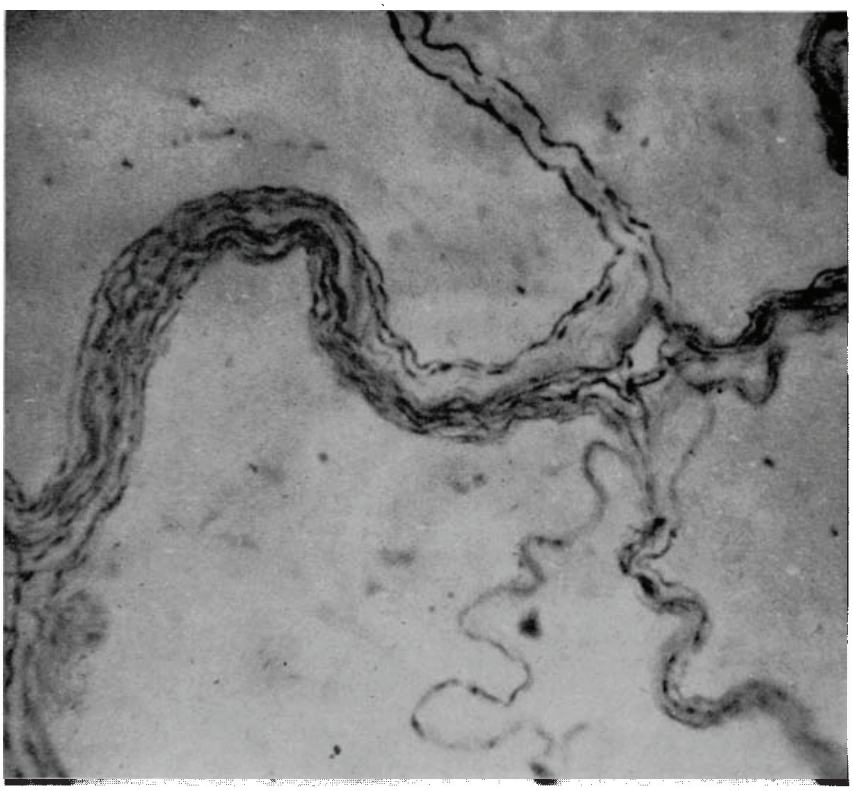


FIG. 4.
Nerve bundles (×135) forming part of the pharyngeal plexus displayed by combined intravital and supravital staining with methylene blue.

THE LARYNX.

The larynx is innervated by branches of the vagus and sympathetic. The vagal fibres arise in the nucleus ambiguus which is developed from the special visceral efferent column. Galen showed that the recurrent branches of the vagus nerves are the main motor supply of the larynx, but even now there are differences of opinion about their exact distribution, a matter of more than academic importance since these nerves are liable to injury in various operations.

Exner (1884) stated that the superior laryngeal nerves carry fibres for muscles other than cricothyroideus, and in particular to the transverse (inter-) arytenoid muscle, but Onodi (1902) claimed that they supply the

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

cricothyroid muscles only and that all the other laryngeal muscles are innervated by the recurrent nerves. Lahey (1938, 1944) alleged that in a proportion of cases the recurrent nerves divide outside the larynx into adductor and abductor branches, an idea that was accepted by Week and Hinton (1942), King and Gregg (1948), and Morrison (1952), and which is quoted by Rundle (1951) in the latest edition of Joll's *Diseases of the Thyroid Gland*.

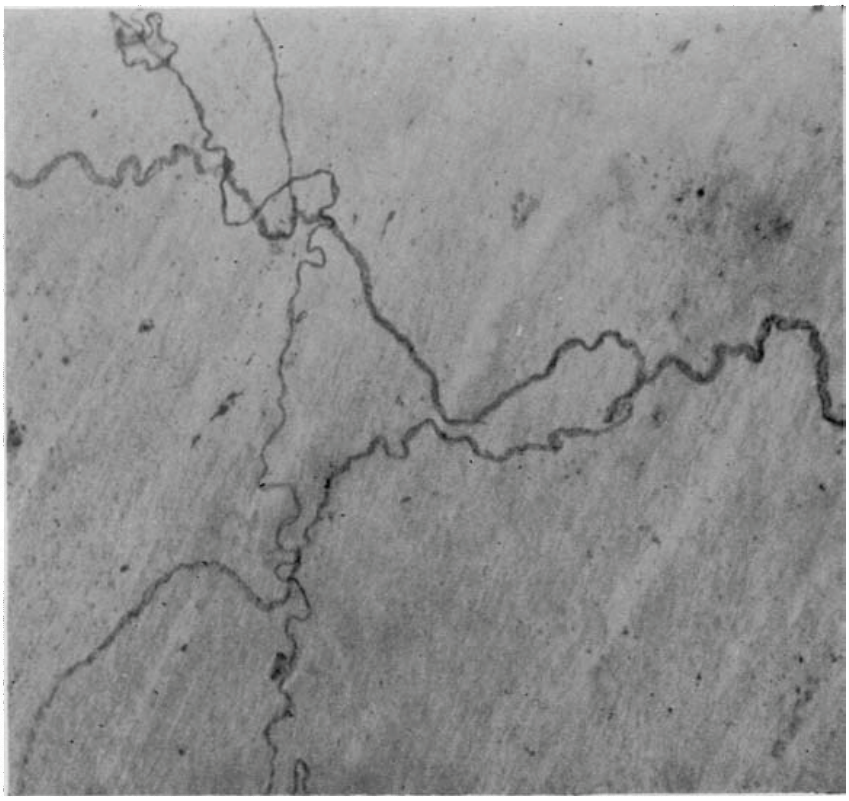


FIG. 5.
Fine bundles of nerve fibres (× 130) in the submucous tissue of the pharynx shown by combined intravital and supravital staining with methylene blue.

Williams (1951, 1954) working in my Department, has investigated this problem in man by:

(1) Careful dissections of the nerves in 50 adult larynges.
(2) Studies of serial sections of blocks taken from 16 larynges.
(3) Stimulation of the superior laryngeal nerve in two patients during block dissection operations on the neck and coincident observation of the cords.

He found that each *recurrent nerve* bifurcates into larger anterolateral and smaller posteromedial divisions a short distance below the larynx (Fig. 6).

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

The *anterolateral* branch enters the larynx behind the cricothyroid joint and under the lower border of the inferior pharyngeal constrictor. Soon after entering the larynx it gives off a short branch which enters the deep surface of crico-arytenoideus posterior and another which runs upwards between this muscle and the cricoid and arytenoid cartilages to supply the transverse and oblique arytenoid muscles; the rest of the nerve supplies filaments to all the other laryngeal muscles except the cricothyroid. This branch, therefore, carries *both* adductor and abductor fibres.

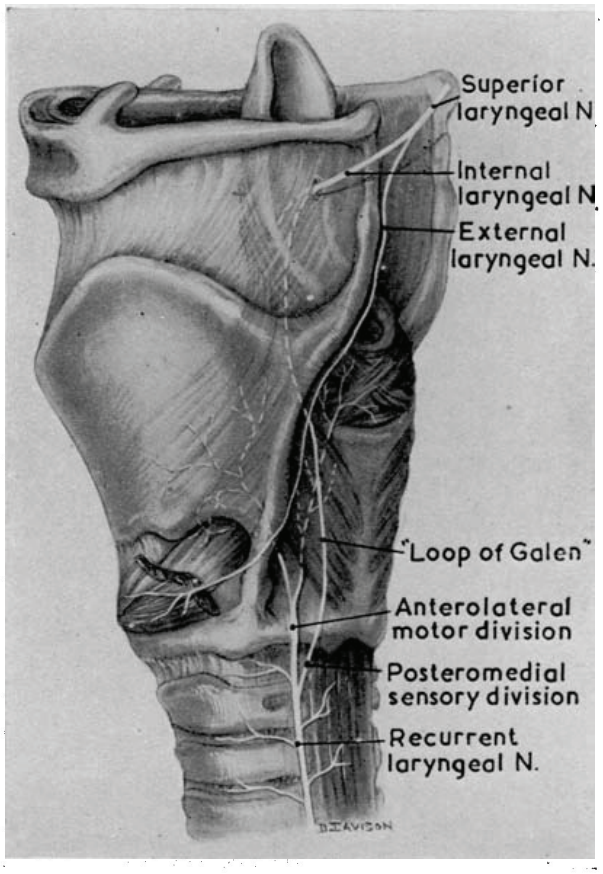


FIG. 6.
The main branches of the superior and recurrent laryngeal nerves. The arrangement shown is based on the findings of Mr. A. F. Williams in 50 complete dissections (100 sides).

The *posteromedial* branch becomes separated from the anterolateral branch by some fibres of the inferior constrictor muscle and as it ascends it runs beneath the mucous membrane overlying the posterior surface of the larynx. In about 75 per cent. of specimens Williams found that it united with a descending twig from the internal branch of the superior laryngeal nerve to form the "loop of Galen" (Fig. 6) which supplies the mucosa in its vicinity.

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

In a few specimens Williams found filaments from the *superior laryngeal nerves* or their branches entering the posterior crico-arytenoid or transverse arytenoid muscles, but he examined all these specimens by serial section techniques and could find no evidence that any of the scanty nerve fibres involved formed motor endings. He concluded that this supply may be proprioceptor in type, or that the filaments pass through the muscles to the overlying mucosa. Lemere (1932) showed that stimulation of these nerves in dogs produced no cord movements; and Williams found that stimulation of the superior laryngeal nerve in two human patients during block dissection operations also produced no cord movements, indicating that the nerve has no, or very scanty, motor fibres.

Williams's work confirms that the superior nerves are the main sensory laryngeal nerves and the motor supply of the cricothyroid muscles, and that any other muscular filaments are possibly proprioceptor. It gives no support to the view that the recurrent nerve bifurcates into abductor and adductor divisions just before entering the larynx. Bifurcation certainly occurs, but into a larger, motor, anterolateral division and a smaller, sensory, posteromedial division.

Sympathetic fibres reach the larynx by several channels. Filaments from the superior cervical ganglion may join the superior laryngeal nerve or its external branch directly, but more often they pass through the pharyngeal plexus and so indirectly to the larynx. A small proportion of laryngeal fibres may run for a short distance with the superior cervical sympathetic nerve before breaking off to join the superior laryngeal nerve. Others accompany the laryngeal branches of the superior and inferior thyroid arteries, the former being derived from the parent external carotid perivascular plexus and the latter from the corresponding plexus on the subclavian artery; the nervelets alongside the inferior thyroid artery are invariably reinforced by filamentous contributions from the middle cervical sympathetic ganglion.

The Nose

This comprises the external nose, the nasal cavities, the paranasal sinuses and the nasopharynx.

The autonomic nerve supply of these structures will be discussed under two headings: (1) the recognized sympathetic and parasympathetic supplies; and (2) the olfactory and terminal nerves, which I believe should be regarded as autonomic.

(1) Sympathetic and Parasympathetic.

Sympathetic and parasympathetic fibres reach the nasal structures by various routes: (*a*) In branches of the sphenopalatine ganglia; (*b*) in branches of the trigeminal nerves; (*c*) through the pharyngeal plexus; (*d*) in paravascular plexuses.

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

The sympathetic and parasympathetic fibres are mainly vasoconstrictor and vasodilator respectively, but they also influence secretion and exercise a trophic influence on the mucosa.

(*a*) *Branches of the sphenopalatine ganglion* (Fig. 7).

These play an important part in nasal innervation and although the majority of their fibres are afferent and run into the maxillary nerve through the inter-connections between the ganglion and this nerve, they

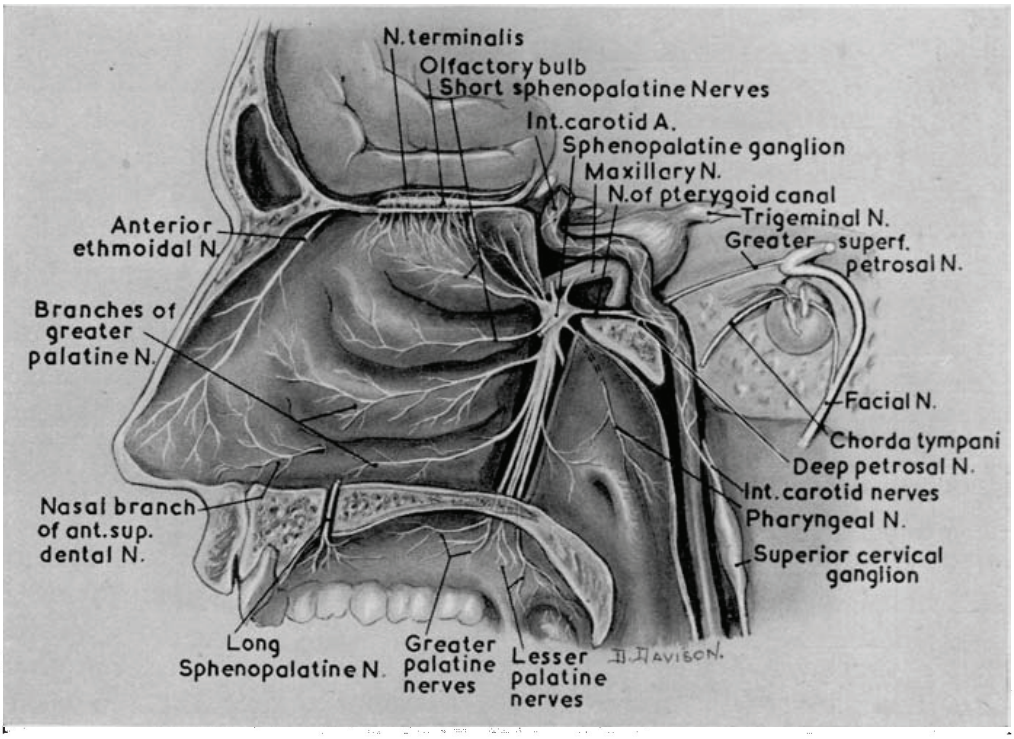


FIG. 7.
The chief nerves supplying the nose and palate. For the sake of clarity all the nerve structures are shown somewhat larger than normal.

also contain an admixture of autonomic fibres. The latter reach the ganglion through the (Vidian) nerve of the pterygoid canal which is formed by the union of the greater superficial petrosal and deep petrosal nerves, the former containing parasympathetic fibres from the facial nerve and the latter sympathetic fibres from the internal carotid plexus.

The sphenopalatine, palatine and pharyngeal branches of the ganglion all supply nasal offshoots.

The *long sphenopalatine nerve* enters the nose through the sphenopalatine foramen, crosses the roof of the cavity below the orifice of the sphenoidal sinus and then runs obliquely downwards and forwards on the posterior part of the nasal septum, lying in a groove on the vomer.

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

It supplies twigs to the posterior part of the roof of the nasal cavity and the nasal septum, finally descending through the incisive canal to supply the hard palate.

The *short sphenopalatine nerve* supplies the mucosa covering the superior and middle nasal conchae, the lining of the posterior ethmoidal sinuses, and the posterior part of the nasal septum.

The *nasal branches* of the *greater palatine nerve* run through openings in the perpendicular plate of the palatine bone and ramify over the inferior nasal concha and the walls of the middle and inferior meatuses.

The *pharyngeal branch* passes through the palatovaginal canal with the pharyngeal branch of the maxillary artery and is distributed to the mucosa of the vault of the nasopharynx, extending downwards as far as the opening of the pharyngotympanic tube.

One or two delicate filaments from the sphenopalatine ganglion pierce the walls of the sphenoidal sinus and help to supply its mucous lining.

(*b*) *Branches of the trigeminal nerve.*

Several branches of the trigeminal nerve assist in nasal innervation and although they consist largely of ordinary sensory fibres all contain a small proportion of autonomic fibres derived from the cavernous part of the internal carotid plexus and perhaps from the greater superficial petrosal nerve, so those branches supplying any part of the nose will be mentioned briefly.

The *anterior ethmoidal* branch (Fig. 7) of the nasociliary nerve descends into the nose through a slit alongside the crista galli and gives off medial and lateral *internal nasal* branches which supply the anterior parts of the nasal septum and the corresponding parts of the lateral wall of the nasal cavity: an *external nasal* branch supplies the skin of the ala nasi and the apex and vestibule of the nose.

The *posterior ethmoidal* branch of the nasociliary nerve supplies twigs to the ethmoidal and sphenoidal sinuses.

The *posterior and middle superior dental* branches arise from the infra-orbital nerve (maxillary) just before it enters the infra-orbital groove, and they supply filaments to the mucosa of the maxillary sinus, besides the molar and pre-molar teeth.

The *anterior superior dental* branch arises in the infra-orbital canal and supplies the mucosa on the anterior wall of the maxillary sinus and the incisor and canine teeth. It sends a small *nasal branch* (Fig. 7) through the lateral wall of the inferior meatus which supplies the adjacent mucosa, communicates with nasal branches of the sphenopalatine ganglion, and terminates near the root of the anterior nasal spine by supplying the contiguous part of the nasal septum.

The *nasal branches* of the infra-orbital nerve supply the skin of the side of the nose and the movable part of the nasal septum.

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

(*c*) *The pharyngeal plexus.*

The formation of this plexus from sympathetic and parasympathetic sources was mentioned above. The uppermost part is related to and innervates the nasopharynx.

(*d*) *Paravascular plexuses.*

Other autonomic fibres reach nasal structures alongside their various arteries of supply—namely the anterior and posterior ethmoidal branches of the ophthalmic artery; the sphenopalatine, infra-orbital, superior dental, palatine and pharyngeal branches of the third part of the maxillary artery; and the septal ramus of the superior labial branch of the facial artery. The nerve fibres accompanying the ophthalmic artery are continued from the cavernous portion of the internal carotid plexus, and the internal maxillary and facial plexuses are offshoots from the external carotid plexus.

(2) The Olfactory Nerves and the Nervi Terminales (Fig. 7).

The olfactory nerves and the associated parts of the brain are generally excluded from the autonomic nervous system, but I believe that they, and the delicate nervi terminales lying alongside them, should be included. There are sound reasons for this belief. Olfactory impulses influence both somatic and autonomic activities, but undoubtedly in microsomatic types, such as man, the effects are predominantly visceral. Moreover the taste pathways, and centres concerned with gustation, are always described as autonomic and it is illogical to exclude those parts concerned with smell, especially as they are no less closely related to autonomic functions. They are involved in various respiratory and alimentary reflexes and influence sexual and emotional behaviour, which is the resultant of somatic and autonomic interactions. These are the main reasons which lead me to place the olfactory apparatus on the autonomic side of the nervous system.

The Terminal Nerves.

These were first noted in fishes and now they are known to exist in most vertebrates. They lie alongside the olfactory bulbs and tracts and are usually embedded in the superficial layer of the pia mater overlying the gyrus rectus (Fig. 8). In man one to seven filaments may be found, and fibrils from these enter the nose through the cribriform plate of the ethmoid to be distributed mainly to the vessels and glands in the olfactory area of epithelium; in lower animals some fibrils supply the vomeronasal organ, along with a few olfactory filaments (the vomeronasal nerve) from the accessory olfactory bulb, but this organ is rudimentary in man.

Proximally the strands of fibres cross over the medial root of the olfactory tract and some apparently end in the anterior perforated

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

substance. In animals, fibres have been traced to the parolfactory area of cortex and to the supra-optic region in the hypothalamus.

Ganglion cells are found along the course of these nerves—the *ganglion terminale* (Fig. 9). Some are bipolar and sensory in type and are found chiefly along the intracranial course of the nervus terminalis, and others are small multipolar cells which are found near the terminations of the nerves and are similar to ganglionic autonomic neurons. According

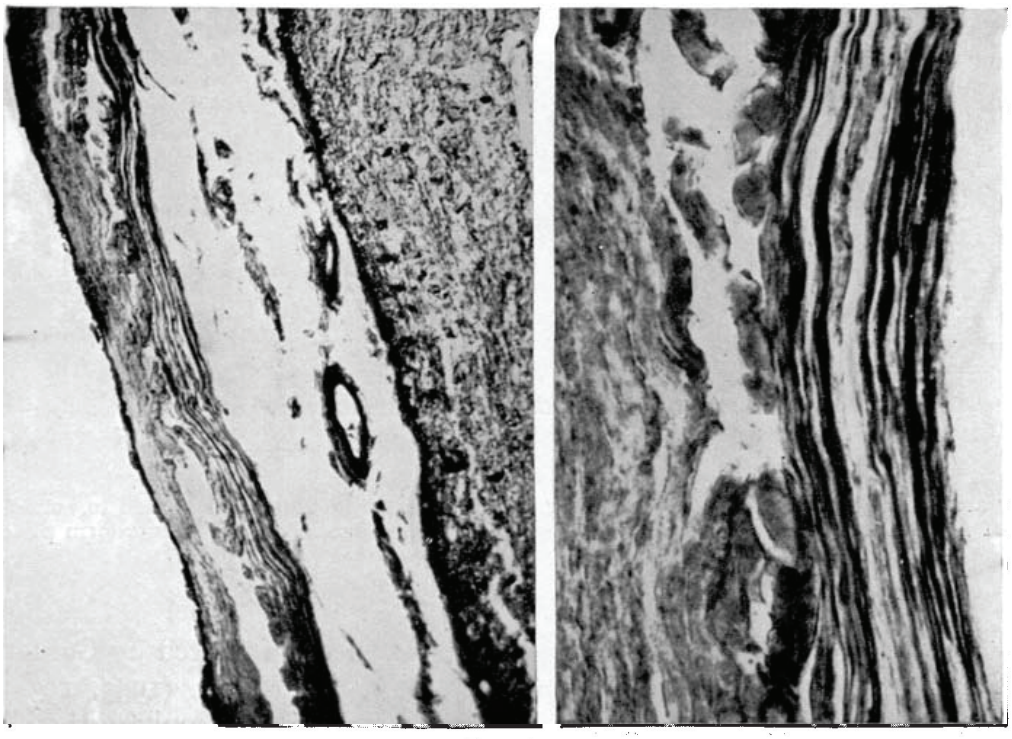


FIG. 8.
Filament of *N. terminalis* (adult human brain: Cajal silver impregnation). In the left photomicrograph (× 102) the nerve bundle is seen embedded in the deeper part of the pia mater which has become detached from the brain during histological preparation. The picture on the right is a high power view (× 520) of a part near the top left-hand corner of the first photograph: note the differing calibre of the nerve fibres.

to Pearson (1941) the bipolar cells are derived from the olfactory placode and their peripheral processes end in the olfactory epithelium, while the proximal processes end in the parolfactory area and perhaps in the hypothalamus. Larsell (1950) suggests that the efferent or pre-ganglionic fibres in these terminal nerves arise in the supra-optic hypothalamic nuclei.

It is believed that these nerves are concerned with glandular and vasomotor reflexes accessory to olfaction, and their situation, their connections, their ganglia and their distribution all suggest that they are parasympathetic.

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press



FIG. 9.

Part of *ganglion terminale* (adult human: Samuel's silver stain: ×125) related to bundles of nerve fibres of the *N. terminalis* lying on the dura mater above the cribriform plate.

The Ear

Judging from the types of operations recently advocated by Garnett Passe and Seymour (1948), Hoogland (1952) and Rosen (1953, 1954), otologists are keenly interested in the autonomic nerve supply of the ear and especially of the middle and internal ears.

The External Ear.

The auricular arteries derived from the posterior auricular, superficial temporal and occipital vessels are all accompanied by paravascular autonomic plexuses derived from the parent plexus around the external carotid artery: they are responsible for the innervation of the vessels and of the numerous arteriovenous anastomoses found in the auricle.

The sensory nerves of the external meatus and of the tympanic membrane are filaments from the auriculotemporal branch of the mandibular nerve and the auricular branch of the vagus (Arnold's nerve). Ramsay-Hunt (1910) suggested that sensory fibres from parts of the ear drum and external meatus, reputedly supplied by the auricular branch of the vagus, really belong to the nervus intermedius of the facial, and are transferred to the auricular vagal branch through a filament

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

inter-connecting it to the facial nerve: sometimes the inter-connection is with the chorda tympani nerve (A. A. Gray, 1922; O. Gray, 1953). The fact that an otitic herpes occasionally accompanies facial nerve lesions supports this view, and Hovelacque (1927) described a sensory branch of the facial which apparently supplies the area described by Ramsay-Hunt, but on anatomical and clinical grounds it seems certain that a proportion of the sensory fibres from the external meatus and ear drum also run in the auricular branch of the vagus: perhaps the truth is that these afferent fibres reach the brain stem both in the facial and

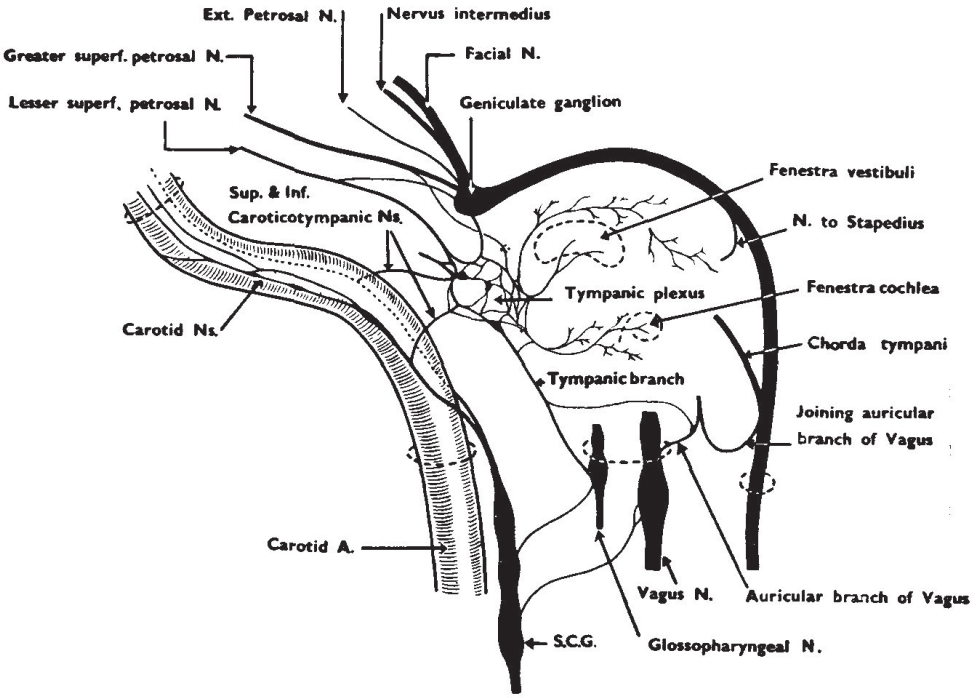


FIG. 10.
Diagram showing tympanic plexus and most of its connections and branches. Filaments for the supply of the aditus, mastoid cells and pharyngotympanic tube are indicated but not named.

vagus nerves. Incidentally the inter-connection between the facial and the auricular vagal branch is inconstant and there seems to be some inter-relationship between it and the so-called "loop of Haller" connecting the auricular branch of the vagus and the glossopharyngeal nerve, because when one is present the other is often absent.

THE MIDDLE EAR.

The lining of the cavity of the middle ear is supplied by filaments from the *tympanic plexus* (Fig. 10) which lies on the promontory and which is formed mainly by sympathetic and parasympathetic contributions coming through the caroticotympanic nerves (Fig. 11) and the

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

tympanic branch (Fig. 12) of the glossopharyngeal nerve respectively: the latter is termed the nerve of Jacobson, but Andersch described it in 1792, twenty-six years earlier than Jacobson. The plexus is inter-connected by a filament with the facial ganglion, with branches of the trigeminal nerve through the petrosal nerves, and with the auricular branch of the vagus through the connection of the latter with the tympanic nerve or the main glossopharyngeal trunk. According to Portmann and Puig (1949) it has "functional connections" with the chorda tympani, but they

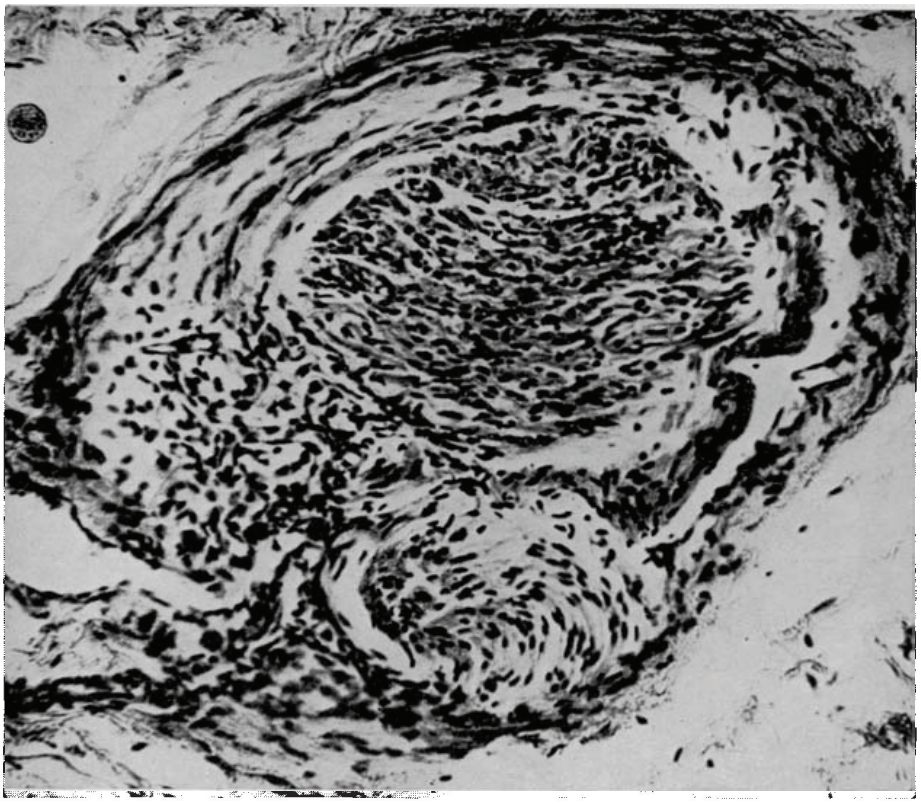


FIG. 11.
Transverse section of internal carotid nerve (H. and E. × 180) at the point where a carotico-tympanic branch is given off. The latter is the small rounded bundle near the foot of the photomicrograph.

do not define these clearly, and there are no reliable accounts of communications between this nerve and the tympanic plexus. They may exist, however, and results reported by Rosen (1953, 1954) seem to show that the chorda tympani is concerned with "sonic-equilibratory, touch and pain" functions as well as taste.

The tympanic branch of the glossopharyngeal nerve conveys afferent fibres from the tympanum and carries the efferent parasympathetic secretomotor fibres for the parotid gland. It may also contain vasodilator fibres for this gland and for the vessels supplying the mucosa of the

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

tympanum, the pharyngotympanic tube and the mastoid air cells. It divides into branches which are inter-connected with each other and with the caroticotympanic nerves to form the tympanic plexus. From this plexus twigs pass in various directions.

One twig runs posteriorly towards the fenestra cochlea, but it is uncertain whether some fibres penetrate through this round window into the internal ear or whether all end in the mucosa over and around the window. Another posterior filament runs to the fenestra vestibuli and again there is dubiety about whether or not it ends in the mucosa or sends

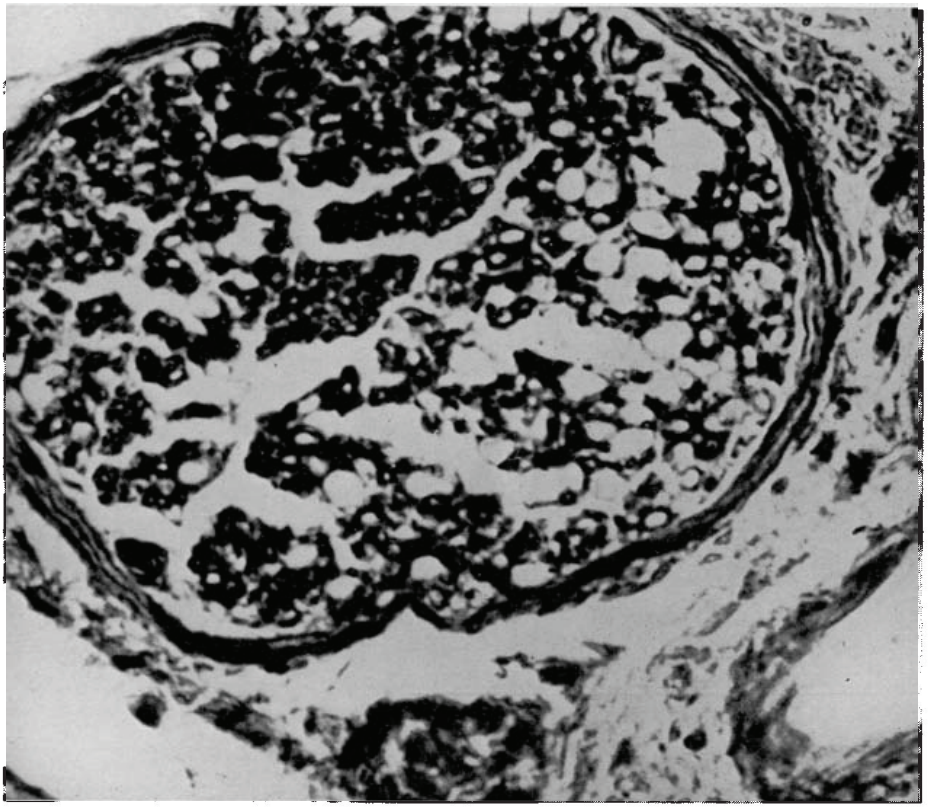


FIG. 12.
Transverse section of tympanic branch of glossopharyngeal nerve (H. and E. × 520) showing fibres of varying thicknesses.

some fibres into the internal ear. Some very fine offshoots run through the aditus and tympanic antrum to the mastoid cells.

One branchlet directed anteriorly supplies the mucosa of the pharyngotympanic tube almost to its pharyngeal orifice, and other anterior fibres run to the internal carotid plexus, alongside or united with the caroticotympanic nerves.

A filament passes through a canaliculus in front of the fenestra vestibuli and joins the greater superficial petrosal nerve. Another forms

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

the chief part of the lesser superficial petrosal nerve which runs in a canaliculus below the canal for the tensor tympani, is joined by a very delicate strand from the facial ganglion, and ultimately joins the otic ganglion. Often there is a slender inter-connection between the tympanic plexus and the facial ganglion.

The nerves forming the tympanic plexus are all minute and some lie in tiny grooves in the bone of the promontory. At or near points where they unite a few nerve cells may be found on microscopic examination, and one or two reddish nodules may even be seen naked eye, usually in the regions where the tympanic and inferior caroticotympanic nerves join the plexus: these are the so-called *tympanic ganglia*. The nerves contain a mixture of fibres of different sizes, some thin and finely myelinated and others thicker and more heavily myelinated.

All the arteries supplying the middle ear have delicate perivascular plexuses which are continued from the plexuses on the main parent vessel. These are the stylomastoid branch of the posterior auricular artery, the anterior tympanic branch of the maxillary artery, the superficial petrosal and superior tympanic branches of the middle meningeal artery, the tympanic branch of the internal carotid artery, a twig from the artery of the pterygoid canal and a branch from the ascending pharyngeal artery.

The Internal Ear.

The majority of the autonomic fibres reaching the internal ear run with the internal auditory artery, which is a branch of the basilar artery or more often of the anterior inferior cerebellar artery. The sympathetic fibres ascend from the stellate ganglion alongside the vertebral and basilar arteries, and parasympathetic fibres may join the basilar perivascular plexus from the facial or vagus nerves. The internal auditory artery divides at the bottom of the internal meatus into cochlear and vestibular branches and each receives a quota of nerve fibres from the nerve plexus around the parent vessel. The cochlear branch divides into several sprays which traverse canaliculi in the modiolus and are distributed to the lamina spiralis and basilar membrane. The vestibular branch gives off branchlets which supply the utricle, saccule and semicircular canals. Lorente de Nó (1937) claimed that some of the sympathetic fibres passing from the internal carotid plexus to the facial nerve are transposed to and distributed with the auditory nerve; and Rasmussen (1946) thought that some parasympathetic fibres arising in the medulla oblongata may run in the auditory nerve to the internal ear.

Very delicate offshoots from the tympanic plexus penetrate the thin septum between the middle and internal ears to supply the latter. Some deny this and claim that the separate development of the otocyst makes it unlikely that fibres from the tympanum could supply it, but there is

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

no doubt that nerve fibres can and do transgress embryological boundary zones. Moreover, the fact that stimulation of the uppermost part of the cervical sympathetic trunk produces cochlear changes (Seymour and Tappin, 1952, 1953) tends to support the view that fibres reaching the tympanic plexus through the caroticotympanic nerves influence the internal ear, although this is not quite certain as sympathetic fibres could reach the basilar and internal auditory plexuses through connections between the superior cervical ganglia and the vertebral plexuses, or through fibres passing backwards from the internal carotid to the basilar plexus by routes which need not be detailed here. This problem still awaits final solution.

Acknowledgments

I wish to thank Mr. A. F. Williams, Dr. K. Rushton, Mr. D. Mayor and Mr. A. W. F. Fisher for allowing me to reproduce some of the results of their researches, carried out in the Anatomy Department, Manchester University, on the laryngeal nerves, tympanic plexus, nervi terminales and enteric plexuses respectively. I am much indebted to Miss D. Davison for her fine drawings; and to Mr. K. Pearson and Mr. P. Howarth for indispensable histological and photographic assistance.

REFERENCES

Berlin, D. D., and Lahey, F. H. (1929) *Surg. Gynec. Obstet.*, **49**, 102.
Dilworth, T. F. M. (1921) *J. Anat., Lond.*, **56**, 48-52.
Exner, S. (1884) *S.B. Akad. Wiss. Wien.* III Abt., **89**, 63.
Gray, A. A. (1922) *J. Laryng.*, **37**, 182.
Gray, O. (1953) *J. Laryng.*, **67**, 128.
Hoogland, G. A. (1952) *Acta-Oto-Laryng., Stockh.*, **42**, 379.
Hovelacque, A. (1927) "Anatomie des nerfs craniens et rachidiens et du système grand sympathique chez l'homme." Paris, G. Doin et Cie.
King, B. T., and Gregg, R. L. (1948) *Ann. Otol. etc., St. Louis*, **57**, 925.
Lahey, F. H. (1938) *Surg. Gynec. Obstet.*, **66**, 775.
——— (1944) *Surg. Gynec. Obstet.*, **78**, 239.
Larsell, O. (1950) *Ann. Otol. etc. (St. Louis)*, **59**, 414.
Lemere, F. (1932) *Anat. Rec.*, **54**, 389.
——— (1932) *Amer. J. Anat.*, **51**, 417.
Lorente De Nó, R. (1937) *Laryngoscope*, **47**, 373.
Meyling, H. A. (1953) *J. comp. Neurol.*, **99**, 495.
Mitchell, G. A. G. (1953) *Anatomy of the Autonomic Nervous System*. Edinburgh, E. & S. Livingstone.
——— (1953) *Acta Anat.*, **18**, 195.
Morrison, L. F. (1952) *Trans. Amer. Laryng. Ass.*, **73**, 132.
Ónodi, A. (1902) *Die Anatomie und Physiologie der Kehlkopfnerven*, Berlin, O. Coblentz.
Pearson, A. A. (1941) *J. comp. Neurol.*, **75**, 39.
Passe, E. R. G. and Seymour, J. S. (1948) *Brit. med. J.*, **2**, 812.
Portmann, G. and Puig, E. (1949) *Rev. Laryng., Paris*, **70**, 1.
Ramsay-Hunt, J. (1910) *Arch. inter. laryng.*, **29**, 134.

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press

RASMUSSEN, G. L. (1946) *J. comp. Neurol.*, **84**, 141.
ROSEN, S. (1953) *N.Y. State J. Med.*, **53**, 1095.
——— (1954) *Lancet*, **1**, 133.
RUNDLE, F. F. (1951) *Joll's Diseases of the Thyroid Gland* (2nd Ed.). London, W. Heinemann.
SEYMOUR, J. C. and TAPPIN, J. W. (1952). *Acta Oto-Laryng. Stockh.*, **42**, 167.
——— ——— (1953) *Acta Oto-Laryng. Stockh.*, **43**, 618.
WEEKS, C. and HINTON, J. W. (1942). *Ann. Surg.*, **116**, 251.
WILLIAMS, A. F. (1951) *J. Laryng.*, **65**, 343.
——— (1954) "The recurrent laryngeal nerve and the thyroid gland," *J. Laryng.*, In the press.

https://doi.org/10.1017/S0022215100049938 Published online by Cambridge University Press