cord, between the anterior and posterior roots of the upper four or five cervical nerves. The filaments of origin are six to eight in number. The most inferior of these is generally single, the other filaments frequently being arranged in pairs. These take their origin from the lateral portion of the cord and are connected with the anterior cornua of gray matter.

Following the nerve from its most inferior filament of origin upward, it gradually increases in size by union with its other roots, enters the cranial cavity by the foramen magnum, and passes to the jugular foramen, by which it emerges, with the glosso-pharyngeal, the pneumogastric and the internal jugular vein.

In its course the spinal accessory anastomoses with several nerves. Just as it enters the cranial cavity, it receives filaments of communication from the posterior roots of the upper two cervical nerves. These filaments, however, are not constant. It frequently though not constantly sends a few filaments to the superior ganglion, or the ganglion of the root of the pneumogastric. After it has emerged by the jugular foramen it sends a branch of considerable size to the pneumogastric, from which nerve it also receives a few filaments of communication. In its course it also receives filaments of communication from the anterior branches of the second, third, and fourth cervical nerves.

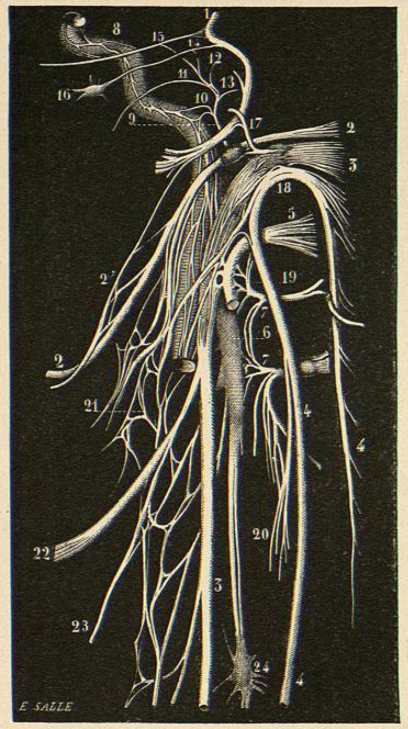

FIG. 207.—*Spinal accessory nerve* (Hirschfeld).

1, trunk of the facial nerve ; 2, 2, glosso-pharyngeal nerve ; 3, 3, pneumogastric ; 4, 4, 4, *trunk of the spinal accessory* ; 5, sublingual nerve ; 6. superior cervical ganglion ; 7, 7, anastomosis of the first two cervical nerves ; 8, carotid branch of the sympathetic; 9, 10, 11, 12, 13, branches of the glosso-pharyngeal; 14, 15, branches of the facial : 16, otic ganglion ; 17, auricular branch of the pneumogastric ; 18, *anastomosing branch from the spinal accessory to the pneumogastric* ; 19, anastomosis of the first pair of cervical nerves with the sublingual ; 20, *anastomosis of the spinal accessory with the second pair of cervical nerves* ; 21, *pharyngeal plexus* ; 22, superior laryngeal nerve ; 23, external laryngeal nerve ; 24, middle cervical ganglion.

In its distribution the spinal accessory presents two branches. The internal, or anastomotic branch, passes to the pneumogastric just below the plexiform enlargement which is sometimes called the ganglion of the trunk of the pneumogastric. This branch is composed principally if not entirely of the filaments that take their origin from the medulla oblongata. As it joins the pneumogastric it subdivides into two smaller branches. The first of these forms a portion of the pharyngeal branch of the pneumogastric. The second becomes intimately united with the pneumogastric, lying at its posterior portion, and furnishes filaments to the inferior, or recurrent laryngeal branch, which is distributed to all of the muscles of the larynx except the crico-

thyroid. The passage of the filaments from the spinal accessory to the pharyngeal branch of the pneumogastric is easily observed; but the fact that filaments from this nerve pass to the larynx by the recurrent laryngeal has been ascertained by physiological experiments.

The external, or large branch of the spinal accessory, called the muscular branch, penetrates and passes through the posterior portion of the upper third of the sterno-cleido-mastoid muscle, and goes to the anterior surface of the trapezius, which muscle receives its ultimate branches of distribution. In its passage through the sterno-cleido-mastoid, it joins with branches from the second and third cervical nerves and sends filaments of distribution to the muscle. Although the two muscles just mentioned receive motor filaments from the spinal accessory, they are also supplied from the cervical nerves; and consequently they are not entirely paralyzed when the spinal accessory is divided.

Properties and Uses of the Spinal Accessory.—Notwithstanding the great difficulty in exposing and operating upon the roots of the spinal accessory, it has been demonstrated that their stimulation produces convulsive movements in certain muscles. By stimulating the filaments that arise from the medulla oblongata, contractions of the muscles of the pharynx and larynx are produced, but no movements of the sterno-mastoid and trapezius. Stimulation of the roots arising from the spinal cord produces movements of the two muscles just mentioned and absolutely no movements in the larynx (Bernard). In view of these experiments, it is evident that the true filaments of origin of the spinal accessory are motor; and it is farther evident that the filaments from the medulla oblongata are distributed to the muscles of the pharynx and larynx, while the filaments from the spinal cord go to the sterno-cleido-mastoid and trapezius.

The trunk of the spinal accessory, after the nerve has passed out of the cranial cavity, has a certain degree of sensibility. If the nerve be divided, the peripheral extremity manifests recurrent sensibility, but the central end is also sensible, probably from direct filaments of communication from the cervical nerves and the pneumogastric.

Uses of the Internal Branch from the Spinal Accessory to the Pneumogastric.—Bischoff attempted to ascertain the uses of this branch by dividing the roots of the spinal accessory upon both sides in a living animal. The results of his experiments may be stated in a very few words: He attempted to divide all of the roots of the nerves upon both sides by dissecting down to the occipito-atloid space and penetrating into the cavity of the spinal canal. In the first three experiments upon dogs, the animals died so soon after section of the nerves, that no satisfactory results were obtained. In two succeeding experiments upon dogs, the animals recovered. After division of the nerves the voice became hoarse, but a few weeks later it became normal. On killing the animals, an examination of the parts showed that some of the filaments of origin had not been divided. An experiment was then made upon a goat, but this was unsatisfactory, as the roots were not completely divided. Finally another experiment was made upon a goat. In this the results were more satisfactory. After division of the nerve upon one side, the voice became hoarse. As the filaments were divided upon the opposite side, the voice was enfeebled, until finally it became extinct. The sound emitted afterward was one which could in nowise be called voice ("*qui neutiquam vox appellari potuit*"). This experiment was made in the presence of Tiedemann and Seubertus and was not repeated.

Bernard, who determined exactly the influence of the spinal accessory over the vocal movements of the larynx, first repeated the experiments of Bischoff; but the animals operated upon died so soon, from hæmorrhage or other causes, that his observations were not satisfactory. After many unsuccessful trials, he succeeded in overcoming all difficulties, by following the trunk of the nerve back to the jugular foramen, seizing it here with a strong forceps and drawing it out by the roots. The operation is generally most successful in cats, although Bernard succeeded frequently in other animals.

When one spinal accessory is extirpated, the vocal sounds are hoarse and unnatural. When both nerves are torn out, in addition to the disturbance of deglutition and the partial paralysis of the sterno-mastoid and trapezius muscles, the voice becomes extinct. Animals operated upon in this way move the jaws and make evident efforts to cry, but no vocal sound is emitted. Bernard kept animals, with both nerves extirpated, for several months and did not observe any return of the voice. His observations, which have been fully confirmed, show that the internal branch of the spinal accessory is the nerve of phonation. The filaments which preside over the vocal movements of the larynx pass in greatest part through the recurrent laryngeal branches of the pneumogastrics; but the recurrent laryngeals also contain motor filaments from other sources, which latter are concerned in the respiratory movements of the glottis.

Influence of the Internal Branch of the Spinal Accessory upon Deglutition.—There are two ways in which deglutition is affected through this nerve: 1. When the larynx is paralyzed as a consequence of extirpation of both nerves, the glottis can not be completely closed to prevent the entrance of foreign bodies into the air-passages. In rabbits particularly, it has been noted that particles of food penetrate the trachea and find their way into the lungs. 2. The spinal accessory furnishes filaments to the pharyngeal branch of the pneumogastric, and through this nerve, it directly affects the muscles of deglutition; but the muscles animated in this way by the spinal accessory have a tendency to draw the lips of the glottis together, while they assist in passing the alimentary bolus into the œsophagus. When these important acts are wanting, there is some difficulty in the process of deglutition itself, as well as danger of the passage of foreign particles into the larynx.

Influence of the Spinal Accessory upon the Heart.—The spinal accessory furnishes to the pneumogastric the inhibitory fibres which influence the action of the heart. A sufficiently powerful Faradic current, passed through one pneumogastric only, will in some animals arrest the cardiac movements. Waller found that if he extirpated the spinal accessory upon one side, after four or five days the action of the heart could not be arrested by stimulating the pneumogastric upon the same side; but inhibition followed stimulation of the pneumogastric upon the opposite side, on which the connections with the spinal accessory were intact. In these observations, it seemed necessary that a sufficient time should elapse after extirpation of the spinal accessory for the excitability of the filaments that join the pneumogastric to become extinct; but the experiments are sufficient to show the direct inhibitory influence of the spinal accessory upon the heart. After extirpation of the spinal accessory, degenerated fibres are found in the trunk of the pneumogastric. The mechanism of inhibition of the heart has already been considered in connection with the physiology of the circulation.

Uses of the External, or Muscular Branch of the Spinal Accessory.—Observations have shown that the internal branch of the spinal accessory, and the internal branch only, is directly concerned in the vocal movements of the larynx, and to a great extent, in the closure of the glottis during deglutition. It has been noted, in addition, that animals in which both branches have been extirpated present irregularity of the movements of the anterior extremities and suffer from shortness of breath after violent muscular exertion. The use of the corresponding extremities in the human subject is so different, that it is not easy to make a direct application of these experiments; still, certain inferences may be drawn from them with regard to the action of the external branch in man.

In prolonged vocal efforts, the vocal chords are put upon the stretch, and the act of expiration is different from that in tranquil breathing. In singing, for example, the shoulders frequently are fixed; and this is done to some extent by the action of the sterno-cleido-mastoid and the trapezius. It is probable, then, that the action of the branch of the spinal accessory which goes to these muscles has a certain synchronism with the action of the branch going to the larynx and the pharynx; the one fixing the upper part of the chest so that the expulsion of the air through the glottis may be more nicely regulated by the expiratory muscles, and the other acting upon the vocal chords.

In what is known as muscular effort, the glottis is closed, the thorax is fixed after a full inspiration, and respiration is arrested so long as the effort, if it be not too prolonged, is continued. The same synchronism, therefore, obtains in this as in prolonged vocal efforts. In experiments in which the muscular branch only has been divided, shortness of breath, after violent muscular effort, is observed; and this is probably due to the want of synchronous action of the sterno-cleido-mastoid and trapezius. The irregularity in the movements of progression in animals in which either both branches or the muscular branches alone have been divided is due to anatomical peculiarities. Bernard has observed these irregularities in the dog and the horse, but they are not so well marked in the cat. There have been no opportunities for illustrating these points in the human subject.

Sublingual (Twelfth Nerve).

The last of the motor cranial nerves is the sublingual; and its action is intimately connected with the physiology of the tongue in deglutition and articulation, although the sublingual is also distributed to certain of the muscles of the neck.

Physiological Anatomy.—The apparent origin of the sublingual is from the medulla oblongata, in the groove between the olivary body and the anterior pyramid, on the line of the anterior roots of the spinal nerves. At this point, its root is formed of ten to twelve filaments, which extend from the inferior portion of the olivary body to about the junction of the upper with the middle third of the medulla. These filaments of origin are separated into two groups, superior and inferior. From this apparent origin, the filaments have been traced into the gray matter of the floor of the fourth ventricle, between the deep origin of the pneumogastric and the glosso-pharyngeal. Although there is much difference of opinion upon this point, it is probable that some of the filaments of origin of these nerves decussate in the floor of the fourth ventricle. The superior and inferior filaments of origin of the nerve unite to form two bundles, which pass through distinct perforations in the dura mater. These two bundles then pass into the anterior condyloid foramen and unite into a single trunk as they emerge from the cranial cavity.

After the sublingual has passed out of the cranial cavity, it anastomoses with several nerves. It sends a filament of communication to the sympathetic as it branches from the superior cervical ganglion. Soon after it has passed through the foramen, it sends a branch to the pneumogastric. It anastomoses by two or three branches with the upper two cervical nerves, the filaments passing in both directions between the nerves. It anastomoses with the lingual branch of the fifth, by two or three filaments passing in both directions.

In its distribution the sublingual presents several peculiarities:

Its first branch, the descendens noni, passes down the neck to the sterno-hyoid, sterno-thyroid and omo-hyoid muscles.

The thyro-hyoid branch is distributed to the thyro-hyoid muscle.

The other branches are distributed to the stylo-glossus, hyo-glossus, genio-hyoid and genio-hyo-glossus muscles, their terminal filaments going to the intrinsic muscles of the tongue.

It is thus seen that the sublingual nerve is distributed to all of the muscles in the infra-hyoid region, the action of which is to depress the larynx and the hyoid bone after the passage of the alimentary bolus through the pharynx; to one of the muscles in the supra-hyoid region, the genio-hyoid; to most of the muscles which move the tongue; and to the muscular fibres of the tongue itself. The action of these muscles and of the tongue itself in deglutition has already been fully discussed.

Properties and Uses of the Sublingual.—The fact that the sublingual nerve arises from a continuation of the motor tract of the spinal cord and has no ganglion upon its main root would lead to the supposition that it is an exclusively motor nerve. In operating upon the roots of the spinal accessory—when the origin of the sublingual is necessarily exposed—Longet has irritated the roots in the dog, without any evidence of pain on the part of

the animal. Such experiments, taken in connection with the anatomical characters of the nerve, render it almost certain that its root is devoid of

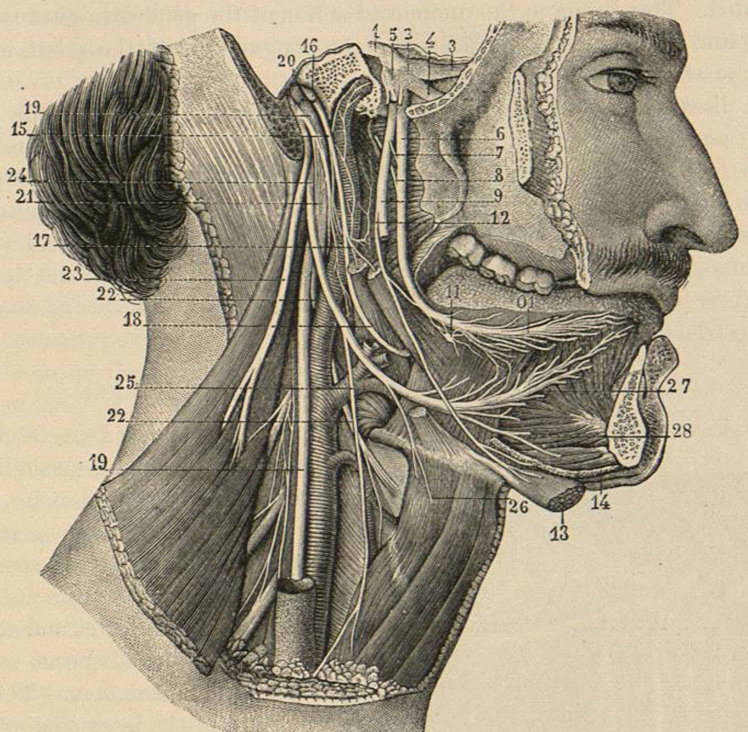

FIG. 208.—*Distribution of the sublingual nerve* (Sappey).

1, root of the fifth nerve; 2, ganglion of Gasser; 3, 4, 5, 6, 7, 9, 10, 12, branches and anastomoses of the fifth nerve; 11, submaxillary ganglion; 13, anterior belly of the digastric muscle; 14, section of the mylo-hyoid muscle; 15, glosso-pharyngeal nerve; 16, ganglion of Andersch; 17, 18, branches of the glosso-pharyngeal nerve; 19, 19, pneumogastric; 20, 21, ganglia of the pneumogastric; 22, 22, superior laryngeal branch of the pneumogastric; 23, spinal accessory nerve; 24, *sublingual nerve*; 25, *descendens noni*; 26, *thyro-hyoid branch*; 27, *terminal branches*; 28, *two branches, one to the genio-hyo-glossus and the other to the genio-hyoid muscle.*

sensibility at its origin. All modern experimenters have confirmed the observations of Mayo and of Magendie, with regard to the sensibility of the sublingual after it has passed out of the cranial cavity. The anastomoses of this nerve with the upper two cervical nerves, with the pneumogastric, and with the lingual branch of the fifth, afford a ready explanation of this fact.

The sublingual may be easily exposed in the dog by making an incision just below the border of the lower jaw, dissecting down to the carotid artery and following the vessel upward until the nerve is seen as it crosses its course. On applying a feeble Faradic current at this point, there are evidences of sensibility, and the tongue is moved at each stimulation.

The phenomena following section of both sublingual nerves point directly to their uses. The most notable fact observed after this operation is that the movements of the tongue are entirely lost, while general sensibility and the sense of taste are not affected. The phenomena which follow division of these nerves consist simply in loss of power over the tongue, with considerable difficulty in deglutition.

In the human subject the sublingual is usually more or less affected in hemiplegia. In these cases, as the patient protrudes the tongue the point is deviated. This is due to the unopposed action of the genio-hyo-glossus upon the sound side, which, as it protrudes the tongue, directs the point toward the side affected with paralysis.

A disease of rather rare occurrence has been described under the name of glosso-labio-laryngeal paralysis, characterized by paralysis of the muscles of the lips, tongue, soft palate, pharynx, and frequently the intrinsic muscles of the larynx. The phenomena referable to the loss of power over the tongue correspond to those observed in animals after section of the sublingual nerves. Patients affected in this way experience difficulty in deglutition, and in addition there is some interference with articulation, which can not be observed in experiments upon animals.

Trifacial (Large Root of the Fifth Nerve).

A single nerve, the large root of the fifth pair, called the trifacial or the trigeminal, gives general sensibility to the face and to the head as far back as the vertex. This nerve is important, not only as the great sensitive nerve of the face, but from its connections with other nerves and its relations to the organs of special sense.

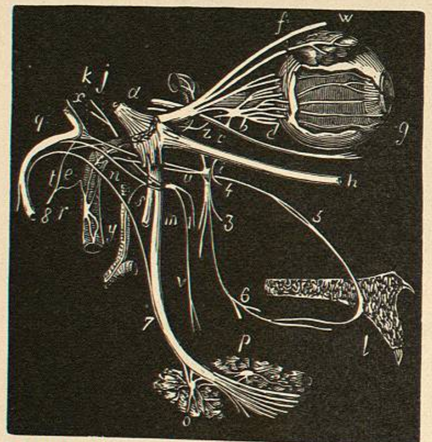

Fig. 209.—*Principal branches of the large root of the fifth nerve* (Robin).

a, ganglion of Gasser; a–w, ophthalmic division of the fifth; b, ophthalmic ganglion; c, branch from the ophthalmic division of the fifth to the ophthalmic ganglion; d, motor oculi communis; *e,* carotid; *f,* ciliary nerves; *g,* cornea and iris; *a–h, superior maxillary division of the fifth; i, two branches from the superior maxillary division of the fifth to the spheno-palatine ganglion; j,* deep petrosal nerve; *k,* filaments from the motor root of the fifth to the internal muscle of the malleus; *l,* naso-palatine ganglion; *m,* otic ganglion; *n,* small superficial petrosal nerve; *o, branches of the fifth to the submaxillary ganglion; p, branches to the sublingual gland; q,* facial nerve; *r,* sympathetic ganglion; *s,* nerve of mastication; *t, chorda tympani, joining the lingual branch of the fifth; u,* Vidian nerve; *v,* branch from the motor root, to the internal pterygoid muscle; *w, branch of the fifth to the lachrymal gland; x,* bend of the facial nerve; *y,* middle meningeal artery; *z,* filament from the carotid plexus, to the ophthalmic ganglion; (1 and 2 are not in the figure) 3, external spheno-palatine filaments; 4, spheno-palatine ganglion; 5, naso-palatine nerve; 6, anterior palatine nerve; 7, *inferior maxillary division of the fifth;* 8, nerve of Jacobson.

Physiological Anatomy.—The apparent origin of the large root of the fifth is from the lateral portion of the pons Varolii, posterior and inferior to the origin of the small root, from which it is separated by a few transverse fibres of white substance. The deep origin is far removed from its point of emergence from the encephalon. The roots pass entirely through the substance of the pons, from without inward and from before backward, without any connection with the fibres of the pons itself. By this course the fibres reach the medulla oblongata, where the roots divide into three bundles. The anterior bundle passes from behind forward, between the anterior fibres of the pons and the cerebellar portion of the restiform bodies, to anastomose with the fibres of the auditory nerve. The other bundles, which are posterior, pass, the

one in the anterior wall of the fourth ventricle to the lateral tract of the medulla oblongata, and the other, becoming grayish in color, to the restiform bodies, from which they may be followed as far as the point of the calamus scriptorius. A few fibres from the two sides decussate at the median line, in the anterior wall of the fourth ventricle. From this origin, the large root of the fifth passes obliquely upward and forward to the ganglion of Gasser, which is situated in a depression in the petrous portion of the temporal bone, on the internal portion of its anterior face.

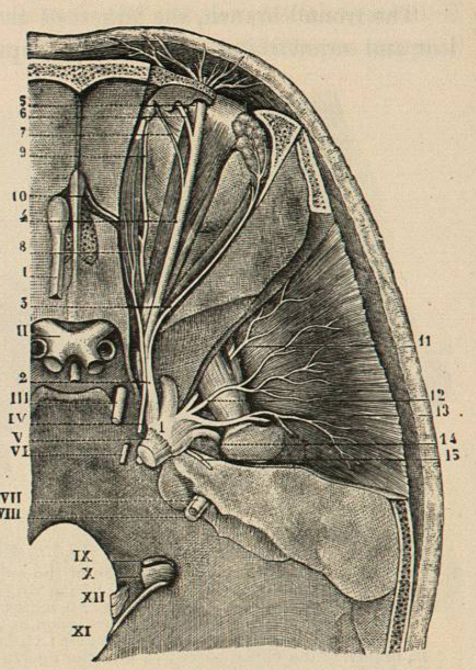

Fig. 210.—*Ophthalmic division of the fifth* (Hirschfeld).

1, *ganglion of Gasser; 2, ophthalmic division of the fifth; 3, lachrymal branch; 4, frontal branch; 5, external frontal; 6, internal frontal; 7, supratrochlear; 8, nasal branch; 9, external nasal; 10, internal nasal;* 11, anterior deep temporal nerve; 12, middle deep temporal nerve; 13, posterior deep temporal nerve; 14, origin of the superficial temporal nerve; 15, great superficial petrous nerve.
I to XII, roots of the cranial nerves.

The Gasserian ganglion is semilunar in form, with its concavity looking upward and inward. At the ganglion the nerve receives filaments of communication from the carotid plexus of the sympathetic. This anatomical point is of importance in view of some of the remote effects which follow division of the fifth nerve through the ganglion in living animals.

At the ganglion of Gasser, from its anterior and external portion, are given off a few small and unimportant branches to the dura mater and the tentorium.

From the convex border of the ganglion the three great divisions, or branches arise, which have given to the nerve the name of trifacial or trigeminal. These are: 1, the ophthalmic; 2, the superior maxillary; 3, the inferior maxillary. The ophthalmic and superior maxillary branches are derived entirely from the sensory root. The inferior maxillary branch joins with the motor root and forms a mixed nerve.

The ophthalmic branch, the first division of the fifth, is the smallest of the three. Before it enters the orbit it receives filaments of communication from the sympathetic, sends small branches to all of the motor nerves of the eyeball and gives off a small recurrent branch which passes between the layers of the tentorium.

Just before the ophthalmic branch enters the orbit by the sphenoidal fissure it divides into three branches, the lachrymal, frontal and nasal.

The lachrymal, the smallest of the three, sends a branch to the orbital branch of the superior maxillary nerve, passes through the lachrymal gland,