in the cranium the two roots are distinct; but after the small root passes through the foramen, it is united by a mutual interlacement of fibres with the sensory branch.

The inferior maxillary nerve, made up of the motor root and the inferior maxillary branch of the sensory root, just after it passes out by the foramen ovale, divides into two branches, anterior and posterior. The anterior branch, which is the smaller, is composed almost entirely of motor filaments and is distributed to the muscles of mastication. It gives off five branches. The first of these passes to be distributed to the masseter muscle, in its course occasionally giving off a small branch to the temporal muscle and a filament to the articulation of the inferior maxilla with the temporal bone. The two deep temporal branches are distributed to the temporal muscle. The buccal branch sends filaments to the external pterygoid and the temporal muscles, and a small branch is distributed to the internal pterygoid muscle. From the posterior branch, which is chiefly sensory but contains some motor filaments, branches are sent to the mylo-hyoid muscle and to the anterior belly of the digastric. In addition the motor branch of the fifth sends filaments to the tensor muscles of the velum palati.

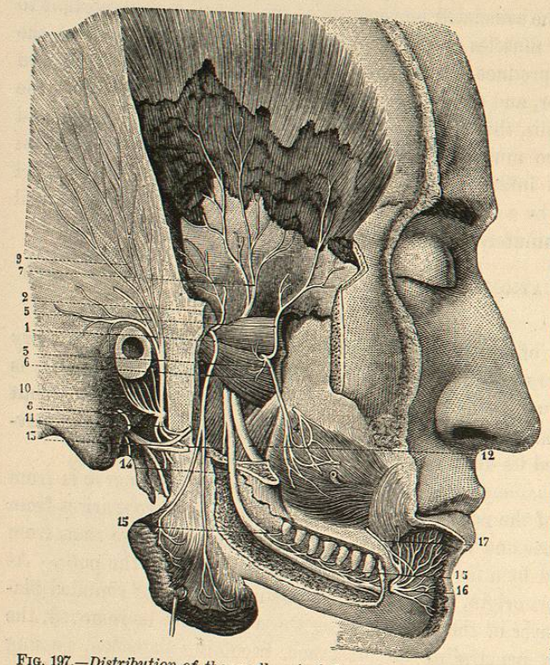

FIG. 197.—*Distribution of the small root of the fifth nerve* (Hirschfeld).
1, *branch to the masseter muscle*; 2, *filament of this branch to the temporal muscle*; 3, *buccal branch*; 4, *branches anastomosing with the facial nerve*; 5, *filament from the buccal branch to the temporal muscle*; 6, *branches to the external pterygoid muscle*; 7, *middle deep temporal branch*; 8, auriculo-temporal nerve; 9, temporal branches; 10, auricular branches; 11, anastomosis with the facial nerve; 12, lingual branch; 13, *branch of the small root to the mylo-hyoid muscle*; 14, inferior dental nerve, with its branches (15, 15); 16, mental branch; 17, anastomosis of this branch with the facial nerve.

The above description gives in general terms the distribution of the nerve of mastication, without taking into consideration its various anastomoses, the most important of which are with the facial. Experiments have shown that the buccinator muscle receives no motor filaments from the fifth but is supplied entirely by the facial. The buccal branch of the fifth sends

motor filaments only, to the external pterygoid and the temporal, its final branches of distribution being sensory and going to integument and to mucous membrane.

In treating of the physiology of digestion, a table has been given of the muscles of mastication, with a description of their action. It will be seen by reference to this table that the following muscles depress the lower jaw; viz., the anterior belly of the digastric, the mylo-hyoid, the genio-hyoid and the platysma myoides. Of these the digastric and the mylo-hyoid are animated by the motor root of the fifth; the genio-hyoid is supplied by filaments from the sublingual; and the platysma myoides, by branches from the facial and from the cervical plexus. All of the muscles which elevate the lower jaw and move it laterally and antero-posteriorly; viz., the temporal, masseter, and the internal and external pterygoids—the muscles most actively concerned in mastication—are animated by the motor root of the fifth.

Properties and Uses of the Nerve of Mastication.—The anatomical distribution of the small root of the fifth nerve points at once to its uses. Charles Bell, whose ideas of the nerves were derived almost entirely from their anatomy, called it the nerve of mastication, in 1821, although he did not state that any experiments were made with regard to its action. All anatomical and physiological writers since that time have adopted this view. It would be difficult if not impossible to stimulate the root in the cranial cavity in a living animal; but its Faradization in animals just killed determines very marked movements of the lower jaw. Experiments have demonstrated the physiological properties of the small root, which is without doubt solely a nerve of motion.

The observations upon section of the fifth pair in the cranial cavity are most important in connection with the uses of its sensory branches and will be referred to in detail in treating of the properties of the large root. In addition to the loss of sensibility following section of the entire nerve, Bernard noted the effects of division of the small root, which can not be avoided in the operation. In rabbits the paralysis of the muscles of mastication upon one side, and the consequent action of the muscles upon the unaffected side only, produce, a few days after the operation, a remarkable change in the appearance of the incisor teeth. As the teeth in these animals are gradually worn away in mastication and reproduced, the lower jaw being deviated by the action of the muscles of the sound side, the upper incisor of one side and the lower incisor of the other touch each other but slightly and the teeth are worn unevenly. This makes the line of contact between the four incisors, when the jaws are closed, oblique instead of horizontal.

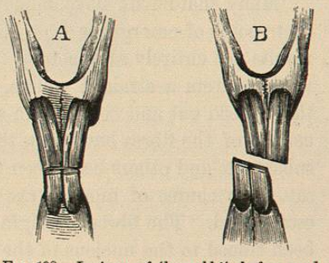

FIG. 198.—*Incisors of the rabbit, before and after section of the nerve of mastication* (Bernard).
A, incisors, normal condition.
B, incisors, seven days after section of the nerve on one side.

There is little left to say with regard to the uses of the motor root of the fifth nerve, in addition to the description of the action of the muscles of mastication, contained in the chapters on digestion, except as regards the action of the filaments sent to the muscles of the velum palati. In deglutition the muscles of mastication are indirectly involved. This act can not be well performed unless the mouth be closed by these muscles. When the food is brought in contact with the velum palati, muscles are brought into action which render this membrane tense, so that the opening is adapted to the size of the alimentary bolus. These muscles are animated by the motor root of the fifth. This nerve, then, is not only the nerve of mastication, animating all of the muscles concerned in this act, except two of the most unimportant depressors of the lower jaw (the genio-hyoid and the platysma myoides), but it is concerned indirectly in deglutition.

Facial, or Nerve of Expression (Seventh Nerve).

The anatomical relations of the facial nerve are quite intricate and it communicates freely with other nerves. As far as can be determined by experiments upon living animals, this nerve is exclusively motor at its origin; but in its course it presents anastomoses with the sympathetic, with branches of the fifth and with the cervical nerves, undoubtedly receiving sensory filaments.

Physiological Anatomy.—The facial nerve has its apparent origin from the lateral portion of the medulla oblongata, in the groove between the olivary and restiform bodies, just below the border of the pons Varolii, its trunk being internal to the trunk of the auditory nerve. It is separated from the auditory by the two filaments constituting what is known as the intermediary nerve of Wrisberg, or the portio inter duram et mollem. As this little nerve joins the facial, it is usually included in its root.

Many anatomists have endeavored to trace the fibres of the facial from their point of emergence from the encephalon to their true origin, but with results not entirely satisfactory. Its fibres pass inward, with one or two deviations from a straight course, to the floor of the fourth ventricle, where they spread out and become fan-shaped. In the floor of the fourth ventricle certain of the fibres have been thought to terminate in the cells of the gray substance, and others have been traced to the median line, where they decussate; the course of most of the fibres, however, has not been satisfactorily established. The fibres of origin of the intermediary nerve of Wrisberg have been traced to the nucleus of the glosso-pharyngeal.

It is evident from physiological experiments, that the decussation of the fibres in the floor of the fourth ventricle itself is not very important. Vulpian made, in dogs and rabbits, a longitudinal section in the middle line of the ventricle, which would necessarily have divided the fibres passing from one side to the other, without producing notable paralysis of the facial nerves upon either side. This single fact is sufficient to show that the main decussation of the fibres animating the muscles of the face takes place, if at all, at some other point.

The pathological facts bearing upon the question of decussation of the

filaments of origin of the facial have long been recognized. They are in brief as follows: When there is a lesion of the brain-substance anterior to the pons Varolii, the phenomena due to paralysis of the facial are observed upon the same side as the hemiplegia, opposite the side of injury to the brain. When the lesion is either in the pons or below it, the face is affected upon the same side, and not upon the side of the hemiplegia. This is called alternate paralysis. In view of these facts, the phenomenon of hemiplegia upon one side and facial paralysis upon the other is regarded as indicating, with tolerable certainty, that the injury to the brain has occurred upon the same side as the facial paralysis, either within or posterior to the pons Varolii.

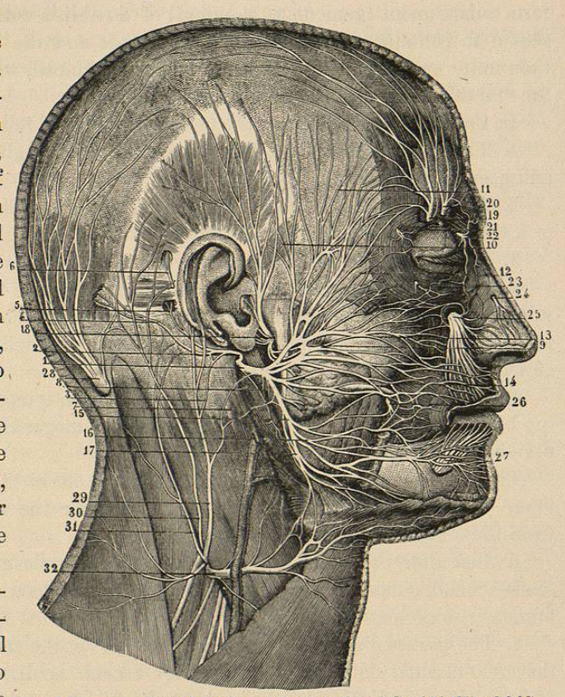

Fig. 199.—*Superficial branches of the facial and the fifth* (Hirschfeld). 1, *trunk of the facial*; 2, *posterior auricular nerve*; 3, *branch which it receives from the cervical plexus*; 4, *occipital branch*; 5, 6, *branches to the muscles of the ear*; 7, *digastric branches*; 8, *branch to the stylo-hyoid muscle*; 9, *superior terminal branch*; 10, *temporal branches*; 11, *frontal branches*; 12, *branches to the orbicularis palpebrarum*; 13, *nasal, or suborbital branches*; 14, *buccal branches*; 15, *inferior terminal branch*; 16, *mental branches*; 17, *cervical branches*; 18, superficial temporal nerve (branch of the fifth); 19, 20, frontal nerves (branches of the fifth); 21, 22, 23, 24, 25, 26, 27, branches of the fifth; 28, 29, 30, 31, 32, branches of the cervical nerves.

As already stated, the fibres of origin of the facial have been traced to the floor of the fourth ventricle, where a few decussate but most of them are lost. The question now is, whether or not the fibres pass up through the pons and decussate above, as the pathological facts just noted would seem to indicate. Anatomical researches upon this point are not satisfactory, and the existence of such a decussation has never been clearly demonstrated. The pathological observations, nevertheless, remain; and however indefinite anatomical researches may have been, there can be no doubt that lesions in one lateral half of the pons affect the facial upon the same side, while lesions above have a crossed action. The most that can be said upon this point is that it is a reasonable inference from pathological facts that the nerves decussate anterior to the pons.

The main root of the facial, the auditory nerve and the intermediary nerve of Wrisberg pass together into the internal auditory meatus. At the bottom of the meatus, the facial and the nerve of Wrisberg enter the aquæductus Fallopii, following its course through the petrous portion of the temporal bone. In the aqueduct the nerve of Wrisberg presents a little, ganglioform enlargement (geniculate ganglion) of a reddish color, which has been shown to contain nerve-cells. The main root and the intermediary nerve then unite and form the common trunk of the facial, which emerges from the cranial cavity, by the stylo-mastoid foramen.

In the aquæductus Fallopii the facial gives off the following branches:

1. The large petrosal branch is given off at the ganglioform enlargement and goes to Meckel's ganglion.

2. The small petrosal branch is given off at the ganglioform enlargement or a very short distance beyond it and passes to the otic ganglion.

3. A small branch, the tympanic, is distributed to the stapedius muscle.

4. The chorda tympani passes through the cavity of the tympanum and joins the lingual branch of the inferior maxillary division of the fifth, as it passes between the two pterygoid muscles, with which nerve it becomes closely united.

5. Opposite to the point of origin of the chorda tympani, a communicating branch passes between the facial and the pneumogastric, connecting these nerves by a double inosculation.

The five branches above described are given off in the aquæductus Fallopii. The following branches are given off after the nerve has emerged from the cranial cavity:

1. Just after the facial has passed out at the stylo-mastoid foramen, it sends a small, communicating branch to the glosso-pharyngeal nerve. This branch is sometimes wanting.

2. The posterior auricular nerve is given off by the facial, a little below the stylo-mastoid foramen. Its superior branch is distributed to the retrahens aurem and the attollens aurem, In its course this nerve receives a communicating branch of considerable size from the cervical plexus, by the auricularis magnus. It sends some filaments to the integument. The inferior, or occipital branch, the larger of the two, is distributed to the occipital portion of the occipito-frontalis muscle and to the integument.

3. The digastric branch is given off near the root of the posterior auricular. It is distributed to the posterior belly of the digastric muscle. In its course it anastomoses with filaments from the glosso-pharyngeal nerve. From the plexus formed by this anastomosis, filaments are given off to the digastric and to the stylo-hyoid muscle.

4. Near the stylo-mastoid foramen, a small branch is given off, which is distributed exclusively to the stylo-hyoid muscle.

5. Near the stylo-mastoid foramen, or sometimes a little above it, a long, delicate branch is given off, which is not noticed in many works on anatomy. It is described, however, by Hirschfeld, under the name of the lingual branch. It passes behind the stylo-pharyngeal muscle, and then by the sides of the pharynx to the base of the tongue. In its course it receives one or two branches from the glosso-pharyngeal nerve, which are nearly as large as the original branch from the facial. As it passes to the base of the tongue, it anastomoses again by a number of filaments with the glosso-pharyngeal. It then sends filaments of distribution to the mucous membrane and finally passes to the stylo-glossus and palato-glossus muscles.

Having given off these branches, the trunk of the facial passes through the parotid gland, dividing into its two great terminal branches:

1. The temporo-facial branch, the larger, passes upward and forward to be distributed to the superficial muscles of the upper part of the face; viz., the attrahens aurem, the frontal portion of the occipito-frontalis, the orbicularis palpebrarum, corrugator supercilii, pyramidalis nasi, levator labii superioris, levator labii superioris alæque nasi, the dilators and compressors of the nose, part of the buccinator, the levator anguli oris and the zygomatic muscles. In its course it receives branches of communication from the auriculo-temporal branch of the inferior maxillary nerve. It joins also with the temporal branch of the superior maxillary and with branches of the ophthalmic. It thus becomes a mixed nerve and is distributed in part to integument.

2. The cervico-facial nerve passes downward and forward to supply the buccinator, orbicularis oris, risorius, levator labii inferioris, depressor labii inferioris, depressor anguli oris and platysma.

General Properties of the Facial Nerve.—It has long been recognized that the facial is the motor nerve of the superficial muscles of the face and that its division produces paralysis of motion and no marked effects upon sensation. It is evident, also, from the communications of the facial with the fifth, that it probably contains in its course sensory fibres. Indeed, all who have operated upon this nerve have found that it is slightly sensory after it has emerged from the cranial cavity. It is a question, however, of great importance to determine whether or not the facial be endowed with sensibility by virtue of its own fibres of origin. The main root is evidently from the motor tract, resembles the anterior roots of the spinal nerves, and is distributed to muscles; but this root is joined by the intermediary nerve of Wrisberg, which presents a small, ganglionic enlargement, that is analogous to the ganglia upon the posterior roots of the spinal nerves. The testimony of direct experimentation is in favor of the insensibility of the facial at its origin. It is true that the intermediary nerve of Wrisberg has a certain anatomical resemblance to the sensory nerves, chiefly by reason of its ganglioform enlargement; but direct experiments are wanting to show that it is sensory.

Uses of the Branches of the Facial given off within the Aqueduct of Fallopius.—The first branch, the large petrosal, is the motor root of Meckel's ganglion. This will be referred to again, in connection with the sympathetic system. The second branch, the small petrosal, is one of the motor roots of the otic ganglion of the sympathetic. The third branch, the tympanic, is distributed exclusively to the stapedius muscle. The second and third branches will be again considered, in connection with the physiology of the

internal ear. The fourth branch, the chorda tympani, is so important that it demands special consideration. The fifth branch is given off opposite the origin of the chorda tympani and passes to the pneumogastric, to which nerve it probably supplies motor filaments. In this branch, sensory filaments pass from the pneumogastric and constitute a part of the sensory connections of the facial.

Uses of the Chorda Tympani.—This nerve passes between the bones of the ear and through the tympanic cavity, to the lingual branch of the inferior maxillary division of the fifth, which it joins at an acute angle, between the pterygoid muscles. As regards the portion of the facial which furnishes the filaments of the chorda tympani, it is nearly certain that these come from the intermediary nerve of Wrisberg.

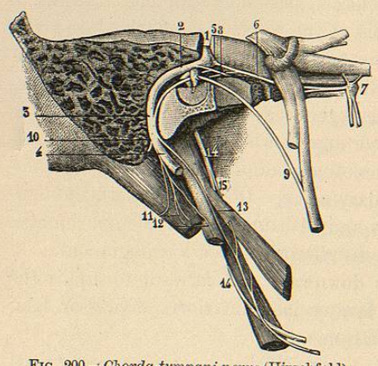

FIG. 200.—*Chorda-tympani nerve* (Hirschfeld).
1, 2, 3, 4, facial nerve passing through the aquæductus Fallopii; 5, ganglioform enlargement (geniculate ganglion); 6, great petrosal nerve; 7, spheno-palatine ganglion; 8, small petrosal nerve; 9, *chorda tympani*; 10, 11, 12, 13, various branches of the facial; 14, 14, 15, glosso-pharyngeal nerve.

There can be no doubt with regard to the influence of the chorda tympani upon the sense of taste in the anterior two-thirds of the tongue. In cases of disease or injury in which the root of the facial is involved so that the chorda tympani is paralyzed, in addition to the ordinary phenomena of paralysis of the superficial muscles of the face, there is loss of taste in the anterior two-thirds of the tongue, upon the side corresponding to the lesion. The action of the chorda tympani will be considered again, in connection with the physiology of gustation.

Influence of Various Branches of the Facial upon the Movements of the Palate and Uvula.—There can be little doubt that filaments from the facial animate certain of the movements of the velum palati and uvula. It has been observed that in certain cases of facial paralysis the palate upon one side is flaccid and the uvula is drawn to the opposite side; but these phenomena do not occur unless the nerve be affected at its root or within the aquæductus Fallopii. It is true that the uvula frequently is drawn to one side or the other in persons unaffected with facial paralysis, but it is none the less certain that it is deviated as a consequence of paralysis of the facial in some instances. The filaments of the facial which influence the levator palati and azygos uvulæ muscles are derived from the large petrosal branch of the nerve, passing to the muscles through Meckel's ganglion, the filaments to the palato-glossus and the palato-pharyngeus being given off from the glosso-pharyngeal, but originally coming from an anastomosing branch of the facial (Longet). As regards the branches of communication from the glosso-pharyngeal, Longet has mentioned a preparation by Richet, in the museum of the *École de médecine*, of Paris, in which branches of the facial

upon one side pass directly to the palato-glossus and the palato-pharyngeus, without any connection with the glosso-pharyngeal nerve. In the anatomical description of the branches of the facial, it has already been noted that a filament, described by Hirschfeld, passes to the stylo-glossus and the palato-glossus muscles. This is the filament affected when there is deviation of the point of the tongue.

In view of the examples of paralysis of the palate and uvula in certain cases of facial palsy, the frequent occurrence of contractions of the muscles of these parts upon stimulation of the facial and the reflex action through the glosso-pharyngeal and the facial, there can be little doubt that the muscles of the palate and uvula are animated by filaments derived from the seventh nerve. The effects of paralysis of these muscles are manifested by more or less trouble in deglutition and in the pronunciation or certain words, with great difficulty in the expulsion of mucus collected in the back part of the mouth and the pharynx.

Uses of the External Branches of the Facial.—The general action of the branches of the facial going to the superficial muscles of the face is sufficiently evident, in view of what is known of the distribution of these branches and the general properties of the nerve. Throughout the writings of Charles Bell, the facial is spoken of as the "respiratory nerve of the face." It is now recognized as the nerve which presides over the movements of the superficial muscles of the face, not including those directly concerned in the act of mastication. This being its general action, it is easy to assign to each of the external branches of the facial its particular office.

Just after the facial nerve has passed out at the stylo-mastoid foramen, it sends to the glosso-pharyngeal the communicating branch, the action of which has just been mentioned in connection with the movements of the palate.

The posterior auricular branch, becoming partly sensory by the addition of filaments from the cervical plexus, gives sensibility to the integument on the back part of the ear and over the occipital portion of the occipito-frontalis muscle. It animates the retrahens and the attollens aurem, muscles that are little developed in man but are very important in certain of the inferior animals. It also animates the posterior portion of the occipito-frontalis muscle.

The branches distributed to the posterior belly of the digastric and to the stylo-hyoid muscle simply animate these muscles, one of the uses of which is to assist in deglutition. The same may be said of the filaments that go to the stylo-glossus.

The two great branches distributed upon the face, after the trunk of the nerve has passed through the parotid gland, have the most prominent action. Both of these branches are slightly sensory, from their connections with other nerves, and are distributed in small part to integument.

The temporo-facial branch animates all of the muscles of the upper part of the face. In complete paralysis of this branch, the eye is constantly open, even during sleep, on account of paralysis of the orbicularis muscle. In cases of long standing, the globe of the eye may become inflamed from con-

stant exposure, from abolition of the movements of winking by which the tears are distributed over its surface and little foreign particles are removed, and, in short, from absence of the protective action of the lids. In these cases the lower lid may become slightly everted. The frontal portion of the occipito-frontalis, the attrahens aurem, and the corrugator supercilii muscles, are also paralyzed. The most prominent symptom of paralysis of these muscles is inability to corrugate the brow upon one side.

Paralysis of the muscles that dilate the nostrils has been shown to have an important influence upon respiration through the nose. It was the synchronism between the acts of dilatation of the nostrils and the movements of inspiration which first led Charles Bell to regard the facial as a respiratory nerve. In instances of complete paralysis of the nostril of one side, there is frequently some difficulty in inspiration, even in the human subject.

Charles Bell and others have also noted an interference with olfaction, due to the inability to inhale with one nostril, in cases of facial paralysis.

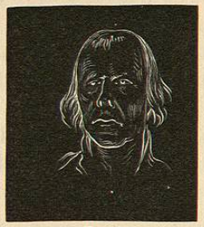

FIG. 201.

FIG. 202.

FIG. 203.

FIG. 204.

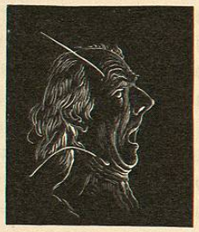

FIG. 205.

FIG. 206.

Expressions of the face produced by contraction of the muscles under electrical excitation (Le Bon, after Duchenne).

Fig. 201, front view of the face in repose.
Fig. 202, profile view.
Fig. 203, expression of laughter upon one side, produced by contraction of the zygomaticus major.
Fig. 204, expression of fear, produced by contraction of the frontal muscle and the depressors of the lower jaw.
Fig. 205, expression of fear, profile view.
Fig. 206, expression of fear and great pain, produced by contraction of the corrugator supercilii and the depressors of the lower jaw.

The influence of the nerve in the act of conveying odorous emanations to the olfactory membrane is sufficiently evident, after what has been said concerning the action of the facial in respiration.

The effects of paralysis of the other superficial muscles of the face are manifested in the distortion of the features, on account of the unopposed action of the muscles upon the sound side, a phenomenon which is sufficiently familiar. When facial palsy affects one side and is complete, the angle of the mouth is drawn to the opposite side, the eye upon the affected side is widely and permanently opened, even during sleep, and the face has upon that side a peculiarly expressionless appearance. When a patient affected in this way smiles or attempts to grimace, the distortion is much increased. The lips are paralyzed upon one side, which sometimes causes a flow of saliva from the corner of the mouth. In the lower animals that use the lips in prehension, paralysis of these parts interferes considerably with the taking of food. The flaccidity of the paralyzed lips and cheek in the human subject sometimes causes a puffing movement with each act of expiration, as if the patient were smoking a pipe.

The buccinator is not supplied by filaments from the nerve of mastication but is animated solely by the facial. Paralysis of this muscle interferes materially with mastication, from a tendency to accumulation of the food between the teeth and the cheek. Patients complain of this difficulty, and they sometimes keep the food between the teeth by pressure with the hand. In the rare instances in which both facial nerves are paralyzed, there is very great difficulty in mastication, from the cause just mentioned.

The action of the external branches of the facial is thus sufficiently simple; and it is only as its deep branches affect the sense of taste, the movements of deglutition, etc., that it is difficult to ascertain their exact office. As this is the nerve of expression of the face, it is in the human subject that the phenomena attending its paralysis are most prominent. When both sides are affected, the aspect is remarkable, the face being absolutely expressionless and looking as if it were covered with a mask.

SPINAL ACCESSORY (ELEVENTH NERVE).

The spinal accessory nerve, from the great extent of its origin, its important anastomoses with other nerves and its peculiar course and distribution, has long engaged the attention of anatomists and physiologists, who have advanced many theories with regard to its office. Its physiological history, however, begins with comparatively recent experiments, which alone have given a positive knowledge of its properties and uses.

Physiological Anatomy—The origin of this nerve is very extensive. A certain portion arises from the lower half of the medulla oblongata, and the rest takes its origin below, from the upper two-thirds of the cervical portion of the spinal cord. That portion of the root which arises from the medulla oblongata is called the bulbar portion, the roots from the cord constituting the spinal portion. Inasmuch as there is a marked difference between the uses of these two portions, the anatomical distinction just mentioned is important.

The superior roots arise by four or five filaments, from the lower half of the medulla oblongata, below the origin of the pneumogastrics. These filaments of origin pass to a gray nucleus in the medulla, below the origin of the pneumogastric.

The spinal portion of the nerve arises from the upper part of the spinal