Nerve Supply to the Head and Neck

The nervous system is akin to a large network of electrical and telephone wires carrying messages to and from a control center. This system can emit and receive thousands of bits of information, integrate them, and determine the response to be made by the body.

The Peripheral and the Central Nervous Systems

The central nervous system is the control center or "home base" for the entire mechanism. It is divided into two parts: the brain and the spinal cord. The brain is housed in the cranium, and the spinal cord is housed in the vertebral column. These two parts are divided only for the purposes of description. Functionally and anatomically they are connected and are coordinated.

The peripheral nervous system refers to the cranial and spinal nerves. There are 31 pairs of spinal nerves and 12 pairs of cranial nerves connecting the central nervous system to all parts of the body. Each cranial nerve and each spinal nerve is made up of many nerve cells.

Nerve cells contain a cell body and several processes. Those processes conducting impulses toward the cell body are called dendrites. They may be very short or quite long; singular or numerous. Those processes carrying impulses away from the cell body are known as axons. There is only one axon per nerve cell. They may vary greatly in length. A nerve cell body together with its dendrites and axons is known as a neuron. It is the processes of many neurons which are "bundled" together to form the nerves of the peripheral nervous system.

The Spinal Cord

When viewed in cross section, the spinal cord is seen to be divided into symmetrical halves by the anterior median fissure and the posterior median fissure. Also one notes in the cross section that the substance of the cord appears to be comprised of two types of tissue. The internal, H-shaped area is the gray matter and contains nerve cell bodies. The outside area is the white matter and contains the nerve cell processes.

Emanating from the posterior aspect of each side of the cord is a branch called the posterior or dorsal root. It contains a swelling, the dorsal root ganglion (spinal ganglion). The dorsal root contains axons between the root ganglion and the central nervous system. Between the root ganglion and the spinal nerve, the dorsal root contains dendrites. From the anterior aspect of the cord is another branch: the ventral root. It does not contain a ganglion and is composed only of axons. A ganglion is a collection of nerve cell bodies. The two roots join on the distal side of the dorsal root ganglion to form a spinal nerve. The spinal nerve then redivides into a dorsal (posterior) primary division and ventral (anterior) primary division. Also two more small nerves leave this area: a recurrent branch to the vertebral canal and meninges and a visceral branch to the sympathetic chain. The fibers in the ventral root
are *efferent fibers*. That is, they are carrying impulses *away* from the cord. Since the dorsal root is carrying impulses toward the cord, the fibers are referred to as *afferent*. In contrast, the dorsal (posterior) primary division of the spinal nerve carries impulses to and from the posterior aspect of the body and the ventral (anterior) primary division carries impulses to and from the anterior portion of the body. Thus *both* primary divisions of the spinal nerve are carrying afferent and efferent fibers.

Nerve impulses are transmitted from one area to another along neurons. A *synapse* refers to the region of contact between processes of two neurons. It is at this region that an impulse is transmitted from one neuron to another. There may be one or more synapses between the peripheral nervous system and the central nervous system, many occurring in ganglia outside the central nervous system. However, in the dorsal root ganglia, no synapses occur.

*The Brain*

The brain is a bulbous enlargement of one end of the spinal cord. It also consists of gray and white substance. However, for the most part, the gray matter is the outer layer and is known as the *cortex*. The mechanics of this reversal of the gray and white matter lies in the complex neuroanatomy of the brain. The cortex is estimated to contain 15 billion nerve cells.

The two largest areas of the brain are the right and left *cerebral hemispheres*. Various convolutions and sulci are seen traversing the cortex of these hemispheres. The two major grooves are the *lateral fissure* and the *central sulcus*. The convolutions are known as *gyri* (singular, *gyrus*). They have specific functions, some of which are quite well understood. For example, the *precentral gyrus* controls most of the voluntary skeletal muscles of the contralateral side of the body. The homunculus illustrates which areas of the precentral gyrus are assigned to various areas of the body. The size of the area is proportional to the complexity and delicateness of the movements. Moreover, the *postcentral gyrus* involves sensory functions. The homunculus also illustrates the cortical *sensory assignments*. Behind and below the cerebral hemispheres is the bilobed *cerebellum*. It coordinates the activity of muscles and muscle groups so that physical and visceral activity is performed smoothly and with accuracy. Thus the cerebrum activates muscles and muscle groups; the cerebellum coordinates the muscles' activity.

*Cerebrospinal Fluid*

The brain and spinal cord are suspended in a clear liquid, which occupies a space known as the *subarachnoid space*. This space lies between the *pia mater* and the *arachnoid*. The pia mater is a delicate film of tissue surrounding the brain and spinal cord and intimately adhering to the outer surface. It dips into the sulci and fissures. The arachnoid is a delicate membrane lying under the *dura mater* and loosely attached to the pia mater by means of delicate fibrils. These fibrils traverse the subarachnoid space and attach the arachnoid to the pia. The dura mater is a loose sheath around the spinal cord and brain. It is located just beneath the internal surface of the skull and the spinal canal. It is thicker and stronger than
the arachnoid and the pia. These various coverings of the brain and spinal cord are collectively referred to as the *meninges*.

There is also a space or cavity within the central core of each cerebral hemisphere. This space is the *lateral ventricle*. In the central portion of the junction of the two cerebral hemispheres is a third space known as the *third ventricle*, which communicates with the lateral ventricles. The fourth ventricle is a widened area that lies under the cerebellum. It communicates anteriorly with the third ventricle and posteriorly and inferiorly with the *central canal* of the spinal cord. The central canal and the cerebral ventricles contain the same cerebrospinal fluid as that in the subarachnoid space.

Thus, the cerebrospinal fluid occupies the subarachnoid space, the central canal of the spinal cord, and the ventricles of the brain. It is found within *and around* the central nervous system. The total volume of this clear, watery fluid is from 90 to 150 cc in adults. It is an excellent indicator of various types of systemic and neurologic disease and is often examined to augment diagnosis of patients. A sample may be withdrawn by aspiration of a small amount via a needle introduced into the subarachnoid space of the spinal cord.

Most cerebrospinal fluid is formed in the *choroid plexuses*, tufts of capillaries projecting into the ventricles in various areas. Plasma-like fluid leaves the capillary tufts and passes into the cerebral ventricles. The fluid drains from the ventricles and central canal of the cord by way of an opening in the roof of the fourth ventricle. This opening communicates with the subarachnoid space of the cerebellum. It then diffuses out of the subarachnoid space, surrounding the brain, and is collected by the superior sagittal sinus. From there it is returned to the blood stream.

Cerebrospinal fluid is thought to serve three main functions. Since it communicates with venous drainage, it removes metabolic waste products from cells of the central nervous system. It is formed from arterial capillaries and therefore acts in a nutritive capacity. Thirdly, it is an excellent shock absorber.

**The Autonomic Nervous System**

In contrast to those body functions over which we have conscious control, there are many body functions over which we have no control. We are able to control arm and leg movements but cannot control heart rate or pupil constriction. The autonomic nervous system supplies efferent nerves for the "automatic" activities of glands, the muscle of the cardiovascular system, and the intrinsic muscles of the eye. The mechanism is purely efferent and is based on a two-neuron pathway. The first neuron originates in the central nervous system. It leaves via a spinal or cranial nerve and synapses in a ganglion distant from the central nervous system. The second neuron then goes to the effector organ.

There are two divisions of the autonomic nervous system: the *sympathetic nervous system* and the *parasympathetic nervous system*. They oppose and compliment one another.
The Sympathetic Nervous System

The sympathetic nervous system is also called the thoracolumbar portion, since the first order neuron exits with the spinal nerves in the thoracic or lumbar regions of the spinal column. The axons of these neurons then go to the sympathetic trunks and synapse with the second order neuron. The sympathetic trunks are long ganglionated chains extending along either side of the vertebral column. The second order neurons then go to the effector organs. Some organs of the gut are supplied by a three-neuron pathway in these instances. The second order neuron goes to a small ganglion near the effector organ where a third order neuron arises and innervates the effector organ. This nervous system is designed to increase the body's response to emergency situations; therefore, it dilates blood vessels in muscles, increasing blood supply to the muscles and thus permitting that organ to function more effectively. The sympathetic nervous system also dilates the pupil of the eye and causes the heart to beat more rapidly and with more force.

All the second order neurons destined for the head and neck arise in the uppermost ganglion of the sympathetic chain. This ganglion has been named the superior cervical ganglion and is located at the level of the second cervical vertebra. The second order fibers then follow the arterial tree to the various effector organs in the head and neck.

The Parasympathetic Nervous System

The parasympathetic nervous system is sometimes called the craniosacral division of the autonomic nervous system. The first order neurons exit either with the spinal nerves in the sacral region of the vertebral column or with the cranial nerves. This system slows the heart, constricts the pupil of the eye, and increases gastric activity and salivation. Once the fibers exit from the central nervous system, they do not synapse until they are in close proximity to the effector organ. A ganglion lies near the effector organ. The second order neurons arise here and by a very short fiber reach the effector organ. There is no parasympathetic ganglion chain as in the sympathetic system.

The Cranial Nerves

The nerves of the body may be classified also by their functions. Those nerves that supply muscles and structures of the body wall are called somatic. Nerves to the internal organs (viscera) are termed visceral. Sensory fibers that carry impulses toward the brain are designated as afferent. Motor (or action-producing) fibers are termed efferent. They carry impulses away from the brain to an effector.

Cranial nerves are comprised of afferent fibers (taste, pain, proprioception), as well as efferent fibers to muscles, glands, and blood vessels. Some nerves are highly specialized and do not carry all the components. The optic nerve, for example, carries only afferent fibers from the retina to the brain, to produce vision.

As noted before, no sympathetic fibers have first order neurons in the brain. The sympathetic second order fibers arise in the superior cervical ganglion and reach effector...
organs by "riding along" with the arteries. There are, however, several parasympathetic fibers originating in the brain.

The cranial nerves are released from the base of the brain and exit from the cranial cavity through various openings and foramina. They are designated by Roman numerals, and all are paired.

I. The Olfactory Nerve

The olfactory nerve is the nerve providing the sense of smell. It is afferent only. A number of bundles of nerve fibers from the superior concha and nasal septum pass upwards through the foramina of the cribriform plate of the ethmoid bone. They synapse in the olfactory bulb, a projection of brain tissue which rests on the intracranial surface of the cribriform plate. Although the olfactory bulb tract appears to be a nerve, it more accurately is classified as part of the brain. Impulses are carried back to the brain, and the sense of smell is realized.

II. The Optic Nerve

The nerve of sight is also an afferent nerve with no efferent component. The flat, cup-shaped retina is the internal surface of the back of the eyeball. It converges behind the bulb of the eye and coalesces into a nerve. The nerve passes into the brain case through the optic foramen. It then courses posteriorly to a point in front of the sella turcica. Right and left optic nerves then cross and pass into the brain. The area of crossover is the optic chiasma.

III. The Oculomotor Nerve

The third cranial nerve carries both afferent and efferent fibers. It supplies fibers to the extrinsic muscles of the eye with efferent motor fibers and afferent proprioception fibers. Proprioception is that sense of awareness of the movement and position of the body and its organs. Proprioceptors are located in many parts of the body, particularly in muscles and joints.

The oculomotor nerve also carries first order neurons of the parasympathetic nerves to the intrinsic muscles of the eye. A small parasympathetic ganglion, the ciliary ganglion, is located in the orbit, near the posterior wall. This ganglion is the location of synapse between the first order neuron and second order neuron of the parasympathetic portion of the third cranial nerve. First order neurons carried in the oculomotor nerve drop off to synapse in the ciliary ganglion. The second order neurons leave the ganglion via the tiny short ciliary nerves to supply the constrictor of the pupil and the ciliary muscle. The ciliary muscle acts to change the shape of the lens, making it more convex.

There are six extrinsic muscles of the eye: superior, medial, lateral, and inferior rectii; the superior and inferior oblique; and the elevator of the upper lid. The lateral rectus and superior oblique muscles are not supplied by the oculomotor nerve. They are supplied by the sixth and fourth cranial nerves, respectively. In order for the oculomotor nerve to reach the
muscles and ciliary ganglion, it passes from the cranial cavity into the orbit through the superior orbital fissure.

IV. The Trochlear Nerve

The trochlear nerve has only one function: to supply the superior oblique muscle of the eye. It provides both proprioceptive afferent fibers and motor (efferent) fibers to this muscle. After passing through the cavernous sinus, it leaves the brain case and enters the orbit via the superior orbital fissure.

V. The Trigeminal Nerve

Not only is the fifth cranial nerve the largest of the cranial nerves, but also it is the single most important nerve to members of the dental profession. It supplies almost all the pain and proprioception fibers to the face, jaws, and scalp. The trigeminal nerve also innervates muscles and carries parasympathetic fibers to the salivary and lacrimal glands.

The trigeminal nerve arises by a short trunk composed of two closely adapted roots: a thin motor root and a thick sensory root. The two roots pass anteriorly together for a short distance within the cranial cavity. A swelling or bulging of this structure is then noted. This is the semilunar (gasserian) ganglion. In this ganglion lie the cell bodies of the sensory fibers of the fifth cranial nerve. The sensory division then divides into three branches: the ophthalmic, the maxillary, and the mandibular.

The Ophthalmic Nerve

The ophthalmic nerve is the first division of the trigeminal nerve. It exits from the brain case and enters the orbit through the superior orbital fissure. It supplies sensory fibers to the bulb of the eye, the conjunctiva, lacrimal gland, inside of the nose, and skin of the eyelids, forehead, and nose. Before entering the orbit, it divides into three branches - the lacrimal, frontal, and nasociliary - all of which pass into the orbit through the superior orbital fissure.

The Lacrimal Nerve. This branch supplies the lacrimal gland with sensory fibers. In addition, in the orbit, the lacrimal nerve picks up postganglionic parasympathetic fibers from the zygomatico-temporal nerve, a branch of the second division of the trigeminal nerve.

These postganglionic parasympathetic fibers, which are second order neurons from the pterygopalatine (sphenopalatine) ganglion, reach the gland via the lacrimal nerve. They innervate the secretory cells of the lacrimal gland, producing tears.

The Frontal Nerve. This branch of the ophthalmic nerve divides in the orbit into supraorbital and supratrochlear nerves to the upper lid and forehead.

The Nasociliary Nerve. This branch of the ophthalmic nerve courses toward the medial orbital wall, passes through the ethmoid bone, and reenters the cranial cavity just above the cribiform plate. It then pierces the roof of the nasal cavity, passes into the nose,
and supplies the mucosa of the nose. It even sends branches between the cartilage and bone of the nose to supply the skin on the side of the nose.

**The Maxillary Nerve**

The second division of the trigeminal nerve leaves the cranial cavity through the foramen rotundum. It passes into the pterygopalatine fossa, where it ramifies into several branches. The maxillary nerve is sensory, although some of its branches carry parasympathetic motor fibers.

**The Zygomatic Nerve.** This nerve leaves the pterygopalatine fossa and enters the orbit through the inferior orbital fissure. It carries postganglionic parasympathetic motor fibers which it has acquired from the pterygopalatine ganglion in the pterygopalatine fossa. While in the orbit, it divides into the zygomaticofacial nerve and the zygomaticotemporal nerve. The zygomaticofacial nerve pierces the body of the zygoma and supplies sensory fibers to the skin of the cheek. The zygomaticotemporal nerve reaches the skin and side of the forehead by piercing the lateral orbital wall near the sphenozygomatic suture. The zygomaticotemporal nerve also carries the parasympathetic fibers from the zygomatic nerve from which it branched. While in the orbit, the zygomaticotemporal nerve releases these parasympathetic fibers to the lacrimal nerve. The lacrimal nerve, a branch of the ophthalmic nerve, then carries these parasympathetic fibers to the lacrimal gland.

**The Infraorbital Nerve.** The infraorbital nerve in the posterior part of the orbit continues the course of the maxillary nerve. It passes out of the pterygopalatine fossa, laterally and anteriorly, towards the infraorbital fissure. It courses in the floor of the orbit through the infraorbital groove. The groove is roofed over further anteriorly and becomes the infraorbital canal. Just before the infraorbital nerve enters the infraorbital groove, it releases the posterior superior alveolar nerves. These branches cross the maxillary tuberosity and supply the molars and buccal gingiva. They also supply the mucosa of the maxillary sinus.

Within the infraorbital canal, the middle superior alveolar nerves may or may not be released. If present, they run downward in the lateral wall of the sinus and supply the premolars and associated buccal gingiva. They communicate with the posterior superior alveolar nerves and the anterior superior alveolar nerves.

Just before the infraorbital nerve exits from the infraorbital canal through the infraorbital foramen, it releases the anterior superior alveolar nerves. The anterior superior alveolar nerves drop to the anterior teeth and labial gingiva via the internal surface of the anterior wall of the maxillary sinus. The infraorbital nerve then exits through the infraorbital foramen and supplies the lower lid, the side of the nose, the upper lip, and the anterior surface of the cheek.

**Pterygopalatine Nerves.** In the pterygopalatine fossa, one to five short branches drop off the maxillary nerve to the pterygopalatine (sphenopalatine) ganglion. At the ganglion area, ramification takes place, and the pterygopalatine branches emerge. They pick up postganglionic parasympathetic fibers and carry them to the nasal and oral cavities. Some postganglionic fibers from this ganglion pass into the zygomatic nerve and supply the lacrimal gland. The rest pass into the pterygopalatine branches.
The sensory fibers of the pterygopalatine nerves have only a topographic relation to the pterygopalatine ganglion. No trigeminal sensory fibers synapse in this ganglion.

**Nasal Branches.** These fibers enter the nasal cavity through the sphenopalatine foramen. They carry sensory fibers from the gasserian ganglion, and they carry second order parasympathetic fibers from the pterygopalatine ganglion to the glands and mucous membrane over the conchae. One long fiber emerges and passes over the septum. It is the *nasopalatine nerve*, which courses as far forward as the nasopalatine canal. It traverses through the canal and enters the mouth through the nasopalatine foramen. The nasopalatine nerve supplies the nasal mucosa and glands on the septum as well as the oral mucosa and minor salivary glands behind the maxillary anterior teeth.

**Greater Palatine Nerve.** This branch emerges from the ganglion and passes downward through the pterygopalatine canal. It carries sensory fibers and postganglionic parasympathetic fibers to the glands of the palate, and afferent taste fibers that pass through the ganglion on their way to greater petrosal nerve. Taste fibers do not synapse in the pterygopalatine ganglion. The greater palatine nerve courses onto the hard palate through the greater palatine foramen and turns horizontally forward. It supplies the glands, taste buds, and mucosa of the palate as far forward as the cuspid.

While in the pterygopalatine canal, the greater palatine nerve releases some *lesser palatine nerves*. These branches emerge on the palate through the *lesser palatine foramina* to supply the glands, taste buds, and mucosa of the soft palate.

The glands of the nasal and oral cavities receive their second order parasympathetic neurons by way of the various branches of the pterygopalatine nerve(s). The first order neurons, that synapse with the second order neurons in the pterygopalatine ganglion, are associated with the facial nerve. Thus, the parasympathetic nerve supply to the glands of the nose and palate has a twofold relation: first order neurons originate with the facial nerve and second order neurons are carried in branches of the trigeminal nerve.

**The Mandibular Nerve**

The mandibular nerve is the third and largest division of the trigeminal nerve. It also is the only division to carry fibers from the motor root to the skeletal muscle. Both roots leave the brain case through the *foramen ovale* and unite into a short main trunk. The nerve then ramifications as it lies in the infratemporal fossa, deep to the lateral pterygoid muscle. Most of the motor nerves to the muscles of mastication are released here.

**Medial Pterygoid Nerve.** This nerve supplies the medial pterygoid muscle and enters it close to the pterygoid process.

**Masseteric Nerve.** It passes laterally through the sigmoid notch and enters the masseter muscle on the deep surface.
Deep Temporal Nerves. Usually one or two nerves leave the mandibular trunk near the origin of the masseteric nerve. They pass laterally through the two heads of the lateral pterygoid muscle and enter the temporalis muscle on the deep surface.

Lateral Pterygoid Nerve. This nerve arises with the other nerves to the muscles of mastication, passes laterally and inferiorly, and enters the deep surface of the lateral pterygoid muscle.

The Buccal Nerve (Long Buccal Nerve). This is primarily a sensory nerve, but it may carry a few motor fibers to the temporalis and lateral pterygoid muscles. (The buccinator muscle receives motor fibers from the facial nerve.) After releasing a few motor fibers to the temporalis and lateral pterygoid muscles, the buccal nerve passes laterally, between the heads of the lateral pterygoid muscle and passes down and forward. It crosses the anterior border of the vertical ramus of the mandible. When it reaches the buccinator muscle. It turns forward and lies on the lateral surface. The buccal nerve then ramifies, and the branches pierce the buccinator muscle and supply the buccal mucosa of the cheek, buccal gingiva of the mandibular molars, and sometimes a portion of the lip mucosa. Branches supply the skin of the cheek.

The Lingual Nerve. This sensory nerve branch of the mandibular nerve passes inferiorly, deep to the ramus of the mandible and laterally to the internal pterygoid muscle. Above the level of the inferior alveolar foramen, the lingual nerve is joined by the chorda tympani nerve which originated with and branched from the 7th cranial nerve. The chorda tympani nerve is carrying taste fibers (afferent) from the tongue and preganglion parasympathetic fibers (efferent) to the submandibular ganglion. Together, the chorda tympani and lingual nerves pass in a common sheath downward through the pterygomandibular space to the level of the occlusal plane of the teeth. Here they turn forward under the pterygomandibular raphe and lie at the posterior border of the mylohyoid muscle. At this point, the chorda tympani fibers drop off to the submandibular ganglion. From the ganglion, after synapse, second order neurons pass into the submandibular salivary gland. Other second order neurons reenter the lingual nerve and are carried to the sublingual gland and the tongue. The taste fibers from the tongue to the central nervous system do not synapse in the ganglion. They are carried in the chorda tympani nerve.

Since the chorda tympani nerve originates with the facial nerve and carries taste fibers from the tongue and preganglion parasympathetic fibers to the submandibular ganglion, it is both afferent (taste) and efferent (salivary).

From the area of the submandibular ganglion, the lingual nerve courses anteriorly, in the floor of the mouth to the tip of the tongue. It supplies sensory fibers to the tongue, floor of the mouth, and lingual gingiva.

Inferior Alveolar Nerve. This nerve descends with the lingual nerve into the pterygomandibular space. It carries some motor fibers, and just before it enters the inferior alveolar foramen it release these fibers as the mylohyoid nerve. The mylohyoid nerve then makes its way to the mylohyoid muscle and the anterior belly of the digastric muscle.
The inferior alveolar nerve, after giving off the mylohyoid nerve, enters the inferior alveolar canal through the inferior alveolar foramen. It passes through the canal, supplying the bone and roots of the mandibular teeth. At the mental foramen, it divides into the incisive and mental nerves. They follow their associated arteries. The incisive nerve supplies the anterior teeth and labial gingiva; the mental nerve supplies the chin and lower lip.

**The Auriculotemporal Nerve.** This nerve turns backward from the trunk of the mandibular nerve, arising shortly after the mandibular nerve exits from the foramen ovale. It splits, encircles the middle meningeal artery, fuses, and runs posteriorly. When it reaches the rear of the neck of the mandible, it turns upward and accompanies the superficial temporal artery. It then passes under the parotid gland and over the root of the zygomatic arch. The auriculotemporal nerve supplies the skin of the ear and temporal region with sensory fibers. It also supplies sensation to the temporomandibular joint, sends a few fibers to the zygomatic portion of the cheek, and carries postganglionic secretory fibers from the ninth nerve to the parotid gland.

**VI. The Abducent Nerve**

The sixth cranial nerve has only one function: it supplies the lateral rectus muscle of the eye. Not only are efferent somatic fibers contained in this nerve, but also proprioceptive afferent fibers. The nerve arises from the ventral surface of the brain. It passes forward in the floor of the cranial cavity, through the cavernous sinus, and enters the orbit through the superior orbital fissure.

**VII. The Facial Nerve**

The facial nerve is an interesting and complex structure. It contains somatic efferent fibers to all the muscles of facial expression. It also supplies motor fibers to the posterior belly of the digastric muscle, the stylohyoideus muscle, and the stapedius muscle of the middle ear. The facial nerve also contains afferent taste fibers from the tongue, afferent proprioceptive fibers and efferent parasympathetic preganglionic fibers to the mucous glands of the nose and salivary glands of the mouth.

The facial nerve arises by two roots: a large motor root and a small nervus intermedius. The latter contains both preganglion parasympathetic secretory fibers and sensory fibers for taste and proprioception. Both roots fuse and pass into the internal auditory meatus and enter the substance of the petrous portion of the temporal bone. While still in the temporal bone, the facial nerve enters the facial canal. It takes a tortuous course within the bone in the facial canal, a channel inside the temporal bone. While still inside the bone, the nerve encounters the sensory ganglion of the facial nerve, the geniculate ganglion. No synapse occurs here. This is the location of sensory cell bodies for taste and proprioception fibers entering the brain via the nervus intermedius. Also, while in the facial canal of the temporal bone, the facial nerve releases several branches.
Greater Petrosal Nerve

The greater petrosal branch contains mixed fibers of afferent sensory and efferent parasympathetic functions. It is a branch of the nervus intermedius. The cell bodies of the efferent parasympathetic fibers are in the brain, and the axons pass through the geniculate ganglion and join the greater petrosal nerve. The cell bodies of the afferent taste fibers and proprioceptive fibers are located in the geniculate ganglion. Their dendrites and the axons of the parasympathetic fibers are all incorporated in the greater petrosal nerve. After arising from the geniculate ganglion, this nerve, by a very complex route, finally reaches the pterygopalatine ganglion in the pterygopalatine fossa. The efferent parasympathetic fibers synapse here, and second order neurons are distributed to the various glands of the mouth and nose and the lacrimal gland, via the branches of the trigeminal nerve.

Afferent taste fibers from the palate and associated region are carried in branches of the trigeminal nerve to the greater petrosal nerve. Thus, they reach the geniculate ganglion via the greater superficial petrosal nerve. As noted above, the cell bodies of these sensory nerves are located in the geniculate ganglion, and the axons are carried in the nervus intermedius to the brain.

Nerve to the Stapedius Muscle

This structure supplies the stapedius muscle of the middle ear.

Chorda Tympani Nerve

After arising from the facial nerve in the facial canal and taking a tortuous course, the chorda tympani nerve exits from the skull at the base of the sphenoid bone near the angular spine. It then courses downward and joins the lingual nerve where the lingual nerve passes between the pterygoid muscles.

The chorda tympani nerve contains preganglionic parasympathetic fibers to the submandibular ganglion. The cell bodies of the first order neurons are located in the brain. The cell bodies of the second order neurons are located in the submandibular ganglion. This nerve also carries taste fibers from the anterior two thirds of the tongue. The cell bodies of the taste fibers are in the geniculate ganglion of the facial nerve and their axons enter the brain via the nervus intermedius along with those of the greater petrosal nerve.

The facial nerve then exits from the petrous portion of the temporal bone through the stylomastoid foramen. Additional branches then arise.

The Posterior Auricular Nerve

The posterior auricular nerve is released near the stylomastoid foramen. It passes back and up and supplies motor fibers to the auricularis muscles and the occipitalis muscle.
Digastric Branch

The digastric branch arises near the stylomastoid foramen. It is the motor nerve to the posterior belly of the digastric muscle.

Stylohyoid Branch

The stylohyoid motor branch to the stylohyoideus is released next. The facial nerve now runs within the substance of the parotid gland. It divides into two primary branches: a superior *temporofacial* trunk and an inferior *cervicofacial* trunk. From these trunks, five main branches arise: the temporal, zygomatic, buccal, mandibular, and cervical branches.

Temporal Branches

The temporal branches emerge from the parotid gland, cross the zygomatic arch, and supply the auricularis muscles, frontalis, orbicularis oculi, and corrugator muscles.

Zygomatic Branches

Also from the superior trunk, the zygomatic branches pass across the face to the orbicularis oculi muscle.

Buccal Branches

The buccal branches course horizontally forward and supply the procerus, zygomaticus major, quadratus labii superioris, nasal, buccinator, and orbicularis oris muscles.

Mandibular Branch

The mandibular branch passes forward and down and curves anteriorly at the level of the inferior border of the mandible. It supplies the muscles of the lower lip and chin.

Cervical Branch

The final branch, the cervical branch, passes downward to supply the platysma muscle.

VIII. The Acoustic Nerve

The eight cranial nerve arises from the brain just behind the two roots of the facial nerve. It consists of two sets of fibers, the *cochlear fibers* (root) and the *vestibular fibers* (root). Both roots, as a common trunk, enter the internal auditory meatus along with the facial nerve. The acoustic nerve enters the inner ear and divides into the cochlear and vestibular portions. The acoustic nerve is afferent only.

Cochlear Nerve

The cochlear nerve transmits sound impulses to the brain from the inner ear.
**Vestibular nerve**

The inner ear contains a sensitive organ of balance made up of three semicircular canals. The vestibular nerve transmits impulses of body and head position to the brain. The semicircular canals contain fluid, and as the position of the head is altered, this fluid moves about in the canals, stimulating the nerve endings of the vestibular nerve.

**IX. The Glossopharyngeal Nerve**

The glossopharyngeal nerve supplies the tongue and the pharynx. It is composed of a variety of fibers, both afferent and efferent. It leaves the skull through the jugular foramen at which point its two sensory ganglia are located. These ganglia are known as the *superior petrosal and inferior petrosal ganglia*. The glossopharyngeal nerve has several branches.

**The Tympanic Nerve**

The tympanic nerve leaves the inferior sensory ganglion. It carries preganglionic parasympathetic secretory fibers and sensory fibers to the mucosa of the middle ear. After leaving the sensory ganglion, it enters the tympanic cavity. The tympanic nerve then perforates the roof of the cavity and, having lost its sensory fibers, is known as the *lesser petrosal nerve*. Its preganglionic parasympathetic secretory fibers then synapse at the *otic ganglion*. Second order neurons then go to the parotid salivary gland after joining the auriculotemporal nerve.

**Carotid Branch**

At a variable level below the jugular foramen, the carotid branch is released. It supplies afferent fibers to the carotid sinus and carotid bodies. These two tiny organs are blood pressure regulatory mechanisms that are located close to the bifurcation of the common carotid artery.

**Stylopharyngeal Nerve**

With the stylopharyngeal branch the glossopharyngeal nerve supplies the motor fibers to the stylopharyngeus muscle.

**Pharyngeal Branches**

The pharyngeal nerve fibers joint with the vagus and spinal accessory nerves to form the pharyngeal plexus. This network supplies the muscles of the pharynx and soft palate, except for the tensor veli palatini and the stylopharyngeus muscles. Also, this plexus provides sensory fibers to the mucosa of the soft palate and pharynx.

The glossopharyngeal nerve finally enters the base of the tongue. Here it supplies taste fibers to the posterior one third of the tongue, tonsils, and pillars.
X. The Vagus Nerve

The vagus nerve is the longest of the cranial nerves. It reaches as far down as the abdomen. The nerve exits from the skull through the jugular foramen, along with the ninth and eleventh cranial nerves. As it descends in the neck, the vagus nerve is enclosed in the carotid sheath with the internal jugular vein and the carotid artery.

Two sensory ganglia - the jugular (superior) ganglion and the nodose (inferior) ganglion - are located in the portion near the jugular foramen. The jugular ganglion is superior and smaller. The fibers whose cell bodies lie in these ganglia supply sensory innervation to the skin of the ear, the pharynx, larynx, trachea, bronchi, esophagus, and the thoracic and abdominal viscera.

Both somatic and visceral fibers and afferent and efferent fibers are contained in the vagus nerve. It also carries parasympathetic preganglionic fibers. Primarily, the vagus is a visceral nerve. The visceral afferents come from the gut, the lungs, the heart, and the mucous membranes of the pharynx and larynx. This nerve also has a few taste fibers arising in the region of the epiglottis. Parasympathetic preganglionic efferent fibers originate in the brain and go to the heart, lungs, and abdominal viscera. The second order neurons are located in or near the respective organs.

The vagus nerve contributes to the pharyngeal plexus and the muscles of the pharynx. It also provides innervation to the muscles of the larynx. One of the most important functions of the vagus is its parasympathetic control of heart rate. Stimulation of the parasympathetic portion results in bradycardia, decreased heart rate. The parasympathetic portion also supplies the glands of the gastrointestinal tract.

XI. The Accessory (Spinal) Nerve

The eleventh cranial nerve is only partly a cranial nerve. It consists of two roots, one root arising from the brain and the other arising from the spinal cord. The nerve carries efferent and afferent impulses and is intimately associated with the vagus nerve.

Cranial Root

The cranial root portion of the accessory nerve arises by several small rootlets just behind the root of the vagus. It passes into the jugular foramen after joining the spinal part.

The Spinal Part

The spinal portion of the accessory nerve arises from several rootlets of the first five cervical divisions of the spinal cord. These spinal roots fuse and pass upward through foramen magnum into the cranial cavity. The nerve then passes into the jugular foramen and joins the cranial part. The cranial and spinal fibers intermix and pass through the foramen as one nerve, the spinal accessory nerve.

As the spinal accessory nerve exists from the foramen, it divides into two nerves again, each carrying representatives of both roots but still containing a majority of either
spinal fibers or cranial fibers. The cranial fibers join the vagus and contribute to the pharyngeal plexus. The spinal fibers pass backward and down to supply the trapezius and sternocleidomastoideus muscles.

The spinal accessory nerve not only contributes to the pharyngeal plexus and supplies motor impulses to the trapezius and sternocleidomastoideus, but also it carries proprioceptive afferent fibers from the muscles it supplies. Loss of function of this nerve results primarily in paralysis of the trapezius and sternocleidomastoideus muscles.

XII. The Hypoglossal Nerve

The twelfth cranial nerve supplies motor fibers to all the intrinsic and extrinsic muscles of the tongue. No other nerve supplies these muscles with motor fibers. In addition, the hypoglossal nerve carries proprioceptive impulses from the muscles of the tongue to the brain.

The course of this nerve is extremely interesting. It arises by several rootlets at the base of the brain, just inferior to the origin of cranial nerves IX, X, and XI. These rootlets merge into a trunk, which passes out from the brain case via the hypoglossal canal. At the level of the mandibular foramen, as the nerve is passing downward, it turns anteriorly and superficially. It courses forward and is almost horizontal as it reaches a level deep to the angle of the mandible. Passing deep to the posterior belly of the digastric muscle, and stylohyoideus muscle it ramifies to supply the muscles of the tongue.

As the nerve descends from the hypoglossal canal, it picks up fibers from the first cervical nerve. It carries these fibers for a short distance and then drops them off to the geniohyoid and thyrohyoid muscles. The rest of the cervical fibers then leave the hypoglossal nerve and pass downward as the descendens hypoglossi. The descendens hypoglossi, passing down to the infrahyoid muscles, sends a branch to the superior belly of the omohyoid muscle. The descendens then joins branches from the 2nd and 3rd cervical nerves. The loop thus formed is known as the ansa hypoglossi. From the ansa, branches composed of fibers from C1, C2, and C3 are distributed to the inferior belly of the omohyoid, sternohyoid and sternothyroid muscles.

Loss of function due to lacerations or tumor destruction of the hypoglossal nerve will result in inability of the patient to move one side of the tongue. When the patient attempts to protrude the tongue, the tongue will deviate toward the affected side.

Autonomic Nervous System of the Head

Many organs of the head are controlled partially or completely by the autonomic nervous system. The eye, salivary glands, and nasal glands all have autonomic innervation. The autonomic fibers are carried to the various organs by "hitching a ride" on the cranial nerves and arteries supplying that area. For example, the parasympathetic supply to the salivary glands is carried in the trigeminal nerve branches.
Sympathetic Nerves of the Head

All the sympathetic fibers in the head are postganglionic fibers. The short dendrites and the cell bodies of the preganglionic fibers lie in the thoracic portion of the spinal cord. The axon fibers pass out to the sympathetic chain and synapse with second order neurons. This synapse takes place in the superior cervical ganglion which is the uppermost ganglion in the sympathetic chain. It is located about the level of the axis. In this ganglion lie the cell bodies of the second order sympathetic neurons whose fibers (axons) supply sympathetic impulses to the head. The axons leave the ganglion and are carried to various areas by following the arterial tree. The sympathetic fibers do not synapse again. If and when they reach various parasympathetic ganglia in the head, they pass through without synapsing. Only the parasympathetic fibers synapse in the ciliary, pterygopalatine, and otic ganglia. Sympathetic fibers supply the dilator of the pupil and sweat glands of the skin. Reduced salivation, dilation of the pupil, and sweating are examples of sympathetic impulses reaching various areas of the head.

Parasympathetic Nerves of the Head

The parasympathetic fibers are carried in various cranial nerves rather than along arteries. The parasympathetic supply is complex but extremely interesting. It is not difficult to understand if the system is organized by the various parasympathetic ganglia.

The Otic Ganglion

The small otic ganglion is attached to the medial surface of the third division of the fifth nerve just as the nerve exits the foramen ovale. This is purely an anatomic attachment. The otic ganglion contains only cell bodies of second order parasympathetic fibers, and only parasympathetic fibers synapse here. All other fibers pass directly through the ganglion without synapsing.

Preganglionic parasympathetic fibers destined for the otic ganglion originate in the brain and exit with the glossopharyngeal nerve through the jugular foramen. They branch from the glossopharyngeal nerve as the tympanic nerve which becomes the lesser petrosal nerve after emerging from the tympanic cavity. The fibers of the lesser petrosal nerve synapse in the otic ganglion. Post-ganglionic fibers joint the auriculotemporal branch of the mandibular nerve and are carried to the parotid gland. The function of these parasympathetic fibers is to activate production and secretion of saliva from the parotid gland.

The sympathetic fibers to the parotid gland pass up with the external carotid artery and the internal maxillary artery and finally reach the parotid gland via the middle meningeal artery.

Submandibular Ganglion

The submandibular ganglion lies above the submandibular gland at the posterior border of the mylohyoid muscle. It is suspended from the lingual nerve by several preganglionic parasympathetic fibers of the chorda tympani nerve, which had joined the lingual nerve before the lingual nerve reached the submandibular ganglion.
Preganglionic parasympathetic fibers destined for the submandibular ganglion begin in the brain and exit as the nervus intermedius of the facial nerve. They leave the intermediate nerve as the chorda tympani, which joins the lingual nerve. Preganglionic fibers drop off the lingual nerve and synapse with postganglionic fibers at the submandibular ganglion. Some postganglionic secretomotor fibers rejoin the lingual nerve and are carried to the sublingual salivary gland under the tongue. Other postganglionic secretomotor fibers leave the ganglion and pass down into the submandibular salivary gland which lies below the mylohyoid muscle.

The sympathetic fibers to these two salivary glands arrive by following the facial artery.

**Pterygopalatine (Sphenopalatine) Ganglion**

The pterygopalatine ganglion is located in the pterygopalatine fossa. It is positioned quite close to the maxillary nerve as the nerve exits from the foramen rotundum. Preganglionic parasympathetic fibers destined for this ganglion also originate in the brain as the intermediate nerve, a branch of the facial nerve. They leave the intermediate nerve as the greater petrosal nerve.

The greater petrosal nerve passes through a small canal, enters the pterygopalatine fossa, and synapses with postganglionic parasympathetic neurons. From the ganglion, postganglionic fibers easily join various branches of the first and second divisions of the trigeminal nerve.

Fibers to the lacrimal gland leave the ganglion and join the maxillary nerve, course through the zygomatic nerve, and its branch, the zygomaticotemporal nerve, switch to the lacrimal nerve (branch of the ophthalmic nerve), and innervate the lacrimal gland.

The postganglionic fibers to the salivary and mucous glands of the palate leave the ganglion and join the greater and lesser palatine branches of the maxillary nerve.

The fibers to the nasal mucous glands reach that area from the ganglion by way of the nasal branches of the maxillary nerve. Those to the pharynx are carried in small pharyngeal branches of the maxillary nerve. The greatest parasympathetic activity of the pterygopalatine ganglion, however, is to supply innervation for production and secretion of tears from the lacrimal gland.

**Ciliary Ganglion**

No secretory activity is associated with the ciliary ganglion. The ciliary ganglion serves as a synaptic center for parasympathetic supply to the constrictor of the pupil. Preganglion fibers originate in the brain and are carried to the ganglion via the oculomotor nerve. The ciliary ganglion is located in the posterior of the orbit. Postganglionic fibers leave the ganglion and supply the constrictor muscle of the eye.

Sympathetic nerve fibers to the eye dilate the pupil. They are carried into the cranial vault on the internal carotid artery and pass into the orbit through the superior orbital fissure.