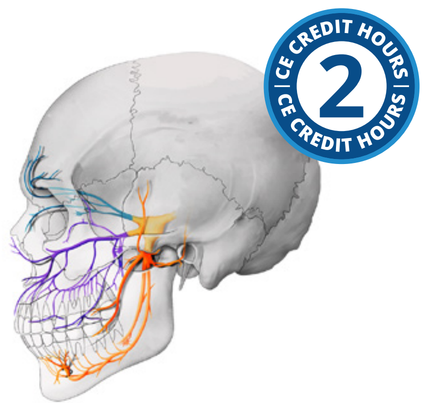
Head and Neck Anatomy: Part III – Cranial Nerves



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Conflict of Interest Disclosure Statement

- Dr. LoPresti reports no conflicts of interest associated with this course. He has no relevant financial relationships to disclose.

Introduction

This course is an overview of the cranial nerves with special emphasis on the branches that are important to the dental professional. This course can be used as a reference for the location and function of the nerves of the head and neck. This is the last part of a three-part series including the bony structures of the head and neck and the muscles of the head and neck.

Dental Students: Please note this is Part II of a three-part series. To gain the full benefit of the concepts covered in this course, be sure to read "*Head and Neck Anatomy: Part I – Bony Structures*" and "*Head and Neck Anatomy: Part II – Musculature*".

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Learning Objectives

Upon completion of this course, the dental professional should be able to:

- Understand the basic structure of a neuron and how they function.
- Understand the basic function of the nervous system.
- Possess foundational knowledge of the cranial nerves.
- Know the location and function of each important nerve found in the head and neck.

Introduction

This three-part course presents basic facts and concepts of head and neck anatomy. The course is not intended to replace an in-depth study of anatomy but is a guide to review the basics of anatomy as it relates to the dental field. It is essential for all dental professionals to recognize the normal appearance and functions of the head and neck. Nerves are of paramount importance to the proper functioning of all parts of the body as they sense the external and internal environments and constantly adjust to maintain homeostasis. In the head and much of the neck the cranial nerves are the connections between the brain and the body. Therefore, understanding their location and function is a key to understanding the normal function of the stomatognathic system and many pathologies one might encounter as a dental professional.

A note to the student – The study of head and neck anatomy is not a murder mystery where you cannot stop reading to see which of the characters was the killer and their motivation. Anatomy is full of terminology and should not be read as one would read a novel. It is easy to conflate the information if read all at once. You should take breaks on occasion to allow what you have read to sink in before attacking yet another set of structures.

Words are not sufficient to understand this topic so referring to diagrams is absolutely necessary. The diagrams have been placed near the text that it refers to and should be, if possible, on the screen as one reads the text and referred to often. As the pathways of the nerves refer to both bones and muscles plus the endpoint of motor nerves is skeletal muscle you should be familiar with the bony structures of the head covered in **Head and Neck Anatomy: Part I – Bony Structure (CE591)** and the muscles covered in **Head and Neck Anatomy: Part II – Musculature (CE597)** prior to attempting this course.

Glossary

Organization terms

Central nervous system (CNS) – This consists of the brain and spinal cord. This is where integration occurs and where the majority of neuronal connection are found.

Peripheral nervous system (PNS) – This consists of all the nerves which are found exclusively outside the CNS. Nerves themselves are composed only of extensions from the body of the neuron. Nerves do not contain cell bodies.

Autonomic Nerves – These are motor nerves that control involuntary actions of the body generally involved in maintaining homeostasis. These nerves are connected to smooth muscle, cardiac muscle and glands. They are unique in having a synapse outside of the CNS.

Sympathetic Division – This division of the autonomic nervous system is responsible for the ability to respond to perceived danger. This is often called the "fight or flight" response.

Parasympathetic Division – This division of the autonomic nervous system opposes the sympathetic division, lowering heart rate, blood pressure and respiratory rate while increasing the motility of the digestive system. This is sometimes referred to as the "rest and repose" response.

Functional terms

Afferent – In reference to nerves this denotes a nerve carrying signals to the CNS from the periphery. These are also known as sensory nerves as the tissues are sending impulses containing information from sensing cells in the body. In the text sensory and afferent will be used interchangeably.

Efferent – In reference to nerves this denotes a nerve carrying signals from the CNS to the periphery. These are also known as motor nerves as the tissues stimulated perform an action and again motor and efferent will used as equivalent terms in this course.

Integration – This is the interface between the afferent and efferent system where incoming signals from sensory nerves are interpreted and responses generated by the CNS then sent to the organs and muscle in the periphery to respond to the stimulus.

Cellular terms

Neuron – The cell that forms all nervous tissue.

Fiber – An extension from the neuronal cell body that carries signals to or from the neuronal cell body.

Synapse – A gap between neurons where chemical mediators are released to affect the adjacent neuron. This is the primary means for neurons to communicate with each other.

Ganglion – This is an appendage to a peripheral nerve where neuronal cell bodies are found outside the central nervous system. These are found associated with all sensory and autonomic nerves.

Preganglionic fibers – These are the autonomic neuronal fibers that enter a ganglion.

Postganglionic fibers – These are the autonomic neuronal fibers that leave the ganglion after they synapse with the preganglionic fibers.

Basic Nervous System Structure

Neurons

Neurons are the working cells in the nervous system. They are metabolically very active cells and the vast majority of them are located in the central nervous system (CNS). The brain uses energy at a prodigious rate. Anyone who has taken a CPR course knows that in just minutes the brain runs out of oxygen for proper metabolism and the cells start to die off. To understand the structure of nerves we must look at these unique cells that are so important to our survival.

While there are differences in morphology between neurons whose functions are different, they all have some commonalities. They all have a central area known as the **body** which contains a **nucleus** and numerous organelles that produce energy and make proteins.

Projecting off the body are processes that extend away from the body. There are two types of these appendages: **axons** of which each neuron has exactly one and **dendrites** which are found in variable numbers from none to several depending on the function of the neuron.

Neuronal membranes carry an electrical charge based on the ionic movement across the membrane. By alternating between depolarizing and repolarizing the membrane an electric wave is created along the neuron. Directionally this wave travels from the distal end of the dendrites, through the cell body, and then passes down the axon to its **terminus**. If the signal is strong enough, it will cause a release of proteins known as neurotransmitters from the end of the axon into the space between the neuronal ends which is called a **synapse**. The electrical signal down the axon is known as the **action potential** and if the voltage of the action potential reaches the point at which it causes release of neurotransmitters it is said to have reached the threshold potential.

You can see why the neuron has such high metabolic requirements as it has to pump ions across the membrane against the concentration gradient. It also has to produce proteins for release and transport them down the axon in addition to removing the neurotransmitter from the synapse quickly so that it does not linger in the synapse and cause unwanted effects.

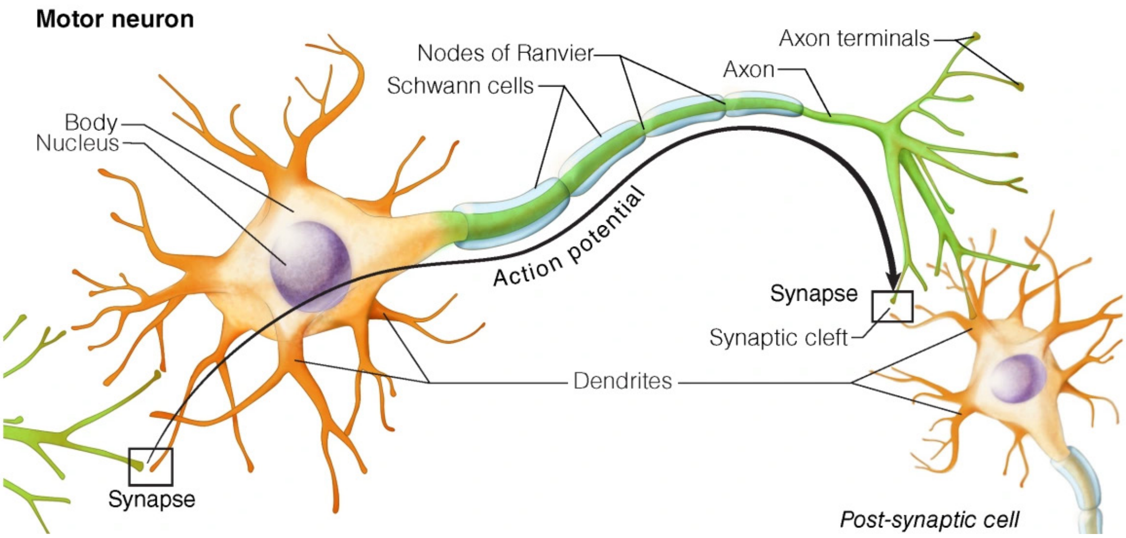

Figure 1 - Motor Neuron

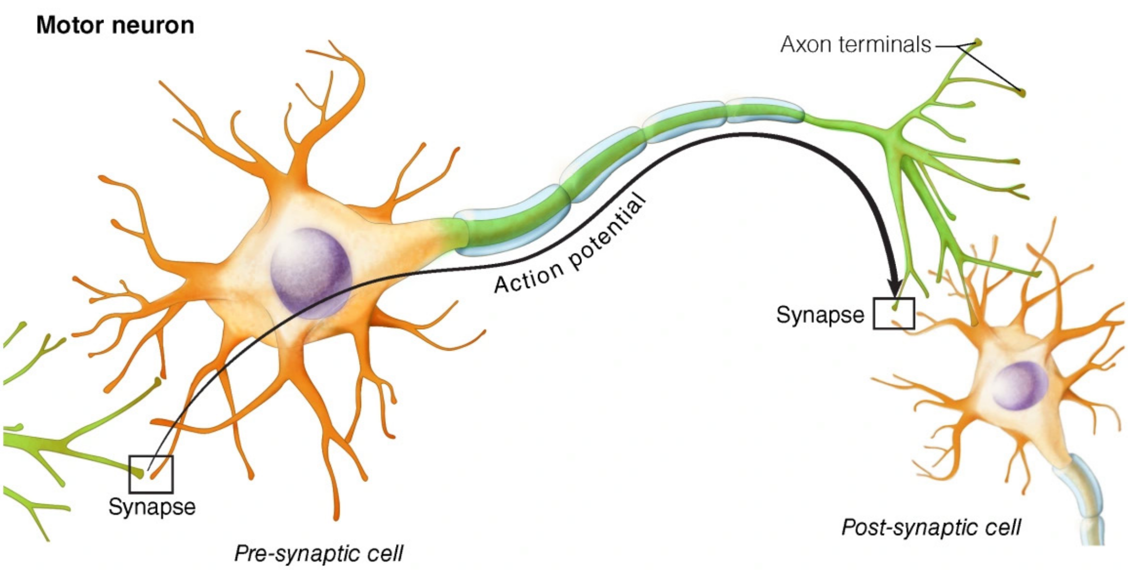

Figure 2 - Action potential

Synapse

Neurons generally do not touch each other so despite carrying electrical charges they communicate via neurotransmitters which are proteins released into a small space known as the **synaptic cleft** between the neurons. There are numerous neurotransmitters but most synapses are mediated by just seven of them. Detailing the neurotransmitters is not within the scope of this course but they are a fascinating area of research and many pharmacologic interventions, especially for mental illness, focus on regulating these compounds. To give one quick example, Parkinson's disease is due to the inadequate production of one of these proteins, dopamine, in the brain.

Once the neurotransmitter is released into the synaptic cleft it attaches to receptors on the opposing neuron. This interaction between the neurotransmitter and its specific receptor will have one of two effects on the receiving neuron. It will either increase the action potential in the second neuron if it is an excitatory response, or if it is an inhibitory response, it will decrease the action potential. As each neuron has many connections with other neurons the net effect on any specific neuron is the net result of all the excitatory and inhibitory signals it is exposed to at any one time. Once the neurotransmitter is in the cleft it must be rapidly removed from the cleft to keep the response from being persistent. As mentioned previously this is another process where the neuron must use energy to reabsorb and recycle these neurotransmitters.

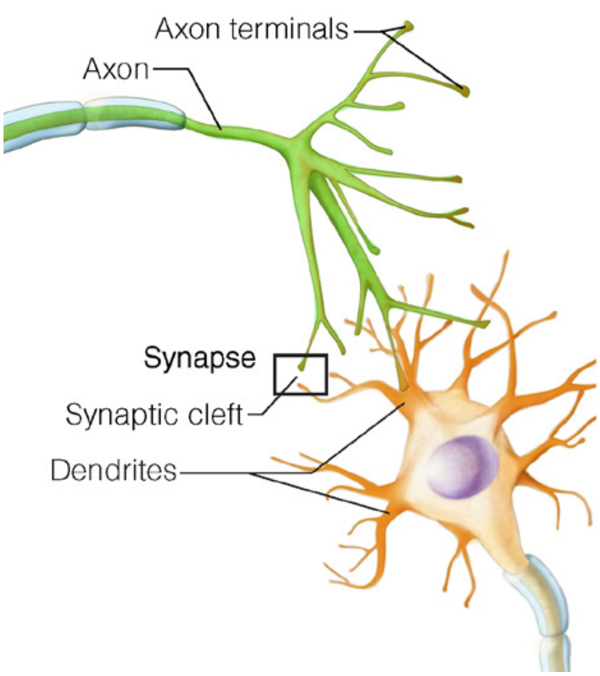

Figure 3 - Synaptic cleft

Nerves

As mentioned earlier the neuron cell bodies are generally located in the CNS and even those outside the CNS are clustered into areas known as ganglia (singular – ganglion). Nerves, which we will be looking at in this course are constructed of axons and dendrites and associated supporting cells. It is important to realize that the cell body that controls them can be quite distant from the terminal ends of the neuron and there is a time delay in signaling due to the length of the fibers in addition to the delay caused by any synapses involved.

To use an illustration to tie all of the above together, think of the response to touching a hot surface, which is a common human error. Pain receptors in the skin of the finger create an action potential in a sensory neuron. The greater the number of receptors connected to that neuron that are stimulated the larger the action potential created. Depending on the size of the burn there may be multiple neurons involved but let us stay with just one for now. The signal is carried back to the neuron cell body located in a ganglion just outside the spinal cord. There the signal is sent into the CNS where there are multiple connections. The sensory neurons synapse with neurons in the spinal cord and the brain. The neurons in the spinal cord are connected to motor neurons in the spinal cord that control the flexor muscles of the arm causing those muscles to pull the hand back. This reflex is mediated in the spinal cord as it is a shorter distance for the signals to pass and therefore the hand sustains less damage as it is pulled away faster. The signal also passes to the brain area that receives sensory information registering the unfortunate event as a burn and then relays through other neurons in multiple areas of the brain that can process that you burned yourself using stored memories of other burns and not only registers it but stores that new burn memory also. Other sensory neuronal information will be synthesized to determine whether there are other people in the room or some other reason that you should not swear. If this information does not send sufficient inhibitory signals to overcome the urge to vocalize your displeasure, then you will use all of your favorite swear words pulled from yet another area of the brain. But note that by the time you are choosing the proper words your fingers have been away from the hot surface for some time.

Supporting Cells

Neurons are very important to life and as such are extraordinarily protected. The CNS is encased in bone with three layers of protective coverings underneath the skull cap. In addition, the brain and spinal cord are surrounded and cushioned by cerebral spinal fluid (CSF). The brain has a lower specific gravity than the CSF so it actually floats in the skull. Beyond the physical barriers there are also physiological barriers. Neurons in the CNS have cells that support them known as neuroglial cells. There are specific cell types that nourish the neurons, insulate them electrically from one another and protect them from toxins and microbiological invaders. They create, along with the less permeable capillaries in the brain, what is known as the blood-brain barrier which acts to keep toxic substances and microbiological invaders out of the CNS but also makes delivering medications to the brain problematic.

While those neuroglial cells are important in the CNS we are concerned with nerves in this course and they are in the PNS. In the PNS each nerve fiber, whether dendrite or axon, is surrounded by a layer of connective tissue known as the endoneurium. These fibers are collected into bundles known as fascicles and surrounded by a connective tissue sheath known as the perineurium. If this is reminding you of the nomenclature used for the tissue surrounding muscle fibers you have already deduced that the entire nerve has a connective tissue sheath called the epimysium. Nerves go one step further and have a series of cells that wrap around the individual fibers. These cells are known as **Schwann cells** and come in two types depending on whether they contain a fatty substance known as myelin. Myelin is used as an electrical insulator and its presence in the Schwann cells increases the speed of nerve conduction. When myelin surrounds the fiber, depolarization of the membrane is restricted only to the small gaps known as the **nodes of Ranvier** where one Schwann cell ends and the next begins. This causes the electrical signal to leap along the fiber from gap to gap rather than flowing along the whole length of the fiber. This greatly speeds conduction on these fibers.

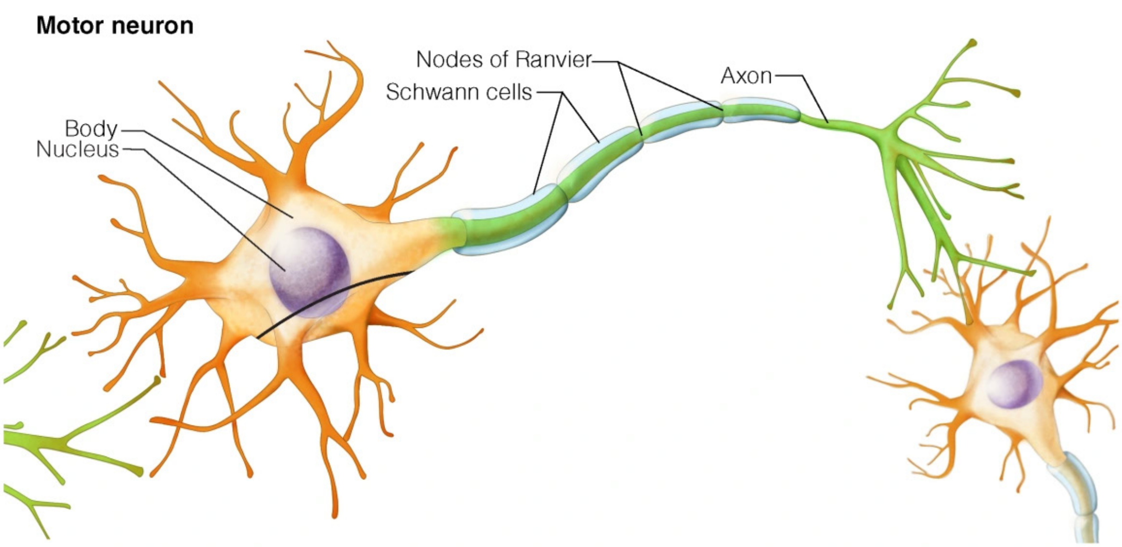

Figure 4 - Schwann cells & Nodes of Ranvier

There are other fibers that do not have myelin surrounding them and these transmit the action potential more slowly. This difference in transmission rates is the basis of the gate control theory of pain perception. We use this by applying pressure to the injection point prior to a palatal injection to lessen the pain of the needle insertion. The pressure stimulates nerves that have a slow conduction path but act to inhibit the quicker pain signals that the needle will cause. Pressure at the time of, or after, the injection is much less effective as the pain signal is already through the gate.

Divisions

Different neurons have different functions. This section will explain in more detail many of the terms in the definition sections and how that impacts the anatomy of the individual cranial nerves. We have already been exposed to the fact that there are sensory neurons and motor neurons. To better understand the structure of the cranial nerves we need to look more closely at the way the nervous system is organized. The most basic division is into the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS consists of the brain and the spinal cord. All of the nerves found in the body compose the PNS. The PNS consists of 12 pairs of cranial nerves that are the subject of this course and 31 spinal nerves which will be only briefly mentioned.

Within the PNS there are differences in the function of the fibers contained in the nerves. The main division used to classify them is into afferent fibers which carry sensory impulses towards the CNS and efferent fibers that carry impulses away from the CNS (Figure 5). Anatomically all sensory neurons have their cell bodies outside the CNS in ganglia. Each spinal nerve has a motor root and a sensory root adjacent to the area where they enter the spinal cord. The sensory ganglia are found attached to the sensory root of the spinal nerve so are in close proximity to the CNS. Cranial nerves are not as uniform and we will have to look at each of them individually. They generally have their sensory ganglia in the cranial cavity where the root of the cranial nerve is found.

To make matters more complex sensory fibers in the cranial nerves can be further divided into general somatic sensory fibers, general visceral sensory and special sensory fibers. General sensations are those found throughout the body. Somatic refers to their being on the body surface. These sensations include touch, pressure, pain and temperature. Visceral sensations are from the internal organs and include not just the aforementioned but chemoreceptors, stretch receptors and baroreceptors. Special senses are those senses that are only found in specific, localized areas. These senses include sight, hearing, equilibrium, smell and taste, which not coincidentally, are all found in the head and neck. Their position in the head makes sense as these organs are taking in vast quantities of information from the environment so their close proximity to the brain is crucial for timely responses to external events.

On the motor side of the PNS there are also two types of innervating fibers. The motor fibers are divided into somatic motor fibers and autonomic motor fibers. The somatic fibers provide stimulation to skeletal muscle fibers. These fibers all have their cell bodies in the CNS. The axon leaving the CNS can be quite long as they must project from the spinal cord to the muscle they control. Each axon and its associated muscle fibers is known as a motor unit. Each nerve fiber controls a variable number of muscle fibers depending on what the amount of fine control needed. The eye muscles have small motor units of about ten muscle fibers per axon while postural muscles can have up to one hundred times that number.

Autonomic fibers control smooth muscle, glands and cardiac muscle. They are collectively known as visceral efferent fibers. They come in two varieties: sympathetic fibers and parasympathetic fibers. Each of these fibers have opposing actions and organs controlled by these nerves generally have dual innervation with the action taken by the organ depending not on the absolute level of either system but the degree to which one predominates over the other.

Sympathetic responses are geared to what is termed the “fight or flight” response. It turns down the digestive system activity while increasing the heart rate and respiratory rate all of which act to increase oxygenated blood flow to the muscles. This response is strong but once the threat is gone the mediating neurotransmitters

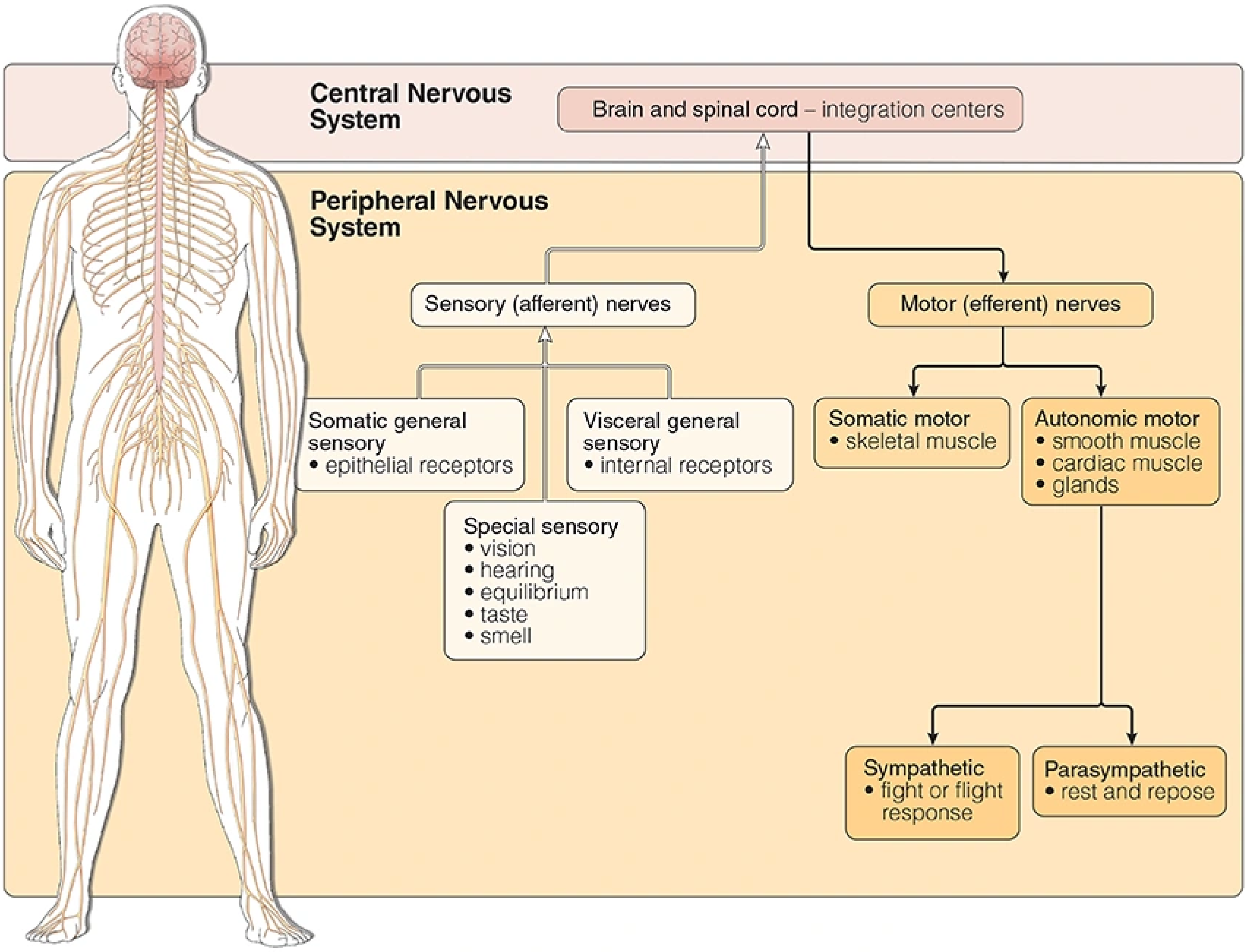

Figure 5 - Central & Peripheral Nervous System

epinephrine and norepinephrine are rapidly eliminated. As an example of this, in dentistry we use epinephrine to constrict blood vessels in the area we are injecting the local anesthetic. This works because these blood vessels are not going to muscles and therefore are constricted by epinephrine as they are not crucial to providing oxygen to the muscles. Occasionally the epinephrine ends up in a blood vessel and can cause the patient to feel their heart racing as the epinephrine gets to the heart, stimulating it to beat faster. This clears up in a few minutes due to the rapid metabolism of the epinephrine.

Parasympathetic responses on the other hand are the opposite. The digestive system blood supply and motility are increased and the heart rate and respiratory rate are slowed. This is mediated by a different neurotransmitter and does not dissipate as rapidly as the sympathetic response. This is the reason that patients often faint after the thing they are most afraid of is over rather than during the threat. The mechanism is as follows: in response to the threat the patient's sympathetic system is activated, but in order to not look nervous, their parasympathetic system is also activated. Due to the fact that the sympathetic system only slightly predominates, the patient's pulse and blood pressure are only slightly elevated. The procedure is accomplished, and the patient perceives the threat is now passed. The sympathetic outflow is turned off, but the parasympathetic outflow reacts more slowly. The heart rate and blood pressure plummet and the patient faints due to inadequate cerebral circulation.

Autonomic fibers anatomically are different than somatic fibers. All autonomic fibers that leave the spinal cord will synapse with a second neuron in the periphery that then innervates the target organ. The outflow from the spinal cord is also regionally restricted. All parasympathetic fibers leave the CNS only along cranial nerves III, VII, IX, X and spinal nerves S2-S4 while sympathetic fibers leave only from spinal nerves T1-L2. The sympathetic system covers the whole body by having a chain of ganglia that run along the spinal column bilaterally the entire length of the spinal cord. These interconnected ganglia allow fibers that enter the chain at any level to leave at a different level. In many cases the second neuron is in the chain and the fiber that leaves is known as a post-synaptic or post ganglionic fiber. Some pass through the ganglia as pre-synaptic fibers heading to the digestive system and synapse in ganglia in the abdomen. The sympathetic fibers in the head and neck are all post-ganglionic and generally join and travel with branches of cranial nerves to their target organ. They are often not recognized as separate nerves as they are small and often join other more substantial nerves on their way. We will not often specifically mention them as we are more concerned with fibers that originate in cranial nerves but they are assumed to be following parasympathetic fibers in the head and following other nerves to the blood vessels in the head.

To be complete there is also a more recent finding that there are a number of autonomic ganglion in the gut that act as a reflex center for proper regulation of the many organs that are involved in proper function of the digestive system. Some authors regard this as a separate entity deserving equal billing with the CNS as it has numerous associative neurons which are not found in the PNS. Thus, it is believed to be largely autonomous though it does communicate with the CNS through cranial nerve X, which seems to modulate the response of the gut. Therefore, this cranial nerve may not have as much control of the digestive system as previously believed. As the digestive system itself is outside of the scope of this course we will not wade into the debate about whether it is part of the PNS or a whole separate entity but will note the contribution of cranial nerve X to its control.

Nerve Nomenclature

In this course, to avoid confusion we will try to be clear about the transitions from one nerve to another. Because the signals in sensory nerves are running towards the CNS as smaller nerves merge together to form larger nerves, we will speak of them as joining. Motor nerves on the other hand start as larger nerves and divide to form smaller nerves and we will refer to that as splitting. Many nerves have both a sensory and motor component and we will refer to those as branching. This is not perhaps how all texts will use the nomenclature and it is only done here to try to alleviate confusion within this course.

In the study of individual cranial nerves those that are pure sensory nerves will be started at their origin in the sense organs and traced back to the CNS. Pure motor nerves and mixed motor and sensory nerves will be traced from the CNS to the periphery.

Another fine point that we will ignore in the quest for keeping the verbiage to a minimum is that many cranial nerves, even ones we will classify as sensory will have some sympathetic motor fibers that are travelling with the nerve. The ones classed as motor nerves carry visceral sensory information from sense organs within the muscle that sense tension and muscle length. However, these fibers are found in small numbers and generally originate elsewhere. Therefore, here we will ignore them while classifying nerves as sensory, mixed or motor. While some authors are very exacting and classify them by all the fibers that are in a nerve, most use the convention of using the types of fibers at the point of origin or, in the case of sensory nerves, the termination point.

To make the text less repetitive the terms motor and efferent will be used interchangeably as will sensory and afferent. We will also use the equivalent terms autonomic and visceral to break up the monotony when describing the parasympathetic or sympathetic nerves but will use the specific terms for the division involved. Pre-synaptic and pre-ganglionic will also be used to describe the fibers that have not yet synapsed in an autonomic ganglion as will post-synaptic and post-ganglionic.

Lastly it must be noted that all cranial nerves occur in pairs, one on the right and one on the left, as they are symmetrical often the text will refer to a nerve in the singular but that means we are just looking at one of the pair, not that there is just a single entity.

Cranial Nerves

We finally turn of attention to the items in the title of this course. Knowing the background will make learning what follows easier as it will make more sense to you. We will take each nerve separately, explain its function and trace the course of the nerve and its main branches.

Each cranial nerve is numbered with a Roman numeral but also has a name and in the case of a couple of them, more than one name. If you look at the base of the brain (Figure 6) the nerves are numbered by their connection point to the brain with I being the furthest anterior in the cerebrum and XII being the one closest to where the spinal cord originates from the brain stem. The names generally refer to the function of the nerve as you will see. Students often use a pneumonic as a guide to which name goes with which Roman numeral. These are easily found on the internet or you can make your own. The key is to find one you will have little trouble remembering.

Cranial Nerve I - Olfactory Nerve

The olfactory nerve originates as axons of the olfactory cells found in the nasal cavity just inferior to the cribriform plate of the ethmoid bone. In fact, it is not a defined pair of nerves but numerous fiber fascicles that pass through the openings in the cribriform plate to reach an area that sits just superior to the plate known as the olfactory bulb where they terminate. This means these fibers are very short. This arrangement can be seen in Figure 7 above. Olfaction is the biologist's word for the sense of smell so this, the shortest cranial nerve, carries only special sensory fibers for that specific sense. **Cranial**

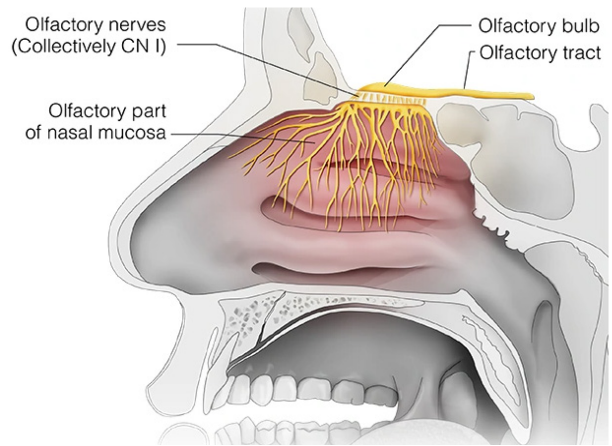

Figure 7 - Cranial Nerve I -Olfactory Nerve

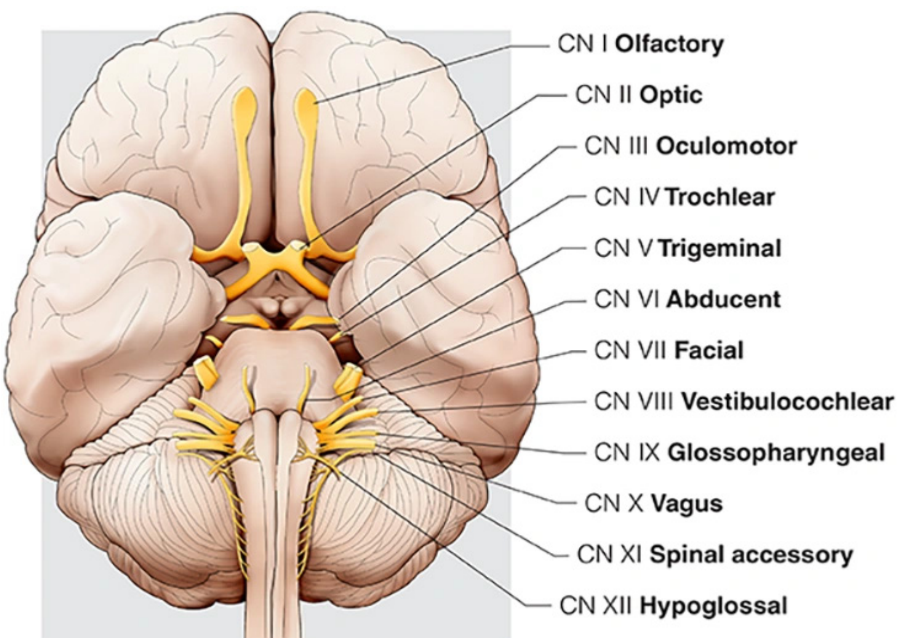

Figure 6 - Cranial Nerves

Cranial Nerve II - Optic Nerve

This nerve, like the olfactory is exclusively a special sensory nerve and as can be surmised by its name it is involved with the sense of vision. The nerve originates in the retinal ganglion cells which are the third neuron the signal passes through in the retina. These axons gather at an area known as the optic disc in the medial portion of the retina and exit each eyeball as an **optic nerve**. The optic disc has no light sensing cells so it corresponds to the blind spot of the eye. Having left the eye each of the pair of nerves passes through their respective optic canal. The two optic nerves then join at the **optic chiasm** where, as one can see in the diagram, the fibers from the medial portion of retina cross the midline and continue with the lateral fibers from the ipsilateral eye as the **optic tract** through the lateral geniculate body which mediates the "hunter's reflex" to turn one's head to better see an object moving in our lateral vision. The signals then pass through the **optic radiations** to the occipital lobe of the brain for processing.

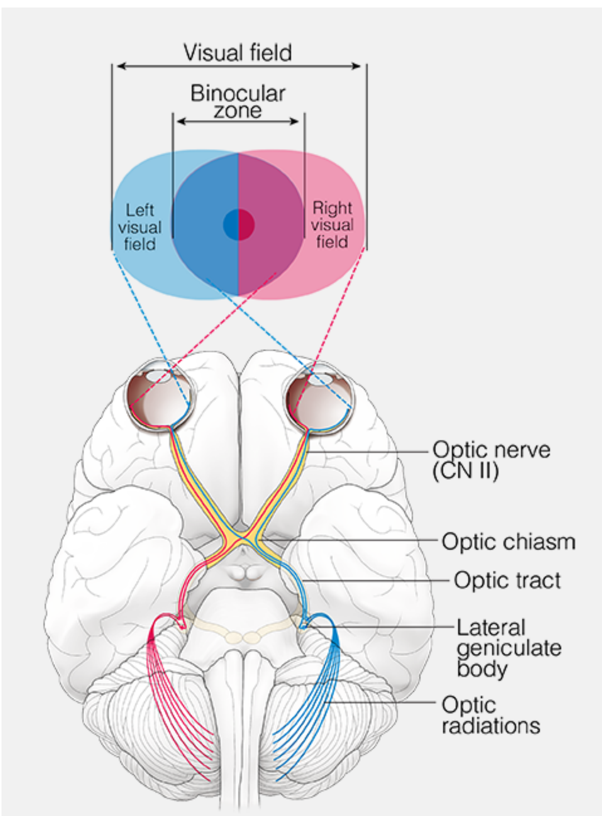

Figure 8. Cranial Nerve II – Optic Nerve

Cranial Nerve III - Oculomotor Nerve

The oculomotor nerve unlike the previous two nerves has more than one type of fiber. As its name indicates they are all motor fibers, in this case, somatic motor and parasympathetic motor. The nerve itself leaves the brain and travels through the superior orbital fissure into the orbit. Once there it divides to innervate four of the six muscles that control eye movement **superior rectus**, **medial rectus**, **inferior oblique**, **superior rectus**, the muscle that controls the upper eyelid, the **levator palpebrae** superioris plus provides autonomic (visceral) innervation to the smooth muscles in the eye. The smooth muscles of the eye are the ciliary muscles which control the shape of the lens thus changing the focal length of the eye to adjust for the distance to the object being observed and the iris which controls the size of the pupil to adjust for different light intensities. While the outflow of this nerve is parasympathetic the nerve is joined by sympathetic nerves along its course to those two muscles.

Cranial Nerve IV - Trochlear Nerve

This small nerve carries somatic motor fibers to a single muscle that moves the eye, the **superior oblique muscle**. It passes like the oculomotor nerve through the superior orbital fissure and terminates at the target muscle.

Cranial Nerve V - Trigeminal Nerve

The trigeminal nerve is the largest cranial nerve and as the name indicates it has three divisions.These are labeled as V1, V2, and V3 (Figure 11) but each also has a name to describe it also. Each branch follows a different course out of the cranium but are collected into a single nerve due to all the sensory nuclei being in a single ganglion that is fed by the three branches. This is the most important nerve in dentistry and we will discuss each division separately noting all the important nerves associated with each.

Divisions of Cranial Nerve V -Trigeminal Nerve:

V1 – Ophthalmic Nerve

This is a purely sensory nerve that supplies the skin over the upper 1/3rd of the face and then in a narrow band down the center of the nose including the philtrum of the upper lip

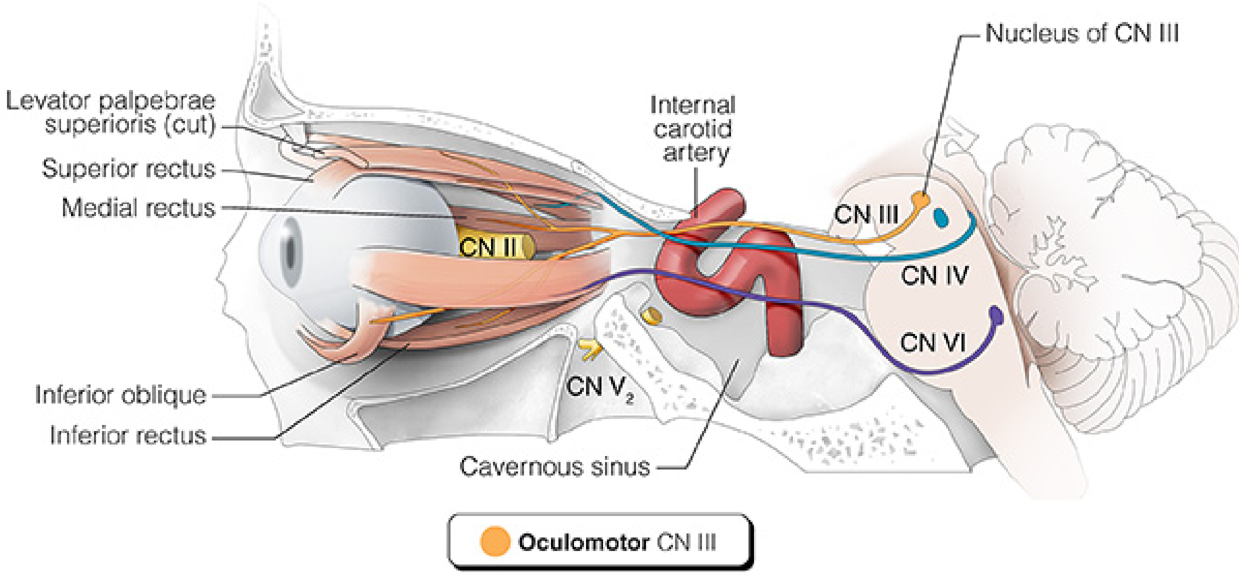

Figure 9. Cranial Nerve III - Oculomotor Nerve

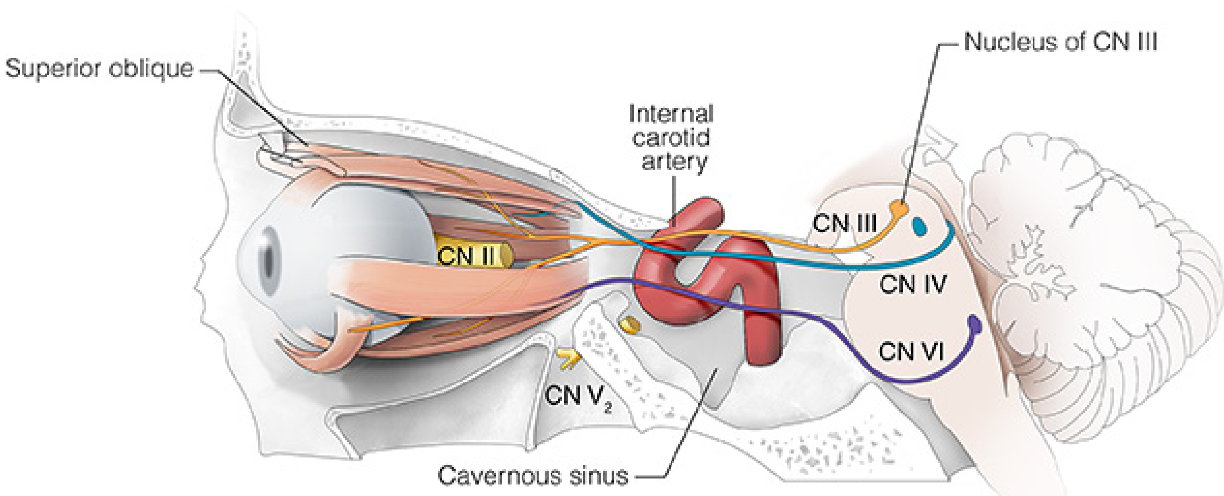

Figure 10. Cranial Nerve IV - Trochlear Nerve

through its **frontal** and **lacrimal branches**. It also supplies sensation to some of the nasal mucous membranes and many structures of the eye including the cornea through its **nasociliary branch**. The lacrimal branch in addition travels to the **lacrimal gland** not only providing sensory fibers but also carrying parasympathetic fibers that originate in the facial nerve but hitchhike on branches of the trigeminal. In figure 15 below, you can see the branches and can also see the **communicating branch** with the **zygomatic nerve** labeled. This small branch is carrying fibers that while they started in the facial nerve are in branch of the second division of the trigeminal prior to connecting to the lacrimal branch. We will discuss that further as we look at that division and again with the facial nerve.

The three branches of CN V join together in the vicinity of the superior orbital fissure and the entire nerve enters the **trigeminal ganglion** where the bodies of the sensory neurons are located. The axons then pass into the CNS.

V2 – Maxillary Nerve

The **maxillary nerve** like the ophthalmic nerve is sensory only in function. It is one of the crucial nerves to learn in dentistry as it provides the sensation of the middle face which includes all of the upper teeth and their supporting structures (Figure 17). It follows a complicated course and has many important branches so hang on tight and make sure you refer to the diagram often.

It terminates like the ophthalmic at the **trigeminal ganglion** but to get there passes through the foramen rotundum. After passing through the foramen but before joining the trigeminal ganglion the maxillary nerve is joined by the **meningeal branch** that carries sensory information from the meninges that surround the brain.

Anterior to the foramen rotundum is the sphenopalatine fossa. In this space the nerve has an appendage known as the pterygopalatine ganglion which is a parasympathetic ganglion associated with pre-ganglionic fibers from the facial nerve that arrive at the ganglion on the greater petrosal nerve. The post-synaptic fibers exit the ganglion on the ganglionic branches to join the maxillary nerve. Additionally post-synaptic sympathetic fibers feed through the ganglion to also pass into the maxillary nerve V2. All of these visceral motor fibers join the maxillary nerve and then pass into the zygomatic nerve from which they connect via a communicating branch to the lacrimal nerve to innervate the lacrimal gland as mentioned in the section on the ophthalmic nerve.

In addition, sensory fibers from a number of sensory branches pass through the ganglion without synapsing. The first of these is the greater palatine nerve which passes from the palate through the greater palatine foramen and provides sensory innervation to much of the hard palate. The second is the lesser palatine nerve which passes through the lesser palatine foramen and provides the same service to the soft palate. The next is the nasopalatine nerve which passes from the anterior palatal tissue first through the single incisive foramen then the left and right fibers pass through individual nasopalatine foramina. It then joins with branches from the nasal septum and joins the maxillary nerve at the pterygopalatine ganglion. This final pair of nerves does the remaining area of the hard palate sensation anterior to the canine teeth along with the mucosa in the inferior part of the nasal septum.

There are also branches that are less important in dentistry whose areas of innervation can be gleaned from their names. These are the pharyngeal, posterior inferior nasal and posterior superior nasal branches. These all join the nerve and proceed to follow it back to the trigeminal ganglion along with palatal branches.

Anterior to the ganglion is another important sensory nerve that joins the maxillary after passing into the space via foramina in the posterior part of the maxillary tuberosity. This nerve, known as the posterior superior alveolar, provides sensory innervation to the posterior maxilla including the maxillary sinus and the molar teeth and their supporting structures including soft tissue on the facial side except the mesiobuccal root of the first molar in some individuals. This nerve is often targeted for obtaining anesthesia in the posterior maxilla.

One can also see in the diagram that this nerve joins with the middle superior alveolar nerve and the anterior superior alveolar nerve to form a continuous network. However, this does not seem to be clinically significant.

To complicate matters further the middle superior alveolar and the anterior superior alveolar do not join directly to the maxillary nerve but rather to a large branch of the nerve that is found in the floor of the orbit. This nerve is known as the infraorbital nerve and begins in the skin of the face inferior to the eye in several locations. There is an inferior palpebral branch that carries sensations from the lower eyelid. There are internal and external nasal branches, a branch known simply as the nasal branch and a branch that runs to the upper lip known as the superior labial branch. The infraorbital nerve thus does most the sensation to the middle face.

The infraorbital nerve passes through a foramen named for it just below the orbital rim. It gathers the anterior and middle superior alveolar branches within the orbit before passing through the inferior orbital fissure into the pterygopalatine space. This is where it meets the posterior superior alveolar to form the maxillary nerve.

The middle superior alveolar nerve is not always present but if it is it supplies sensory innervation to the premolar teeth plus the mesial buccal root of the first molar, their supporting tissue and the facial soft tissue. The anterior superior alveolar serves the same function for the anterior teeth and surrounding tissues. The infraorbital nerve is therefore very important in dental pain control also. Block anesthesia of the infraorbital nerve numbs a large area of the face from the lower eyelid to the lip along with all of the teeth except the molars.

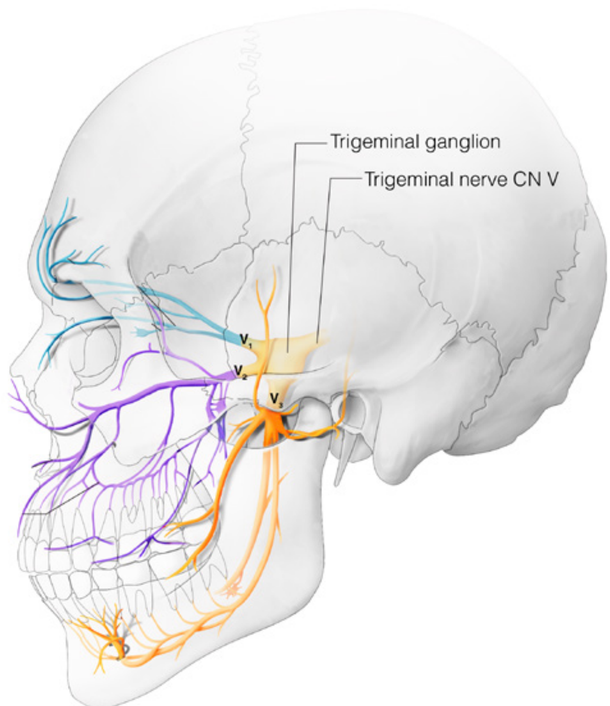

Figure 11. Cranial Nerve V - Trigeminal Nerve

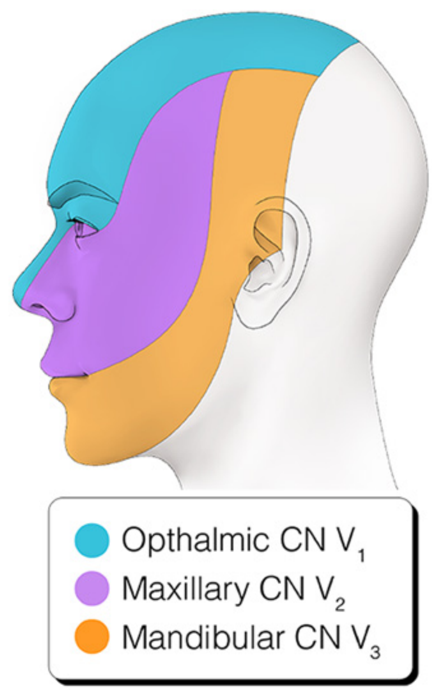

Figure 12. Divisions of Trigeminal Nerve

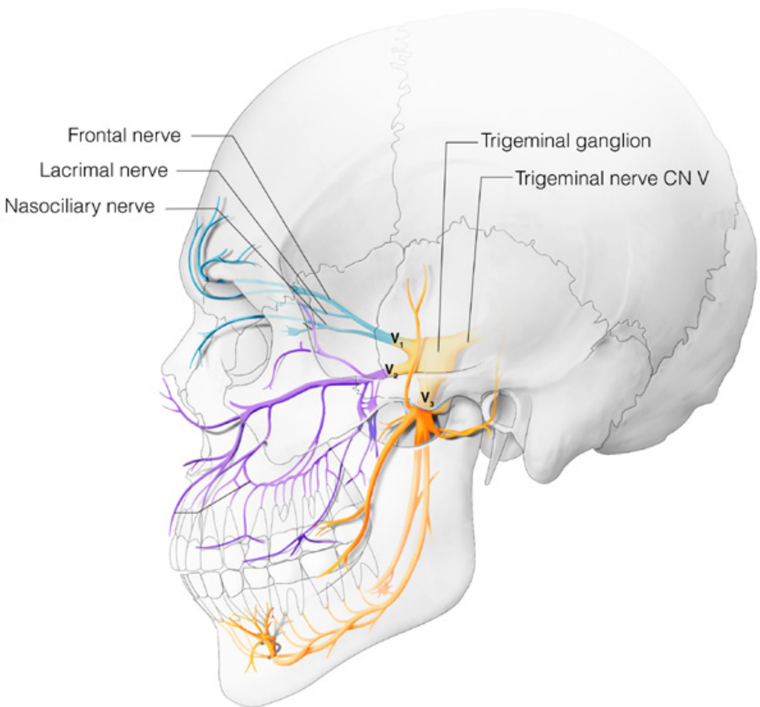

Figure 13. Cranial Nerve V1 – Ophthalmic Nerve (shown in blue)

Figure 14. Cranial Nerve V1 – Ophthalmic Nerve

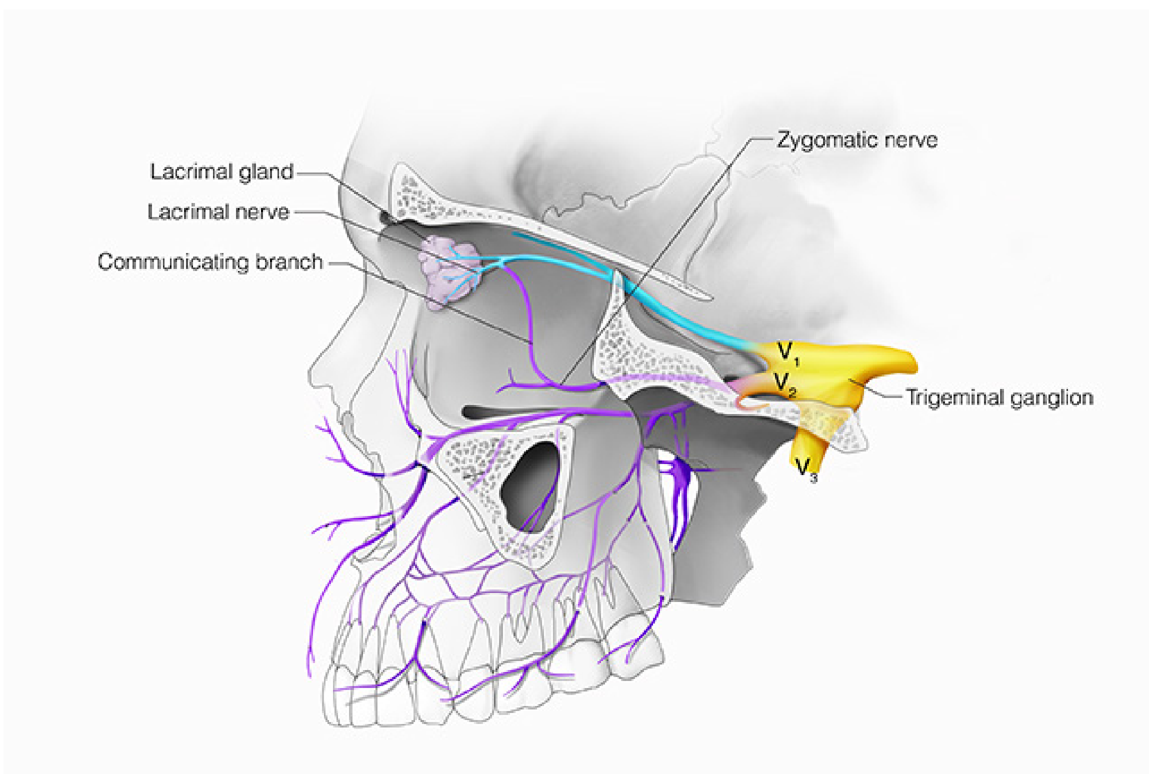

Figure 15.

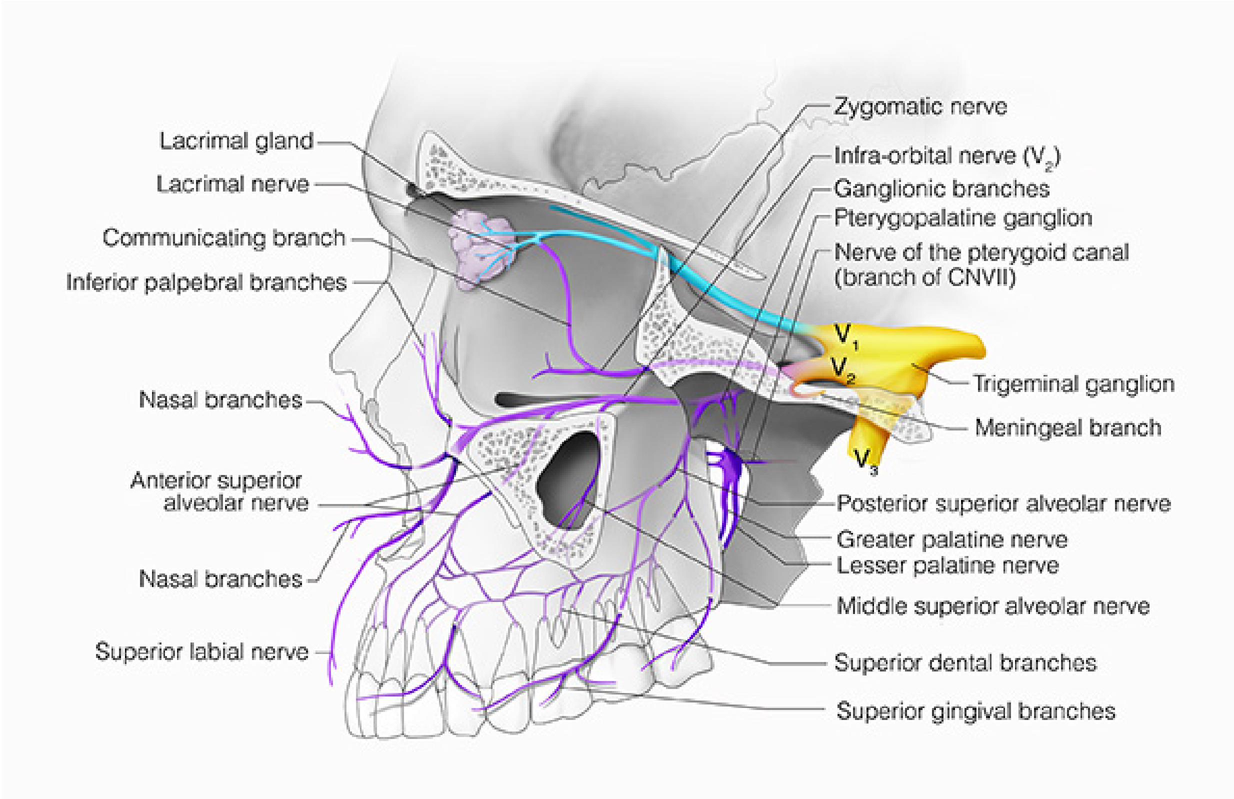

Figure 16. Cranial Nerve V2 – Maxillary Nerve (shown in purple)

Figure 17. Cranial Nerve V2 – Maxillary Nerve

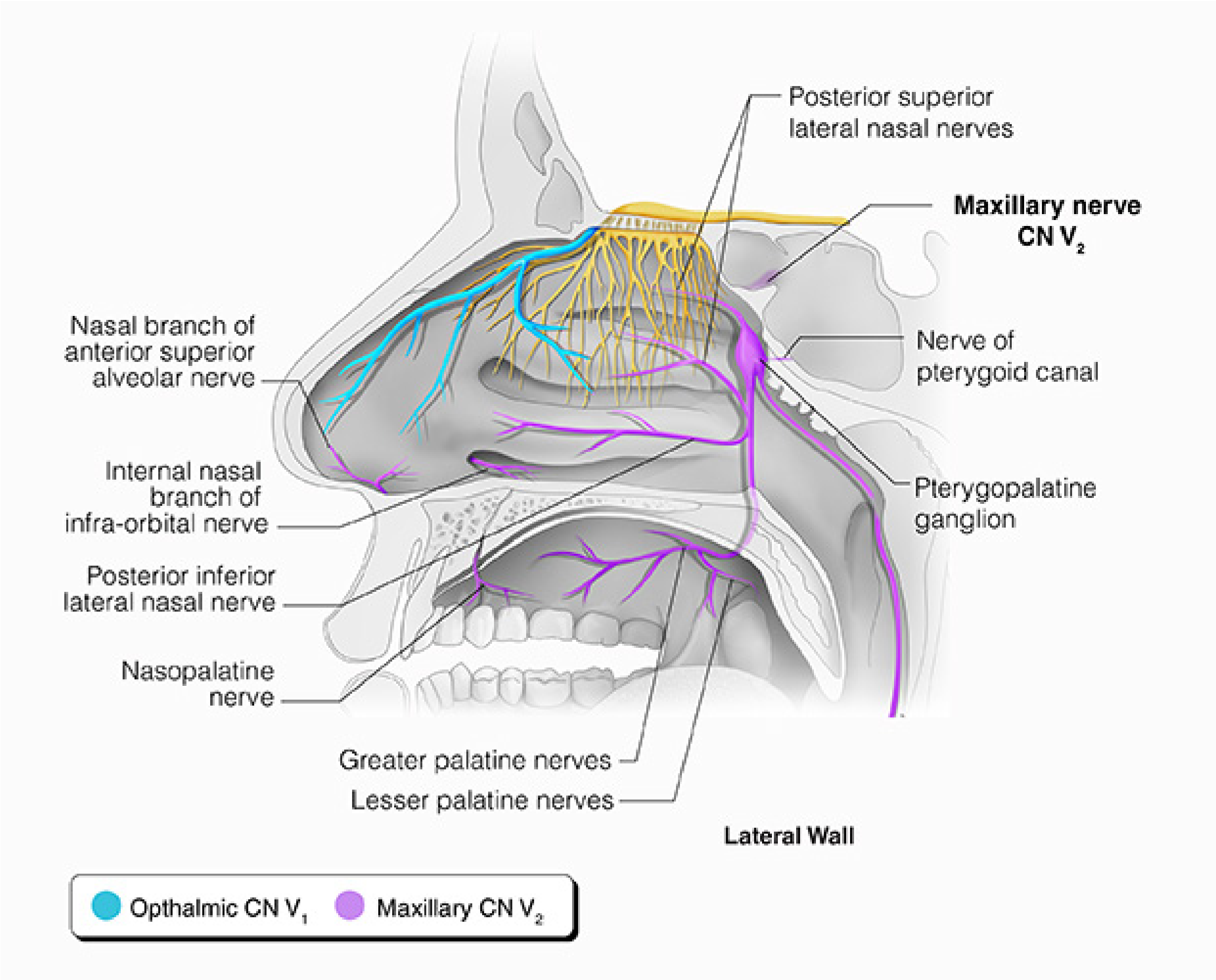

Figure 18. Cranial Nerve V2 – Maxillary Nerve (shown in purple)

V3 – Mandibular Nerve

Unlike the first and second divisions of the trigeminal nerve the third division has a motor root in addition to the sensory one. The smaller motor root is separate from the sensory root as they pass through the foramen ovale which is the cranial exit of the mandibular nerve. Once through the opening they unite to form a single nerve. The motor component of the nerve is responsible for innervating the four muscles of mastication along with the mylohyoid, the tensor veli palatini, the tensor tympani, and the anterior belly of the digastric muscle. The sensory component carries sensory information from the mandible, the mandibular teeth, the periodontium and gingiva of the lower jaw as well as the skin overlying the mandible including the lower lip and the skin anterior to the ear plus some of the meninges surrounding the brain. As this is a motor nerve in addition to a sensory one we will start our tour of the nerve at the point where the two roots meet just past the foramen ovale.

In close proximity to the foramen ovale a number of branches of the nerve are seen. The closest to the foramen is the sensory **meningeal branch** carrying fibers originating in the meninges. The next branch is a mixed one that splits to form muscular branches and then continues as a sensory nerve. These are the **nerves to the temporalis**, **masseteric**, the **nerve to the medial and lateral pterygoids**. In addition, there are some very small branches serving the tensor tympani and tensor veli palatini. After these motor fibers leave the nerve continues as the **buccal nerve** carrying sensation from the cheek and facial gingiva posterior to the mental foramen. This nerve is generally referred to in dentistry as the long buccal nerve to distinguish it from an identically named buccal nerve that is a branch of the facial nerve.

Entering the mandibular nerve posteriorly is the **auriculotemporal nerve** which is the afferent nerve from the ear, the temporal region and the TMJ. In addition, this nerve carries parasympathetic fibers that originate from the glossopharyngeal nerve (cranial nerve IX) that it picks up while passing through the **otic ganglion**. These post-synaptic fibers provide innervation to the parotid gland.

The mandibular nerve then splits into two terminal branches, **inferior alveolar** and the **lingual nerve** which lie in close proximity to one another until the **inferior alveolar nerve** enters the mandible at the mandibular foramen. The lingual nerve is the sensory nerve for the anterior two-thirds of the tongue and the tissues on the lingual of the mandible. Like the auriculotemporal nerve it carries postganglionic fibers that originate elsewhere. In this case they are fibers from the facial nerve and are destined for the submandibular and sublingual salivary glands. These merge with the nerve at the submandibular ganglion (see facial nerve diagram) which is attached to the lingual nerve. To make matters more complicated as the general sensory fibers form the lingual nerve in the tongue and they are joined by fibers from the taste buds of the tongue. These fibers ultimately will join the chordae tympani which is the same branch of the facial nerve carrying parasympathetic fibers to the submandibular ganglion.

The other branch, the **inferior alveolar nerve** passes into the mandible through the mandibular foramen but prior to that gives off a couple of final motor branches, the **nerve to the mylohyoid** and the nerve to the anterior belly of the digastric. Once those branches have separated the remaining fibers are all afferent. The nerve passes through the mandible in a tunnel in the bone known as the mandibular canal. Throughout its passage it is joined by fibers carrying sensory fibers from the posterior teeth and the surrounding bone. At the other end of the canal is the mental foramen. This is the point at which the inferior alveolar nerve is formed by the union of the **mental nerve** which originates in the lower lip and facial gingiva, anterior to the mental foramen, plus the **incisive nerve** which consists of small branches that originate in the mandible and the teeth anterior to the mental foramen. This can be confusing as in the maxilla there is an incisive canal through which passes the nasopalatine nerves. The incisive nerve, however, remains within the mandible so there is no opening associated with it.

Cranial Nerve VI – Abducens

The **abducens nerve** is a small, somatic efferent nerve that controls the **lateral rectus** muscle of the eye. This muscle when contracted causes the eye to abduct hence the name of the nerve. It leaves the orbit along with cranial nerve III, IV and V1 through the superior orbital fissure.

Cranial Nerve VII - Facial Nerve

Hopefully you were disappointed in the simplicity of the abducens nerve because the facial nerve is a very complex one. It has all the possible fiber types: somatic motor, visceral motor, general sensory and special sensory. We have already seen the autonomic fibers in the discussion of the maxillary and ophthalmic nerves carrying its fibers to the lacrimal gland and the mandibular nerve in regards to the submandibular and sublingual glands plus the special sensory component of taste. Now we get to see how the fibers got to those nerves plus the other components that we have not seen.

As this is a mixed nerve we will start at the cranial exit. The facial nerve leaves the cranial cavity through the internal acoustic meatus. This leads into the petrous portion of the temporal bone. Within the bone it gives off two branches which means that leaving the temporal bone there are three nerves, the facial itself and two branches, each leaving through a separate foramen. We will cover the branches first before following the main nerve trunk.

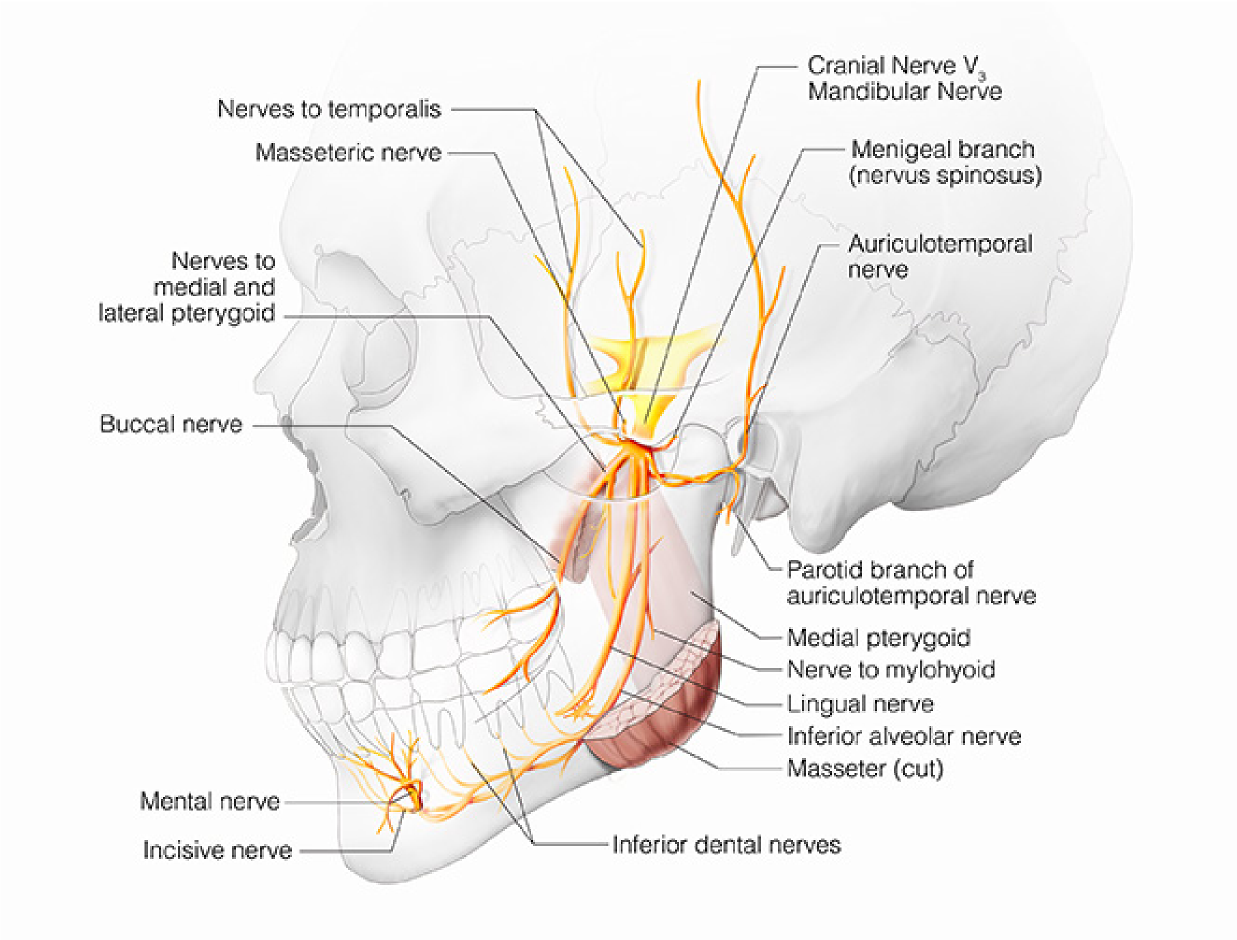

Figure 19. Cranial Nerve V3 – Mandibular Nerve

Figure 20. Cranial Nerve V3 – Mandibular Nerve

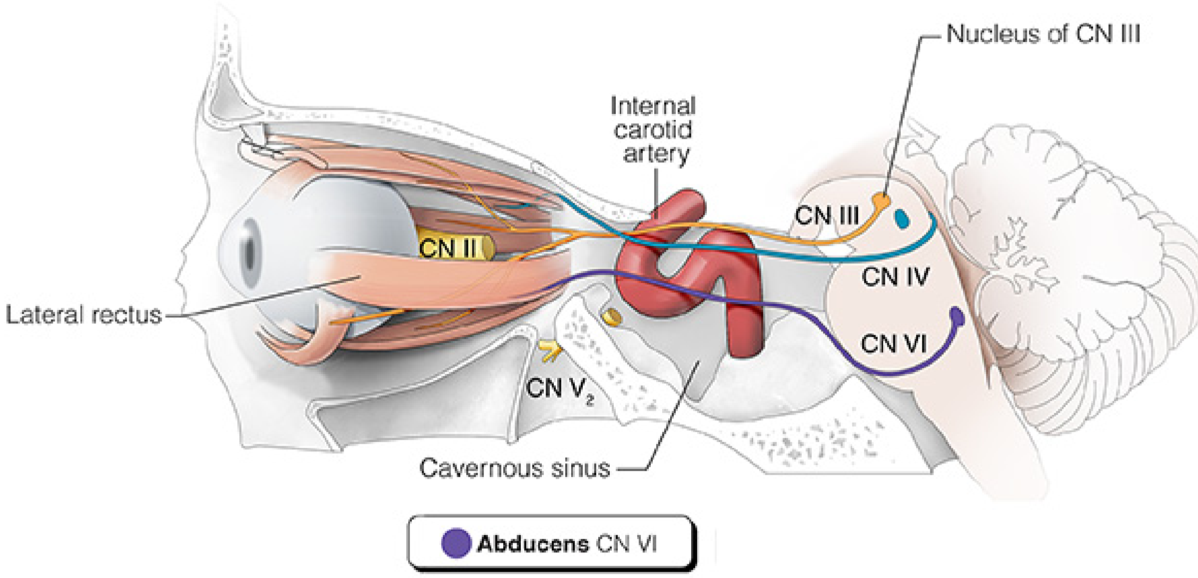

Figure 21. Cranial Nerve VI – Abducens Nerve (shown in purple)

Greater Petrosal Nerve

The greater petrosal nerve is the first to branch within the temporal bone. It carries parasympathethic fibers out of the temporal bone through the hiatus of the greater petrosal nerve back into the middle cranial fossa. It then passes out of the cranium for good entering the foramen lacerum where it joins the deep petrosal nerve to become the nerve of the pterygoid canal. The deep petrosal carries postganglionic sympathetic fibers from spinal ganglia while the greater petrosal is mostly composed of pre-ganglionic parasympathetic fibers. This combined nerve of the pterygoid canal immediately enters the pterygoid canal in the sphenoid. After passing through the sphenoid the canal opens into the pterygopalatine fossa where the nerve enters the pterygopalatine ganglion which is associated with the maxillary nerve as mentioned in the earlier section. The parasympathetic fibers synapse in the ganglion and the post ganglionic fibers pass into the maxillary nerve along with post-ganglionic sympathetic fibers already traveling in the nerve. These fibers travel along the maxillary nerve to the zygomatic nerve. Finally, they travel through a communicating branch to the ophthalmic nerve which gives off the lacrimal nerve to the lacrimal gland.

Chorda Tympani

The **chorda tympani** carries special sensory fibers from taste buds in the anterior 1/3 of the tongue and presynaptic parasympathetic fibers to the sublingual and submandibular glands along with the minor salivary glands. It separates from the main trunk of the facial nerve just before the latter passes out of the temporal bone through the stylomastoid foramen. The chorda tympani, however, travels anteriorly into the middle ear. The nerve gets its name from its passage across the internal surface of the tympanic membrane colloquially known as the ear drum. At the anterior edge it leaves the temporal bone through the petrotympanic fissure into the infratemporal fossa. At this point it associates itself with the lingual nerve which as mentioned earlier is a branch of the mandibular nerve. The parasympathetic fibers will synapse in the **submandibular ganglia** and the post-ganglionic fibers will follow the lingual nerve to the **submandibular** and **sublingual salivary glands**. The sensory fibers do not synapse but are directly attached to the taste buds in the fungiform and foliate papillae.

tnerve is mainly a somatic motor nerve with a minor somatic sensory component. The sensory component carries sensation from a small area of the pharynx and another small area of skin around the ear. Having noted the small sensory contribution, we will follow the somatic motor fibers. It must be mentioned that the first somatic efferent branch of the facial nerve is given off in the temporal bone. This nerve carries somatic motor fibers to the stapedius muscle which is located in the middle ear. The remainder of the nerve passes through the stylomastoid foramen into the facial portion of the head.

From here, there is a branch serving muscle in the immediate vicinity named the **posterior auricular** which carries both somatic sensory fibers as mentioned earlier to the area around the ear and motor fibers to the muscles around the ear as the name implies. These are in the muscles of facial expression group of muscles, as they move soft tissue rather than a joint.

The next branch given off runs to muscles that are not in the group of muscles of facial expression. This short branch goes to the posterior belly of the digastric muscle. The anterior belly is connected to the mandibular nerve which makes this muscle more interesting than ones with single innervation. There is also a short nerve that goes to a suprahyoid muscle, the stylohyoid, which is also anatomically in the path of the nerve as it exits the stylomastoid foramen.

From there the facial nerve enters the parotid gland and even while it is surrounded by the gland, it does not innervate it. Within the gland it splits into five terminal branches that innervate all of the numerous muscles of facial expression except the ones innervated by the aforementioned posterior auricular nerve. These branches are labeled by the area where they travel. These can be clearly seen in Figure 24 and from inferior to superior are the **cervical**, **marginal mandibular**, **buccal**, **zygomatic** and **temporal**. Confusion can sometimes result between the buccal branch of the mandibular nerve and this buccal branch of the facial nerve. The mandibular nerve branch is only sensory and the facial nerve branch is only motor. So just remember if you are doing a buccal nerve block it would logically be the sensory one. However, if during any anesthetic administration one injects into the capsule of the parotid gland the patient will experience transient Bell's palsy as that affliction is caused by lack of function in the facial nerve serving the muscles of facial expression.

Cranial Nerve VIII – Statoacoustic, Vestibulocochlear, Auditory Nerve

The eighth cranial nerve wins the most names contest but if you are trying to remember what the function of the nerve is remember only the first two names as you will see that the third one on the list is incomplete. The **vestibulocochlear nerve** passes like the facial nerve, through the **internal acoustic meatus**, but stays within the temporal bone. It originates at the **cochlea**, the **semicircular canals**, the **maculae**, the **saccule** and the **utricle**. The cochlear is the area where the cells that sense vibrations that are ultimately translated into auditory information so it carries fibers going towards the brain. The other four organs mentioned are involved with the special sense of equilibrium and their afferent fibers form the vestibular branch of the nerve hence the name vestibulocochlear as that is just the name of the two nerves that form it. The statoacoustic name comes from the two special senses that it carries, those of equilibrium (stato) and hearing (acoustic). While some authors use the acoustic nerve for cranial nerve VIII that name neglects an important function as anyone with vertigo will attest as it carries special sensory fibers for equilibrium as well as hearing.

Cranial Nerve IX – Glossopharyngeal Nerve

The glossopharyngeal nerve contains, like the facial and along with the vagus nerve which we have not studied yet, all four types of nerve fibers. Unlike those other two nerves where motor fibers predominate the glossopharyngeal nerve is mainly a sensory nerve. The somatic motor fibers innervate only the stylopharyngeus muscle. The visceral motor fibers travel to the **otic ganglion** where they synapse and continue on mandibular nerve branches to the **parotid gland**. The special sensory fibers carry fibers that originate in the taste buds in the posterior one-third of the tongue. The general sensory fibers convey sensations from both internal receptors, the baroreceptors of the **carotid sinus** and the chemoreceptors found in the carotid body which is in the area where the carotid artery splits into the internal and external carotids. The carotid body importantly monitors blood gases. There are also more conventional receptors it carries signals from. There are general sensory ones in the posterior one-third of the tongue and the adjacent tissues covering the epiglottis, the upper pharyngeal walls and the skin of the ear and the deep surface of the tympanic membrane. This is nerve that is the main carrier of pain when you have a sore throat.

Having made a long introduction let us follow the path of the nerve. Like the other mixed nerves we have discussed we will start with the cranial exit but one should recognize that the sensory nerves are not leaving there but are entering the cranium. The **superior** and **inferior ganglia** are sensory in function. Only the **otic ganglion** is associated with parasympathetic motor fibers.The cranial exit/entrance of the glossopharyngeal nerve is the jugular foramen. The first branch of the nerve is the small **tympanic nerve** which passes through a small opening between the carotid canal and the jugular foramen orifices into the body of the temporal bone. It passes into the tympanic cavity where it forms a network of nerve fibers called the **tympanic plexus**. This network collects general sensory fibers from the internal surface of the tympanic membrane and surrounding tissues. The remaining fibers, that are all pre-ganglionic parasympathetic fibers, form the **lesser petrosal nerve** which enters the otic ganglion where they synapse. The post synaptic fibers pass into the mandibular nerve and are carried to the parotid gland on the **auriculotemporal nerve**.

The main trunk continues after the branch into the neck until it splits. It is formed mainly of sensory fibers that join to form the trunk. These come from general sensory fibers that come from branches in the tonsillar region, the pharynx and receptors from the carotid artery and both the somatic sensory and taste sensory fibers from the posterior one-third of the tongue. The small motor nerve to the stylopharyngeus muscle is also included in the formation of the main trunk.

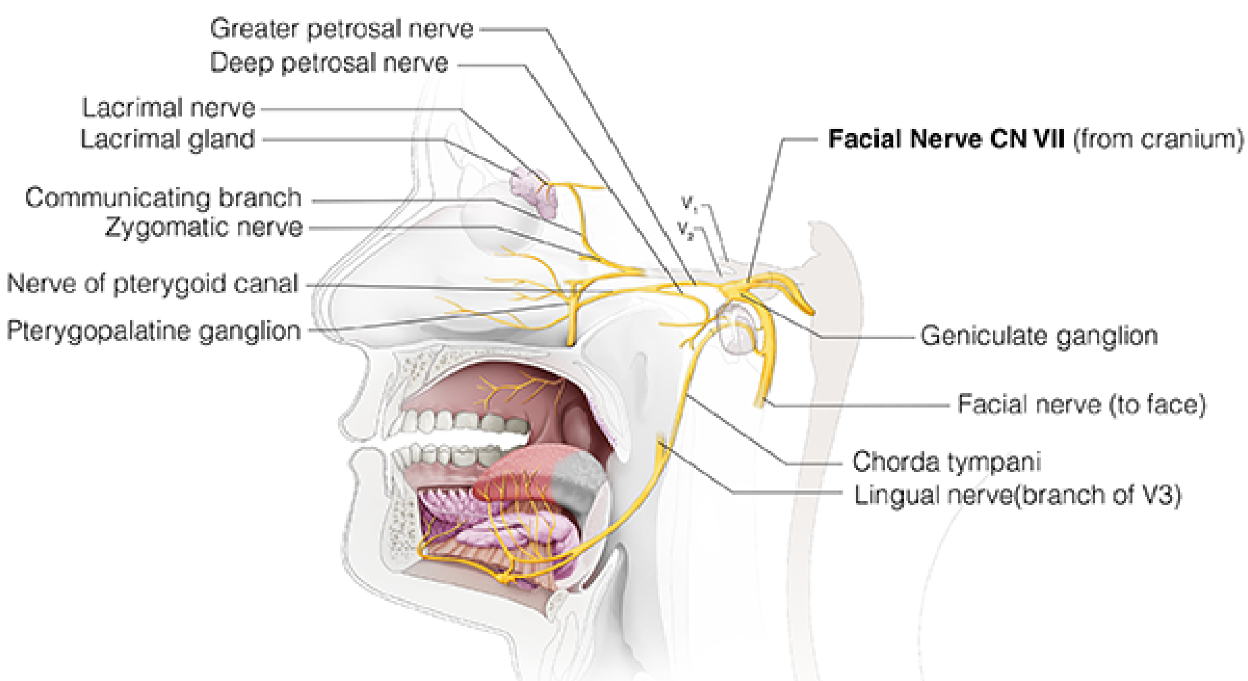

Figure 22. Cranial Nerve VII - Facial Nerve

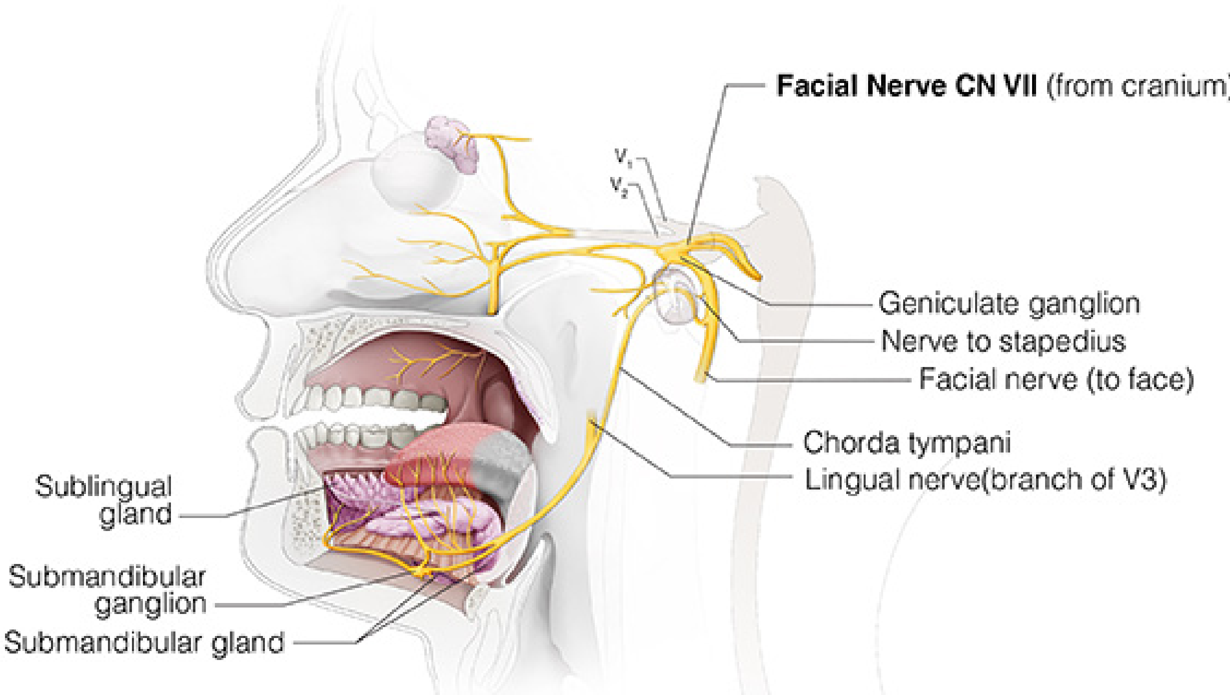

Figure 23. Cranial Nerve VII - Facial Nerve

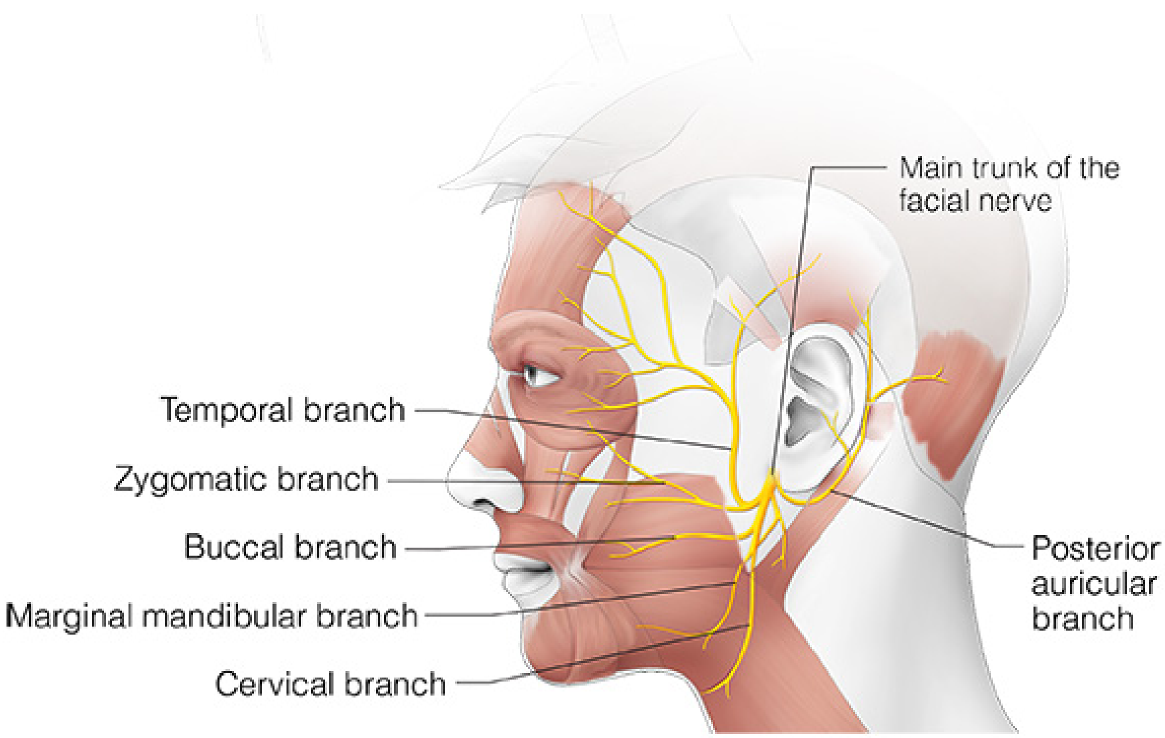

Figure 24. Cranial Nerve VII - Facial Nerve (main trunk)

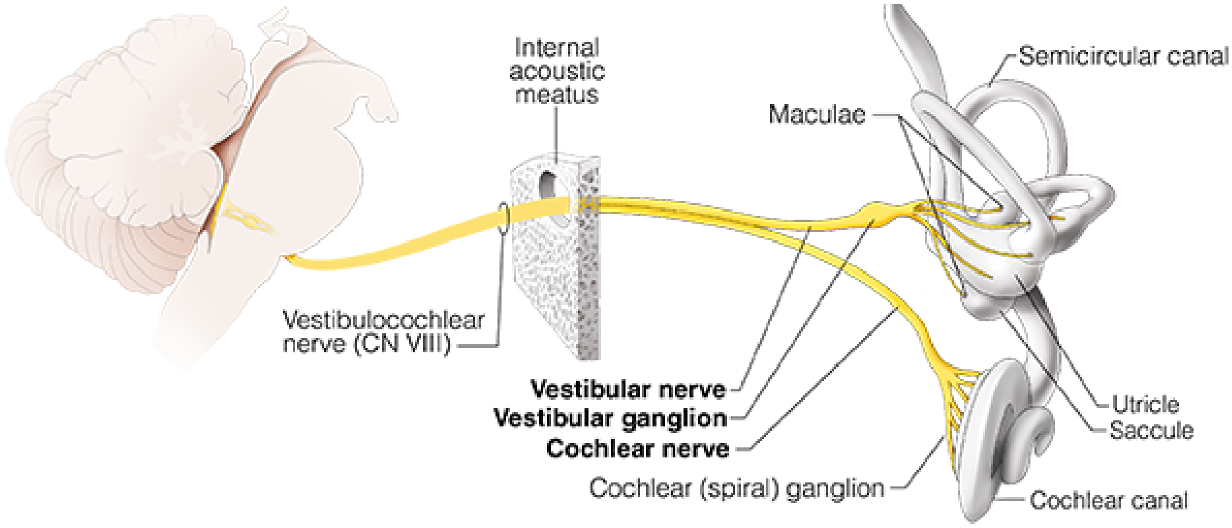

Figure 25. Cranial Nerve VIII – Statoacoustic, Vestibulocochlear, Auditory Nerve

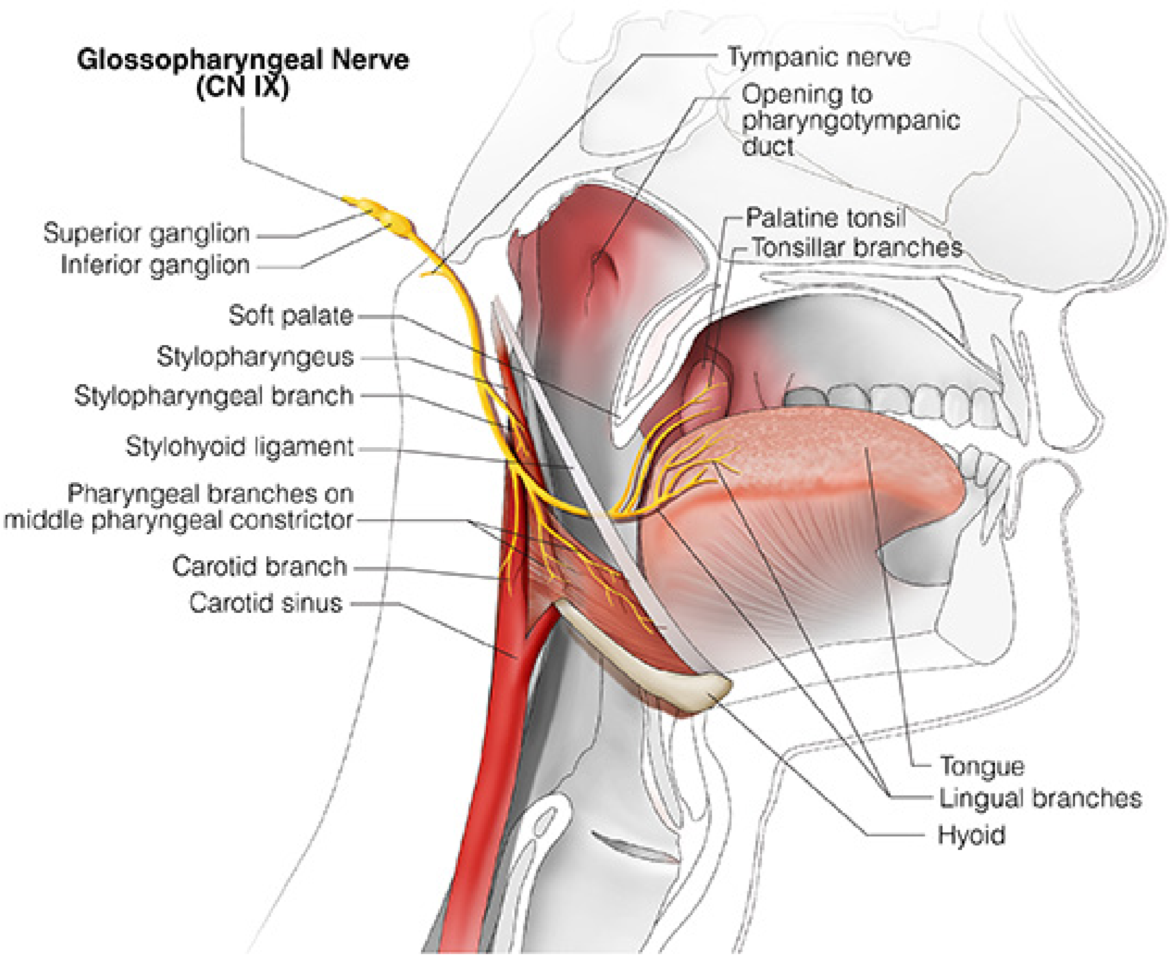

Figure 26. Cranial Nerve IX – Glossopharyngeal Nerve

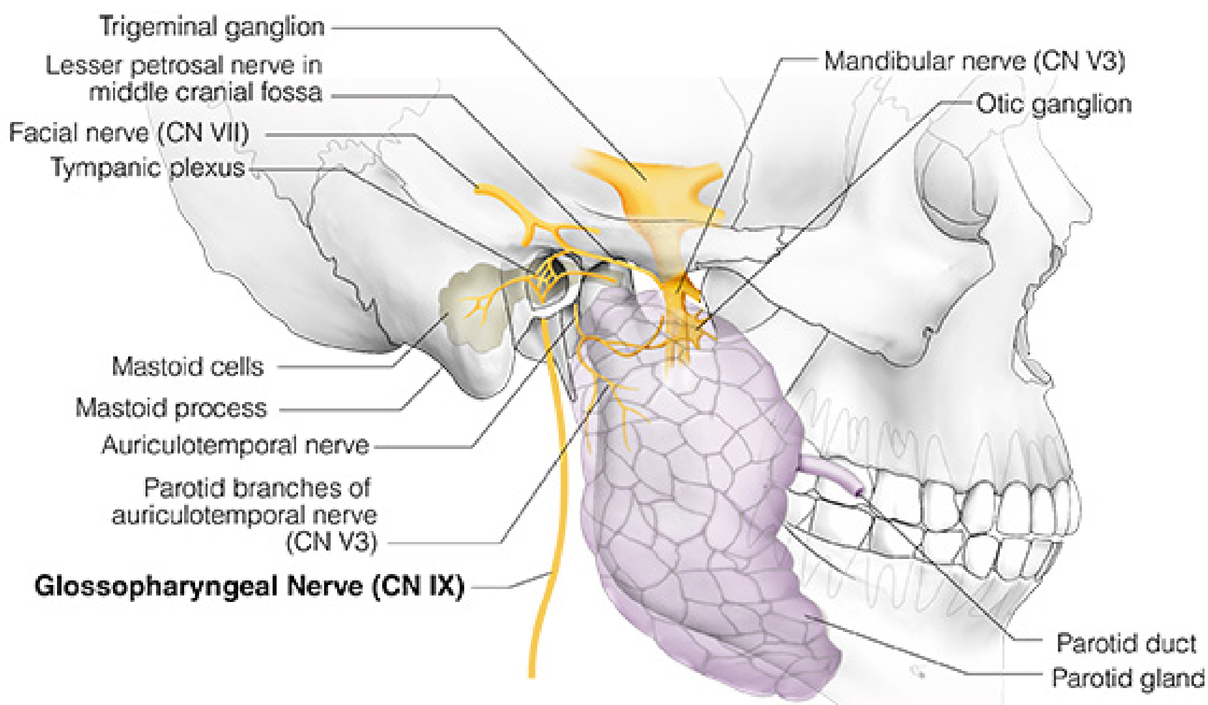

Figure 27. Cranial Nerve IX – Glossopharyngeal Nerve

Cranial Nerve X – Vagus Nerve

The vagus nerve is the longest cranial nerve. It is like the facial and the glossopharyngeal in that it carries fibers of all types. Most of these fibers are either visceral motor or visceral sensory fibers and most are not found in the head and neck. Nevertheless, anyone who has taken any course in office emergencies is familiar with the term vasovagal syncope. So, despite the nerve having few branches in the area where dental personal work it does play a role in dental care.

As done previously with mixed nerves we will start as the cranial exit which in the case of the vagus nerve is the jugular foramen. Through the neck it is found in the carotid sheath with the common carotid artery and the internal jugular vein. Before it enters the sheath it sometimes gives off a branch that splits off an area where IX, X, and XI all join together. It then passes to the area around ear. We have already seen components of the trigeminal, facial and glossopharyngeal nerve in the vicinity of the ear so you can appreciate that the external ear is an area where several nerves are involved with general sensation. The vagus provides fibers to the external acoustic meatus but all of the nerves involved overlap to some extent.

Another early branch is the pharyngeal branch which carries fibers from taste buds in the pharynx. It is also of importance in the head and neck as it gives off branches that innervate all of the palatal muscles except the tensor veli palatini which, as mentioned earlier, is connected to the mandibular nerve. It also contributes to the pharyngeal plexus which supplies motor innervation to all the pharyngeal muscles except the stylopharyngeus and parts of the inferior pharyngeal constrictor which is supplied by laryngeal branches of the vagus. The stylopharyngeus muscle is supplied by the glossopharyngeal nerve.

The next branches are a couple of nerves that serve the larynx. The first is the superior laryngeal which gives rise to the external laryngeal, and the internal laryngeal nerves and the later branch is the recurrent laryngeal. The external laryngeal is a motor nerve to the cricothyroid muscle which allows one to vary the pitch of one's voice. The internal laryngeal is a sensory nerve carrying fibers that originate in the tissues within the superior portion larynx and the laryngeal surface of the epiglottis. This will also carry taste sensation from the epiglottis. The recurrent laryngeal is motor to

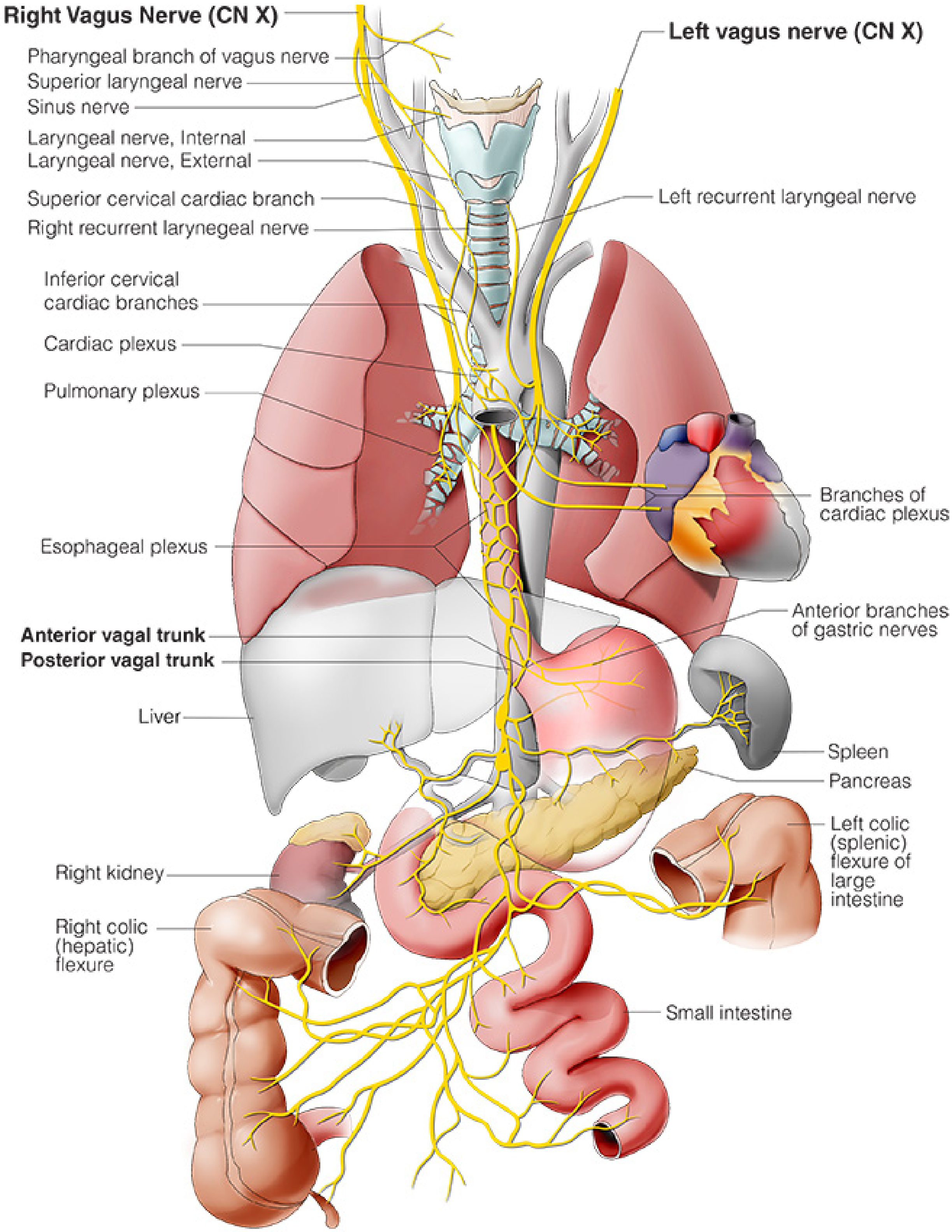

Figure 28. Cranial Nerve X - Vagus Nerve

all the other small muscles in the larynx and sensory to the membranes found below the vocal folds. These nerves provide virtually all of the motor and sensory innervation to the larynx.

The vagus gives off no more branches in the neck and enters the thorax where it supplies pre-synaptic parasympathetic fibers to the viscera, most importantly the heart. It is these fibers that are implicated in vasovagal syncope as they slow down the heart rate. If these fibers provide vastly more stimulation than countered by the sympathetic fibers the heart rate slows down greatly and blood pressure falls precipitously. Not only are there autonomic motor fibers to the thorax but the vagus also has sensory fibers from all the thoracic organs. After giving off branches to ganglia in the thorax the vagi (this is the plural of vagus to remind one that there are both a left and right vagus) follow the aorta into the abdominal cavity where it connects with the nerves that control the motility of the digestive system. It receives sensory information from the digestive organs except from the distal portion of the transverse colon to the rectum.

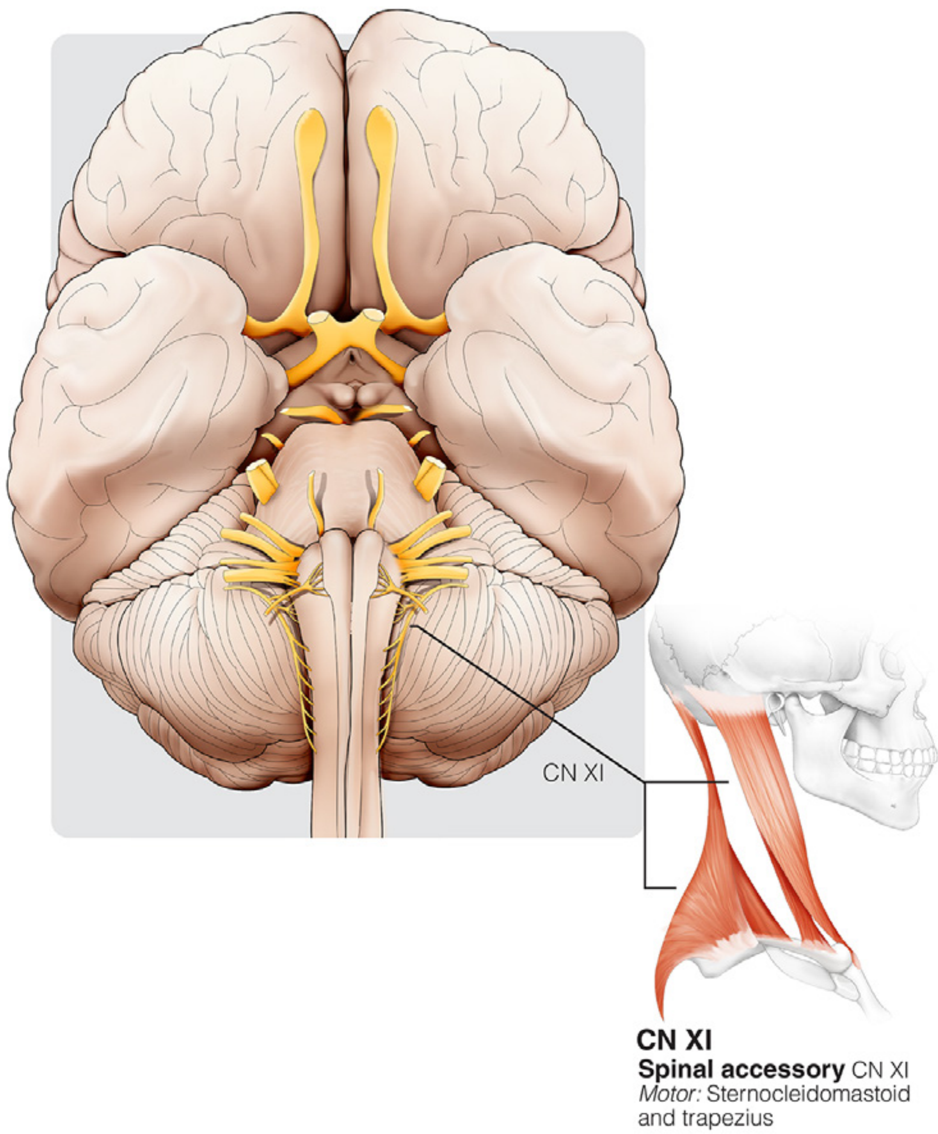

Figure 29. Cranial Nerve XI - Spinal Accessory, Accessory

Cranial Nerve XI - Spinal Accessory Nerve

This an odd cranial nerve hence one of its names containing the word spinal. The reason for the name is that the main portion of nerve originates in the spinal cord. The nerve passes from the spinal cord back through the foramen magnum, joins up with cranial nerves IX and X briefly and then cranial root from the brain stem then leaves with IX and X through the jugular foramen. It is purely somatic efferent in function supplying motor innervation branches to the trapezius and sternocleidomastoid muscles.

Cranial Nerve XI - Spinal Accessory Nerve

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Cranial Nerve XII - Hypoglossal Nerve

The hypoglossal nerve which is considered a somatic efferent nerve leaves the brain stem just prior to the origin of the spinal cord. It passes laterally through the hypoglossal canal, and travels in the carotid sheath for a short distance before running towards the angle of the mandible. It then sends fibers to all of the intrinsic muscles of the tongue and to all of the extrinsic muscles of the tongue except the palatoglossus which as mentioned earlier is innervated by the vagus nerve.

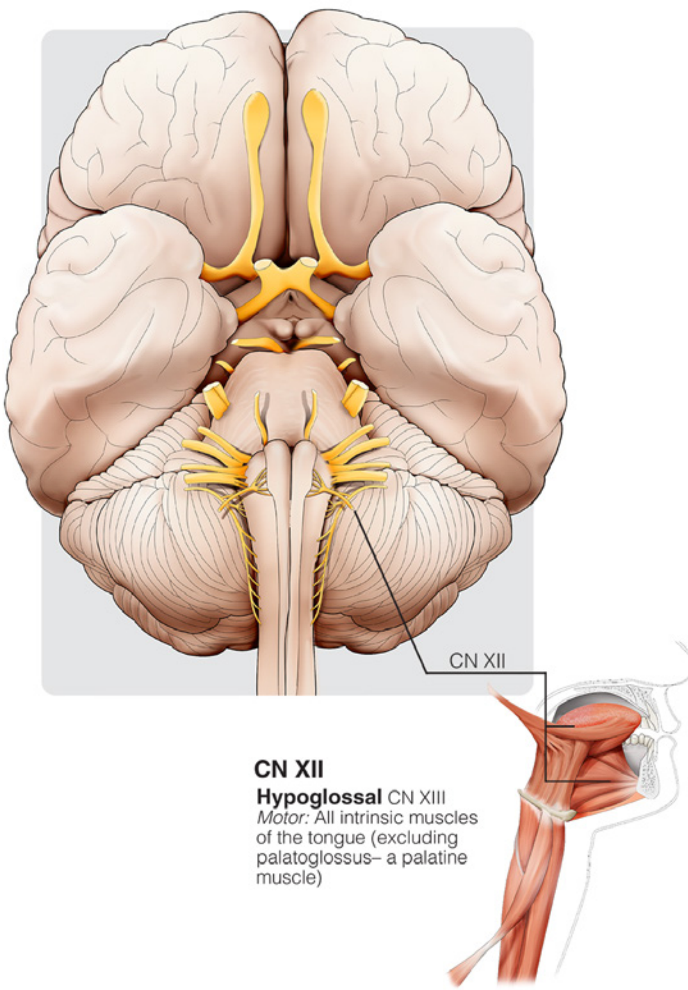


Figure 30. Cranial Nerve XII – Hypoglossal

Summary

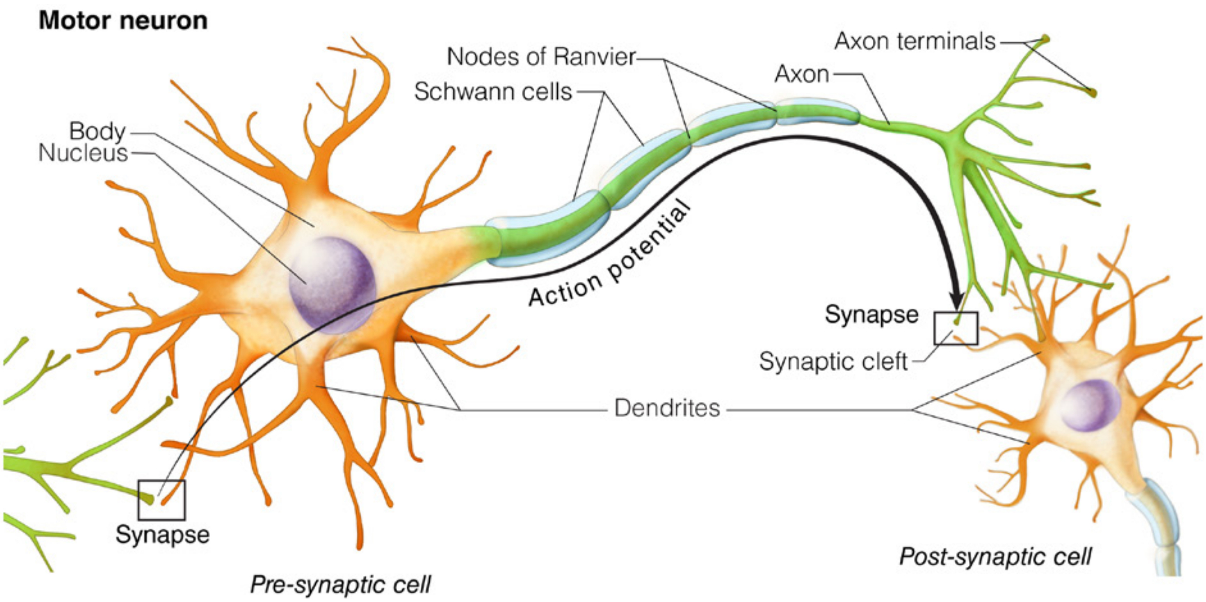
The best way to summarize the cranial nerves is with a table showing the major attributes of each.

Cranial Nerve	Types of Fibers	Passages Traversed	Major Branches
I - Olfactory	special sensory - smell	olfactory foramina	none
II - Optic	special sensory - vision	optic canal	none
III - Oculomotor	somatic motor - eye muscles visceral motor - iris and ciliary muscles	superior orbital fissure	none
IV - Trochlear	somatic motor - superior oblique muscle	superior orbital fissure	none
V - Trigeminal V_1 - Ophthalmic	general sensory - eyes, upper portion of face, nose and philtrum of the lip	superior orbital fissure	none
V - Trigeminal V_2 - Maxillary	general sensory - midface including tissues of oral cavity associated with the maxilla	foramen rotundum inferior orbital fissure infraorbital foramen (as infraorbital nerve)	greater palatal lesser palatal zygomatic posterior superior alveolar infraorbital middle superior alveolar anterior superior alveolar

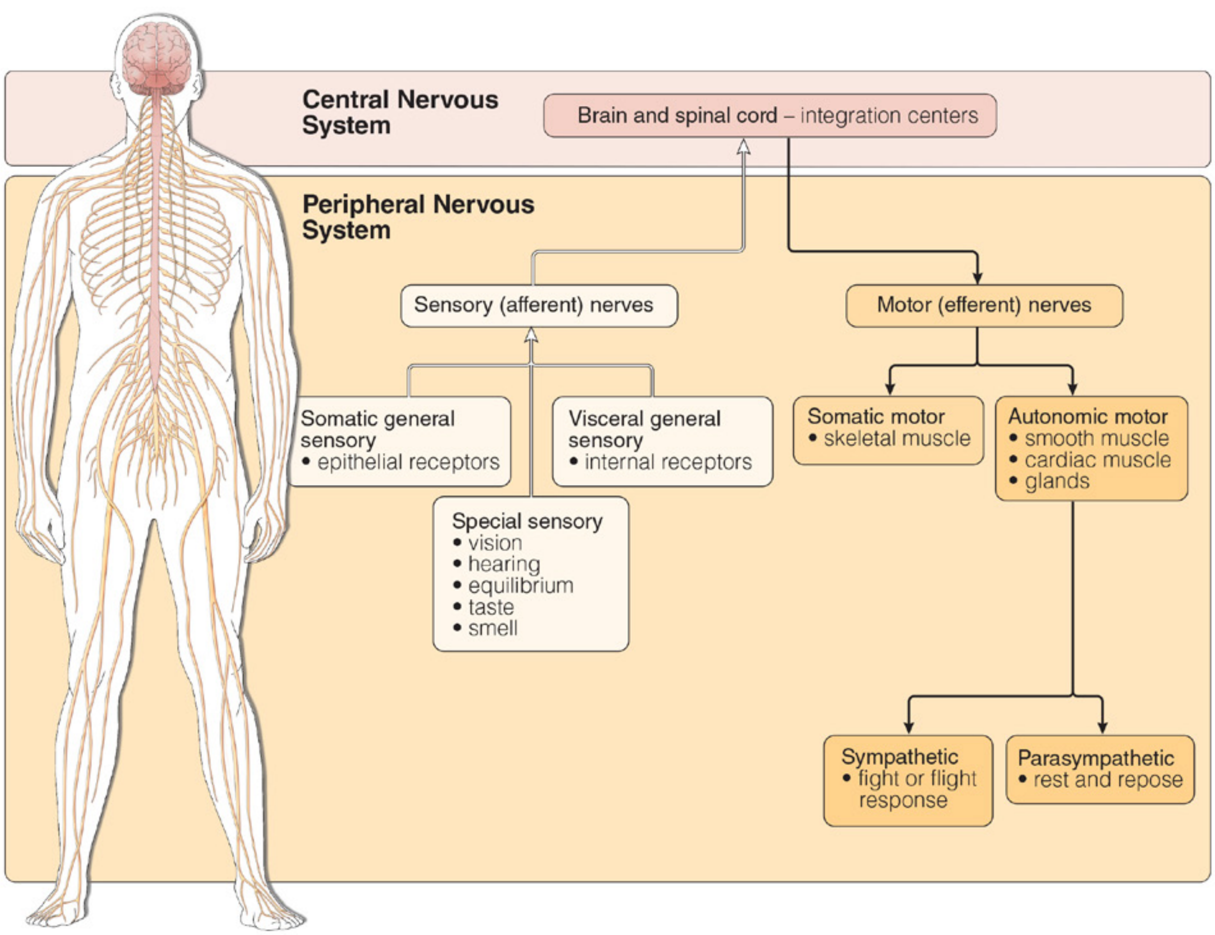
V - Trigeminal V_3 - Mandibular	general sensory - lower face following the mandible including oral structures in the lower jaw and the tongue Somatic motor - muscles of mastication, tensor veli palatini, anterior belly of the digastric. tensor tympani and the mylohyoid	foramen ovale mandibular foramen mandibular canal (as inferior alveolar) mental foramen (as mental - a branch of the inferior alveolar)	muscular branches lingual inferior alveolar mental incisive
VI - Abducens	somatic motor - lateral rectus muscle	superior orbital fissure	none
VII - Facial	somatic motor - muscles of facial expression, stylohyoid, posterior belly of the digastric and the stapedius. visceral motor - lacrimal, submandibular, sublingual and minor salivary glands general sensory - portion of pharynx and small area around ear special sensory - taste to the anterior 2/3 of the tongue	internal acoustic meatus stylomastoid foramen petrotympanic fissure (as chorda tympani) hiatus of the greater petrosal nerve (as greater petrosal) foramen lacerum (as greater petrosal)	greater petrosal chorda tympani muscular branches (temporal, zygomatic, buccal, marginal mandibular, cervical)
VIII - Vestibulocochlear, Statoacoustic, Acoustic	special sensory – hearing and equilibrium	internal acoustic meatus	vestibular cochlear

IX -Glossopharyngeal	somatic motor - stylopharyngeus muscle visceral motor - parotid salivary gland general sensory - posterior 1/3rd of tongue, portions of both the pharynx and larynx and to some skin around the ear special sensory - taste to the posterior 1/3 of the tongue	jugular foramen	tympanic
X- Vagus	somatic motor - all palatal muscles except the tensor veli palatini, all muscles of the pharynx except the stylopharygeus, laryngeal muscles visceral motor - thoracic and abdominal viscera except the distal 1/3rd of the colon general sensory - a small area around ear special sensory - taste from the taste buds of the pharynx	jugular foramen	superior laryngeal laryngeal recurrent laryngeal
XI - Spinal Accessory	somatic motor - trapezius and sternocleidomastoid muscles	jugular foramen	none
XII - Hypoglossal	somatic motor - intrinsic and extrinsic muscles of the tongue except the palatoglossus	hypoglossal canal	none

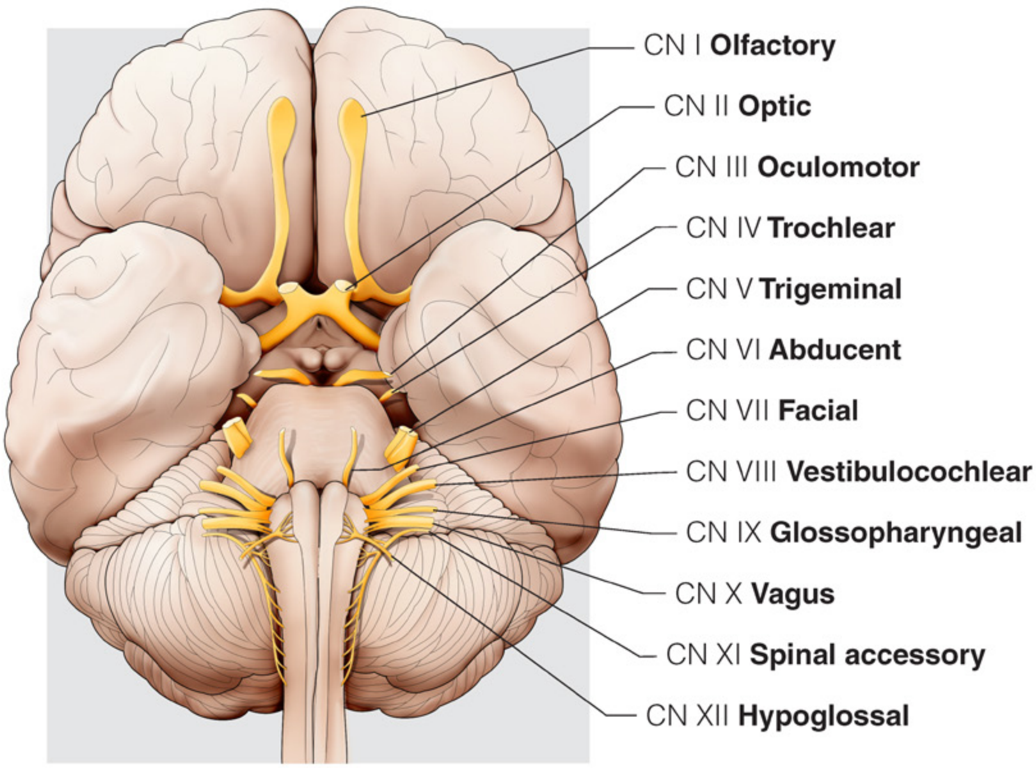
Appendices



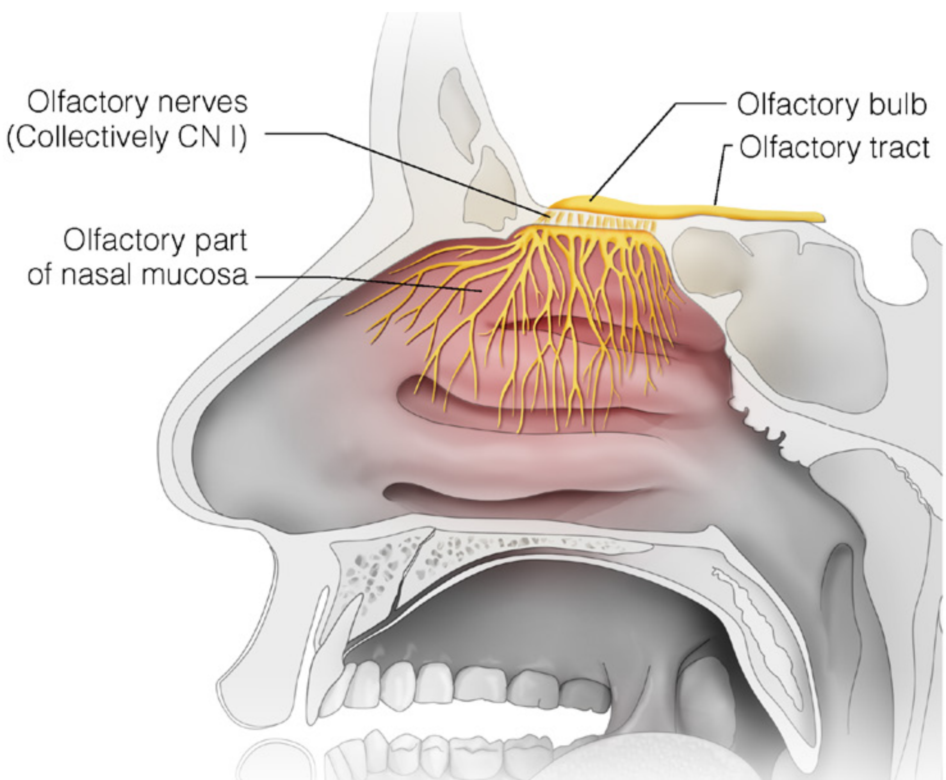
Appendix A



Appendix B



Appendix C



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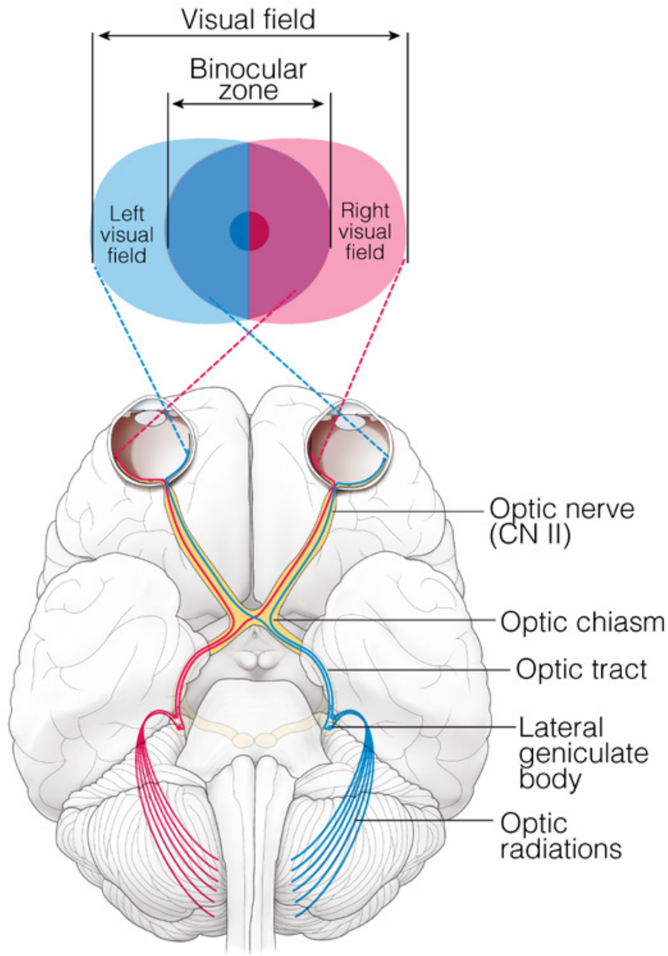
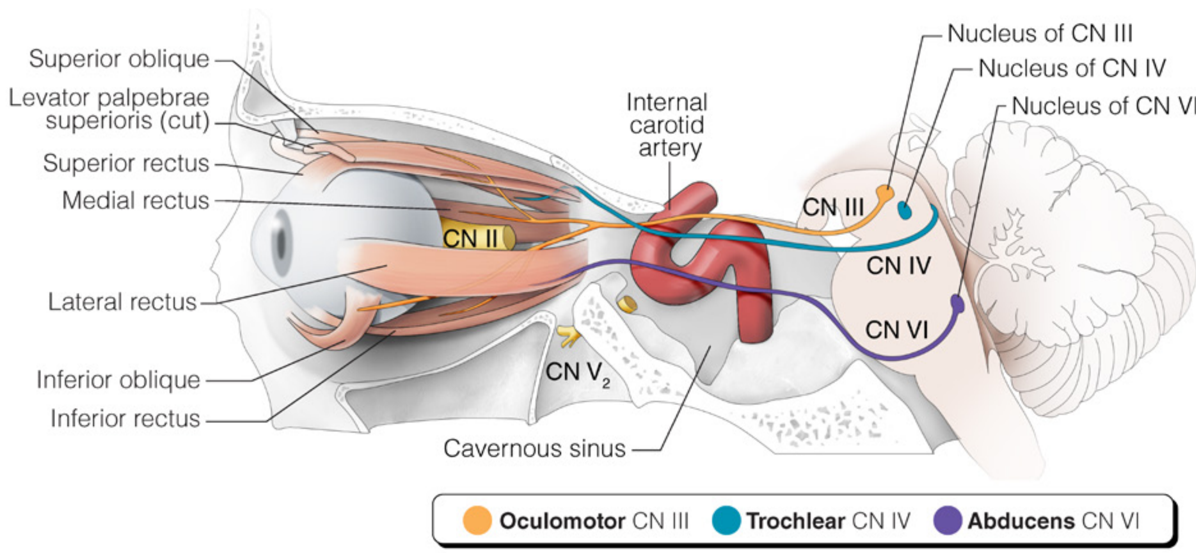


Appendix E



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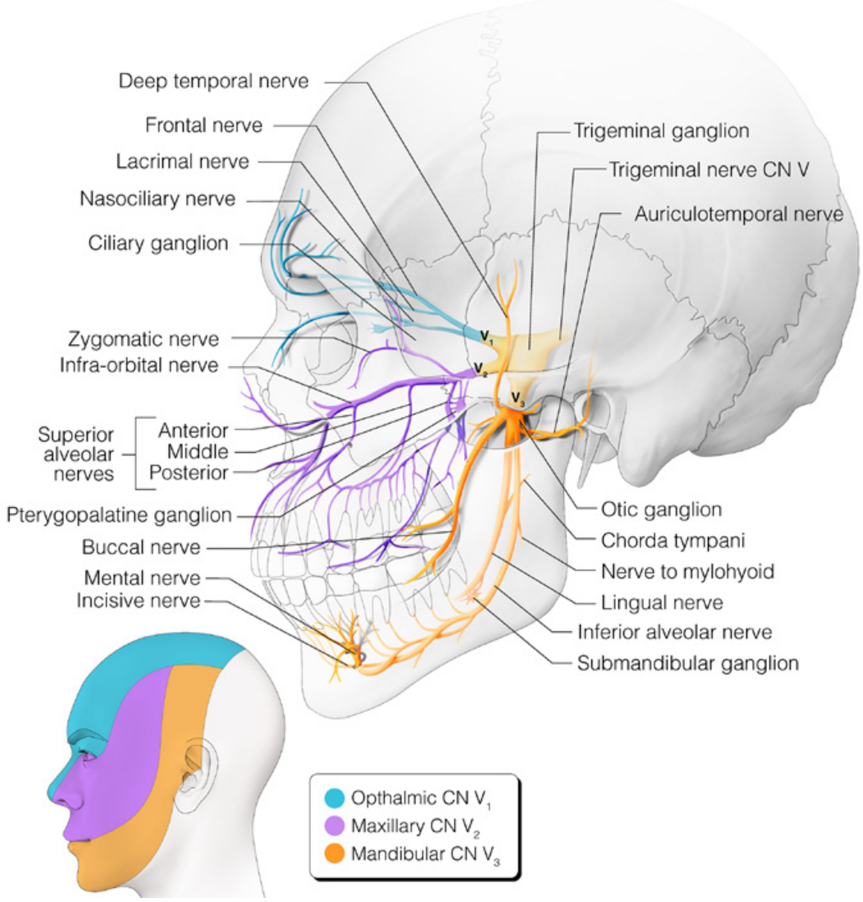
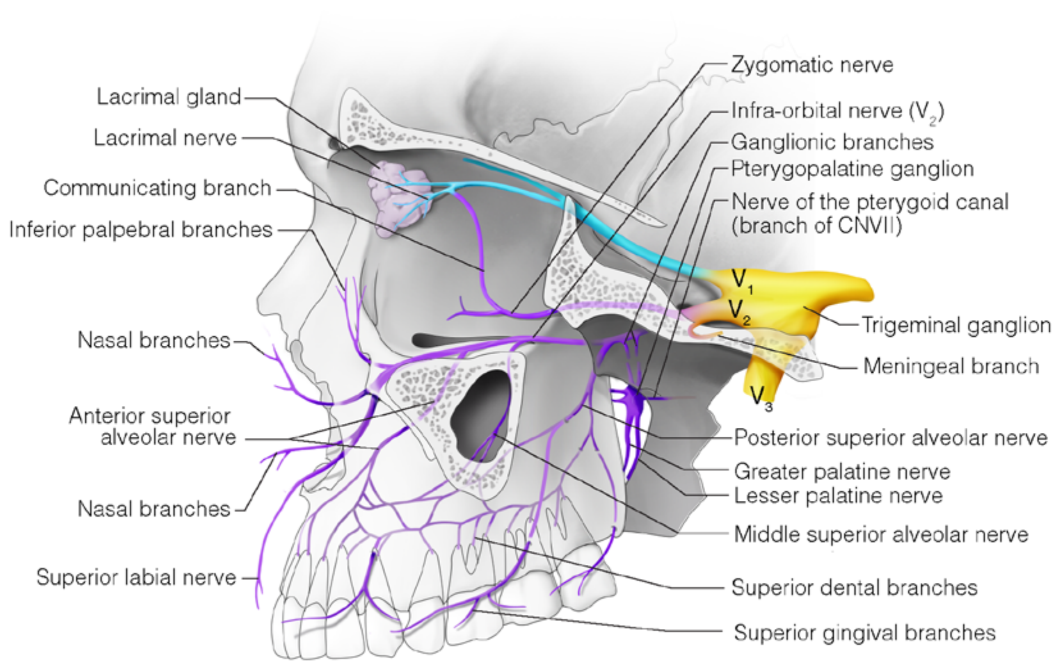
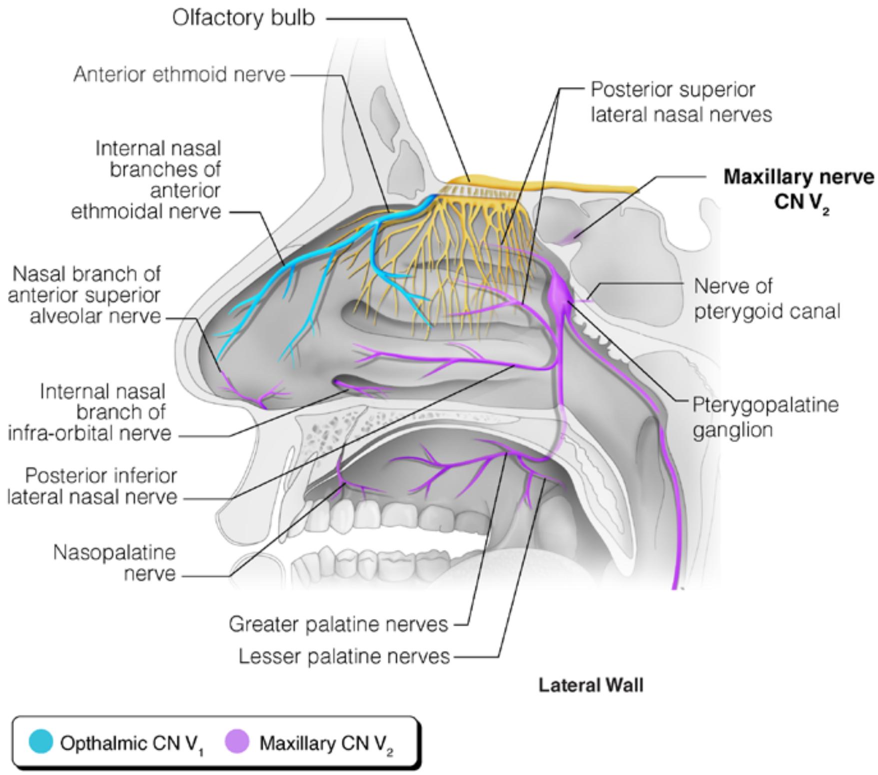


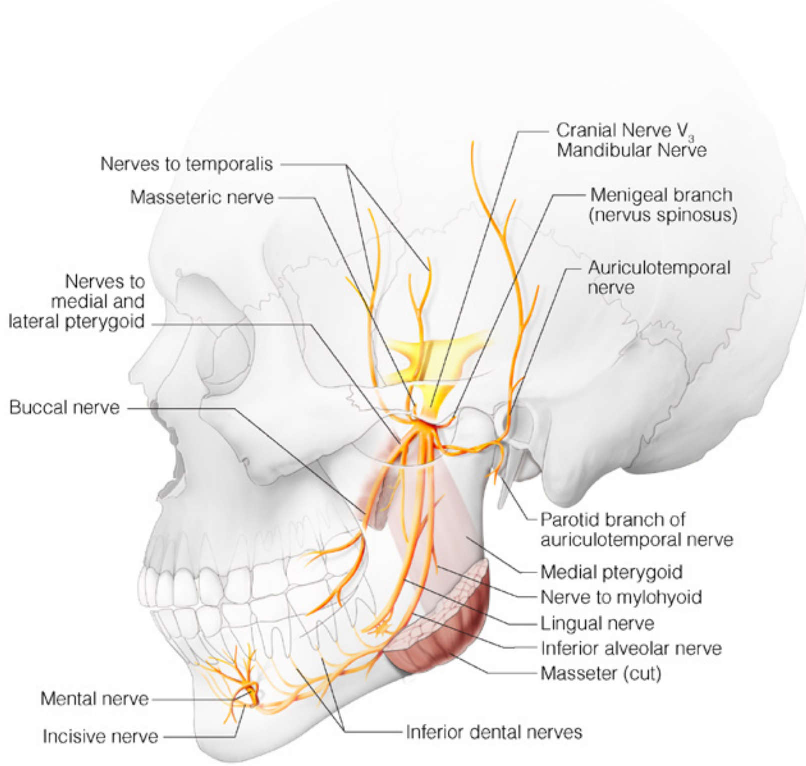
Appendix G



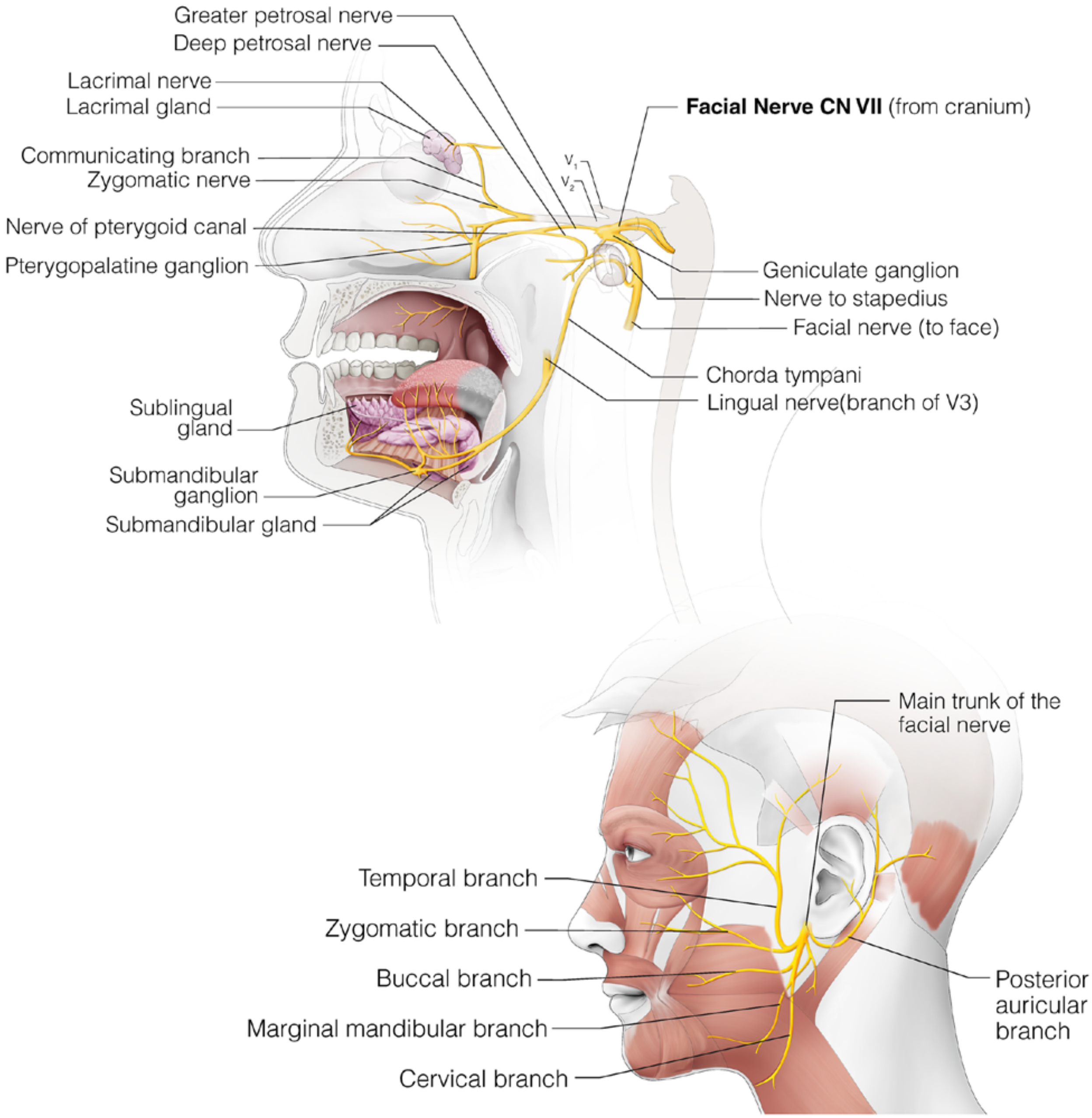
Appendix H



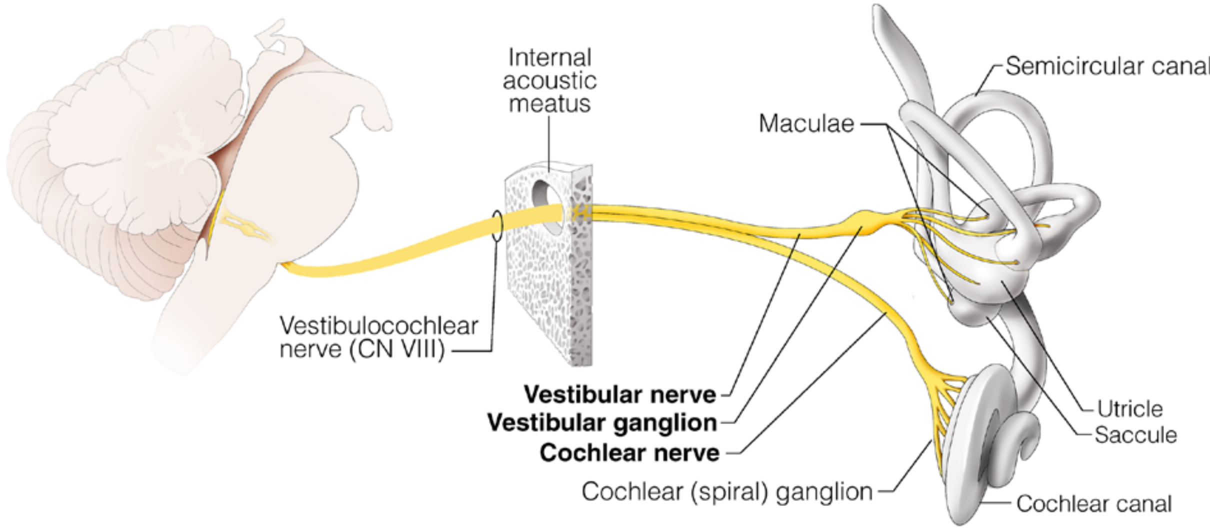
Appendix I



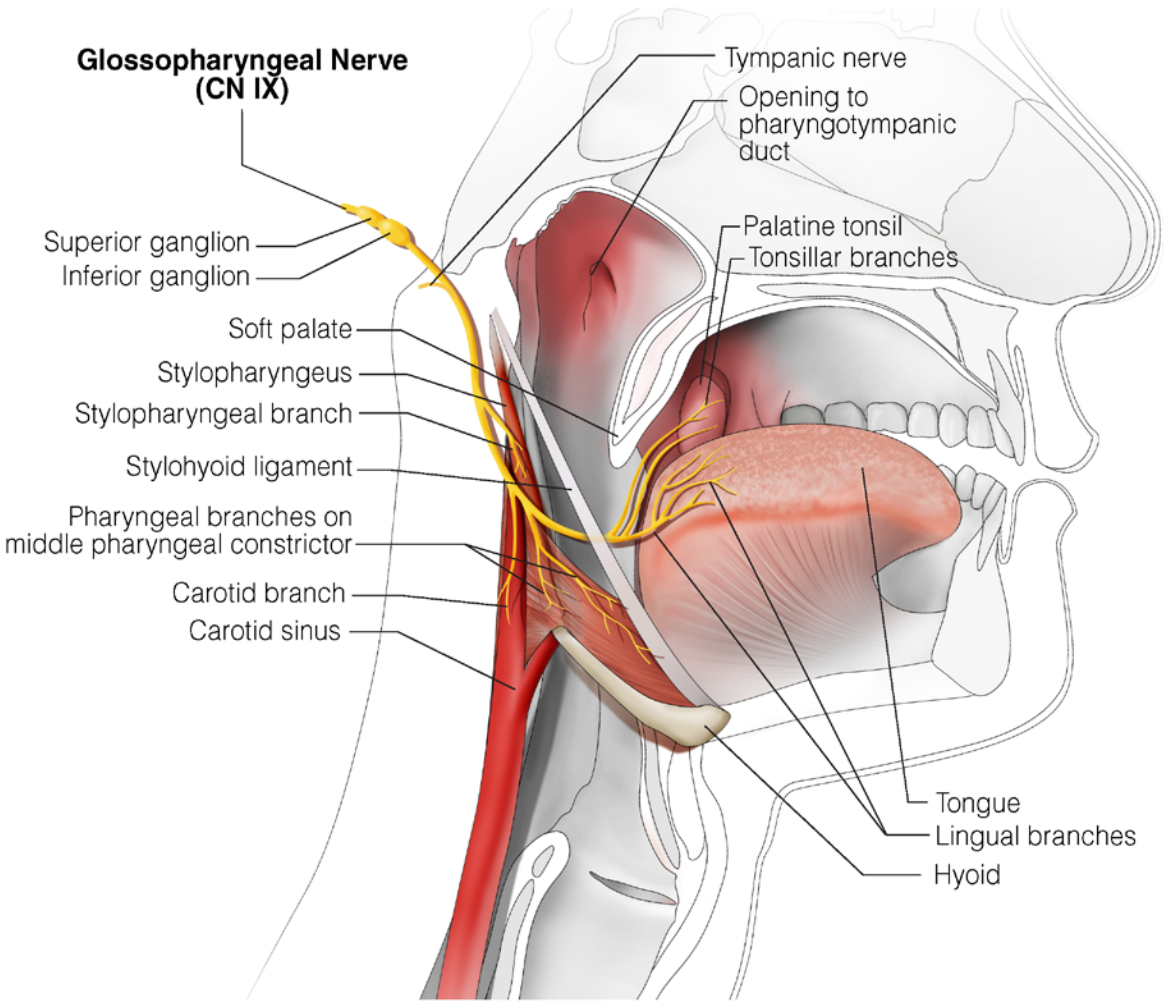
Appendix J


Greater petrosal nerve
Deep petrosal nerve
Lacrimal nerve
Lacrimal gland
Communicating branch
Zygomatic nerve
Nerve of pterygoid canal
Pterygopalatine ganglion
Facial Nerve CN VII (from cranium)
V_1
V_2
Geniculate ganglion
Nerve to stapedius
Facial nerve (to face)
Chorda tympani
Lingual nerve(branch of V3)
Sublingual gland
Submandibular ganglion
Submandibular gland
Main trunk of the facial nerve
Temporal branch
Zygomatic branch
Buccal branch
Marginal mandibular branch
Cervical branch
Posterior auricular branch

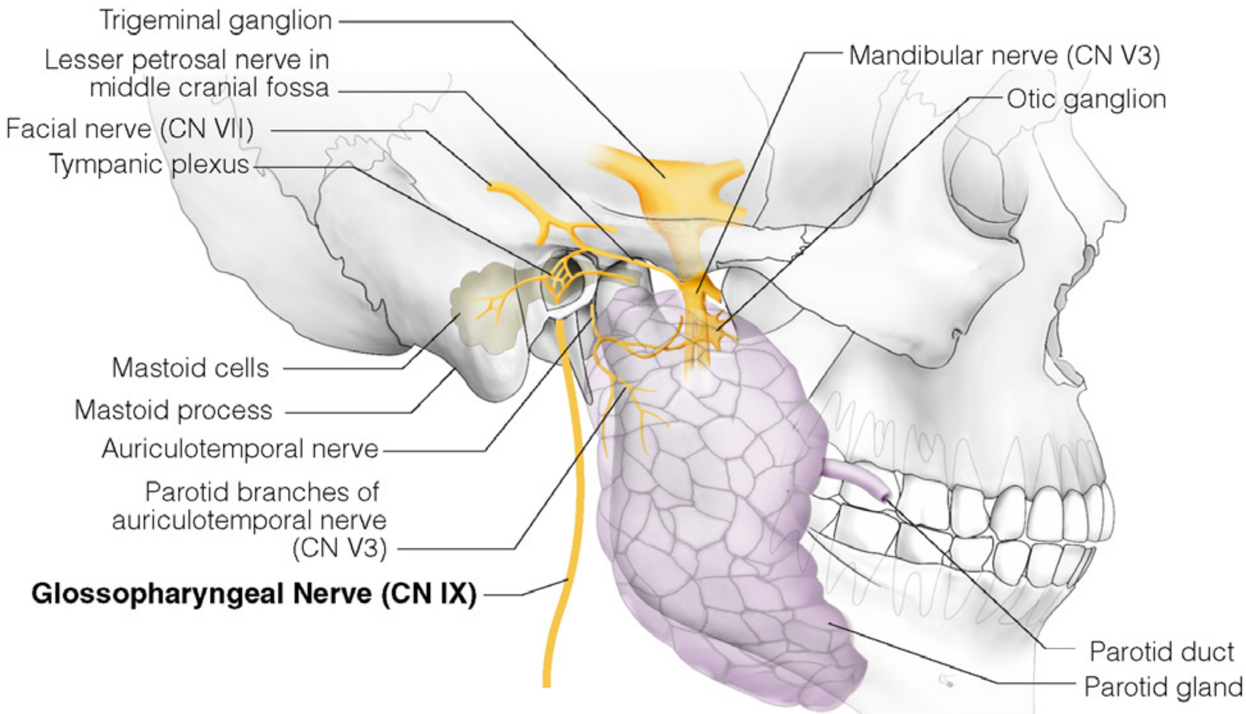
Appendix K



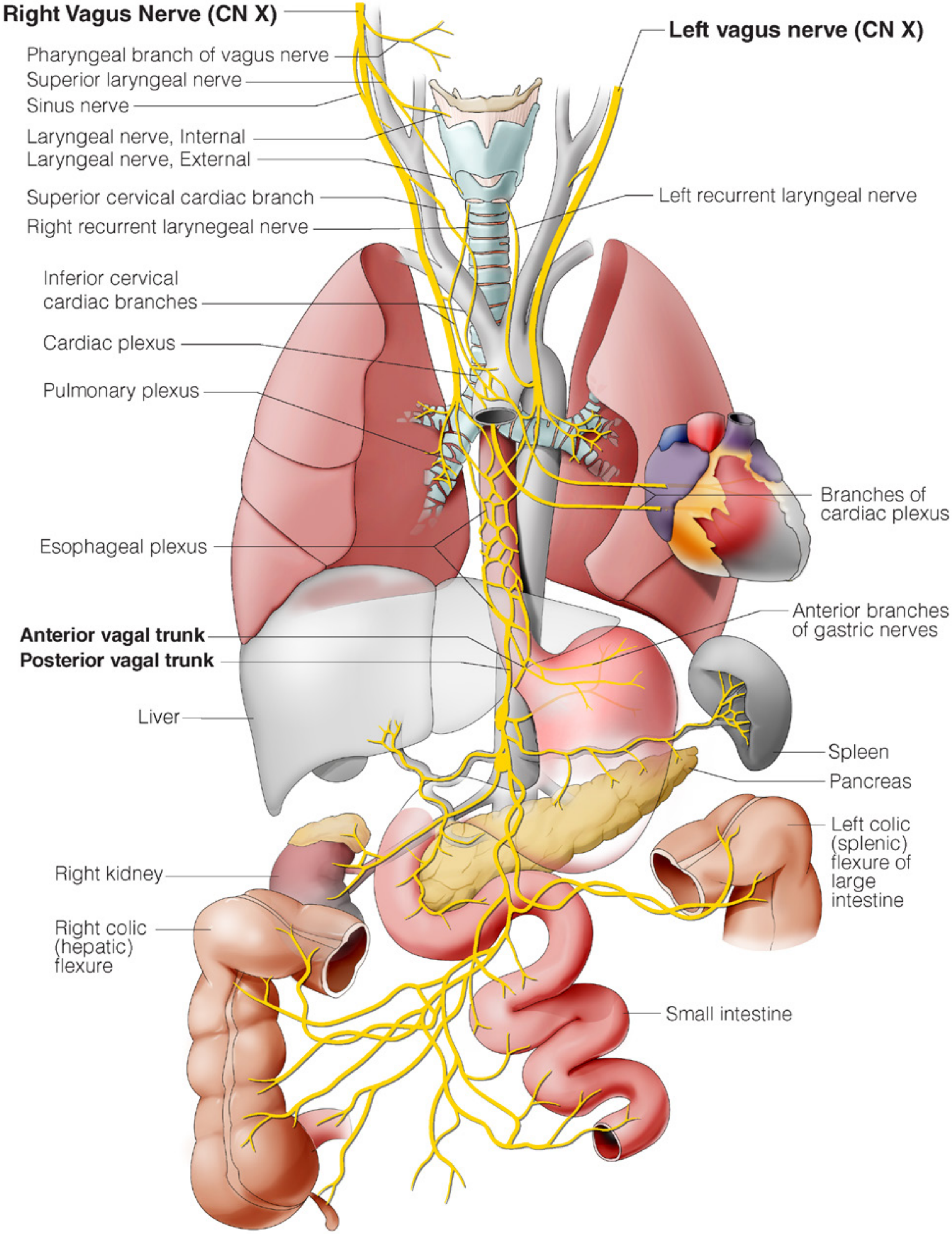
Appendix L



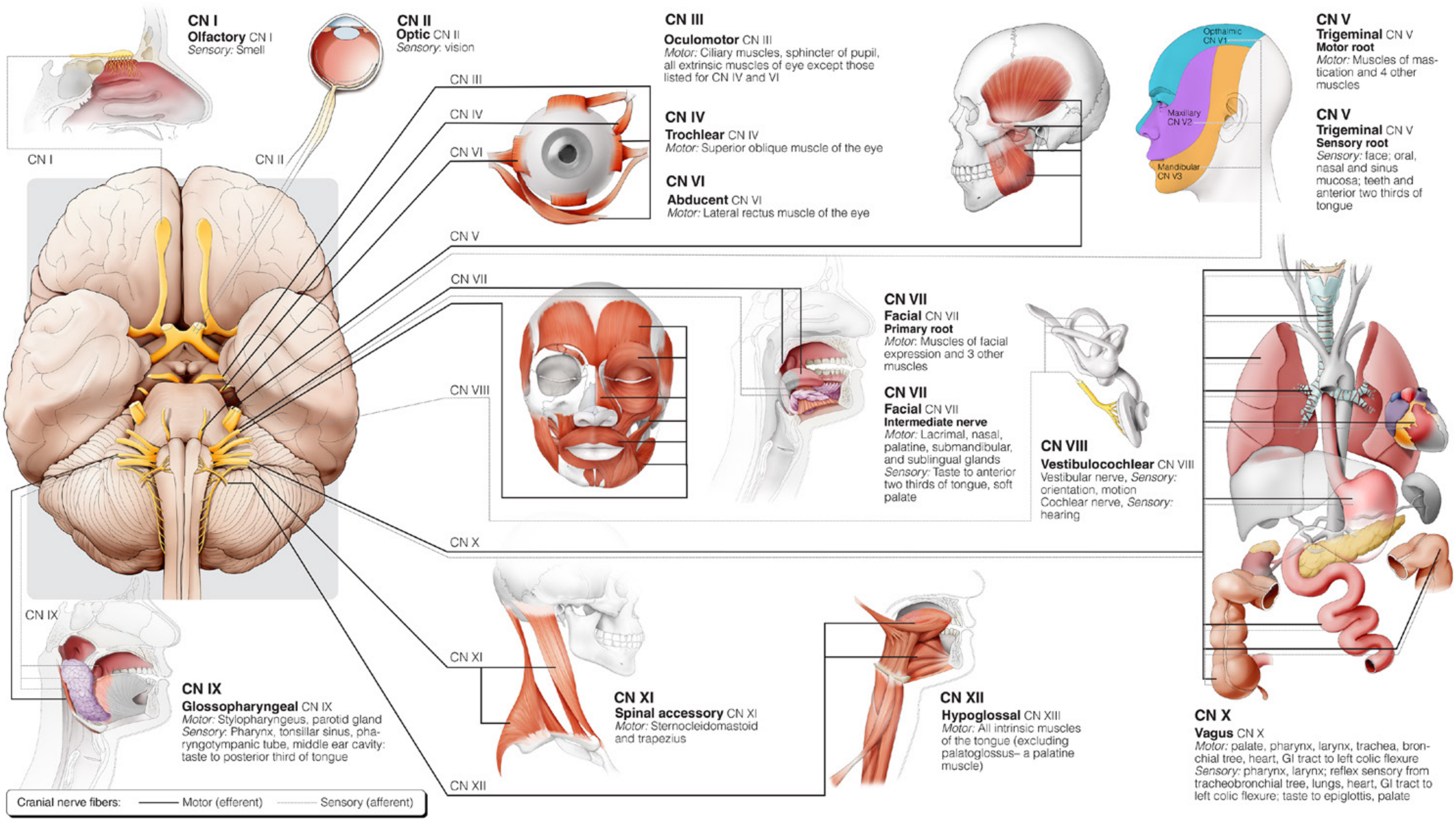
Appendix M


Trigeminal ganglion
Lesser petrosal nerve in
middle cranial fossa
Facial nerve (CN VII)
Tympanic plexus
Mastoid cells
Mastoid process
Auriculotemporal nerve
Parotid branches of
auriculotemporal nerve
(CN V3)
Glossopharyngeal Nerve (CN IX)
Mandibular nerve (CN V3)
Otic ganglion
Parotid duct
Parotid gland

Appendix N


Right Vagus Nerve (CN X)
Pharyngeal branch of vagus nerve
Superior laryngeal nerve
Sinus nerve
Laryngeal nerve, Internal
Laryngeal nerve, External
Superior cervical cardiac branch
Right recurrent larynegeal nerve
Inferior cervical cardiac branches
Cardiac plexus
Pulmonary plexus
Esophageal plexus
Anterior vagal trunk
Posterior vagal trunk
Liver
Right kidney
Right colic (hepatic) flexure
Left vagus nerve (CN X)
Left recurrent laryngeal nerve
Branches of cardiac plexus
Anterior branches of gastric nerves
Spleen
Pancreas
Left colic (splenic) flexure of large intestine
Small intestine

Appendix O



CN I
Olfactory CN I
Sensory: Smell
CN II
Optic CN II
Sensory: vision
CN III
Oculomotor CN III
Motor: Ciliary muscles, sphincter of pupil, all extrinsic muscles of eye except those listed for CN IV and VI
CN IV
Trochlear CN IV
Motor: Superior oblique muscle of the eye
CN VI
Abducent CN VI
Motor: Lateral rectus muscle of the eye
CN V
Trigeminal CN V
Motor root
Motor: Muscles of mastication and 4 other muscles
CN V
Trigeminal CN V
Sensory root
Sensory: face; oral, nasal and sinus mucosa; teeth and anterior two thirds of tongue
Opthalmic CN V1
Maxillary CN V2
Mandibular CN V3
CN I
CN II
CN III
CN IV
CN VI
CN V
CN VII
CN VIII
CN X
CN XI
CN XII
CN IX
CN VII
Facial CN VII
Primary root
Motor: Muscles of facial expression and 3 other muscles
CN VII
Facial CN VII
Intermediate nerve
Motor: Lacrimal, nasal, palatine, submandibular, and sublingual glands
Sensory: Taste to anterior two thirds of tongue, soft palate
CN VIII
Vestibulocochlear CN VIII
Vestibular nerve, Sensory: orientation, motion
Cochlear nerve, Sensory: hearing
CN IX
Glossopharyngeal CN IX
Motor: Stylopharyngeus, parotid gland
Sensory: Pharynx, tonsillar sinus, pharyngotympanic tube, middle ear cavity: taste to posterior third of tongue
CN XI
Spinal accessory CN XI
Motor: Sternocleidomastoid and trapezius
CN XII
Hypoglossal CN XIII
Motor: All intrinsic muscles of the tongue (excluding palatoglossus– a palatine muscle)
CN X
Vagus CN X
Motor: palate, pharynx, larynx, trachea, bronchial tree, heart, GI tract to left colic flexure
Sensory: pharynx, larynx; reflex sensory from tracheobronchial tree, lungs, heart, GI tract to left colic flexure; taste to epiglottis, palate
Cranial nerve fibers:
Motor (efferent)
Sensory (afferent)

Appendix P

Course Test Preview

To receive Continuing Education credit for this course, you must complete the online test. Please go to: *www.dentalcare.com/en-us/professional-education/ce-courses/ce598/test*

1. **What type of nerve causes contraction of skeletal muscle fibers?**
   A. Parasympathetic motor
   B. Somatic motor
   C. Sympathetic motor
   D. All of the above

2. **Which of the divisions of the trigeminal nerve have somatic motor fibers?**
   A. Mandibular
   B. Maxillary
   C. Ophthalmic
   D. All of the above

3. **Neurotransmitters are released into the synaptic cleft under what condition?**
   A. More than half of the dendrites are stimulated by other neurons.
   B. The action potential in the axon is above the threshold potential.
   C. The action potential in the dendrite reaches the neuron cell body.
   D. The neuron has transported excess neurotransmitter to the axon.

4. **Which of the cranial nerves is the longest?**
   A. Facial
   B. Oculomotor
   C. Trigeminal
   D. Vagus

5. **Which of the following nerves pass though the ethmoid bone?**
   A. Oculomotor
   B. Olfactory
   C. Optic
   D. Vagus

6. **Bell's palsy which results in drooping of the affected side of the face is due to damage to the nerve which supplies motor innervation to the muscle of facial expression. Which nerve is damaged if the patient exhibits Bell's palsy symptoms?**
   A. Facial
   B. Maxillary
   C. Spinal accessory
   D. Vagus

7. **Which would be the proper path to the brain from a pain stimulus originating in the maxillary central incisor.**
   A. Anterior superior alveolar >> infraorbital >> maxillary
   B. Anterior superior alveolar >> inferior alveolar >> maxillary
   C. Incisive >> infraorbital >> maxillary
   D. Incisive >> inferior alveolar >> mandibular

8. Damage to what nerve will affect the ability to change the pitch of speech?
A. External laryngeal
B. Glossopharyngeal
C. Hypoglossal
D. Recurrent laryngeal

9. Damage to what nerve will affect the ability properly change the shape of the tongue?
A. Glossopharygeal
B. Hypoglossal
C. Lingual
D. Vagus

10. Skin at the tip of the nose is innervated by branches directly from what nerve?
A. Infraorbital
B. Maxillary
C. Nasopalatine
D. Ophthalmic

11. The pterygopalatine ganglion is associated with which nerve?
A. Glossopharygeal
B. Lingual
C. Maxillary
D. Ophthalmic

12. Which is the branch of the facial nerve that carries pre-ganglionic fibers destined to innervate the submandibular salivary gland?
A. Buccal
B. Chorda tympani
C. Lesser petrosal
D. Marginal mandibular

13. The term visceral efferent is synonymous with which of the following?
A. Autonomic motor
B. Somatic motor
C. Somatic sensory
D. Visceral sensory

14. The special sense of equilibrium is carried on which cranial nerve?
A. II
B. V
C. VII
D. VIII

15. Which nerves innervates a muscle that moves the eyeball within the socket?
A. II
B. V
C. VI
D. VII

References

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3. Hiatt, J.L., & Gartner, L.P. (2010). Textbook of Head & Neck Anatomy (4th Edition). Lippincott Williams, & Wilkins.
4. Scheide, R.C., & Weiss, G. (2012). Woelfel's Dental Anatomy (8th Edition). Lippincott Williams, & Wilkins.
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Additional Resources

- radiopaedia.org - various articles

About the Authors

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Dr. LoPresti has a BA from Amherst College and a DMD from Boston University Henry M. Goldman School of Dental Medicine. He has been an adjunct Professor teaching anatomy for over 20 years and is currently employed by MCPHS University Forsyth School of Dental Hygiene. In addition, he has practiced general dentistry both in private practice and FQHC dental centers. Most interestingly, he is the consulting dentist for the Roger Williams Park Zoo in Providence, RI. For the past 6 years, Dr. LoPresti has been a CODA site visitor for allied health.

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