

BRAINSTEM NUCLEI OF THE CRANIAL NERVES

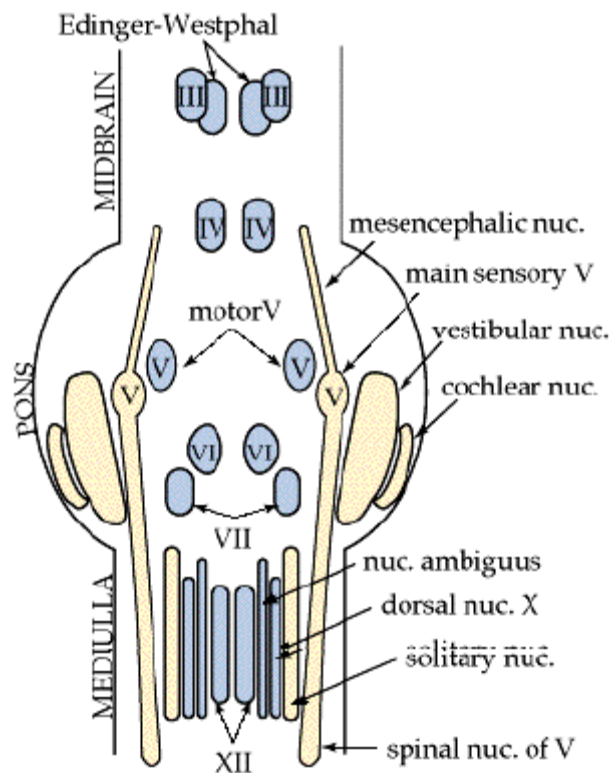
A. The cranial nerves:

The cranial nerves (with the exception of I and II) originate in the brainstem, which includes the **midbrain**, the **pons**, and the **medulla**. The 12 cranial nerves can be divided into sensory, motor, or mixed nerves. Overall, sensory nerve nuclei tend to be located in the lateral brainstem, while motor nuclei tend to be located medially. Nerves with mixed sensory and motor fibers must have more than one nucleus of origin - at least one sensory (**afferent**) and one motor (**efferent**). Sometimes more than one nerve will originate from a single nucleus: for example, the sense of taste is spread across at least two nerves but merges into a single nucleus. Finally, keep in mind that any sensory nucleus is receiving input from the periphery, but the sensory receptor cell bodies are never in the nucleus itself. They will always be located just outside the CNS in a ganglion.

Here is a dorsal view of the brainstem, looking down through it as though it were transparent, so you can see the relative positions of the cranial nerve nuclei. Motor or efferent nuclei are blue, sensory or afferent nuclei are yellow. Note that this is a schematic to give you the big picture - some of these nuclei would technically overlap if you could really see through the brainstem.

Abbreviations:

EW: Edinger-Westphal
nuc.
III: oculomotor nuc.
IV: trochlear nuc.
meV: mesencephalic nuc.
of V
V: trigeminal
moV: motor nuc. of V
senV: main sensory nuc.
of V
spV: spinal nuc. of V
VI: abducens nuc.
VII: facial nuc.
VIIIc: cochlear nuc.
VIIIv: vestibular nuc.



IX: glossopharyngeal
 X: vagus
 amb: nuc. ambiguus
 dnv: dorsal nuc. of the
 vagus
 sol: solitary nucleus
 XII: hypoglossal nuc.

Not shown:
 -cranial nerve I
 -cranial nerve II
 -cranial nerve XI
 -salivatory nuclei

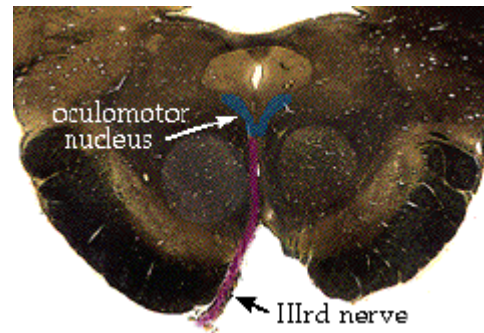
The next sections describe the functions and features of the nerves and nuclei, with highlighted pictures to accompany the text. HOWEVER, these pictures were taken from the student collections of microscope slides at Washington University, and as such are not always ideal images of the nuclei. The purpose of this section is to lay down a conceptual framework of the cranial nerves. For larger, clickable & quizzable anatomy images, please use a specialized neuroanatomy program, such as the Digital Anatomist listed in the "Other Links" section.

B. Nerves that innervate the eye muscles:

Nerves III, IV, and VI are pure motor nerves that innervate the **extrinsic eye muscles**. All are located very close to the midline.

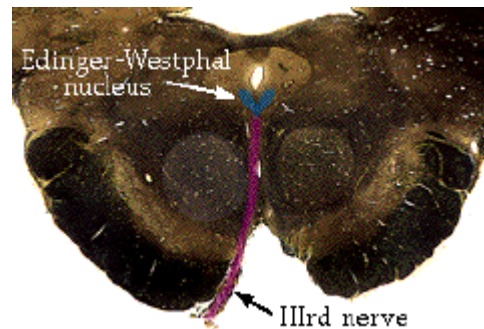
III - the oculomotor nerve -

This nerve innervates the bulk of the eye muscles: **superior and inferior recti, medial rectus, and inferior oblique**. If this nerve is damaged, the action of the remaining two muscles (superior oblique and lateral rectus) pulls the eye "**down and out**". The nucleus is located medially in the midbrain, and the nerve fibers exit ventrally, just inside the peduncles.



Edinger Westphal nucleus -

This nucleus is the source of the **parasympathetics** to the eye, which constrict the pupil and accommodate the lens. It is located just inside the oculomotor nuclei, like nested "V"s. The fibers travel in the IIIrd nerve, so damage to that nerve will also produce a dilated pupil.



Note: the eye drops that you are given at the ophthalmologist's office are an acetylcholine antagonist (blocker) so they inhibit the actions of the parasympathetic system. As a result your eyes are dilated, so the physician can look inside clearly. As a side effect, you cannot accommodate your lens (focus on close objects) which is why you can't read while you are sitting in the waiting room.

IV - the trochlear nerve -

"Trochlea" is from the Latin word for pulley. If you remember from

gross anatomy, the superior oblique muscle loops through a pulley-like sling on its way to the back of the eye. Hence the IVth nerve innervates the **superior oblique**. This nucleus is also located near the midline. It is very small, and hard to find in sections. It looks like a crescent-notch taken out of a dark fiber bundle in the rostral pons. The fiber bundle is the MLF, which carries eye movement signals between brainstem nuclei.

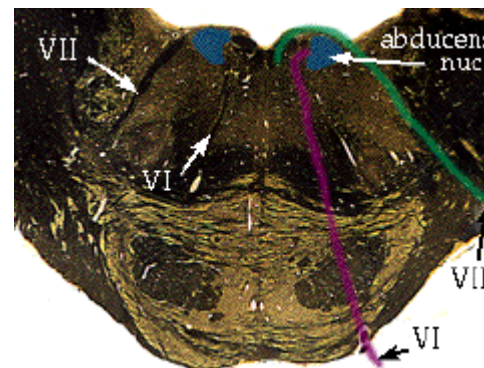
The trochlear nerve is unique for two reasons: 1) it exits the brainstem dorsally, and 2) it crosses on the way out. The fibers cross over each other just like a half-tied shoelace in the roof of the fourth ventricle.

VI - the abducens nerve -

"Abducens" comes from "abduct".

To abduct a part is generally to move it laterally, and the muscle that abducts the eye is the **lateral rectus**. It is the only muscle innervated by VI. The nucleus is again near the midline, but this one is in the pons. The key landmark for finding the abducens is actually the facial nerve. The facial nerve fibers come up to the floor of the fourth ventricle, loop around in a hairpin turn, and dive back into the pons. The bump that they loop over is the abducens nucleus.

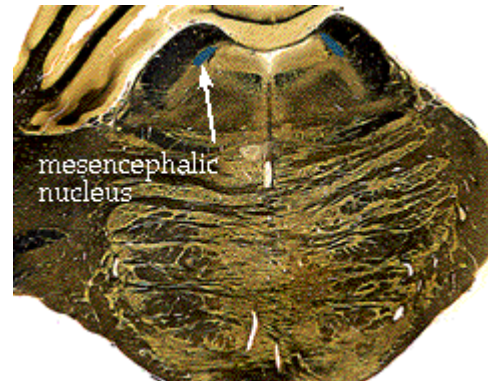
The abducens fibers exit the pons medially and ventrally. Often you can see the facial fibers exiting in the same section; the facial fibers will always be lateral.



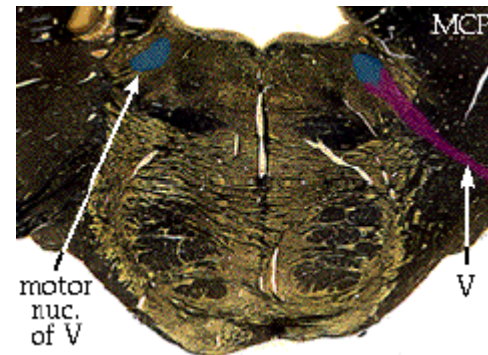
C. The trigeminal nerve:

All **sensation from the face and mouth** is covered by the mixed **trigeminal nerve**. A branch of the trigeminal is injected by your dentist when you have a cavity filled. The trigeminal also carries motor fibers to the **muscles of mastication** (chewing). The most prominent of these is the masseter muscle, the hard knot in your cheek when you clench your teeth. The functions of the different trigeminal nuclei are extensively covered in the "Somatosensory pathways from the face" section, so they will not be repeated here.

The **mesencephalic nucleus** is a thin ribbon of cells that runs along the fourth ventricle and cerebral aqueduct, just outside the periaqueductal grey.

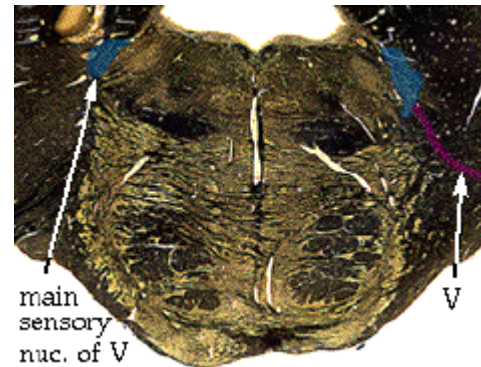


The **motor nucleus** is located in the mid-pons, and is often hard to see. The best landmark is the presence of trigeminal nerve fibers streaking through the adjacent middle cerebellar peduncles (MCP). The fibers appear as a hand gripping a pale egg. The pale egg is the motor nucleus.

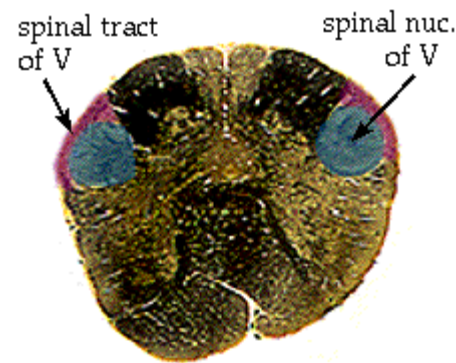


Once you have found the motor nucleus, look immediately lateral to find the **main sensory nucleus**. It is a faint collection of cells

tucked just inside the middle cerebellar peduncle.



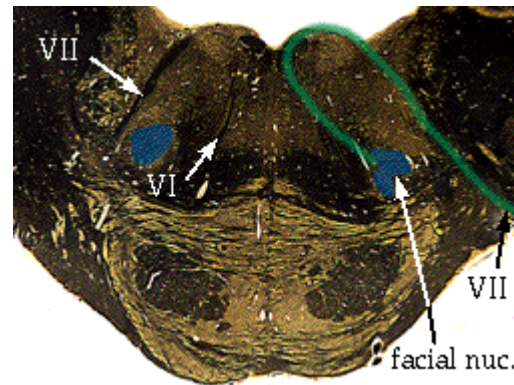
The **spinal nucleus of V** is easiest to see in the caudal medulla, although it extends throughout the entire medulla. Here it bears some resemblance to the dorsal horn of the spinal cord, both functionally and anatomically. Just like the dorsal horn, it receives pain afferents. The adjacent **spinal tract of V** is analogous to Lissauer's tract, as it is carrying those same pain afferents before they synapse.



D. The facial nerve:

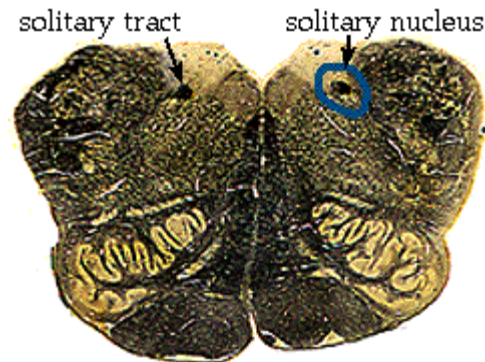
All of the **muscles of facial expression** are innervated by the **facial nerve**. It is considered a mixed cranial nerve, however, since it also carries the sensation of **taste**. The facial nerve also carries some **parasympathetic fibers** to the salivary glands.

Recall that the facial nerve fibers loop over the abducens nucleus in the pons. The facial nucleus itself is hard to see in a myelin stain. The fibers of the facial nerve do not acquire their myelin (and become dark) until they arrive at the hairpin turn, so you cannot even trace them back to the nucleus. The approximate location is shown below, however.



E. Taste:

Taste fibers, from the taste buds, are predominantly (from the front 2/3 of the tongue, anyway) carried by the **facial nerve**. (Keep in mind that touch and pain sensation from the tongue is V, and motor to the tongue is XII.) Taste from the back of the tongue and palate is carried by the **glossopharyngeal nerve**. Regardless of their origin, the taste fibers enter the **solitary tract** of the medulla, and synapse in the surrounding **solitary nucleus**.

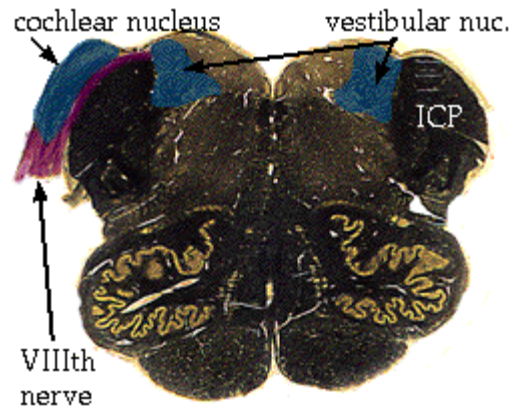


Taste and touch sensation at the back of the throat are carried by the glossopharyngeal nerve, and also synapse in the solitary nucleus. These sensations can trigger the gag reflex.

F. Hearing and balance:

The VIIIth nerve carries **auditory** information from the **cochlea** and **vestibular** information from the **semicircular canals**, **utricle**, and **saccul**e. It is really two nerves running together, the auditory (cochlear) nerve and the vestibular nerve. The VIIIth nerve is very important clinically because a common type of tumor, the acoustic neuroma, can arise from the nerve as it exits the brainstem.

The cochlear nuclei are like small hands draped over the inferior cerebellar peduncles (ICP), and are fairly small in primates. The vestibular nuclei have several subdivisions, however, and extend throughout a large fraction of the pons.



G. The glossopharyngeal nerve:

The IXth nerve has no real nucleus to itself. Instead it shares nuclei with VII and X. The sensory information in IX goes to the **solitary nucleus**, a nucleus it shares with VII and X. All motor information, essentially the innervation of the stylopharyngeus muscle, comes from the **nucleus ambiguus**, also shared with X. Finally, like VII, there are some parasympathetic fibers in IX that innervate the salivary glands.

H. Salivation:

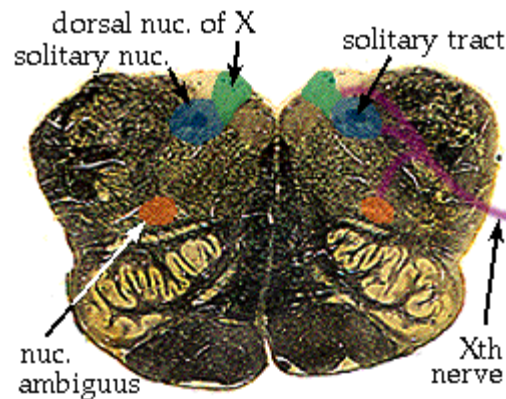
The salivation center is a pair of nuclei located just rostral to the dorsal nucleus of the vagus, the **superior** and **inferior salivatory nuclei**. They supply the parasympathetic innervation of the various salivary glands, and send their axons through the facial and glossopharyngeal nerves.

I. The various and sundry nuclei of the vagus:

When you think vagus, you tend to think parasympathetic - this is a flashback to your gross anatomy days. However, the vagus has dozens of functions. They can be grouped into about three categories, and each category is associated with a medullary nucleus. The first is the **nucleus ambiguus**, which is a motor nucleus. Cells in the nucleus ambiguus are very difficult to see (hence the name), and innervate striated muscle throughout the neck and thorax. This includes some muscles of the palate and pharynx, muscles of the larynx, and the parasympathetic innervation of the heart. Problems with the vagus can show up as hoarseness, or a deviated uvula: X elevates the palate when you open up and say "AH". An asymmetrical uvula would indicate that X is not working on one side.

The second is the **dorsal nucleus of the vagus**, which is the **secretomotor** parasympathetic nucleus. Secretomotor primarily means that it stimulates glands - including mucus glands of the pharynx, lungs, and gut, as well as gastric glands in the stomach. (Incidentally, it is fair-inks, not far-nicks.)

The third is the sensory nucleus of the vagus, the **solitary nucleus**. As we have seen, it receives taste information, sensation from the back of the throat, and also visceral sensation. Visceral sensation includes blood pressure receptors, blood-oxygen receptors, sensation in the larynx and trachea, and stretch receptors in the gut.



J. The spinal accessory nerve:

The XIth nerve actually originates in the **cervical spinal cord**. Were it not for the fact that it sneaks up along side the medulla and exits the skull with IX and X, it might not even be a cranial nerve. It is a motor nerve that innervates two muscles: the **trapezius** and the **sternocleidomastoid**.

K. The hypoglossal nerve:

The XIIth nerve innervates the muscles of the tongue. Like most pure motor nuclei, the XII nucleus is located along the midline, and can be found throughout most of medulla. The tongue muscles actually push the tongue forward, so a problem with the hypoglossal nerve can be detected by asking the patient to stick out his tongue. The tongue will deviate towards the weak side, towards the side of the lesion.



L. Information overload!!

If your head is spinning, it could be your vestibular nerve, but it could also be the sheer volume of information. This is a fairly superficial look at the cranial nerves; the details and subtleties could fill a book (and has, many times - an excellent one is Cranial Nerves, by Wilson-Pauwels, Akesson, and Stewart). For now, you should know a single phrase or two that describes the main function of each cranial nerve - just enough to be able to effectively test each nerve. Evidence of nerve damage could mean a peripheral lesion in the nerve, or a central lesion in the brainstem. Draft a sheet of paper for yourself, including main functions and easy ways to test the nerves. For example:

Nerve	Function	How to test
I	olfaction	with an odorous substance
II	vision	vision chart
III	most eye muscles	"follow the moving finger"
IV	superior oblique	look down at the nose

V	facial sensation	touch the face
	muscles of mastication	clench the teeth
VI	lateral rectus	look to the side
VII	facial expression	smile, raise the eyebrows
	taste	sugar or salt
VIII	hearing	a tuning fork
	balance	look for vertigo
IX	pharynx sensation	gag reflex
X	muscles of larynx and pharynx, parasymp.	check for hoarseness, open wide and say "AH"
XI	trapezius and sternocleidomastoid	test shoulder raise or turning the head
XII	tongue muscles	stick out the tongue

You will also need to know the positions of the nuclei within the brainstem, so that you can localize central lesions. The interactive neuroanatomy programs are great for this!

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