Brainstem Reflexes Herniation Syndromes (CN IX-XII) Lab 8

April 3, 2024 - Dr. Krebs (claudia.krebs@ubc.ca)

Objectives:

1. Describe the relationship of the functional anatomy of CN IX - XII and the location of their respective nuclei to a neurological exam which examines the brainstem.
2. Explain the neuroanatomical pathways associated with brainstem reflexes tested in the conscious and unconscious patient.
3. Describe the relationship between the sympathetic and parasympathetic innervation of the eye to the clinical assessment of eye reflexes.
4. Describe the relationship of changes in upper limb posture of unconscious patient to underlying damage to the brainstem.
5. Describe the consequences of herniation syndromes associated with increases in intracranial pressure.

Resources

Here are the e-tutorials, videos and web resources for this lab - click the green buttons to access them.

Web Syllabus & Links

Modules:

CN IX-X (Module) | CN XI-XII (Module) | Eye Reflexes (Module) | Herniation (Module)

3D Models:

Brainstem 1 (3D) | Brainstem 2 (3D) | Brainstem + Cerebellum (3D) | Brainstem + Cranial Nerves (3D)

Web Links:

Cranial Nerves (Web) | Micrographs (Web)

Videos For Review:

Brainstem Overview (Video) | The Orbit (Video)

Notes:

- For identification of the cranial nerves, use online modules and videos, your atlas and micrographs to locate the nuclei listed.
- On the brain and brainstem specimens, locate cranial nerves IX, X, XI and XII. Note the level at which they are attached to the brainstem.

*This icon located throughout the lab manual indicates **checklist items**!*

** NOTE: Interactive PDFs are best viewed on desktop/laptop computers - functionality is not reliable on mobile devices **

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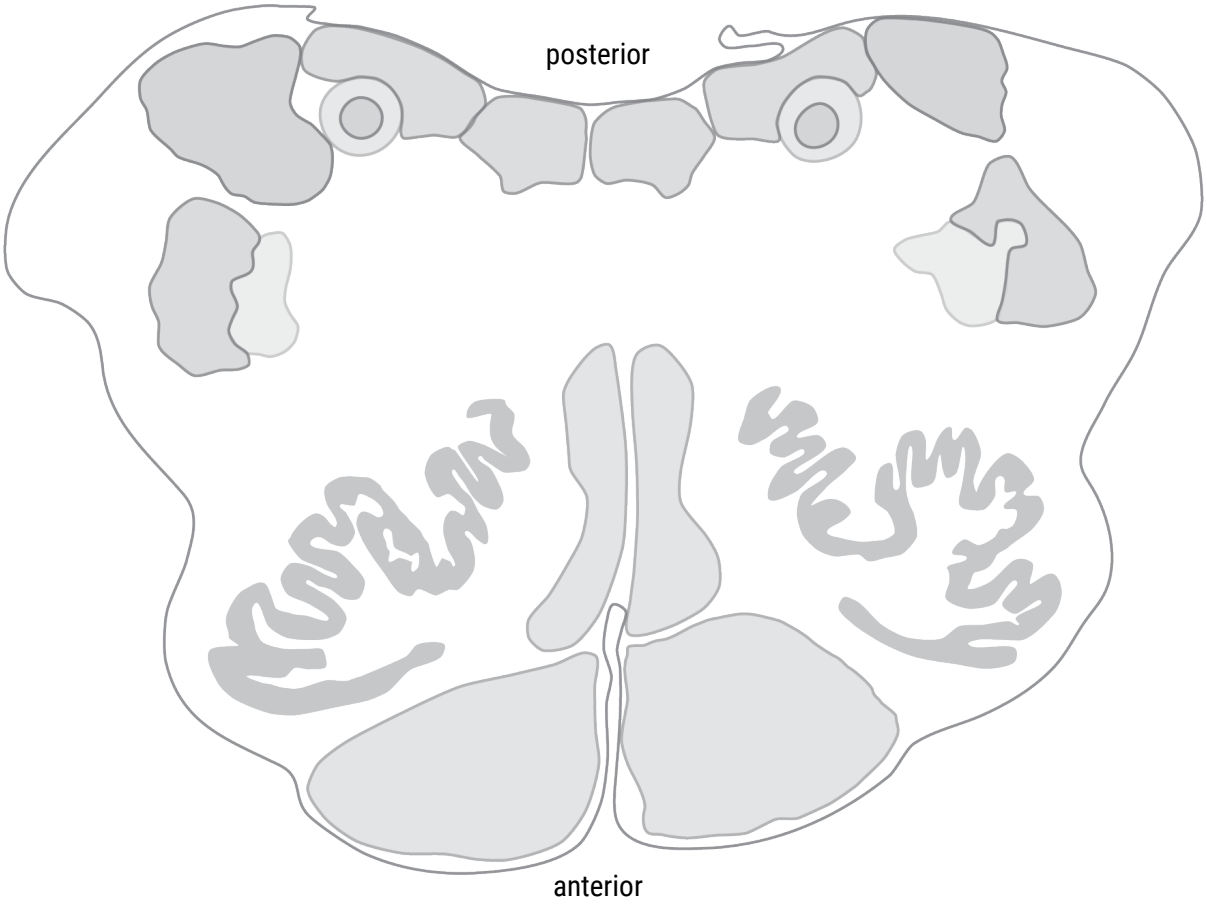
Glossopharyngeal Nerve (CN IX)

Modality	Associated Nucleus	Function
Motor (SVE)	Nucleus ambiguus	Motor to stylopharyngeus muscle
Parasympathetic (GVE)	Inferior salivatory nucleus	Stimulation of parotid gland
Taste (SVA)	Solitary nucleus and tract	Taste from posterior 1/3 of tongue
Somatic Sensory (GSA)	Spinal trigeminal nucleus and tract Chief nucleus of V	General sensation from posterior 1/3 of tongue, pharynx, external ear/tympanic membrane
Visceral Sensory (GVA)	Solitary nucleus and tract	Carotid body, gag sensation from oropharynx

Which foramen does CN IX exit through?

Highlight and label the nuclei associated with CN IX in this diagram and show the types of fibres that comprise this peripheral nerve.



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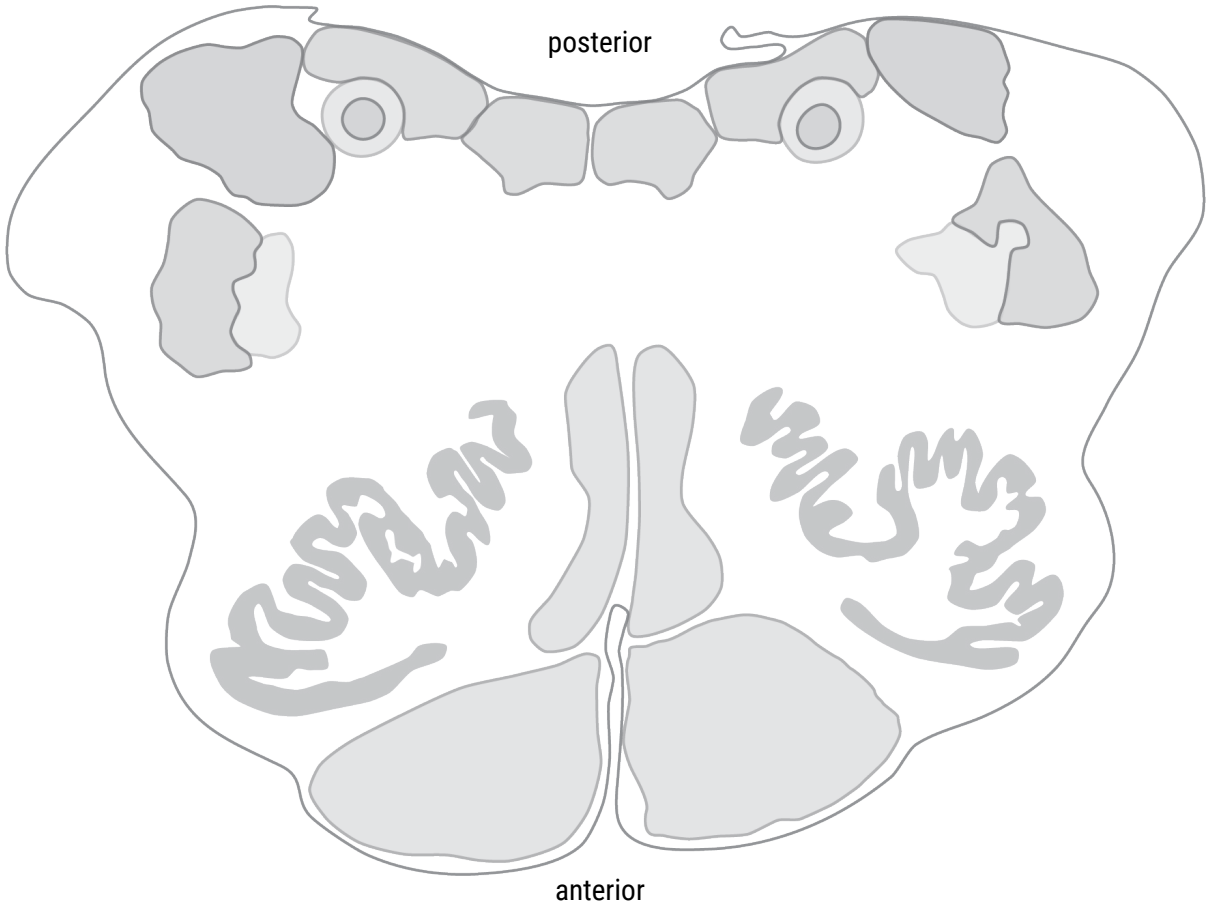
Vagus Nerve (CN X)

Modality	Associated Nucleus	Function
Motor (SVE)	Nucleus ambiguus	Motor to pharyngeal muscles, intrinsic muscles of larynx
Parasympathetic (GVE)	Dorsal motor nucleus of vagus	Thoracic & abdominal viscera, smooth muscle/ glands of pharynx & larynx
Somatic Sensory (GSA)	Spinal trigeminal nucleus and tract Chief nucleus of V	Posterior meninges, skin on back of ear, external acoustic meatus, pharynx, larynx & concha
Visceral Sensory (GVA)	Solitary nucleus and tract	Larynx, thoracic & abdominal viscera, aortic arch stretch receptors, chemoreceptors in aortic bodies
Special Visceral Afferent (SVA)	Solitary nucleus and tract	Taste to epiglottis

Note: the cutaneous sensory distribution of the ear is suppled by multiple cranial nerves and branches from cervical region

Which foramen does CN X exit through?

Highlight and label the nuclei associated with CN X in this diagram and show the types of fibres that comprise this peripheral nerve.



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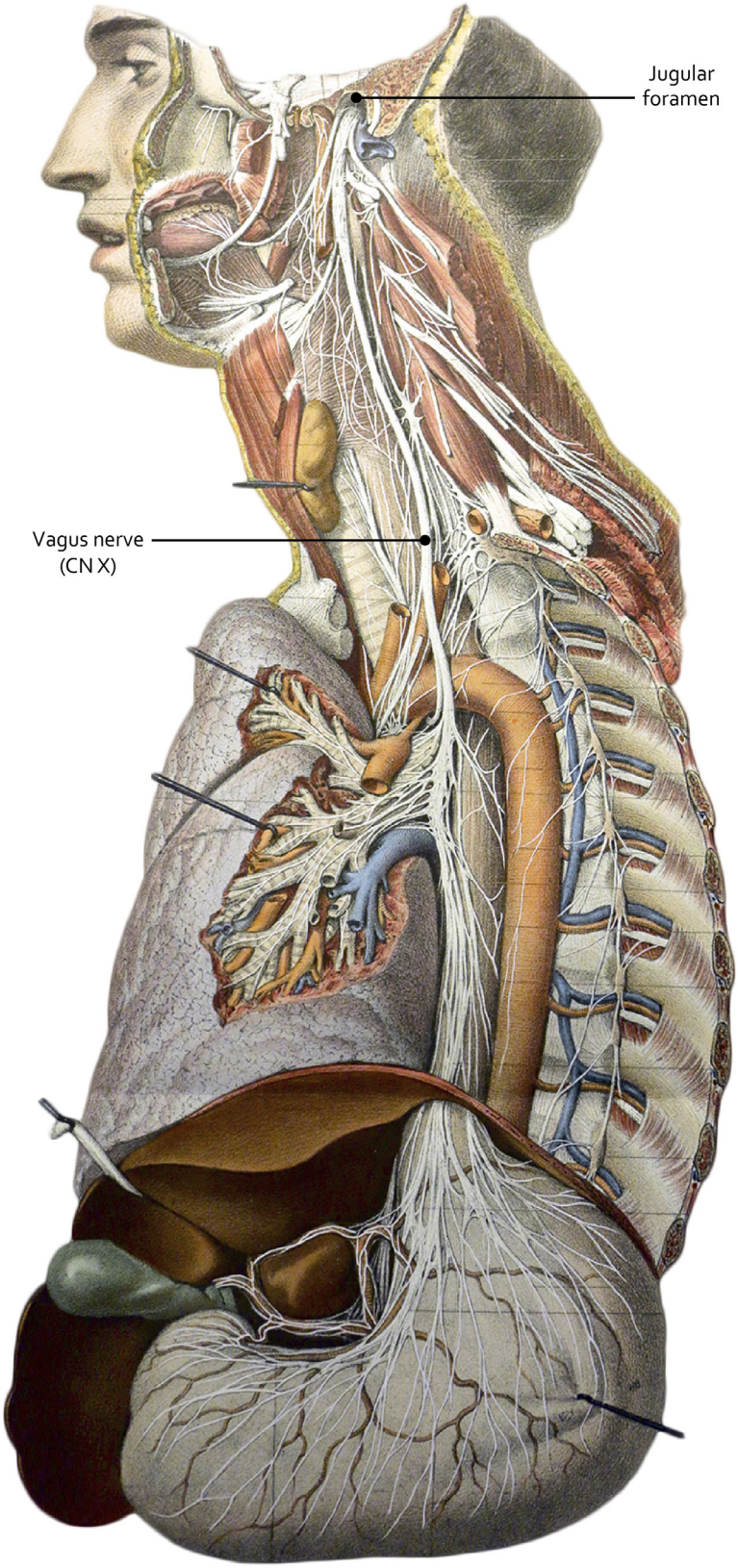
Vagus Nerve (CN X)



Hirschfeld & Leveille, Nevrologie ou description et iconographie du systeme nerveux et des organes des sens de l'homme, JB Bailliere, Paris, 1853.

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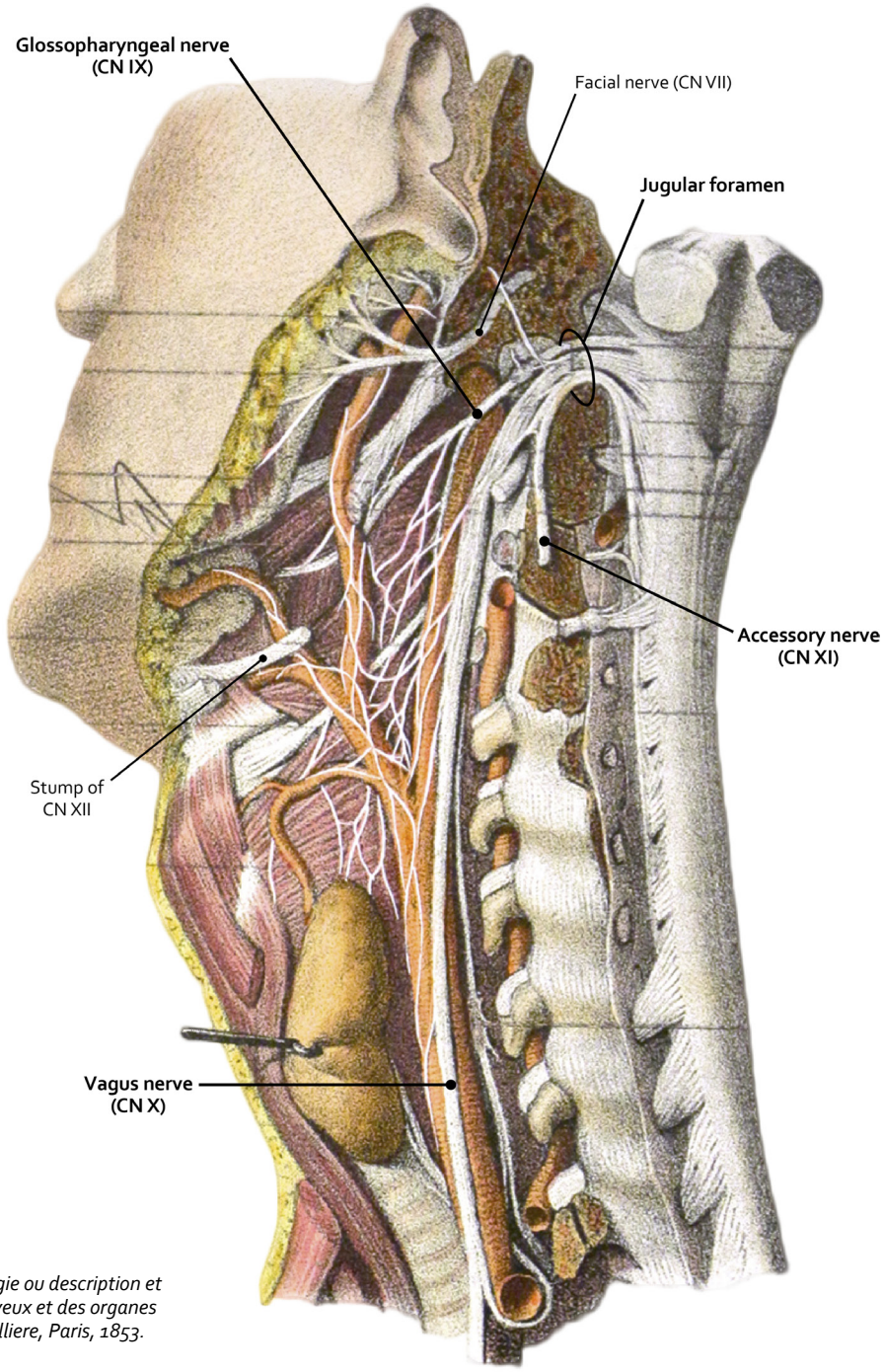
Accessory Nerve (CN XI)

- Its cell bodies are located in the cervical spinal cord.
- CN XI is a motor nerve that innervates sternocleidomastoid and trapezius muscles.

Which foramen does CN XI exit through?



Hirschfeld & Leveille, Nevrologie ou description et iconographie du systeme nerveux et des organes des sens de l'homme, JB Bailliere, Paris, 1853.

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Accessory Nerve (CN XI)

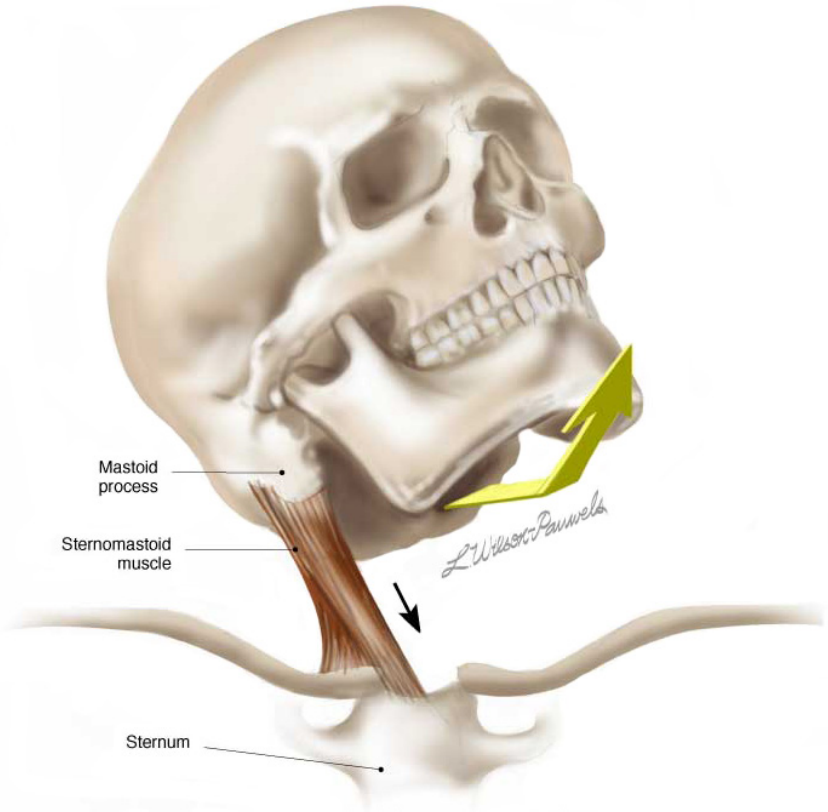
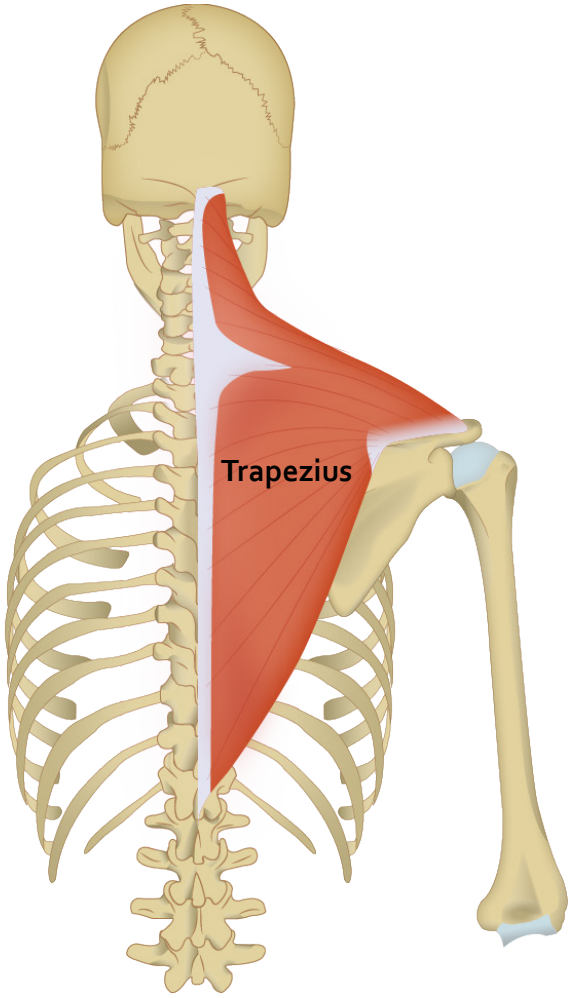


Figure XI–4 Action of the right sternomastoid muscle.
From "Cranial Nerves in Health and Disease" 2002,
© Wilson-Pauwels, Akesson, Stewart, Spacey, B C Decker Inc.



- Sternocleidomastoid elevates the head and rotates to the contralateral side
- Trapezius elevates the upper limb (shoulder)

SCM and Trapezius need to work together so that we can look at what we are holding in our hands.

CN XI is the selfie nerve!

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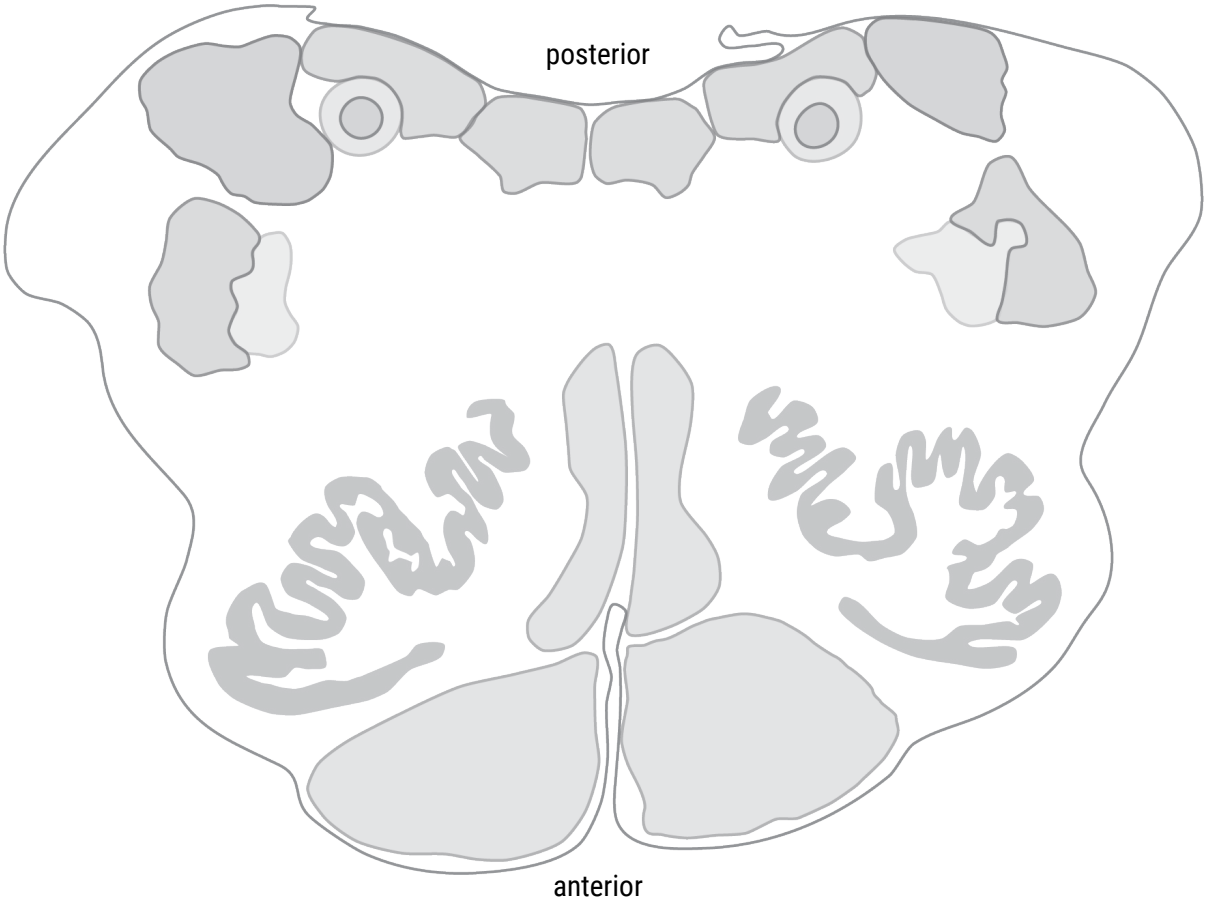
Hypoglossal Nerve (CN XII)

- Its cell bodies are located in the medulla.
- CN XII is a motor nerve that innervates the intrinsic muscles of the tongue.
- UMN projections to the LMNs in the brainstem nucleus are bilateral except for the LMNs to genioglossus.

Which nuclei are associated with CN XII?

Which foramen does CN XII exit through?

Highlight and label the nuclei associated with CN XII in this diagram and show the types of fibres that comprise this peripheral nerve.



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Hypoglossal Nerve (CN XII)

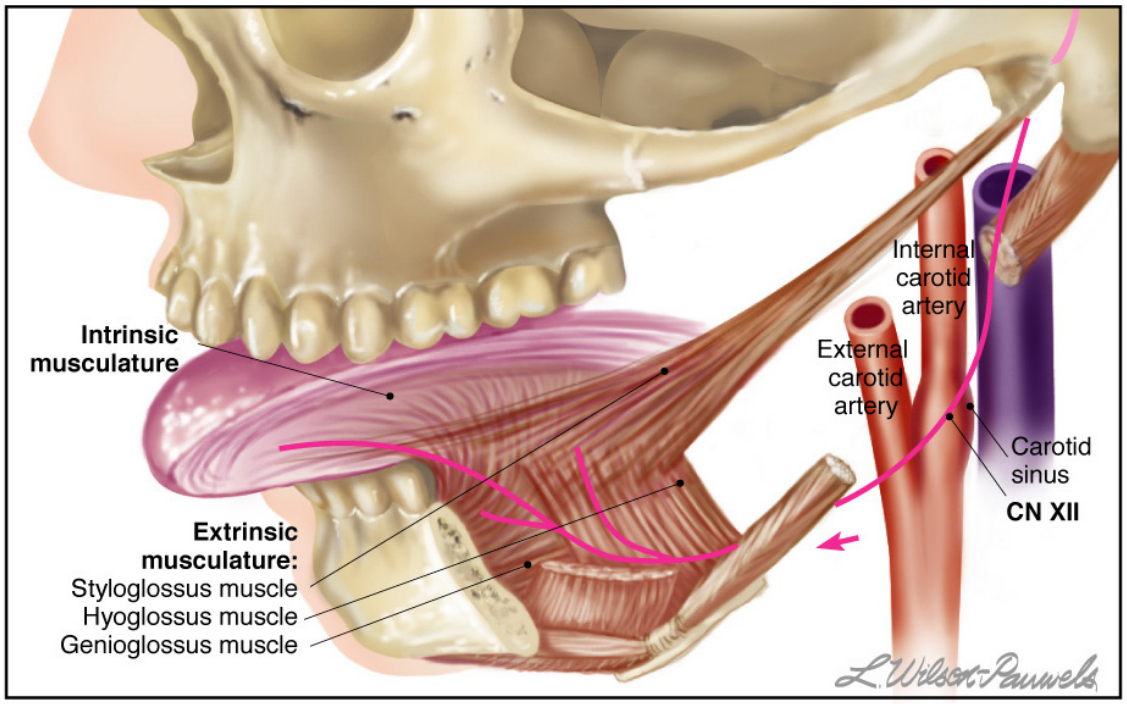

Figure XII–4 Demonstrating the hypoglossal nerve (cranial nerve XII) crossing the bifurcation of the internal and external carotid artery.

From "Cranial Nerves in Health and Disease" 2002, © Wilson-Pauwels, Akesson, Stewart, Spacey, B C Decker Inc.

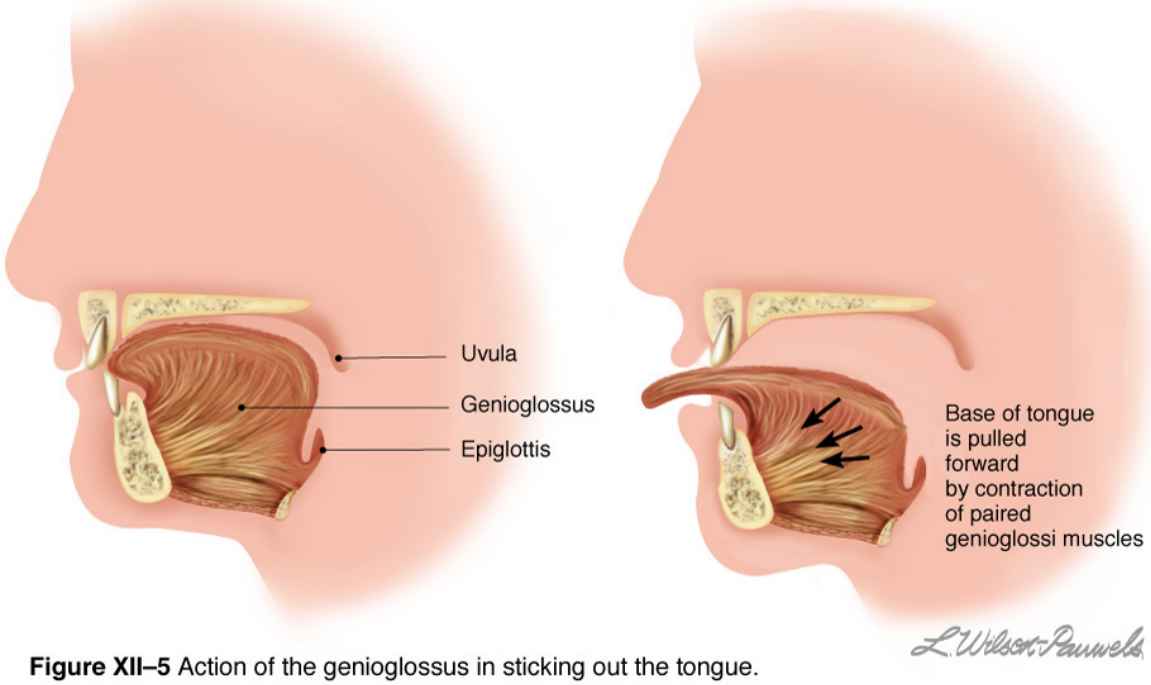

Figure XII–5 Action of the genioglossus in sticking out the tongue.

From "Cranial Nerves in Health and Disease" 2002, © Wilson-Pauwels, Akesson, Stewart, Spacey, B C Decker Inc.

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Case #1

Ms. Singh (she/her) presents with the following symptoms:

- Sudden onset of weakness and numbness on the right side
- She has trouble speaking and during clinical examination you notice that the tongue protrudes to the left side

List the symptoms and the possible etiologies for each symptom:

What could be the underlying pathology?

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Case #2

Mx. Perez (they/them) presents with an acute onset of the following symptoms:

- A progressively hoarse voice
- Chronic coughing
- Trouble swallowing
- Loss of taste in the posterior 1/3 of the tongue on the left side
- Weakness of the trapezius on the left

List the symptoms and the possible etiologies for each symptom:

Where would you look for the lesion?

What could be the underlying pathology?

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Taste

Which cranial nerves carry taste?

Which cranial nerve carries taste from the anterior 2/3 of the tongue?

Which cranial nerve carries taste from the posterior 1/3 of the tongue?

Which brainstem nucleus do all taste fibres project to?

Identify on micrographs:

Micrographs (Web)

- ◯ nucleus and tractus solitarius
- ◯ nucleus ambiguus - general location, it is difficult (ambiguous) to locate precisely
- ◯ dorsal motor nucleus of vagus
- ◯ spinal trigeminal tract and nucleus
- ◯ hypoglossal nucleus

◯ trace structures involved in taste on both *gross specimens* and *micrographs*

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Pupillary Light Reflex (pupillary constriction)

Eye Reflexes (Module)

Direct and Consensual. Can be tested in an unconscious patient.

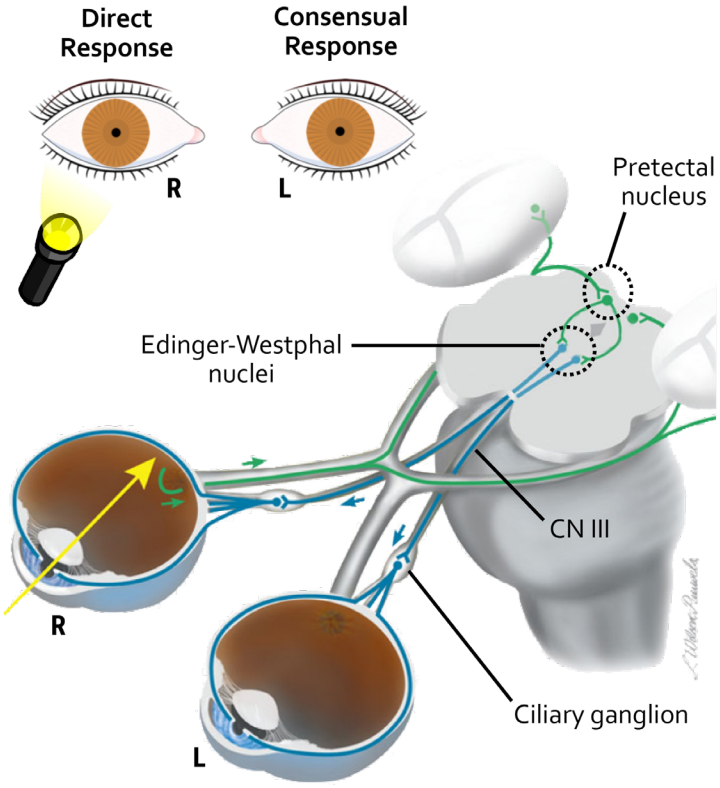
Pupillary constriction occurs via the constrictor pupillae muscles. It is innervated by parasympathetic (GVE) fibers originating in the Edinger-Westphal nuclei that travel with CN III. The pupil constricts when light levels are high.

Afferent component

- Retina (receptors and neuronal elements), optic nerve, optic chiasm, optic tract
- Collateral off optic tract brings information to pretectal region via superior brachium
- Information from pretectal region travels to parasympathetic oculomotor nucleus (Edinger-Westphal) bilaterally

Efferent component

- CN III nerve (parasympathetic fibers), ciliary ganglion, short ciliary nerves, constrictor muscle of iris



From Cranial Nerves 3rd Ed. ©2010 Wilson-Pauwels, Stewart, Akesson, Spacey, PMPH-USA

Corneal (Blink) Reflex

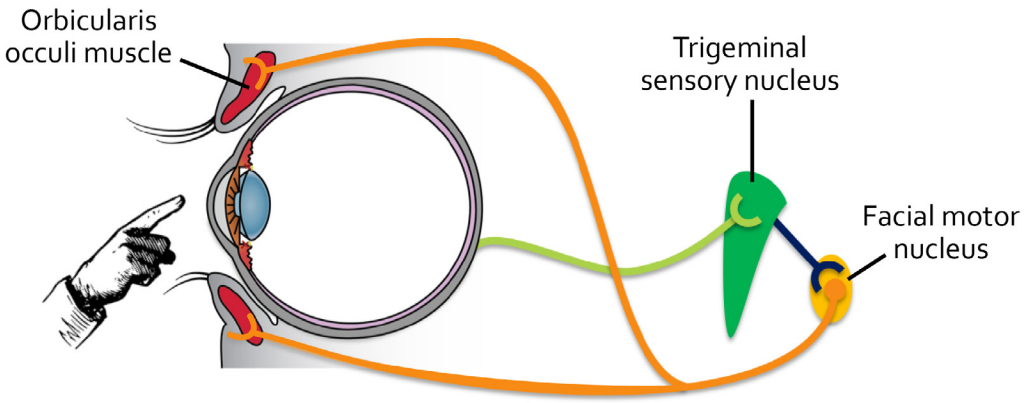
Tested in conscious and unconscious patients.

Afferent component

- Cranial nerve V (V1); chief sensory nucleus, spinal tract of V and spinal nucleus of V

Efferent component

- Facial motor nuclei, cranial nerve VII, orbicularis oculi



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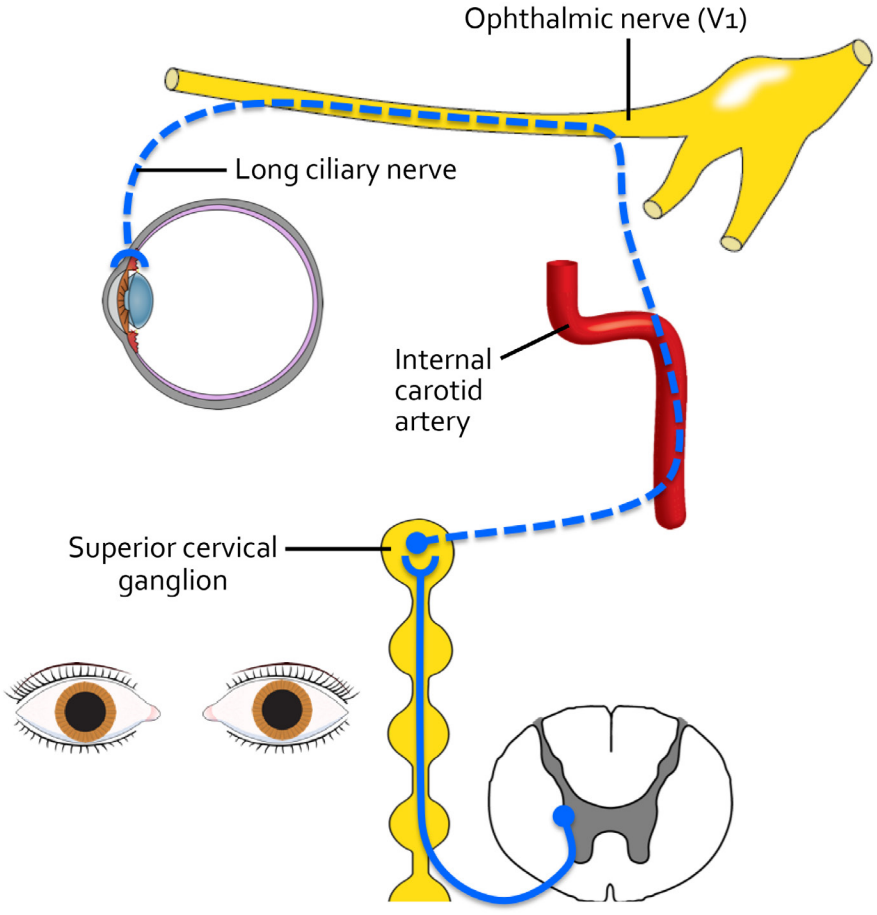
Pupillodilator Reflex

Tested clinically by pinching of the skin near the eye. This increases sympathetic tone.
Pinching the skin on face, neck or upper trunk causes rapid BILATERAL pupillary dilation.

Pupillary dilation is through the pupillodilator muscle. It is innervated by sympathetic fibers, which originate from the superior cervical ganglion. Pupils dilate in low light situations due to loss of constrictor tone or due to high sympathetic tone.

Regulatory input to the sympathetic neurons in the lateral horn of the spinal cord (T1-L1) comes from the hypothalamus. Fibers from the hypothalamus descend to the spinal cord in the lateral brainstem and spinal cord. Sympathetic innervation of the head comes from T1/T2. Fibers exit from the lateral horn and ascend in the sympathetic trunk to the superior cervical ganglion at the base of the skull. Here the fibers synapse and the postganglionic fibers follow the internal carotid artery into the skull and then the opthalmic artery and/or the nasociliary nerve into the orbit. Sympathetic fibers then reach the pupillodilator muscle mostly through the long ciliary nerves.

Clinically Important: Review the gross anatomical relationships of the sympathetic trunk in the thorax and neck.



Note:
Sympathetic activation is BILATERAL; for simplicity, the diagram shows only one side of this reflex.

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Accomodation

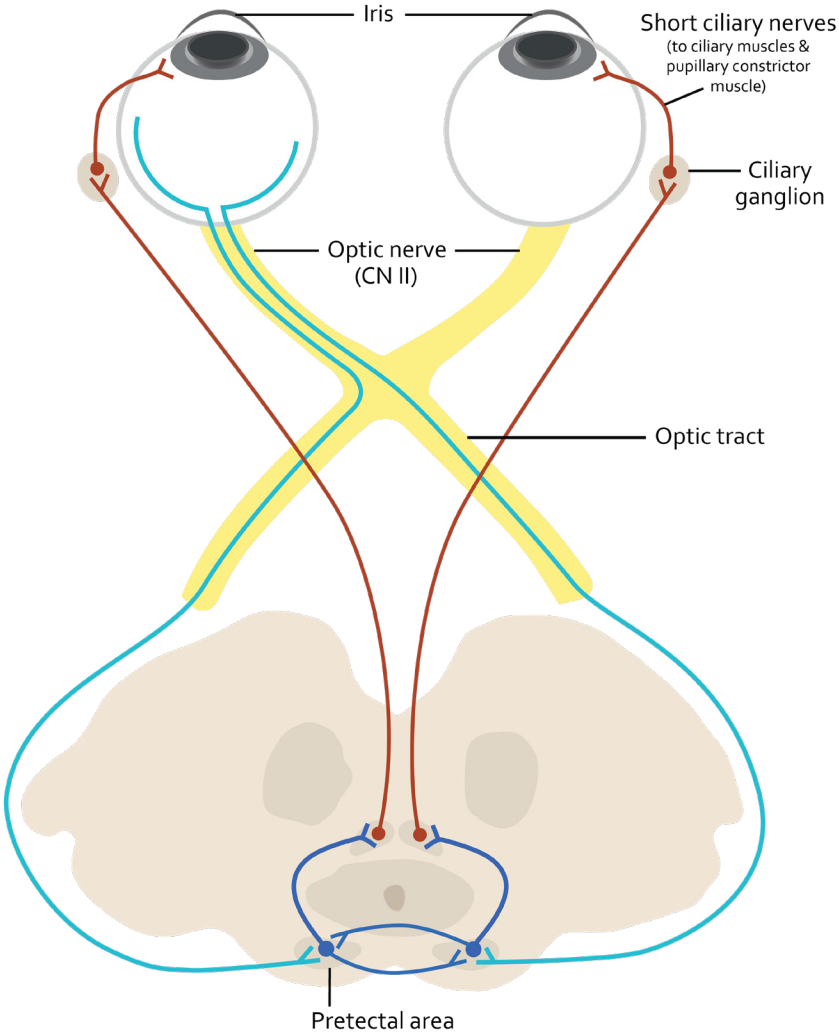
Convergence (Near) reflex. Tested only in a conscious patient.

Near Triad

- Eyes converge
- Rounding of the lens
- Pupillary constriction

How would you achieve each component of the near triad?

How is this coordinated?



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Gag Reflex

Tested in conscious and unconscious patients.

Afferent component

- cranial nerve IX, tractus and nucleus solitarius

Efferent component

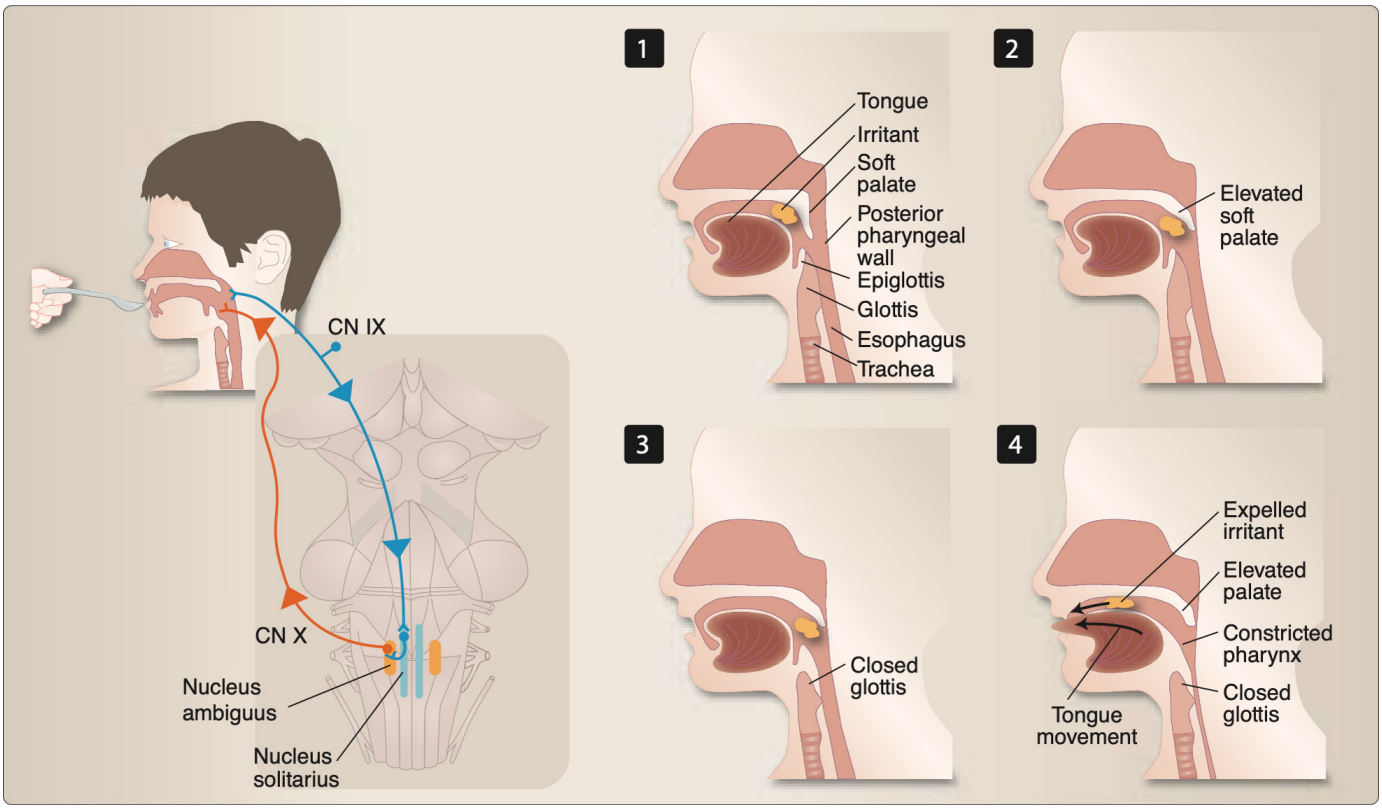
- nucleus ambiguus, cranial nerve X, striated muscles of pharynx

Note:

- When you feel something at the back of your mouth/pharynx it is via GSA fibers to the spinal nucleus of V and chief sensory nucleus of V.
- When you gag on something it is mediated via GVA fibers to the nucleus solitarius.

Why is the gag reflex important?

What does a deficit in the gag reflex tell you?



Modified from Lippincott's Illustrated Reviews: Neuroscience by C. Krebs, J. Weinberg, E.J. Akesson, and E. Dilli.

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For the reflexes described, use the micrographs and gross specimens to:

Micrographs (Web)

- locate the relevant cranial nerves and their nuclei, and
- follow the pathways

Review the vestibulo-ocular reflex from last week.

Eye Movement (Module)

- Slides 5.7 & 5.8 -

It can be tested in the unconscious patient.

This is the basis for the **oculocephalic reflex** or "**doll's eye movement**" and **caloric testing** (see lecture notes from Dr. Chung).

Case #3

While shaving one morning Nick Hendricks (he/him) noticed that his right eyelid was droopy and that his pupil was smaller on the right than the left.

Note: a drooping eyelid is different from a closed eyelid.

Upon examination you find an absent pupillodilator reflex on the right side as well as a drooping upper eyelid. You perform a full head and neck exam. The only notable find is an enlarged cluster of lymph nodes on the right side of the neck.

List the symptoms and the possible etiologies for each symptom:

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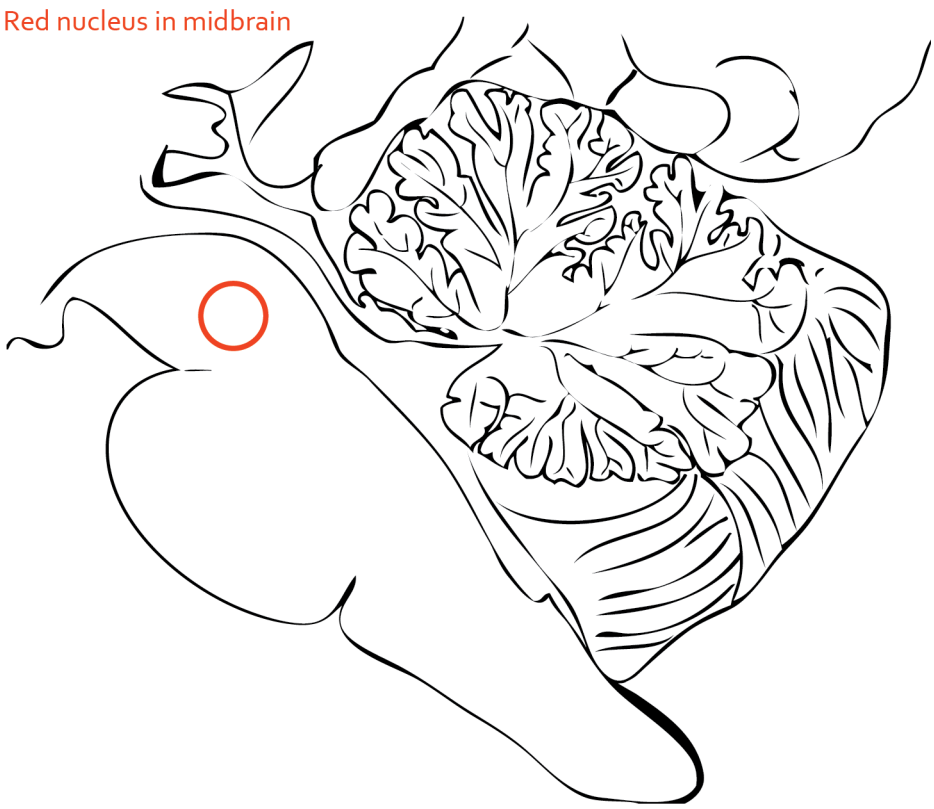
Motor Exam - posturing as an indicator for the level of the lesion in the brainstem

Extensor Posturing

- Lesion in midbrain or rostral pons, involving the red nuclei
- All descending cortical systems (corticospinal, corticorubral, corticoreticular) interrupted
- Rubrospinal tract also lesioned but excitatory and inhibitory components of reticular formation intact
- Hypothesis that extensor rigidity results from excessive excitatory input to gamma motor neurons via reticulospinal fibers

Flexor Posturing

- Lesion rostral to (above) red nuclei
- All descending cortical systems (corticospinal, corticorubral, corticoreticular) interrupted, but both rubrospinal tract and reticulospinal tracts still intact
- Rubrospinal system can be activated by excitatory projections to red nucleus from cerebellar nuclei
- Rubrospinal tract influences primarily flexor muscles or upper extremities - thus, lower extremities exhibit hypertonus for same reasons as in decerebration, but upper extremities show an increase in flexor tone



Draw in the main descending motor tracts in the diagram above, and indicate the level of the lesion resulting in extensor versus flexor posturing.

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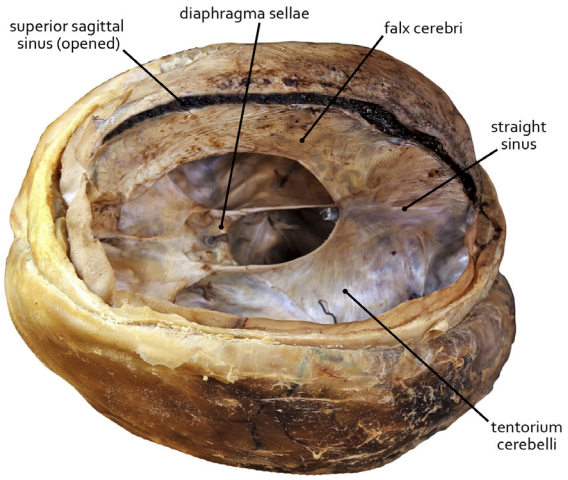
Herniation

Whole Brain (3D) | Half Brain (3D) | Limbic System (3D)

Identify:

- ◯ dural reflections
- ◯ brain-dura relationships
- ◯ uncus: relationship to midbrain, CN III and PCA
- ◯ anterior cerebral artery and its realtionship to falx cerebri
- ◯ cingulate gyrus and falx cerebri
- ◯ cerebellar tonsils and their relationship to foramen magnum and medulla

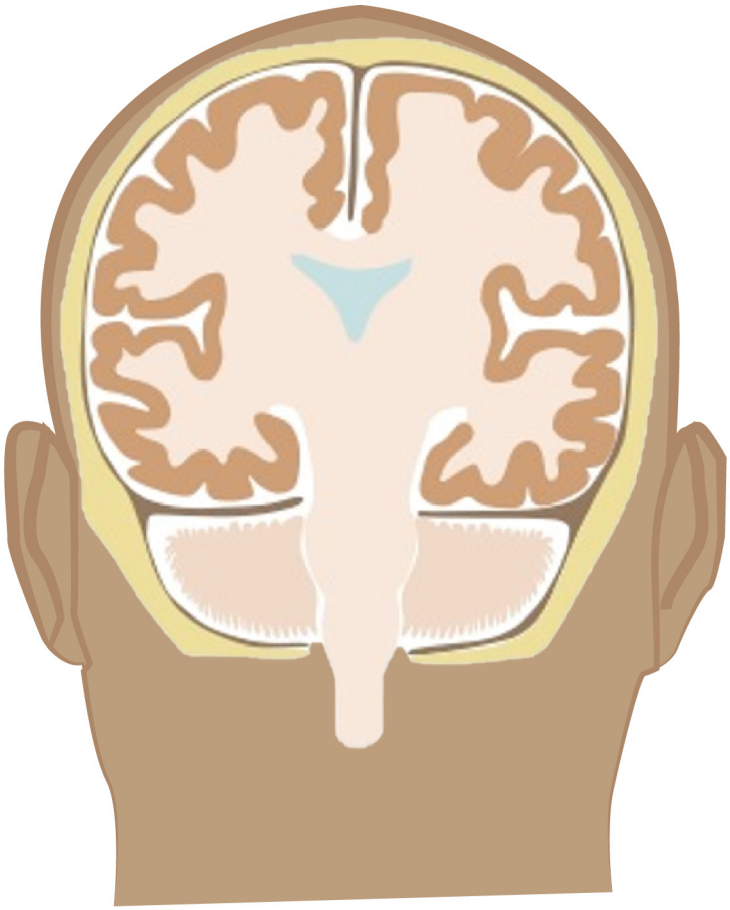


The three main herniation syndromes are:

1. Subfalcine
2. Transtentorial
3. Tonsillar

Herniation (Module)

Describe the main symptoms associated with each type of herniation based on the underlying anatomy:
(click the buttons to show each herniation type on the image)



Subfalcine

Tonsillar

Transtentorial

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Case #4

Mr. Nguyen (he/him) presented in the emergency room after falling and hitting his head. At first he seemed fine, but over the next hour he became increasingly unresponsive.

Upon examination in the emergency room, the following problems were noted:

- dilated right pupil that was unresponsive to light
- weakness of the left arm and leg
- increased tone and increased deep tendon reflexes on the left
- depressed level of consciousness

You suspect an increase in intracranial pressure and herniation.

Based on the clinical findings, which neuroanatomical structures are affected?

Given the anatomical relationships of these structures, what other symptoms might also be observed in this situation and why?

RESOURCES

Websites:

Neuroanatomy | Entrada

Recommended Textbooks:

Lippincott Illustrated Reviews: Neuroscience
By: Claudia Krebs, Joanne Weinberg, Elizabeth J. Akesson, Esma Dilli
Lippincott Williams & Wilkins
ISBN 978-1-4963-6789-1

Neuroanatomy Through Clinical Cases
By: Hal Blumenfeld
Sinauer
ISBN 978-0-8789-3613-7

Neuroanatomy in Clinical Context: An Atlas of Structures, Sections, Systems, and Syndromes
By: Duane E. Haines
Wolters kluwer Health
ISBN 978-1-4511-8625-3

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