Overview of Brainstem Eye Movements (CN III, IV, VI) Lab 4

January 26, 2026 - Dr. Stiver (mikaela.stiver@ubc.ca)

Objectives:

1. Describe the major surface markings, including cranial nerve roots, of the brainstem and how they relate to the tracts and structures within the brainstem.
2. Compare the corticonuclear tract with the corticospinal tract.
3. Describe the functional anatomy of the ascending and descending medial longitudinal fasciculus (MLF).
4. Identify the cranial nerves involved in eye movements on the surface of the brainstem and identify their nuclei within the brainstem on cross sections.
5. Explain the underlying pathways and connections of horizontal eye movements for saccadic and pursuit movements as well as the vestibulo-ocular reflex.
6. Apply the neuroanatomy of the control of eye movements to typical clinical presentations.

Resources

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

Web Syllabus & Links

Videos:

Brainstem Overview (Video)

Modules:

Brainstem Overview (Module) | Brainstem Nuclei (Module) | Control of Eye Movements (Module)

3D Models:

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

Brainstem + Circle of Willis (3D) | Brainstem + Trochlear Nerve (3D)

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

Practice the tracts!

*Check out our neuroanatomy game **Cerebro**!*

APK Download (Android)
App Store (iOS)

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

Identify:

Micrographs (Web)

Whole Brain

- ◯ Cranial nerves
- ◯ Midbrain
  - Cerebral peduncles
  - Interpeduncular fossa
  - Mammillary bodies
  - Tectum (including superior and inferior colliculi)
- ◯ Pons
  - Basal pons
- ◯ Medulla
  - Pyramids
  - Decussation of pyramids
  - Olives
  - Fasciculus gracilis and cuneatus

Half Brain

- ◯ Midbrain
  - Cerebral peduncles
  - Tectum with colliculi
  - Cerebral aqueduct
- ◯ Pons
  - Basal pons
  - 4th ventricle
- ◯ Medulla
  - Pyramids
  - Olives

Micrographs

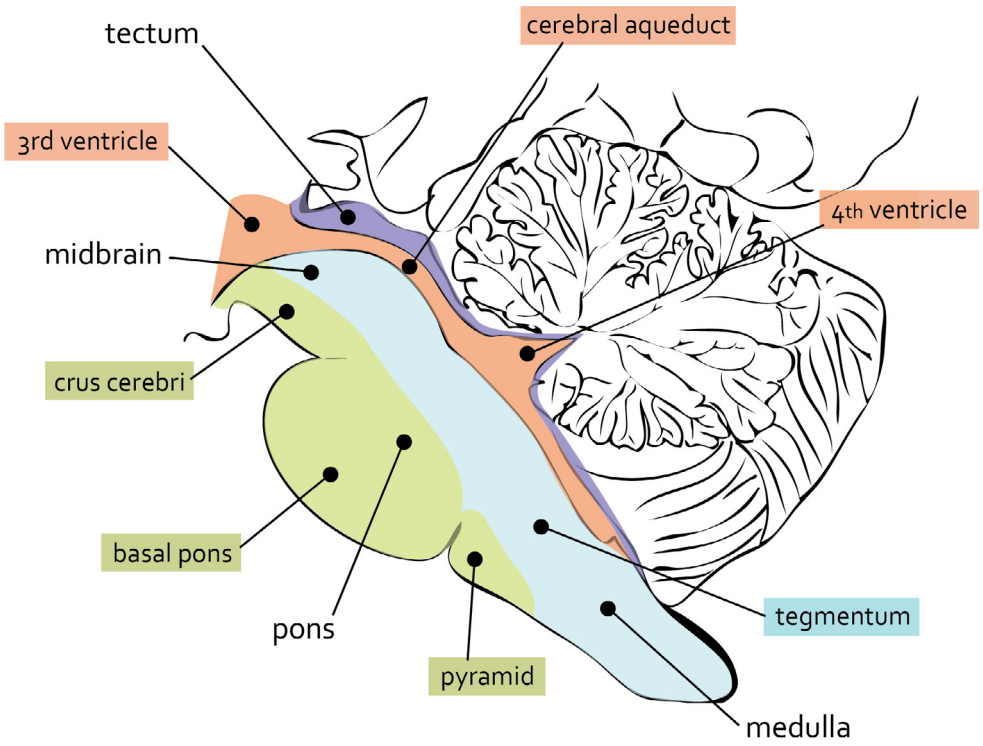
- ◯ Cranial nerve nuclei

Notes

Relate the brainstem cross sections to the gross anatomy, noting where each cranial nerve enters or exits the brainstem.

The diagrams on pages 5–6 can be helpful in this.

There are key structures (e.g., olives, 4th ventricle, cerebral peduncles) that are critical landmarks for identifying the level of different brainstem cross-sections.



Sagittal Section of Brainstem

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The 12 Cranial Nerves & Their Brainstem Nuclei

CN I - Olfactory

CN II - Optic

CN III - Oculomotor

CN IV - Trochlear

CN V - Trigeminal

CN VI - Abducens

CN VII - Facial

CN VIII - Vestibulocochlear

CN IX - Glossopharyngeal

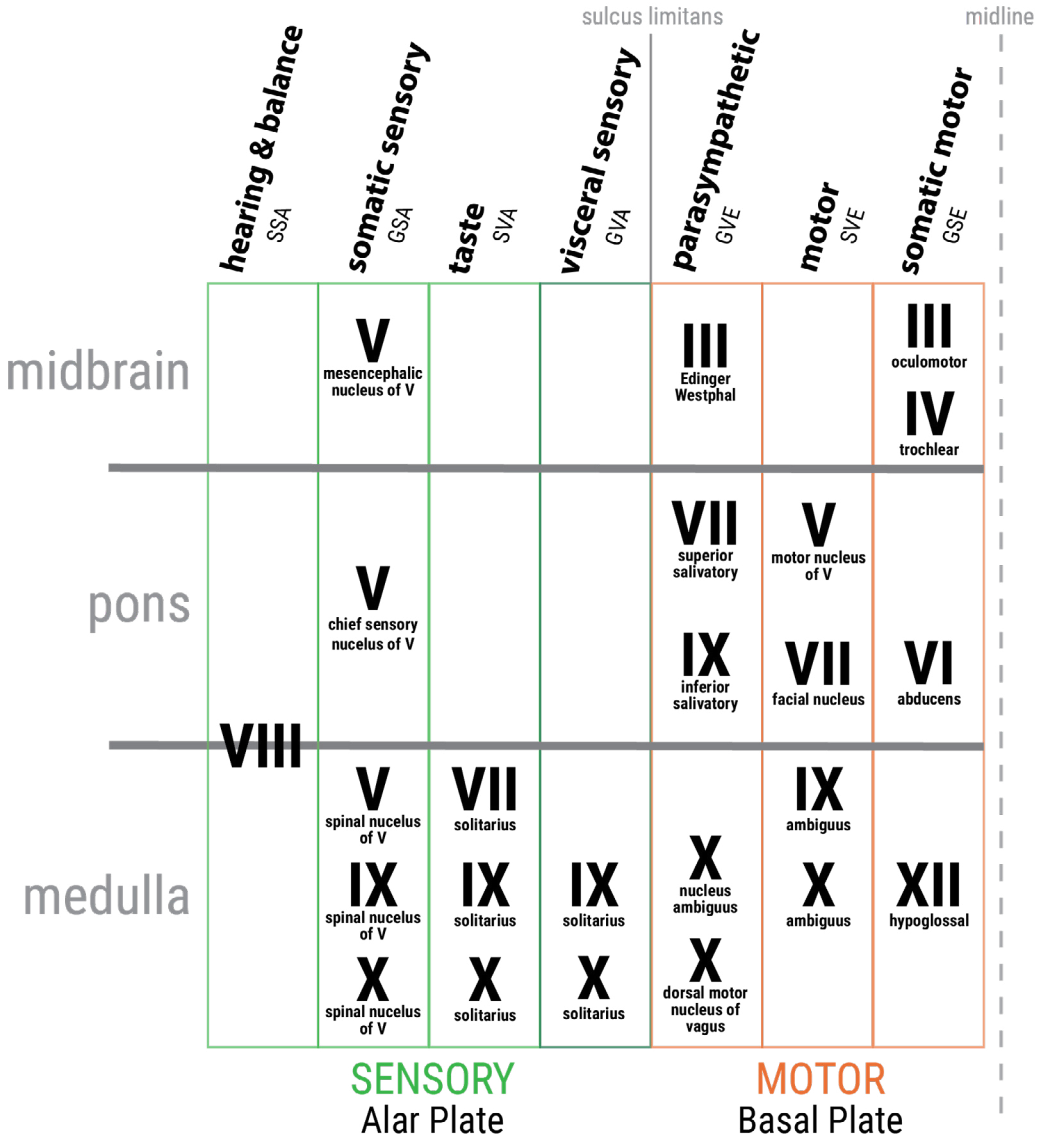
CN X - Vagus

CN XI - Accessory*

CN XII - Hypoglossal

*Nuclei of CN XI are located in the cervical spinal cord

Cranial Nerves (Web)



Cranial nerve nuclei develop in 7 cell columns:

Motor

- **Somatic Motor** - *General somatic efferent (GSE):* innervate skeletal muscle derived from somites
- **Branchial Motor** - *Special visceral efferent (SVE):* innervate skeletal muscle derived from pharyngeal arches
- **Parasympthetic (Visceral Motor)** - *General visceral efferent (GVE):* innervate glands, smooth muscle, cardiac muscle

Sensory

- **Visceral Sensory** - *General visceral afferent (GVA):* sensation from viscera of head and neck
- **Taste** - *Special visceral afferent (SVA):* special sensation from gustatory cells
- **Somatic Sensory** - *General somatic afferent (GSA):* general sensation from head and neck
- **Hearing & Balance** - *Special somatic afferent (SSA):* special sensation from auditory and vestibular cells

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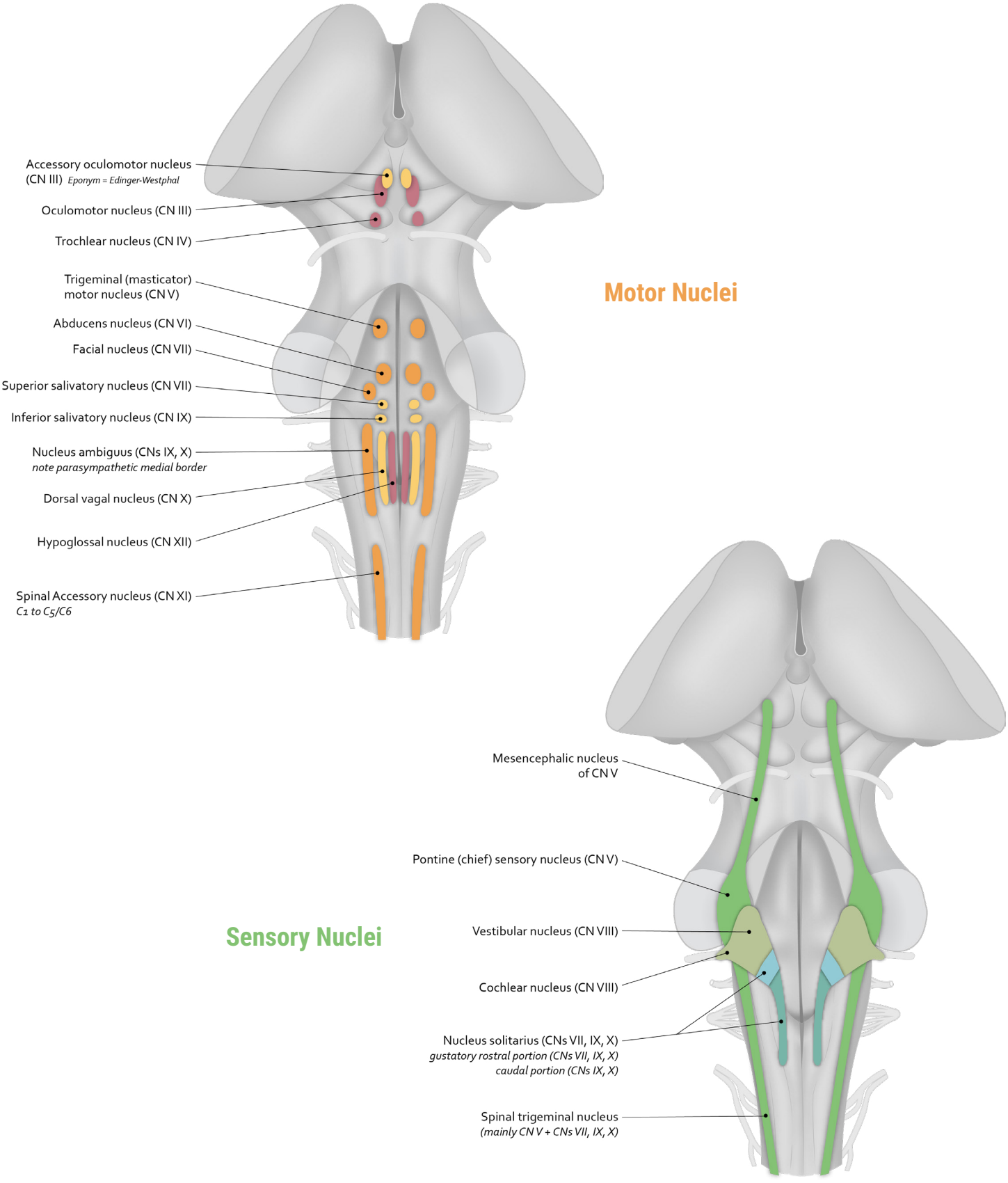
For Conceptual Overview Only:

Brainstem Nuclei (Module)



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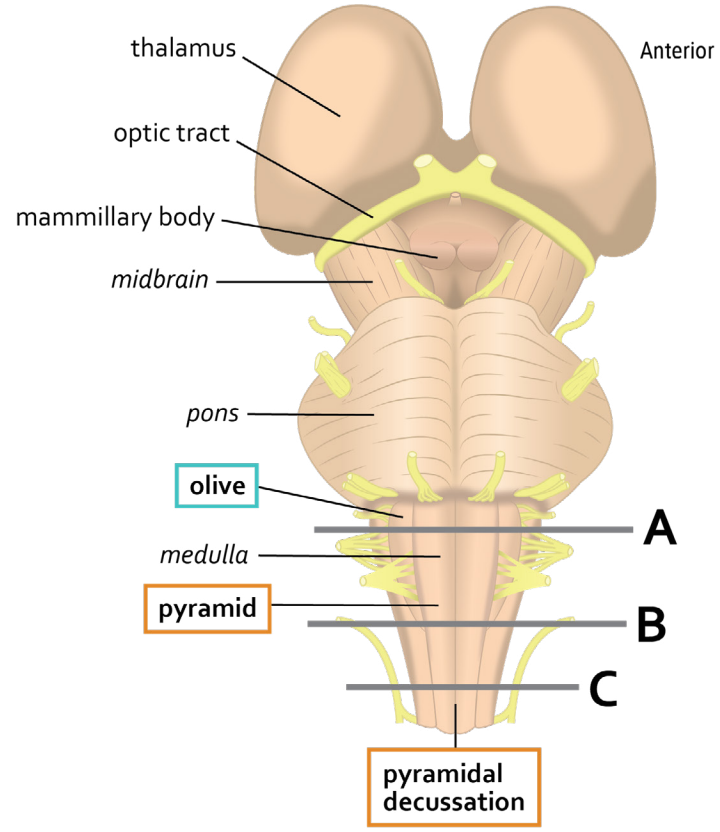
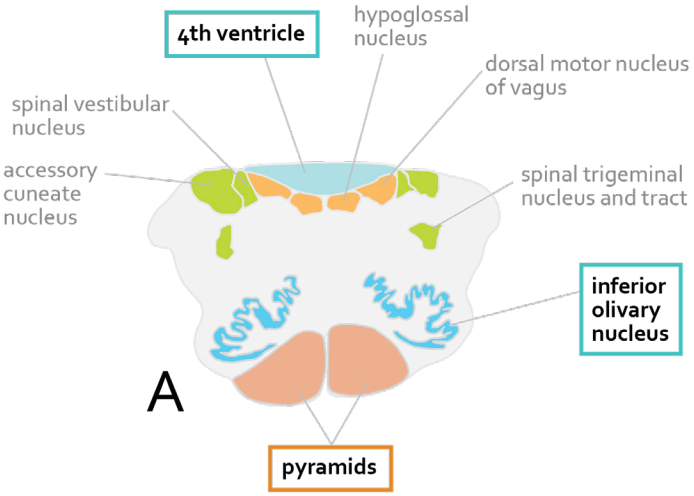
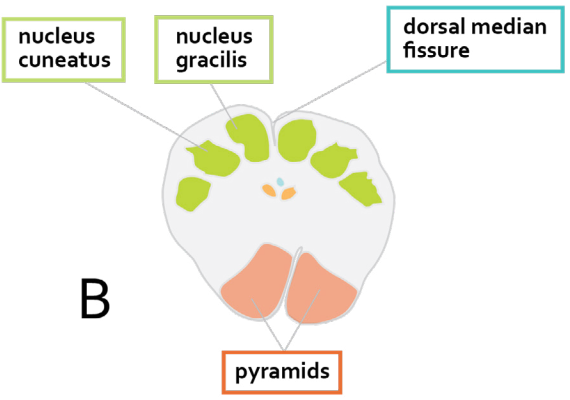
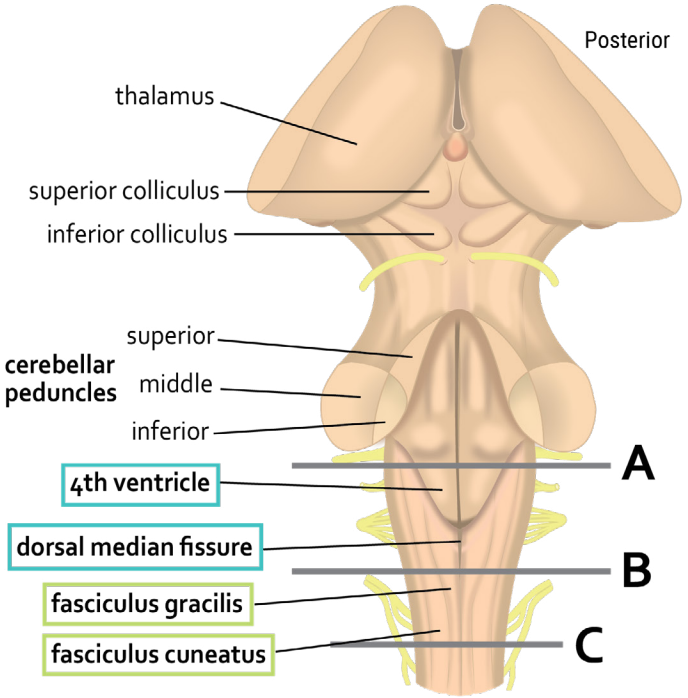
Medulla

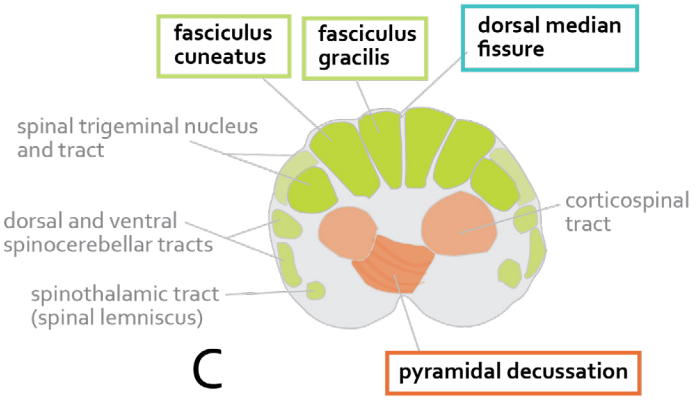
Relating surface anatomy to underlying structures (in bold)











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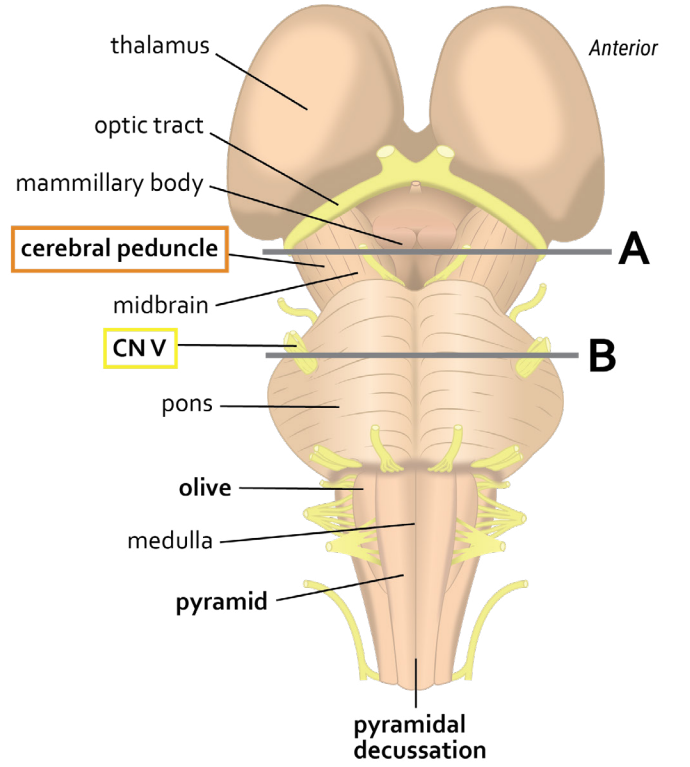
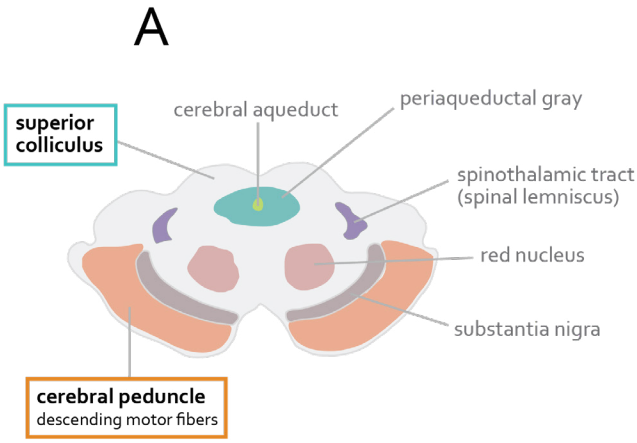
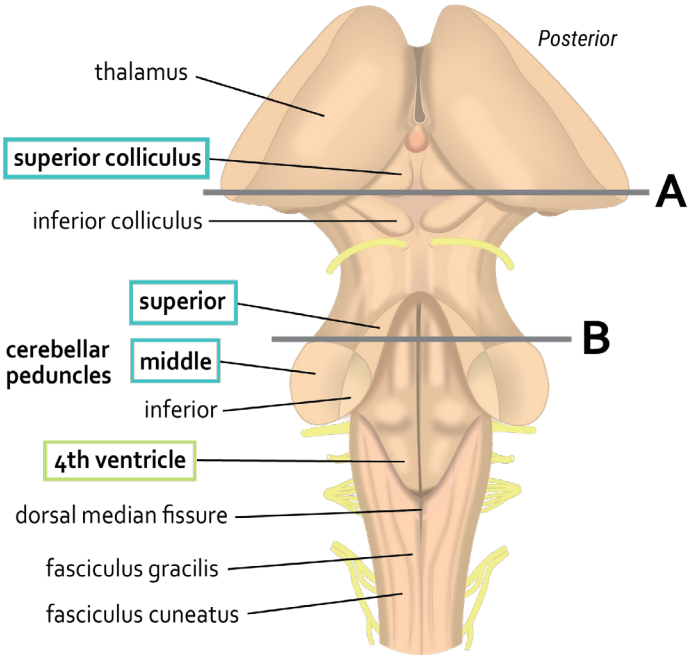
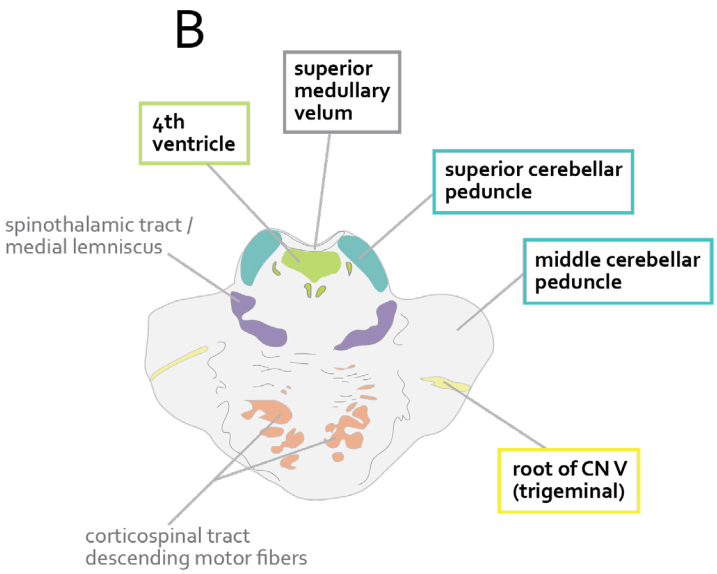
Pons and Midbrain

Relating surface anatomy to underlying structures (in bold)









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Clinical Notes

Clinical Signs of Midbrain Injury

- abnormal motor function, hemiparesis is contralateral to lesion
- abnormal eye movement (CN III and IV)
- abnormal pupillary light reflexes (CN III)
- vertical gaze palsy
- *Sensory Deficits:* contralateral to lesion for both pain and temperature, as well as discriminative touch, vibration, and conscious proprioception

Clinical Signs of Injury to Pons

- abnormal motor function, hemiparesis is contralateral to lesion
- deficits involving cranial nerves V – VIII
- abnormal body posture if the vestibular system or cerebellum is affected
- abnormal levels of consciousness (with severe injury)
- horizontal gaze palsy
- *Sensory Deficits:* contralateral to lesion for both pain and temperature, as well as discriminative touch, vibration, and conscious proprioception

Clinical Signs of Injury to Medulla

- abnormal motor function, hemiparesis is contralateral to lesion (rostral to the pyramidal decussation) or bilateral (at the level of the pyramidal decussation)
- deficits involving cranial nerves VIII – X and XII
- abnormal body posture if the vestibular system is affected
- abnormal levels of consciousness (with severe injury)
- *Sensory Deficits:* contralateral to lesion for both pain and temperature, as well as discriminative touch, vibration, and conscious proprioception

  ** in the *caudal medulla (caudal to level of internal arcuate fibers)*, deficits in discriminative touch, vibration, and conscious proprioception are *ipsilateral* to the lesion **

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The **corticonuclear tract** is the upper motor neuron (UMN) for the lower motor neurons in the motor nuclei of cranial nerves V, VII, and IX – XII. In general, the innervation through the corticonuclear tract is bilateral, but there are some notable exceptions.

Your neurological exam will focus on these exceptions.

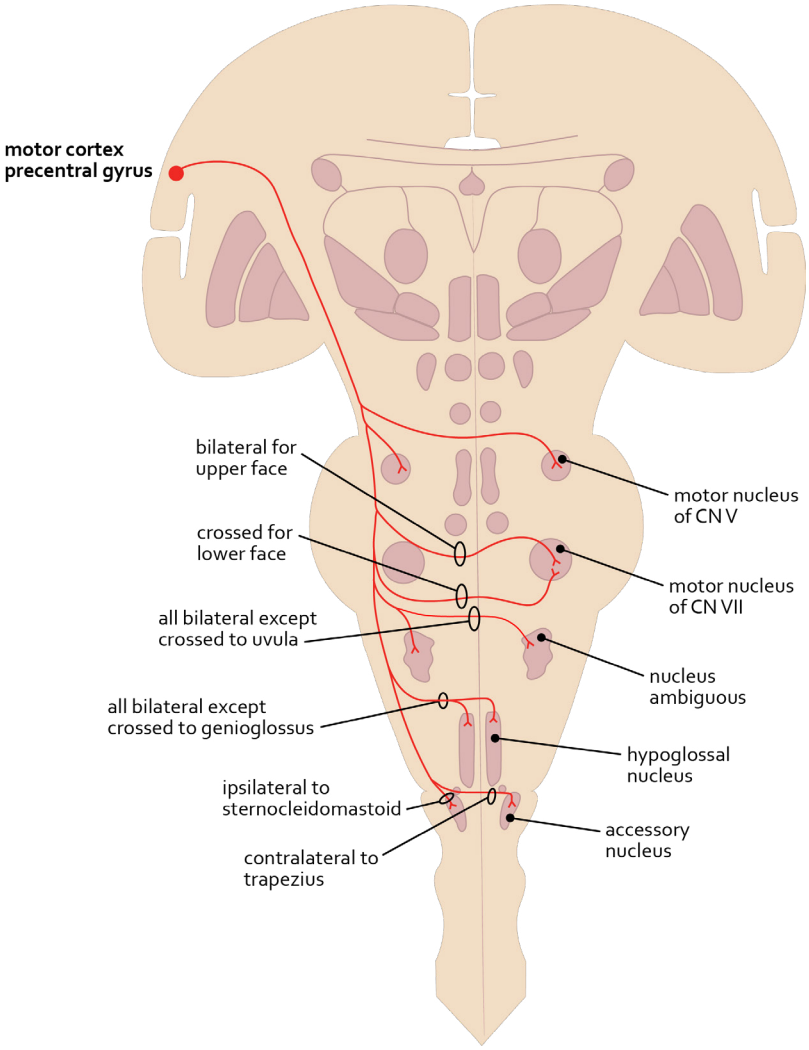
Neurological Exam (Video)

Corticonuclear Tract

Today we will look at the corticonuclear tract conceptually. In later labs we will examine the input from the corticonuclear tract to specific cranial nerve nuclei.

1. Originates mainly in head and face area of **precentral gyrus**.
2. Descends through **corona radiata**.
3. Descends through **genu** and **anterior part of posterior limb of internal capsule**.
4. Travels with **corticospinal tract** through middle 3/5 of cerebral peduncle, basal pons, and medullary pyramids.
5. Terminates on **cranial nerve motor nuclei**. Most synapse bilaterally with lower motor neurons (LMNs) in cranial nerve nuclei.

Cranial nerves that innervate the extraocular muscles (CN III, IV, VI) have more complex input from the cortex and are discussed separately.



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Medial Longitudinal Fasciculus (MLF)

Small tract located on each side of midline:

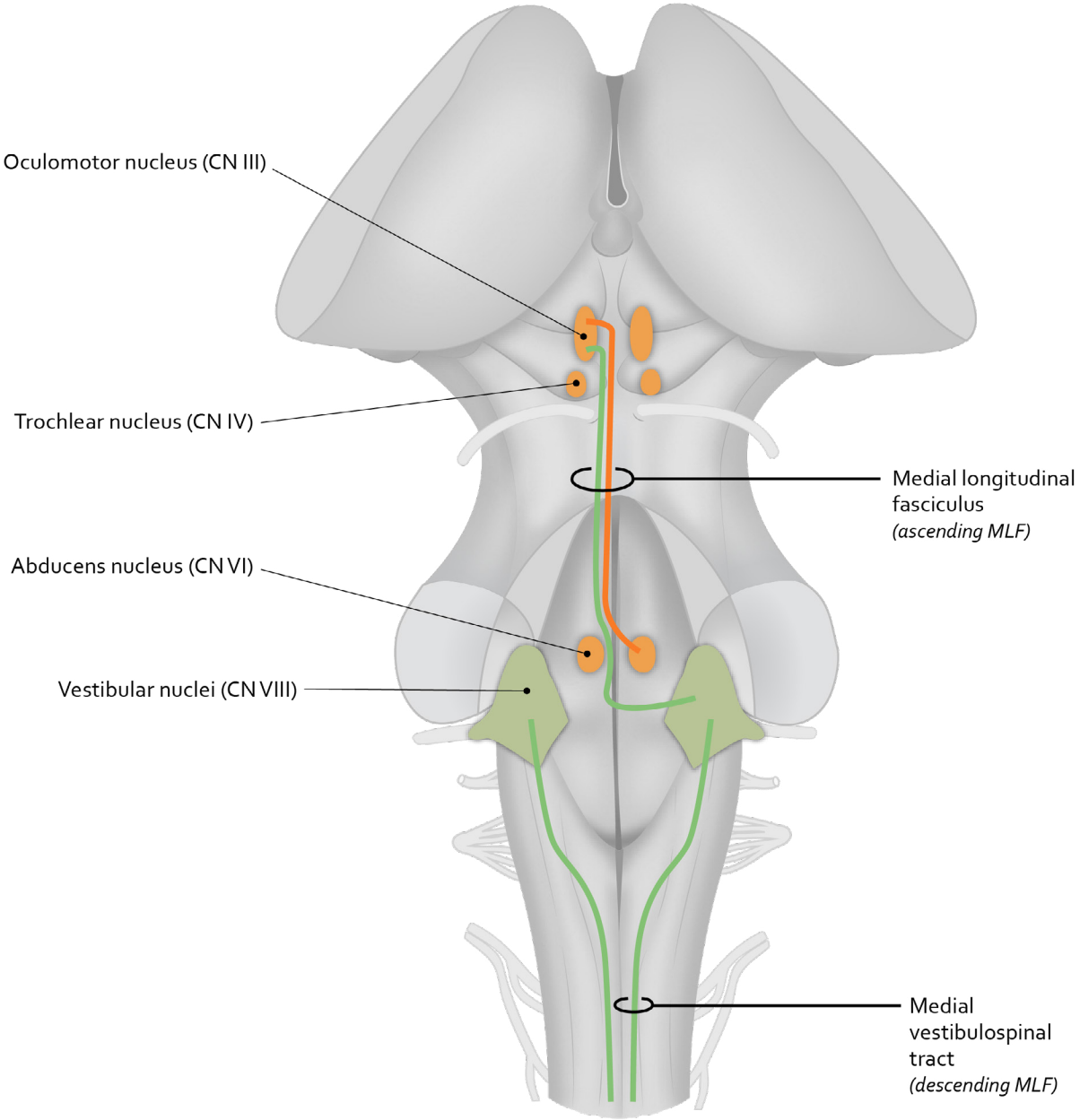
- In caudal and mid pons, just anterior to the fourth ventricle
- In rostral pons and midbrain, anterior to the cerebral aqueduct

Ascending MLF

- Connects somatic motor nuclei of CN VI and CN III (see conjugate horizontal gaze)
- Connects vestibular nuclei to nuclei of CN III, IV and VI (see vestibulo-ocular reflex)
- Connects vestibular nuclei to higher centres

Descending MLF

= **Vestibulospinal tract**: connects vestibular nuclei to spinal cord



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Neuroanatomy of Eye Movements

Cranial Nerves (Web)

Micrographs (Web)

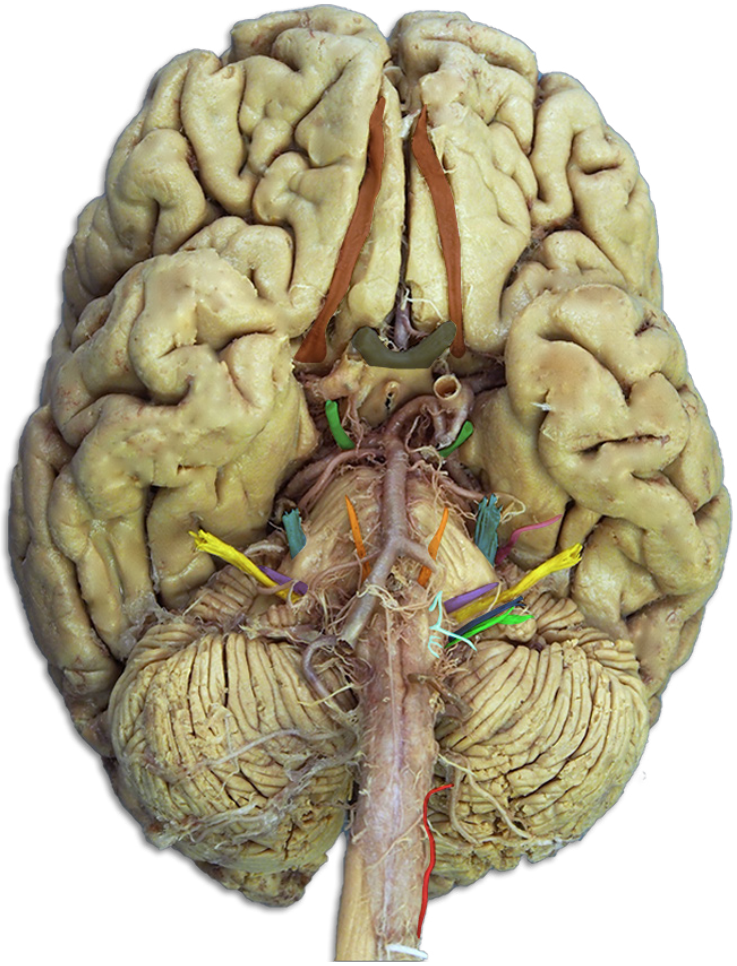
Identify:

Whole Brain

- ◯ CN III (oculomotor)
- ◯ CN IV (trochlear)
- ◯ CN VI (abducens)

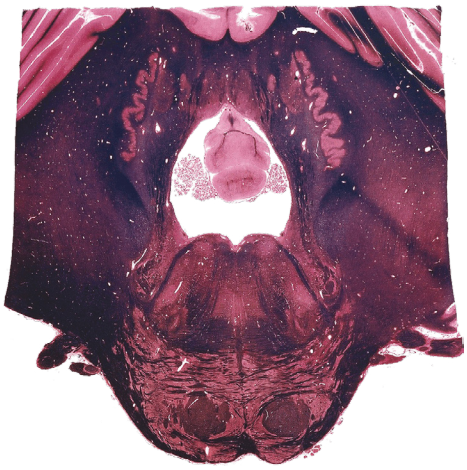
Micrographs ***Nuclei associated with:***

- ◯ CN III (oculomotor)
- ◯ CN IV (trochlear)
- ◯ CN VI (abducens)



Cranial Nerves on Inferior Brain and Brainstem

#7



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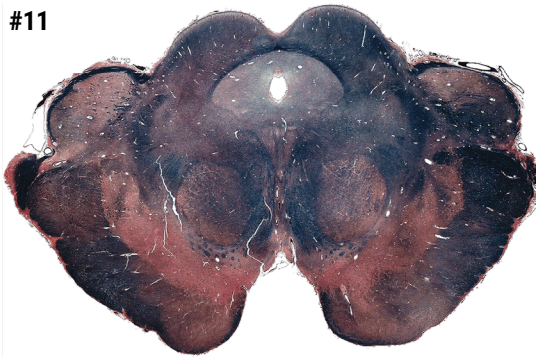

(Micrograph numbers correspond to those on neuroanatomy.ca)

From where do the motor nuclei associated with muscles that move the eye receive their input?

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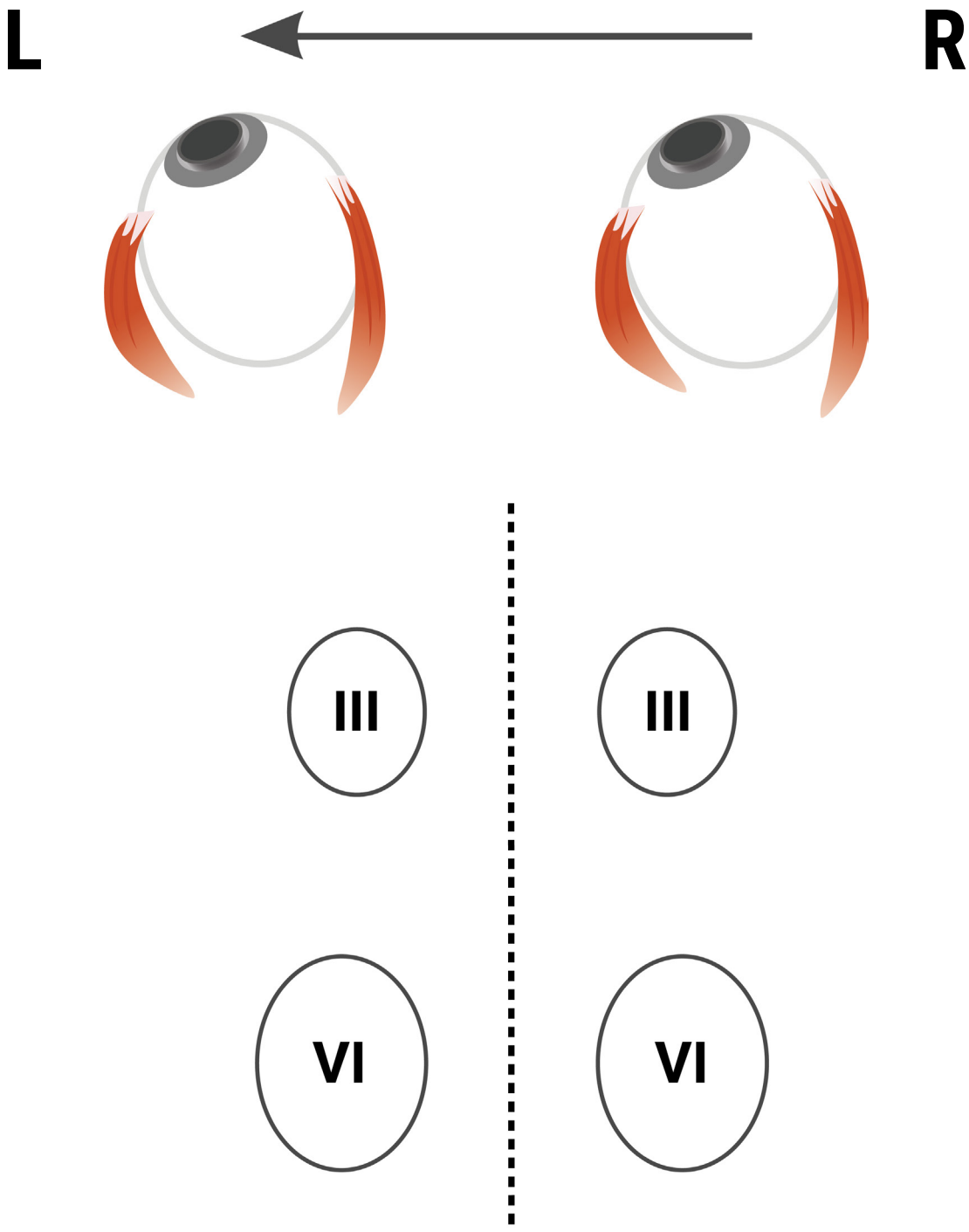
Review the basic wiring of horizontal eye movements from your lecture and the online module.

Control of Eye Movements (Module)

Draw in the basic wiring for eye movement to the left on the diagram below:



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Exercise #1

Describe the deficits in horizontal gaze (toward the right and left) you would expect to see if each of the following structures is damaged:

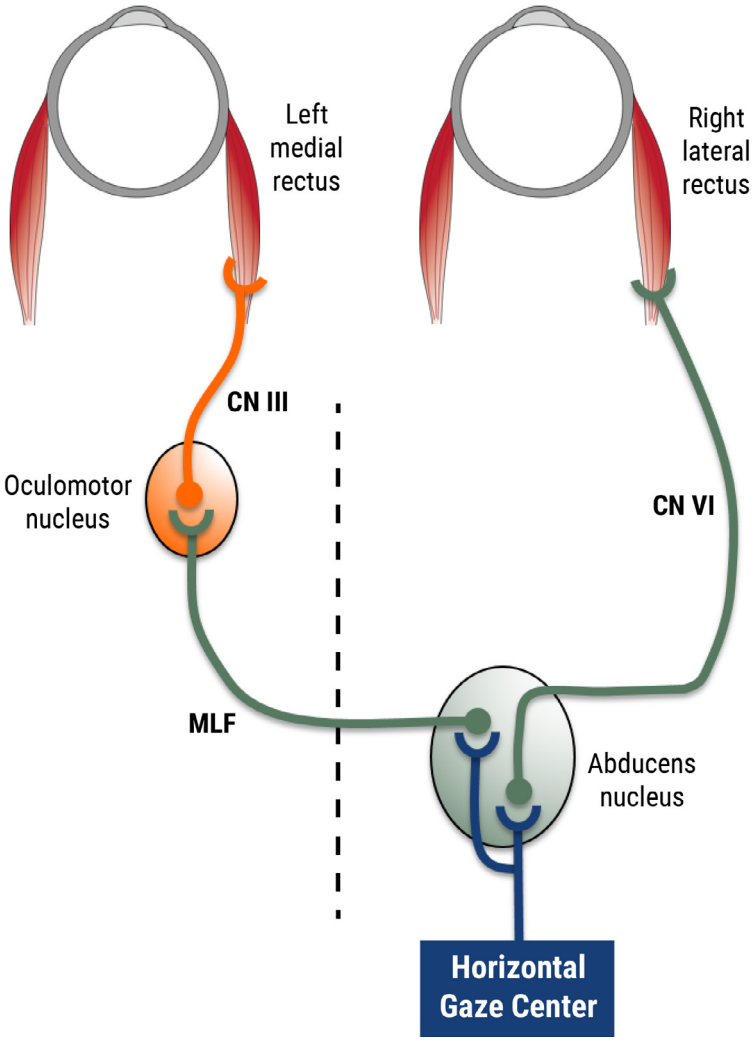
Left VI nerve

Left VI nucleus

Left MLF (between right CN VI nucleus + left CN III nucleus)

Left VI nucleus and left MLF

Both MLFs



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Case #1

Mr. Chen (he/him) was examined by a physician and the following were noted:

1. He was unable to adduct either eye when asked to look to the right or left
2. Abduction of both eyes was intact
3. Both eyes could adduct during convergence
4. There was nystagmus only in the abducting eye when attempting to look to either the right or left

For each symptom listed above, identify the anatomical structure(s) that would most likely be involved. Be specific, including the side where relevant.

1. Structure(s):
2. Structure(s):
3. Structure(s):
4. Structure(s):

What is the most likely site of a lesion that would produce these deficits?

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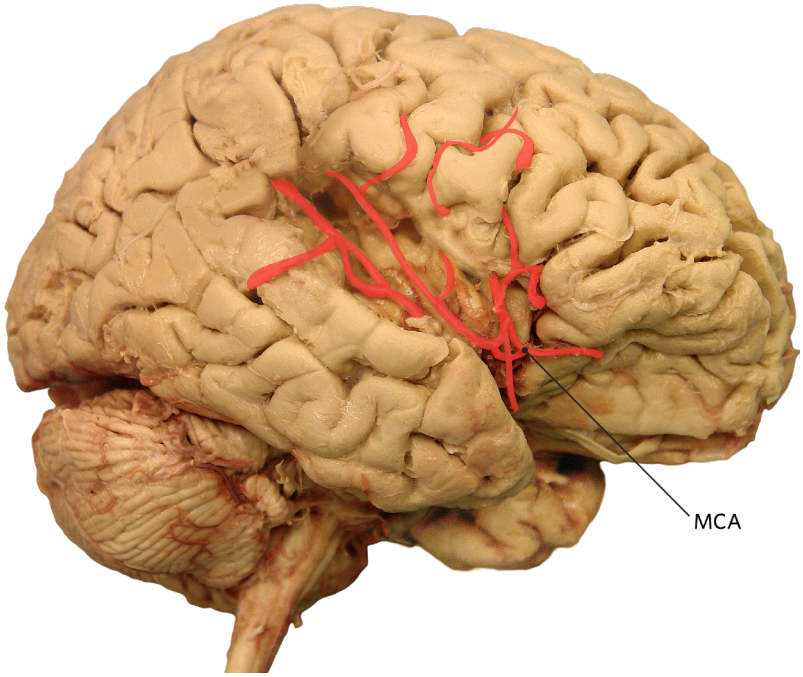
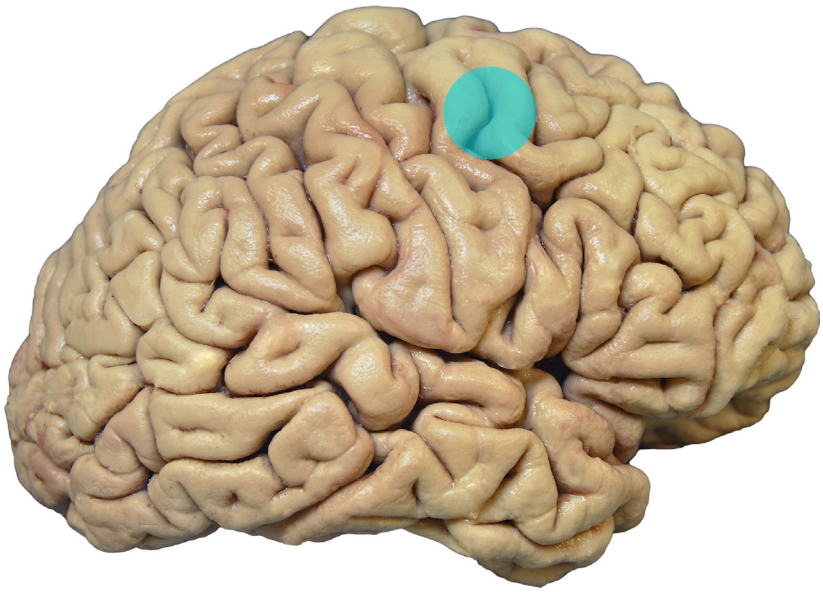
Exercise #2

What deficit would be observed with occlusion of branches of the right middle cerebral artery that supply the **right frontal eye fields**?





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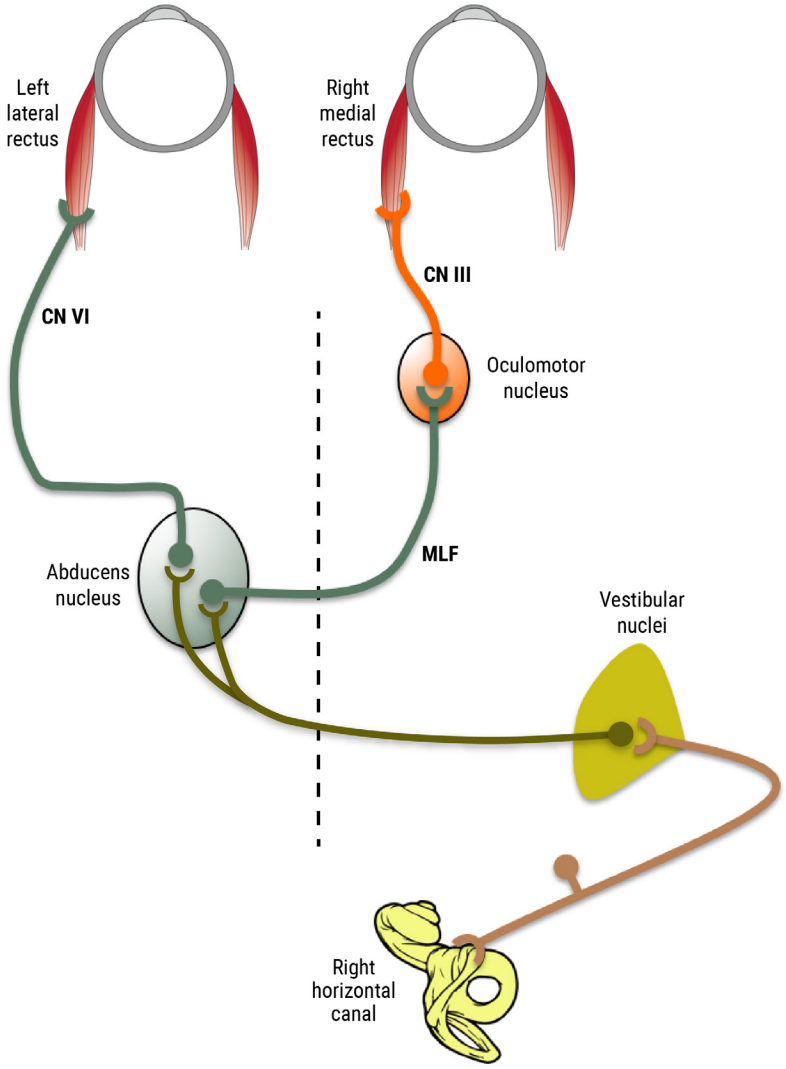
To complete the excercise below, review your lecture on the vestibular system along with the interactive module and video.

Vestibular System (Module) Balance (Video)

Exercise #3

In relation to the vestibulo-ocular reflex, explain how the eyes would move when the head turns to the right if there is a lesion to the **right vestibular nuclei**.



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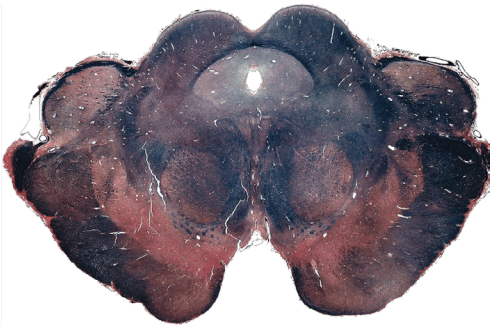
Micrograph Checklist

Micrographs (Web)

Midbrain

#10
#11



- ◯ cerebral peduncle
- ◯ oculomotor nucleus
- ◯ abducens nucleus
- ◯ superior colliculus
- ◯ inferior colliculi

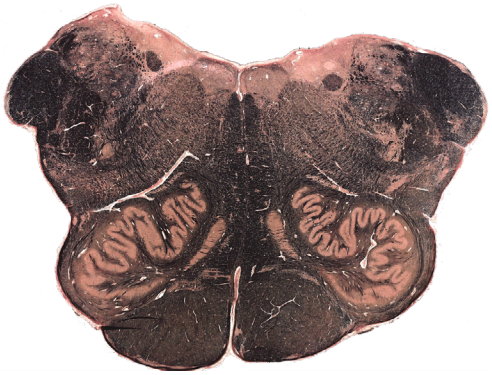
Pons

#7
#8

- ◯ 4th ventricle
- ◯ middle cerebellar peduncle
- ◯ superior cerebellar peduncle
- ◯ superior medullary velum
- ◯ trigeminal nerve root
- ◯ trochlear nerve

Medulla

#4
#5



- ◯ dorsal median fissure
- ◯ fasciculus gracilis
- ◯ fasciculus cuneatus
- ◯ inferior olivary nucleus
- ◯ nucleus gracilis
- ◯ nucleus cuneatus
- ◯ pyramids

(Micrograph numbers correspond to those on neuroanatomy.ca – make sure to look at all of the micrographs listed)

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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