Overview of Brainstem Eye Movements (CN III, IV, VI) Lab 5

January 29, 2024 - Dr. Krebs (claudia.krebs@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 corticobulbar 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 **

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Identify:

Micrographs (Web)

Whole Brain

- ◯ Cranial nerves
- ◯ Midbrain
  - Cerebral peduncles
  - Interpeduncular fossa
  - Mammillary bodies
  - Tectum with 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

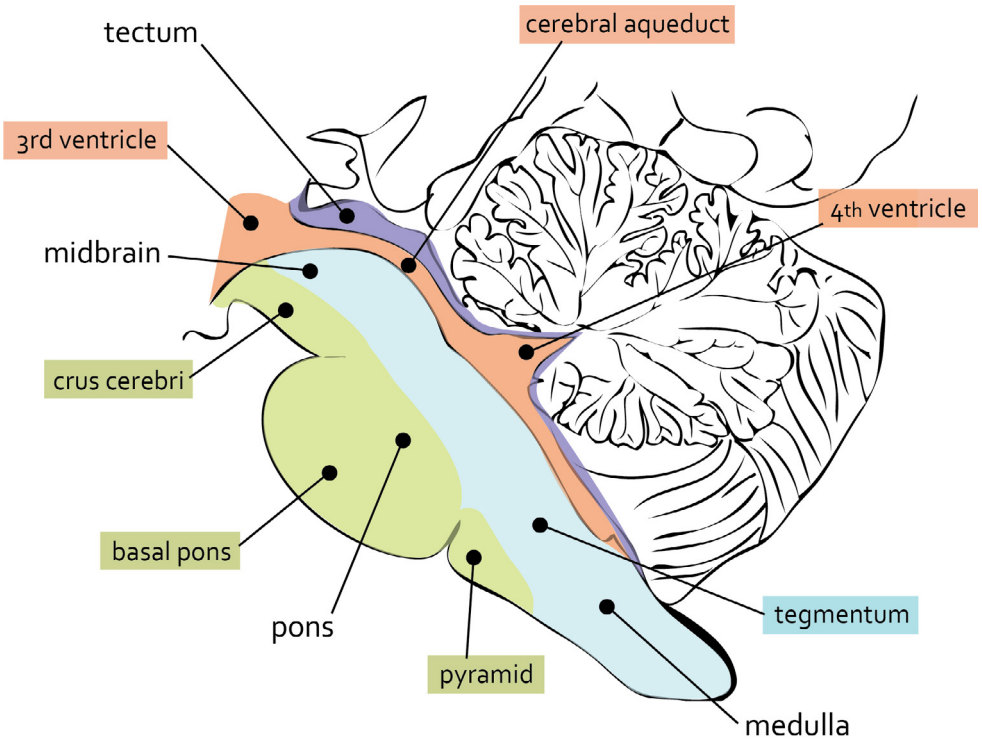
- ◯ Cranial nerve nuclei

Notes

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

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

There are surface markings (i.e. olive or 4th ventricle) that when identified in a cross-section are a critical landmark for knowing where you are in the brainstem.



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

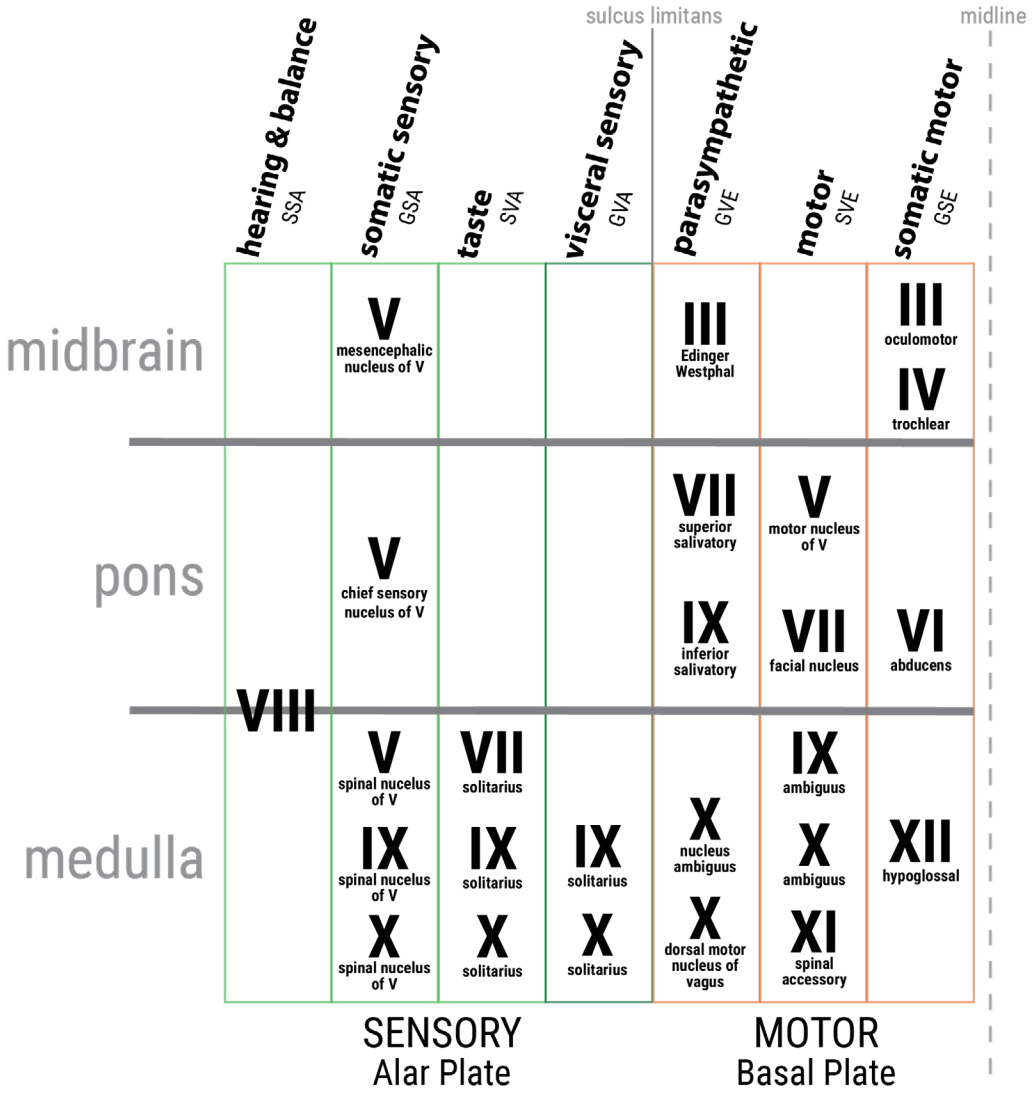
CN IX - Glossopharyngeal

CN X - Vagus

CN XI - Accessory

CN XII - Hypoglossal

Cranial Nerves (Web)



Cranial nerve nuclei develop in 7 cell columns:

Motor

- **Somatic Motor** - *General somatic efferent (GSE):* innervate skeletal muscle derived from somites
- **Motor** - *Special visceral efferent (SVE):* innervate skeletal muscle derived from pharyngeal arches
- **Parasympthetic** - *General visceral efferent (GVE):* visceral motor = parasympathetic

Sensory

- **Visceral Sensory** - *General visceral afferent (GVA):* sensation from viscera of head and neck
- **Taste** - *Special visceral afferent (SVA):* taste
- **Somatic Sensory** - *General somatic afferent (GSA):* general sensation from head and neck
- **Hearing & Balance** - *Special somatic afferent (SSA):* hearing and balance

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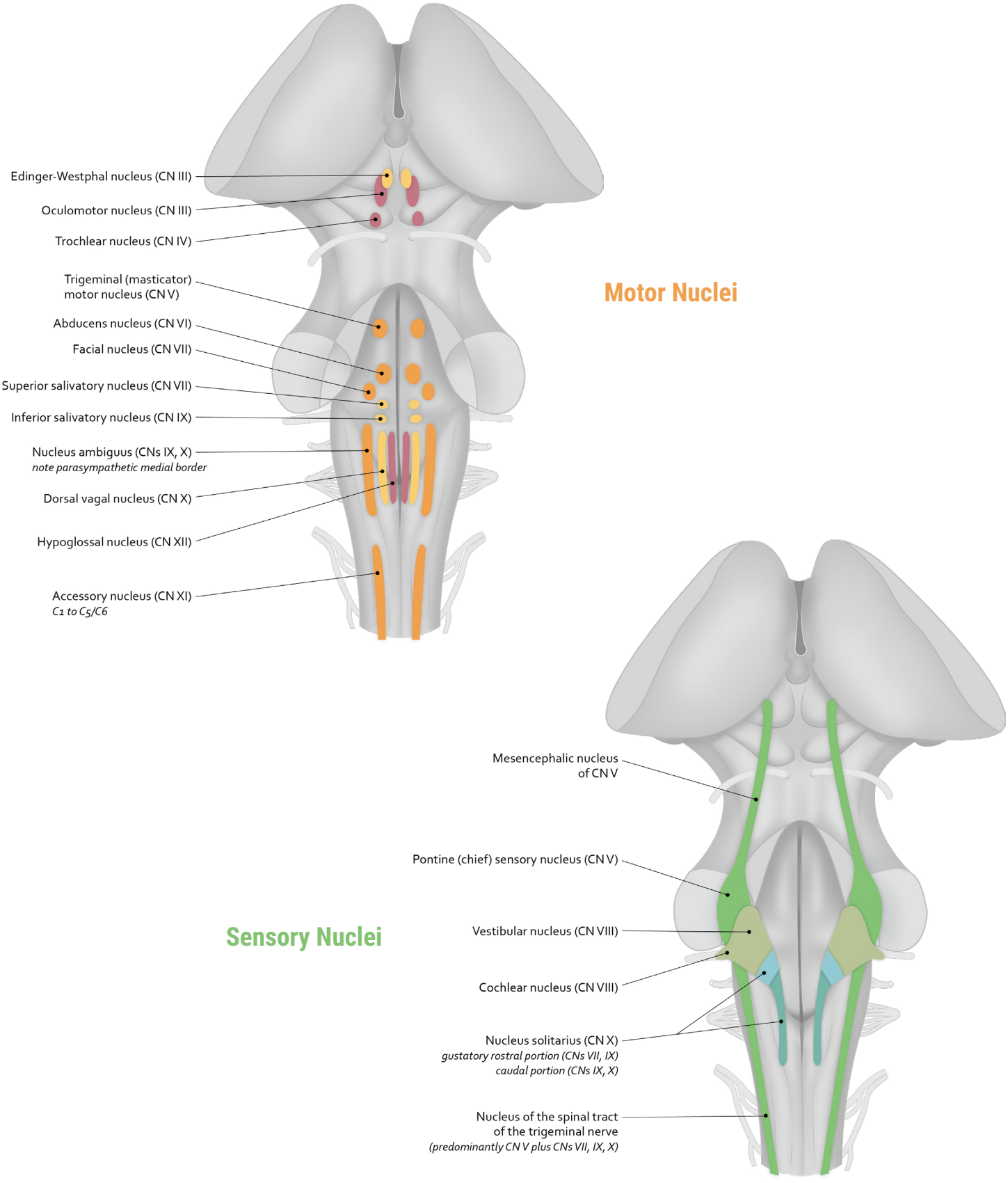
For Conceptual Overview Only:

Brainstem Nuclei (Module)



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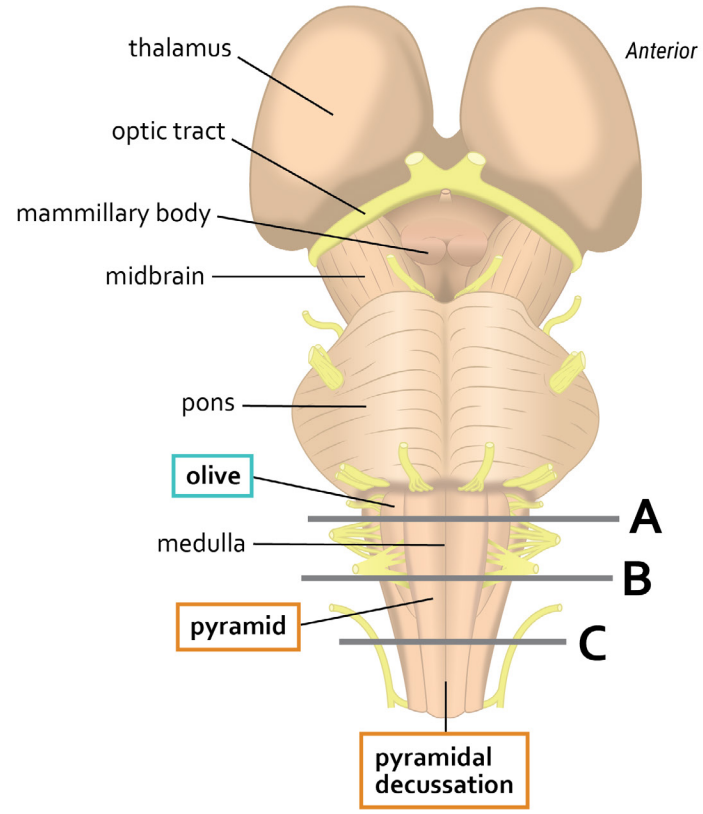
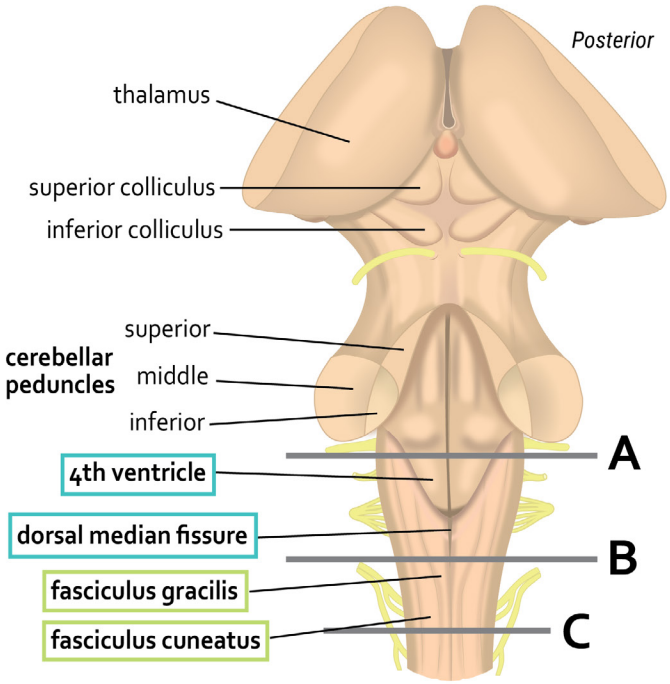
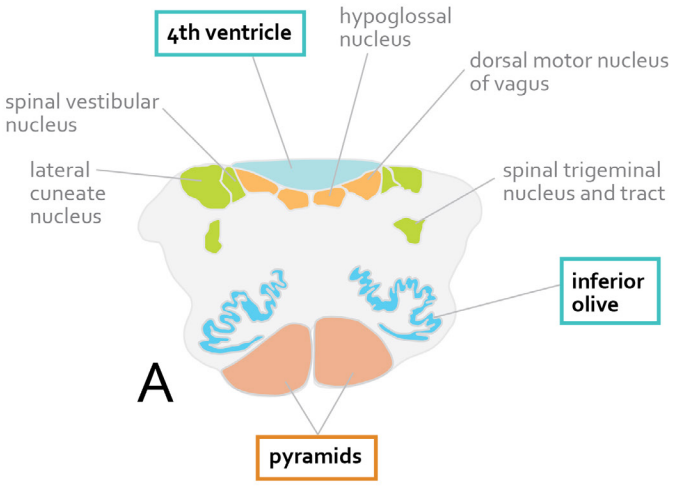
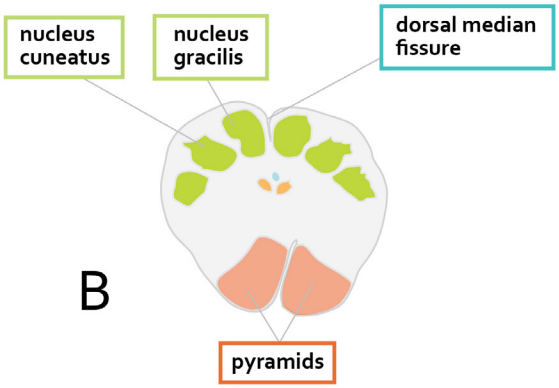
Medulla

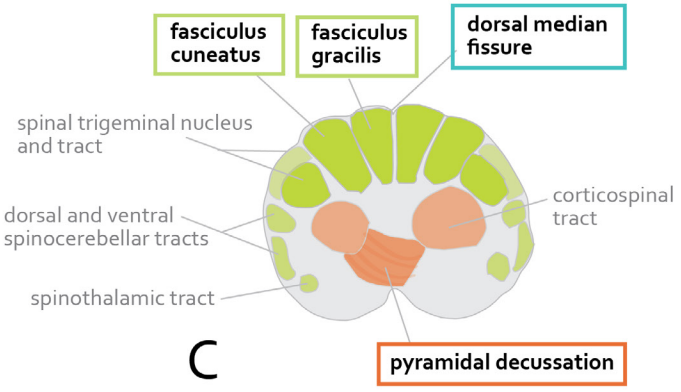
Relating surface anatomy to underlying structures (in bold)











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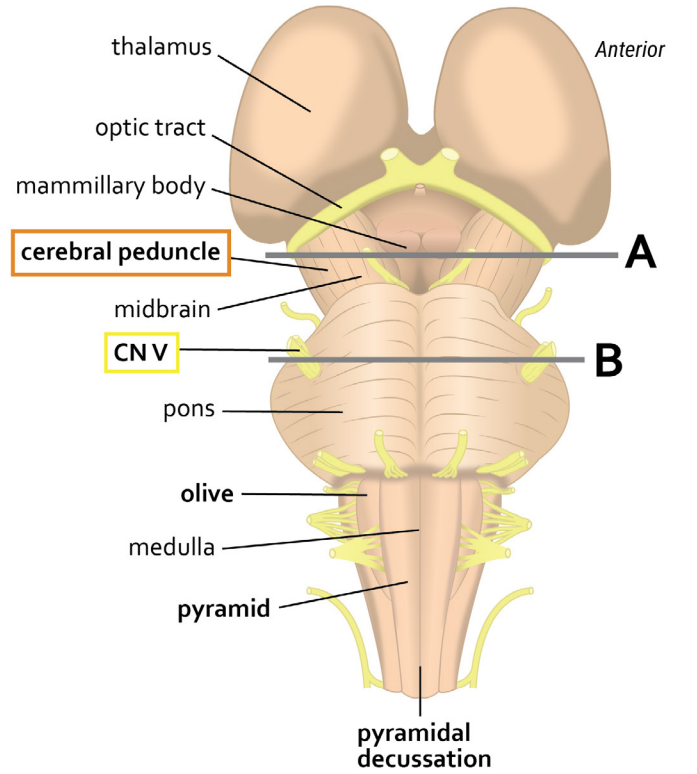
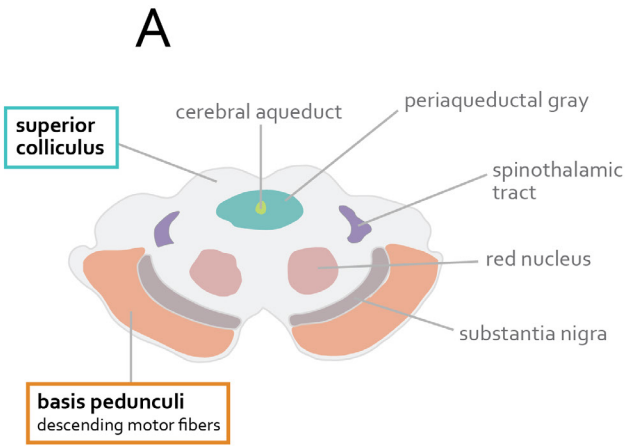
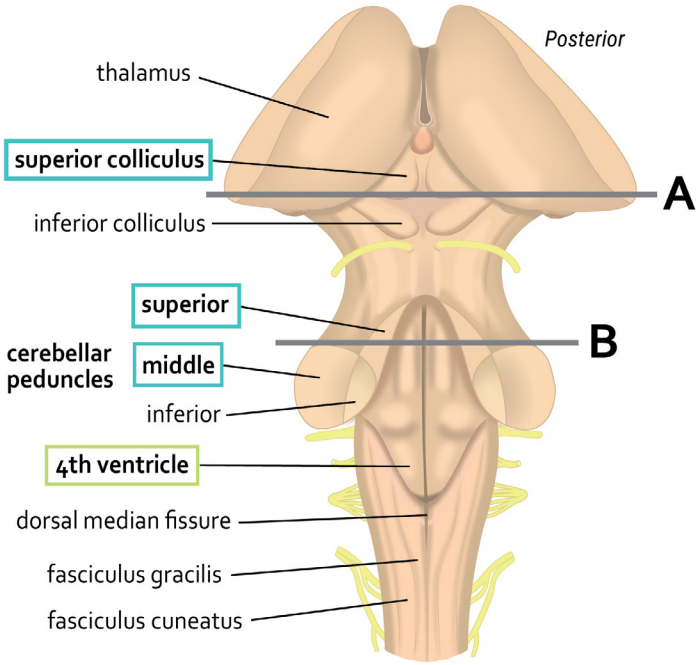
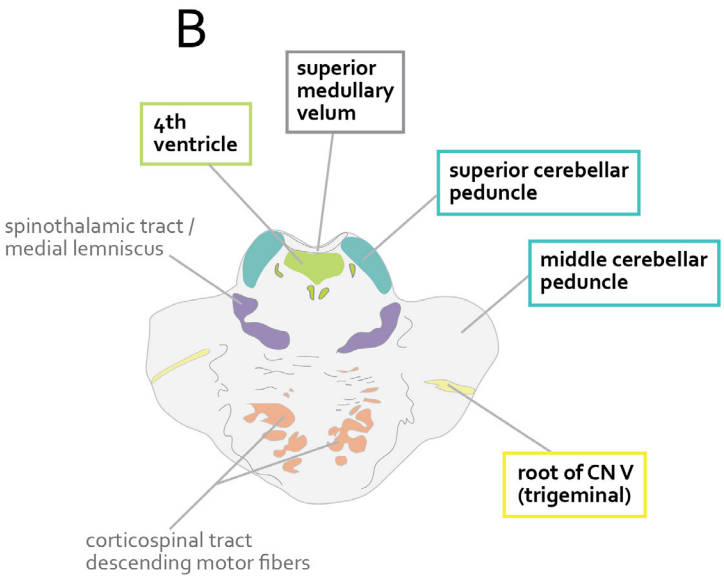
Pons and Midbrain

Relating surface anatomy to underlying structures (in bold)









Clinical Notes

Clinical Signs of Midbrain Injury

- abnormal motor function, hemiparesis is contralateral to lesion
- abnormal extraocular 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 in cranial nerves V – VII
- 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 medulla) or ipsilateral (caudal medulla)
- deficits in cranial nerves VIII – 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*, deficits in discriminative touch, vibration and conscious proprioception are *ipsilateral* to the lesion **

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The **corticobulbar tract** is the upper motor neuron (UMN) for the lower motor neurons in the motor nuclei of cranial nerves V, VII, IX-XII. In general, the innervation through the corticobulbar tract is bilateral - with some notable exceptions.

Your neurological exam will focus on these exceptions.

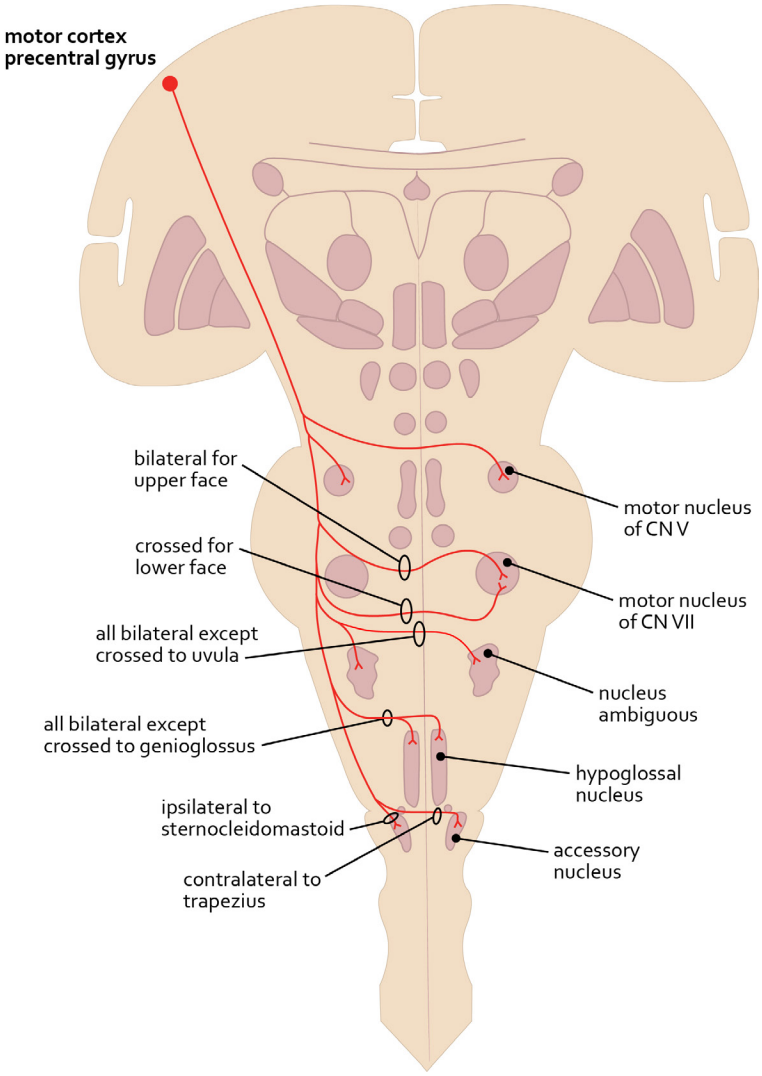
Neurological Exam (Video)

Corticobulbar Tract

Today we will look at the corticobulbar tract conceptually. In later labs we will examine the input from the corticobulbar 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 crus cerebri.
5. Terminates on **cranial nerve motor nuclei**. Most terminate bilaterally.

Cranial nerves that innervate the extraocular muscles (CN III, IV, VI) have more complex afferents and are discussed seperately.



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Neuroanatomy of Eye Movements

Cranial Nerves (Web)

Micrographs (Web)

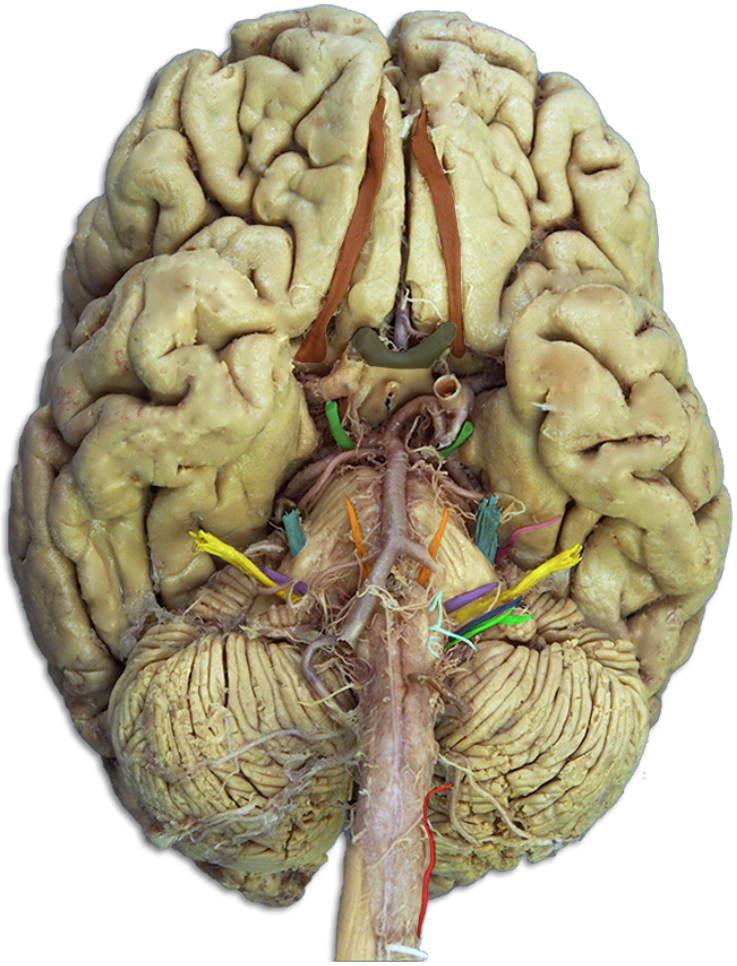
Identify:

Whole Brain

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

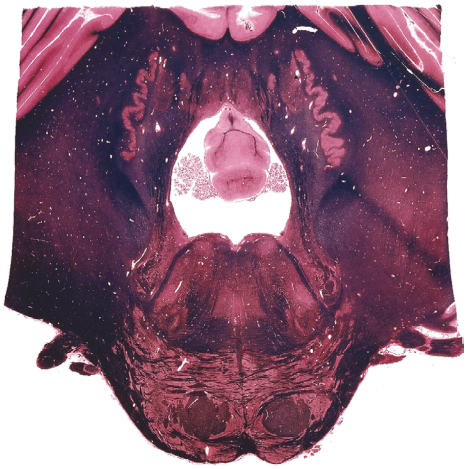
Micrographs ***Nuclei associated with:***

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



Cranial Nerves on Inferior Brain and Brainstem

#7



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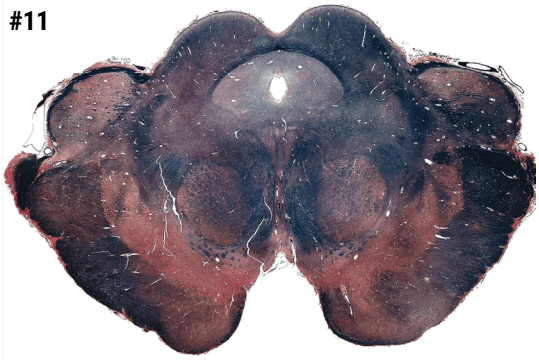

From where do the motor nuclei associated with muscles that move the eye receive their input?

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Medial Longitudinal Fasciculus (MLF)

Small tract located on each side of midline:

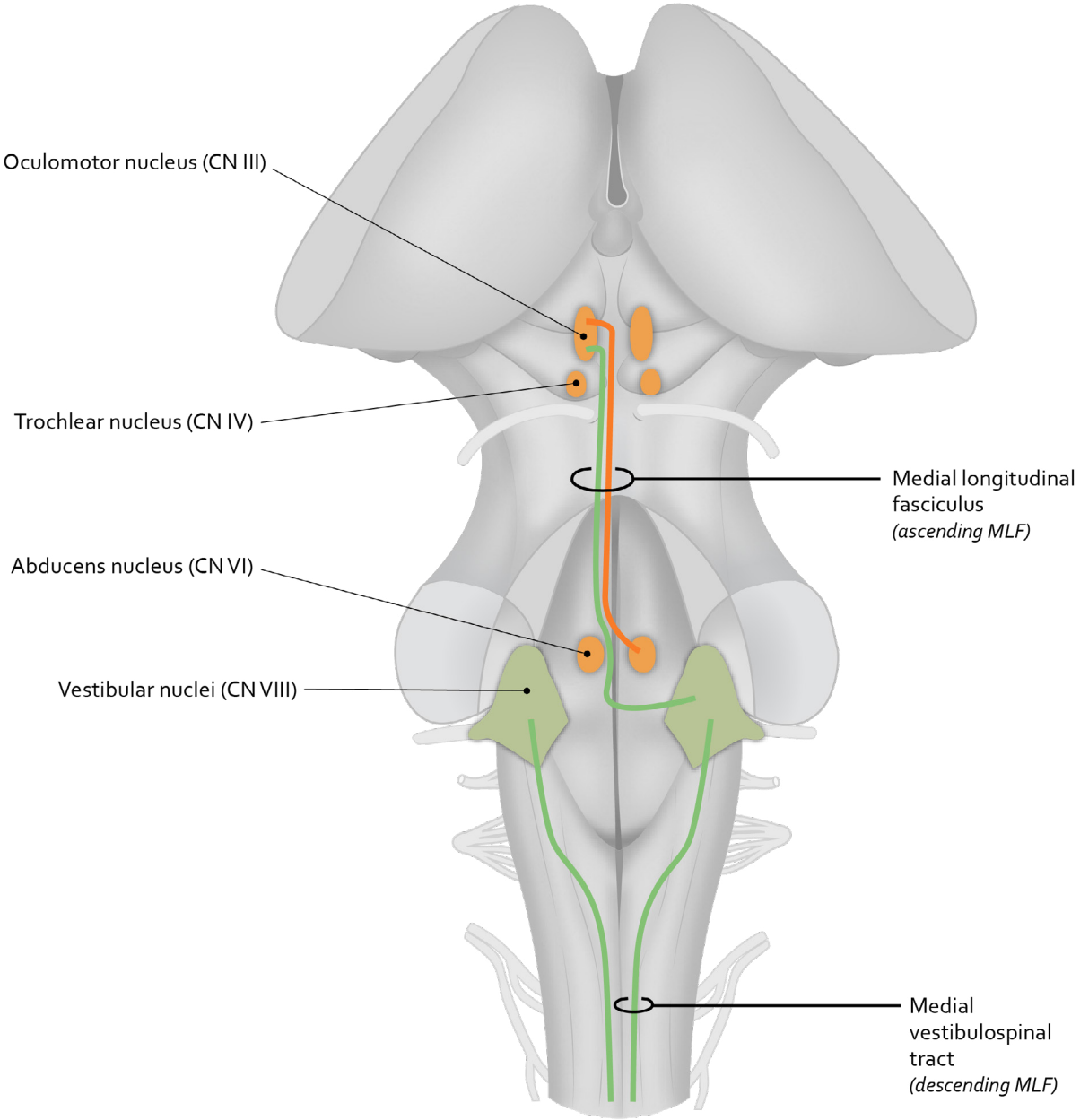
- In caudal and mid pons, just beneath floor of fourth ventricle
- In rostral pons and midbrain, anterior to cerebral aqueduct

Ascending MLF

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

Descending MLF

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



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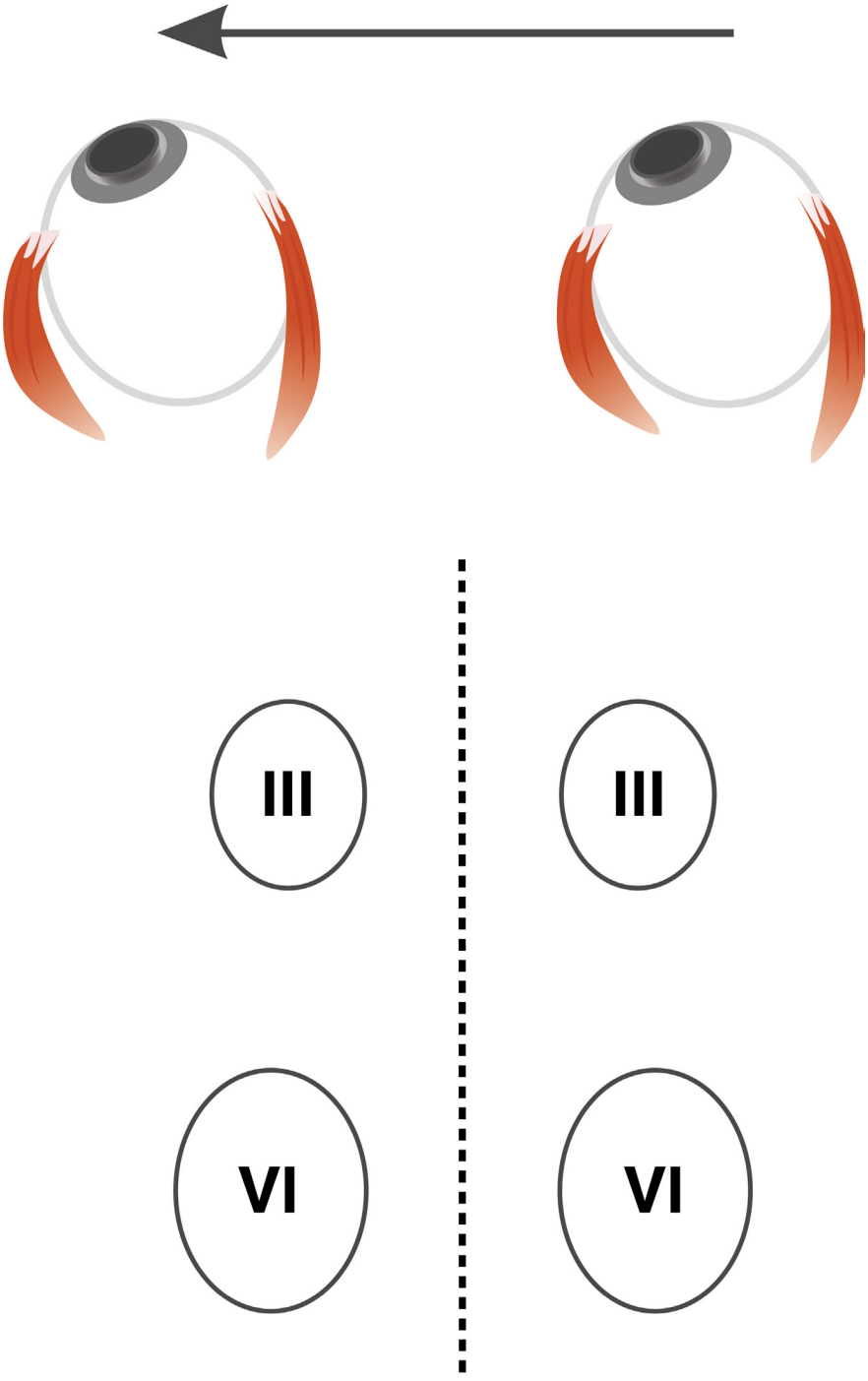
Review the basic wiring of horizontal eye movements from your lecture and the online module.

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 seen if each of the following structures is damaged:

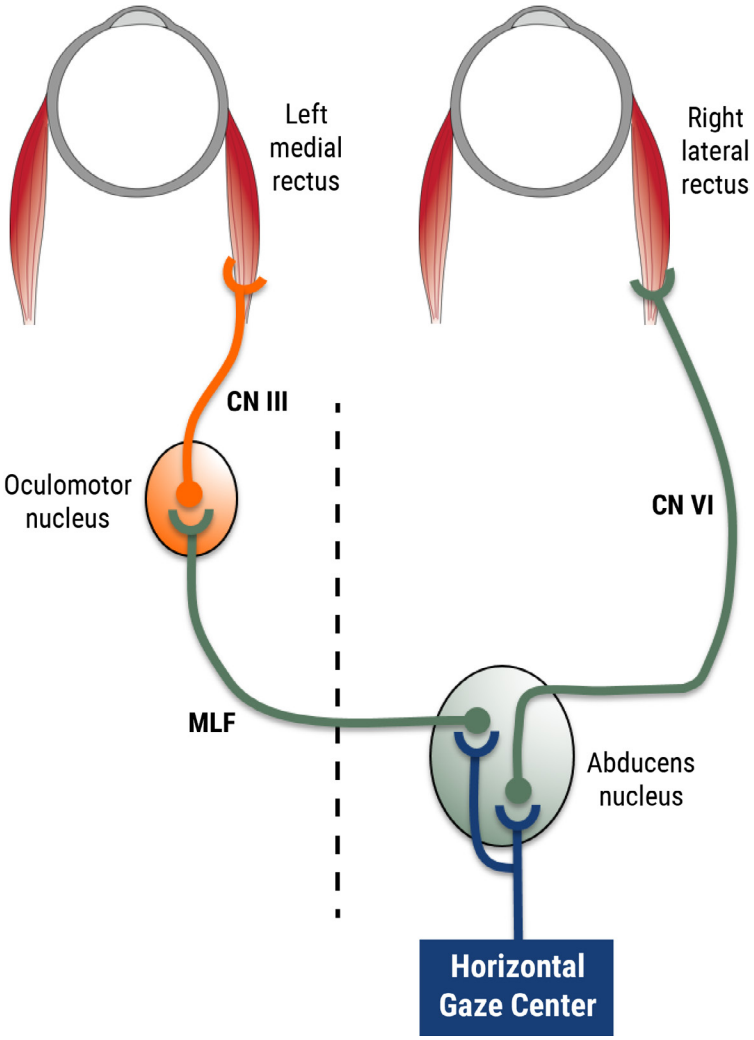
Left VI nerve

Left VI nucleus

Left MLF

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, name the anatomical structure(s) that would most likely be involved. Be specific and indicate side where relevant.

1. Structures:
2. Structures:
3. Structures:
4. Structures:

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

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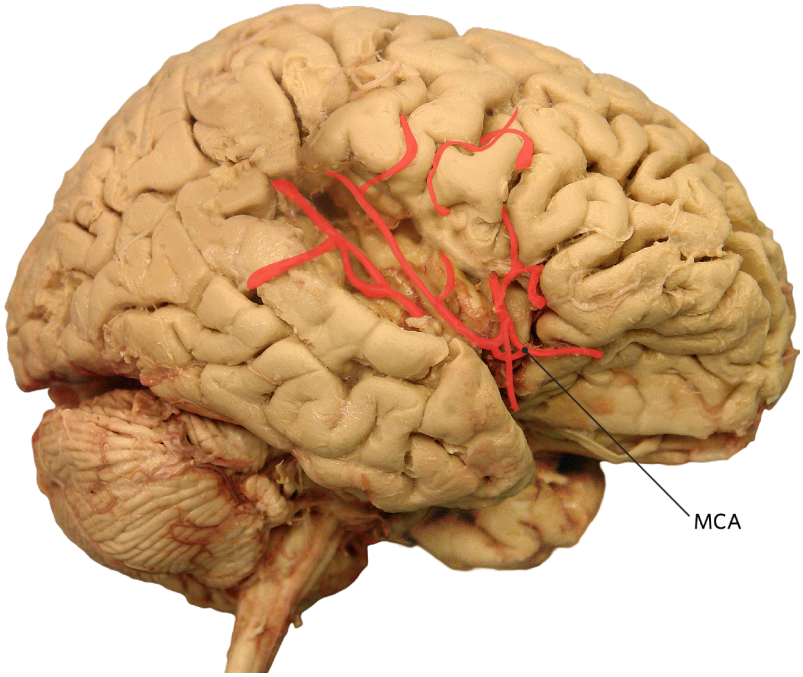
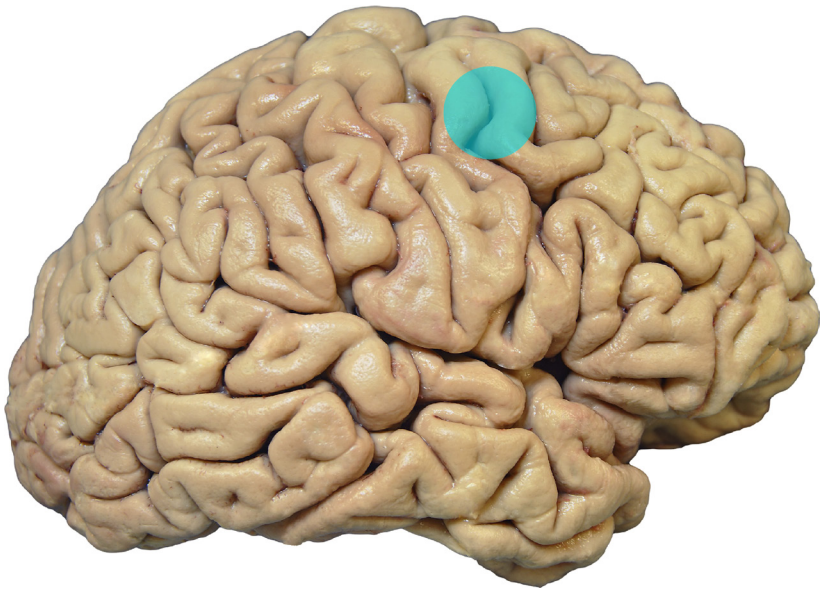
Exercise #2

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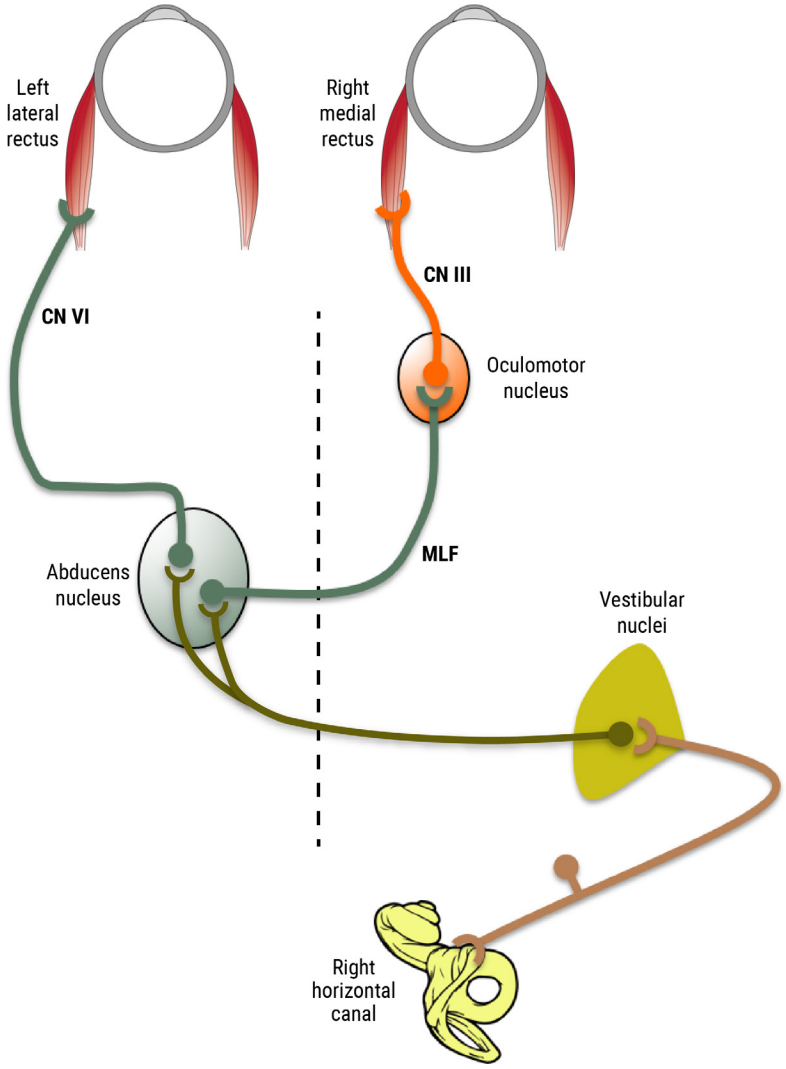
To complete the excercise below, review your lecture on the vestibular system along with the interactive module and video.

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 of the **right vestibular nuclei**.



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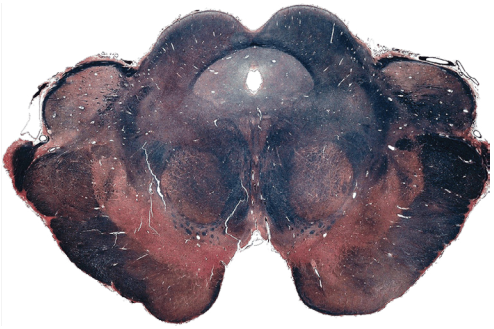
Micrograph Checklist

Micrographs (Web)

Midbrain

#11



- ◯ basis pedunculi (cerebral peduncle)
- ◯ oculomotor nucleus
- ◯ superior colliculus

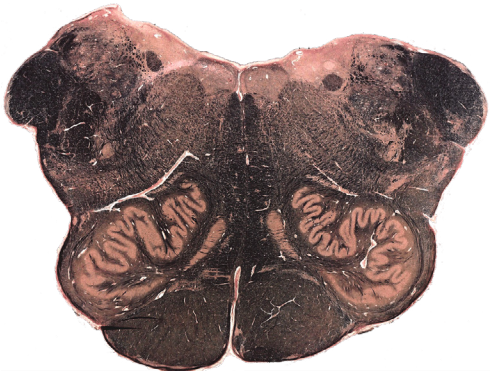
Pons

#7
#8
#10

- ◯ abducens nucleus
- ◯ 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 olive
- ◯ nucleus gracilis
- ◯ nucleus cuneatus
- ◯ pyramids

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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Instructional Design: Monika Fejtek
Medical Illustration Lead: Paige Blumer
Academic Lead: Claudia Krebs

Prosector: Lien Vo

Content Review: Esma Dilli