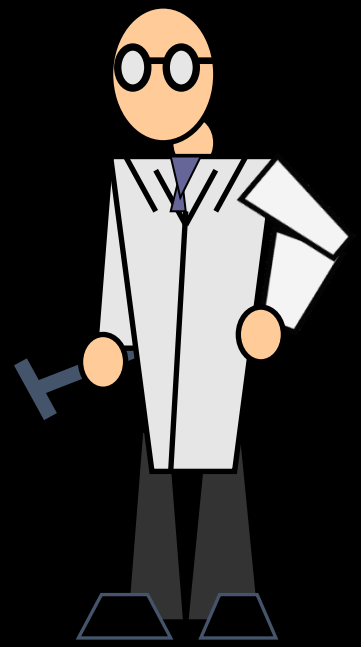
Approach to Localization

Sean J. Udow, MD, FRCPC

Assistant Professor, Section of Neurology

University of Manitoba

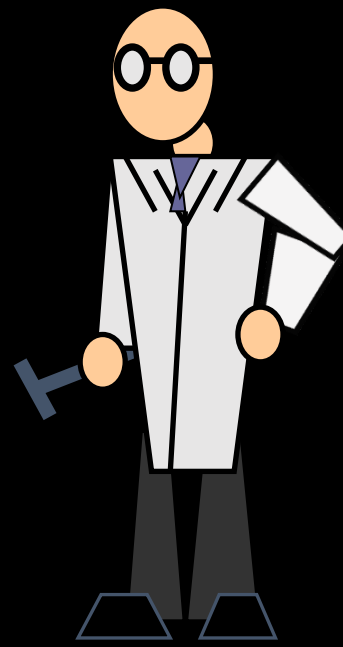
March 2, 2018



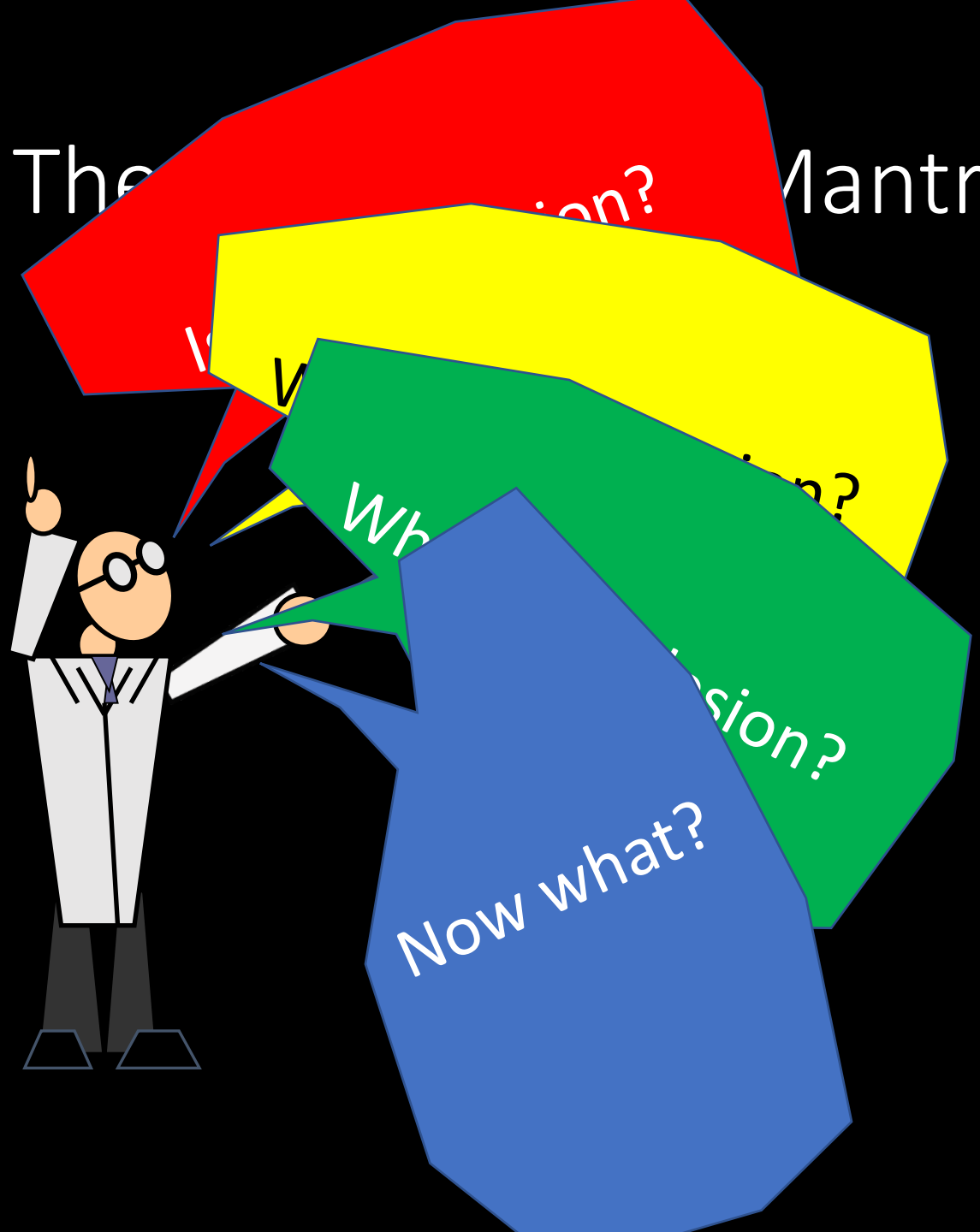
Objectives

- To review the anatomy of the nervous system
- To understand the relationship between clinical symptoms and signs and neuroanatomy
- To develop an approach to localization within the nervous system

- My goal – to help you refine neurological localization skills in 40 minutes
- Your goal – to keep up…



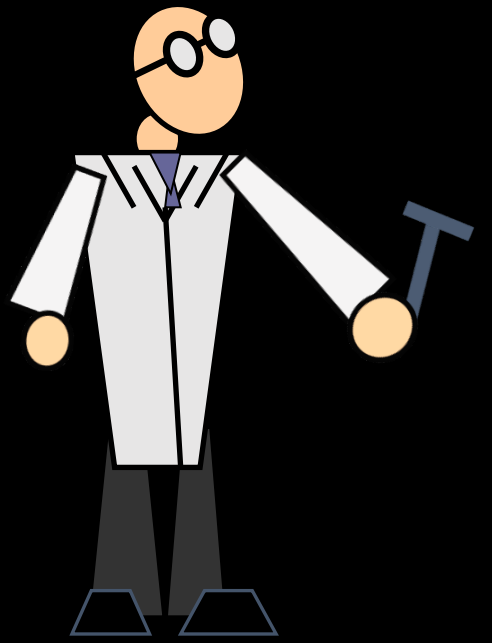
The Mantra:



Localization in Neurology

Where is the Lesion?

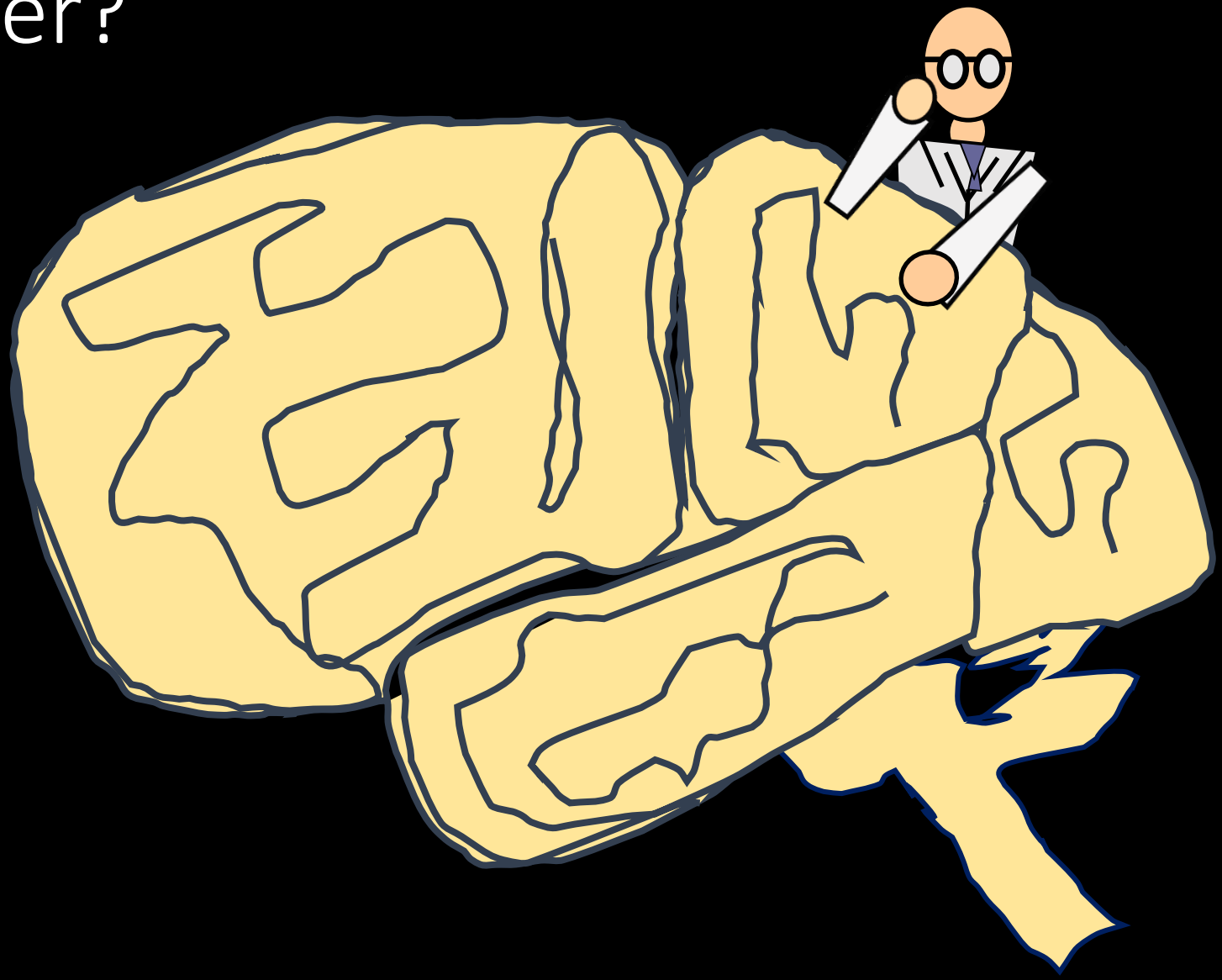
- Central or Peripheral?
  - Upper vs Lower Motor Neuron
- Peripheral:
  - Muscle, neuromuscular junction, nerve, plexus, root
- Central:
  - Spinal cord, brainstem, hemispheres
- Right or Left
- Diffuse, multifocal or focal



Why does it matter?

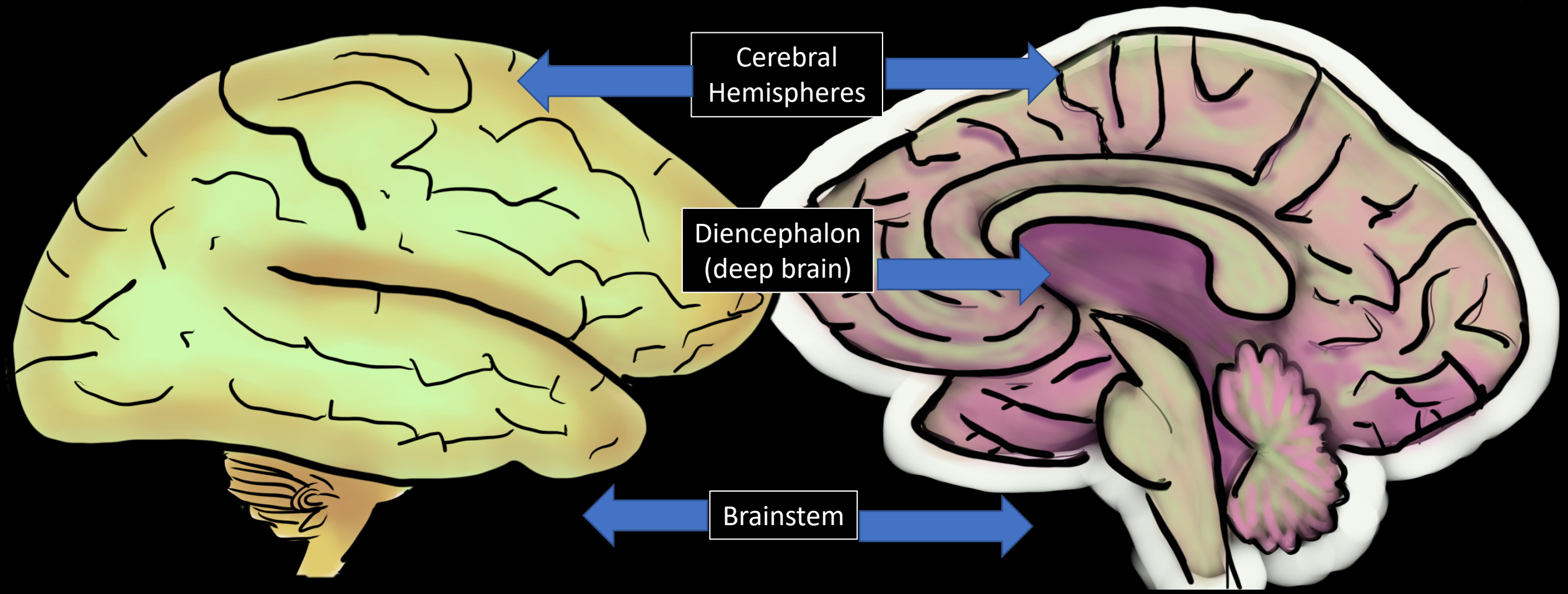
- To sound smart?
- Party trick?

- Guide differential diagnosis
- Inform investigations
- Correlate clinical presentation with diagnostic tests



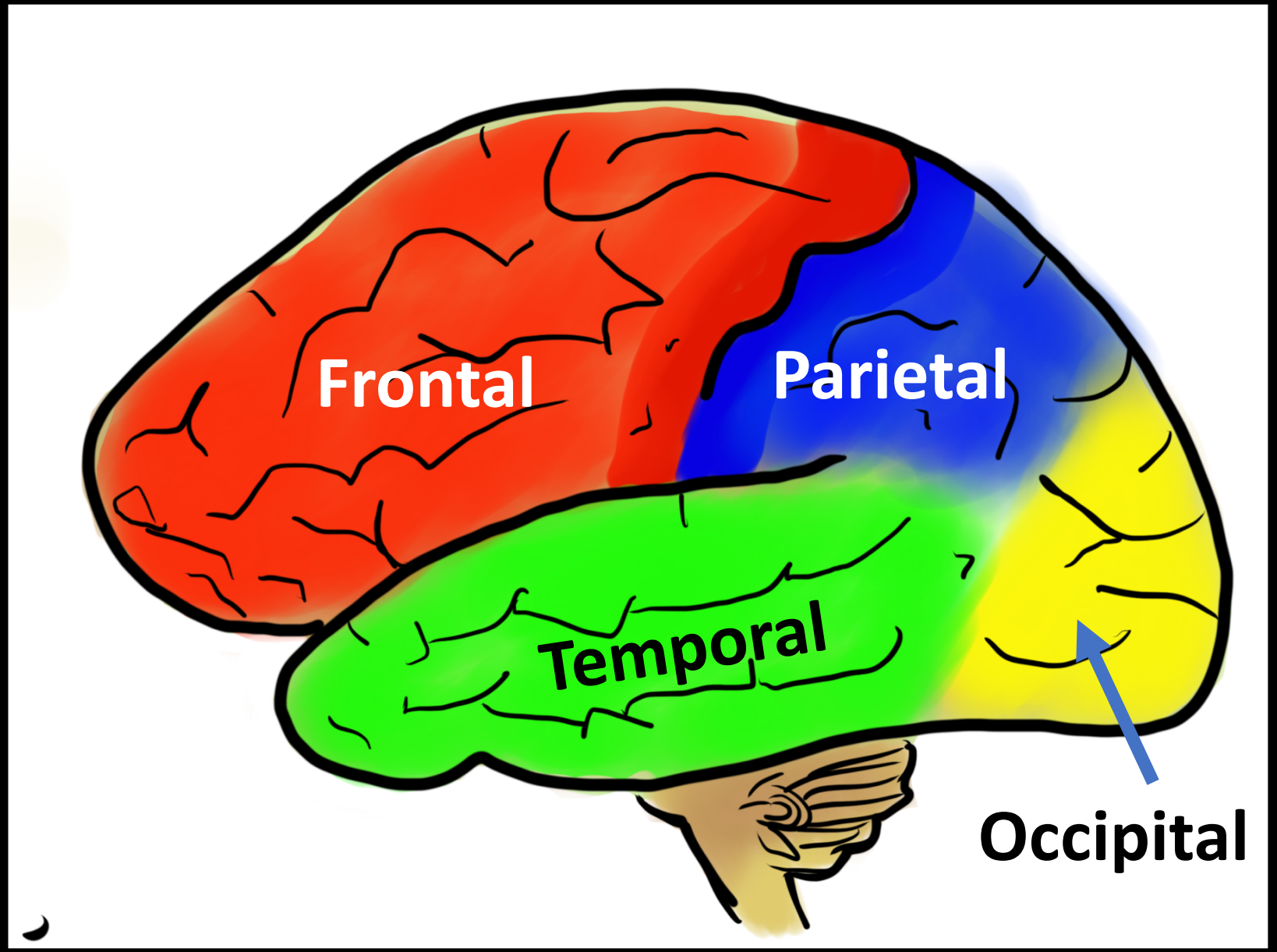
Neuroanatomy Review – The Brain

Neuroanatomy Review – The Brain

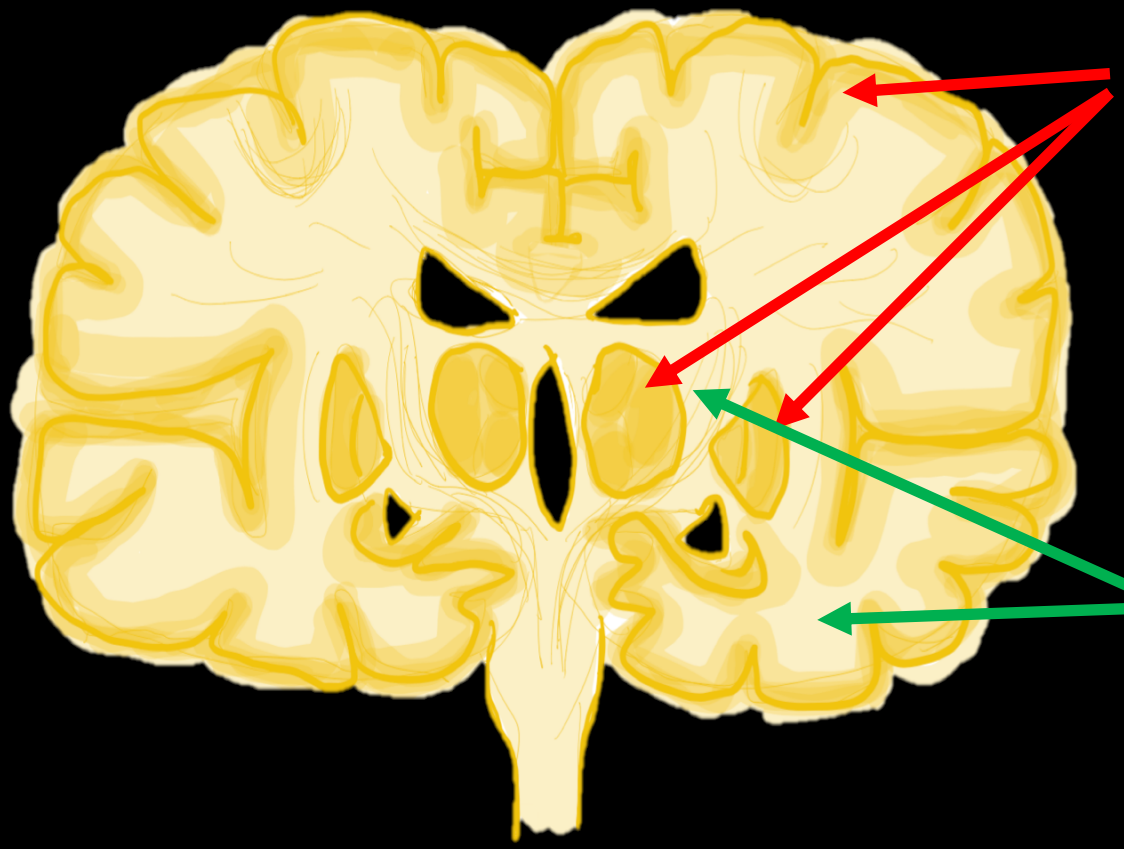



Thalamus
Midbrain
Pons
Medulla
Basal Ganglia
Cerebellum

Lobes of the Brain



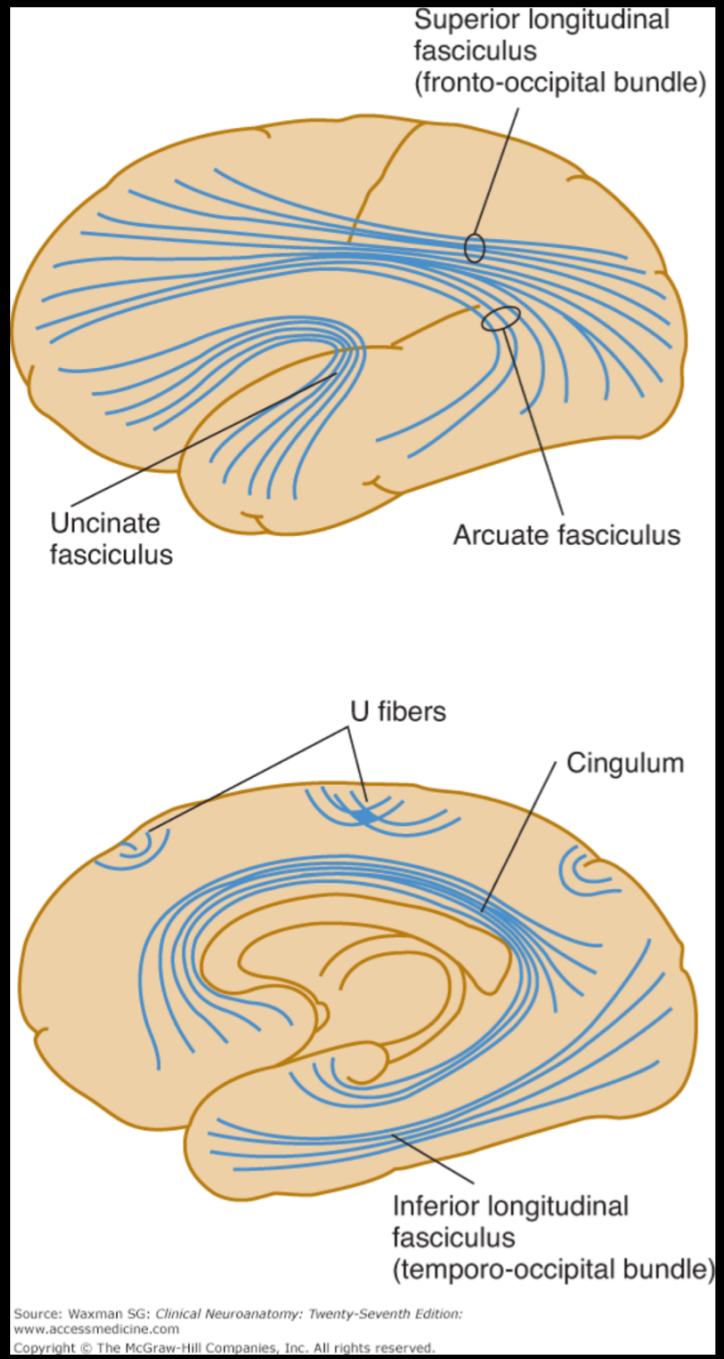
Gray & White Matter



Coronal view

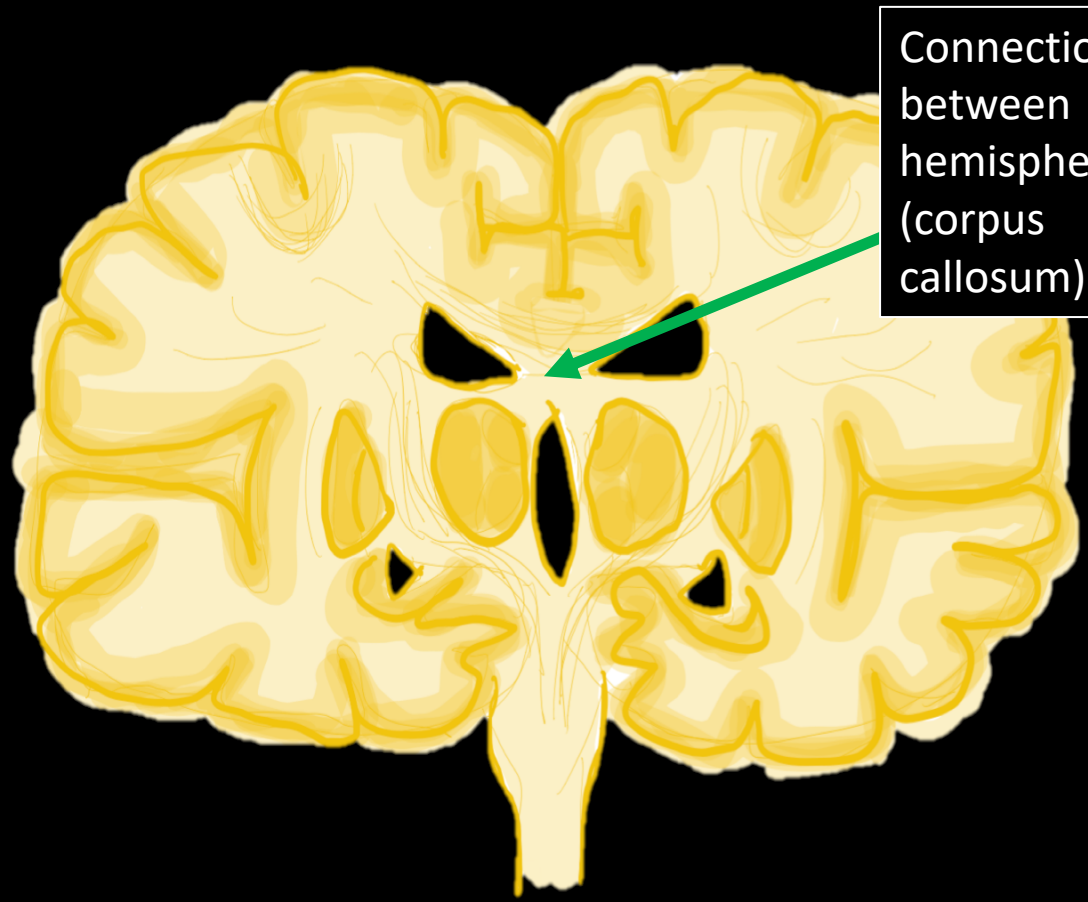
- Gray matter
  - Comprised primarily of the cell bodies of neurons and supporting glial brain cells
  - Synapses
  - Beginning and end of information transfer along neurons (home and office)
- White matter
  - Comprised of the projecting axons of neurons
  - Myelinated, so lighter in color
  - Connections between the beginning and end of neurons (the road)

White matter tracts connect parts of the brain:



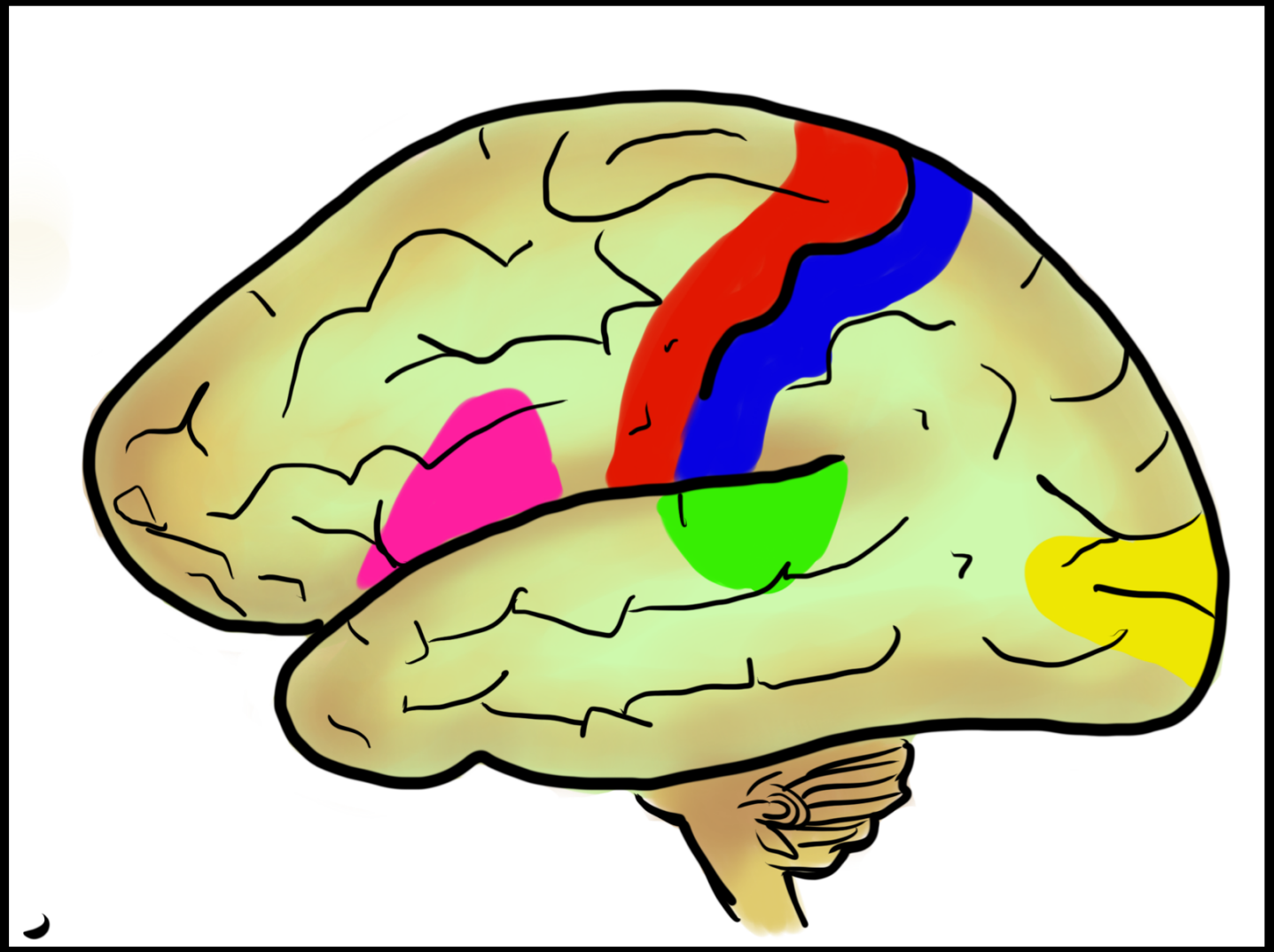
Connections between lobes of the same hemisphere

Connections between gyri



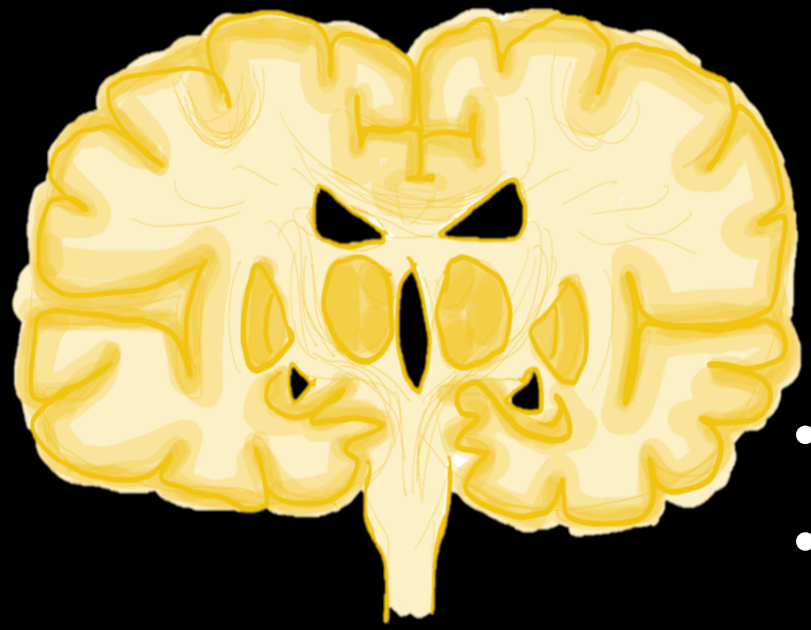
Connections between hemispheres (corpus callosum)

Cortical Function



Non-Dominant (usually right) Hemisphere Functions

- Prosody (emotion conveyed by tone of voice)
- Complex visuospatial skills
- Emotional significance to events and language
- Music perception
- Attention to both sides of the world

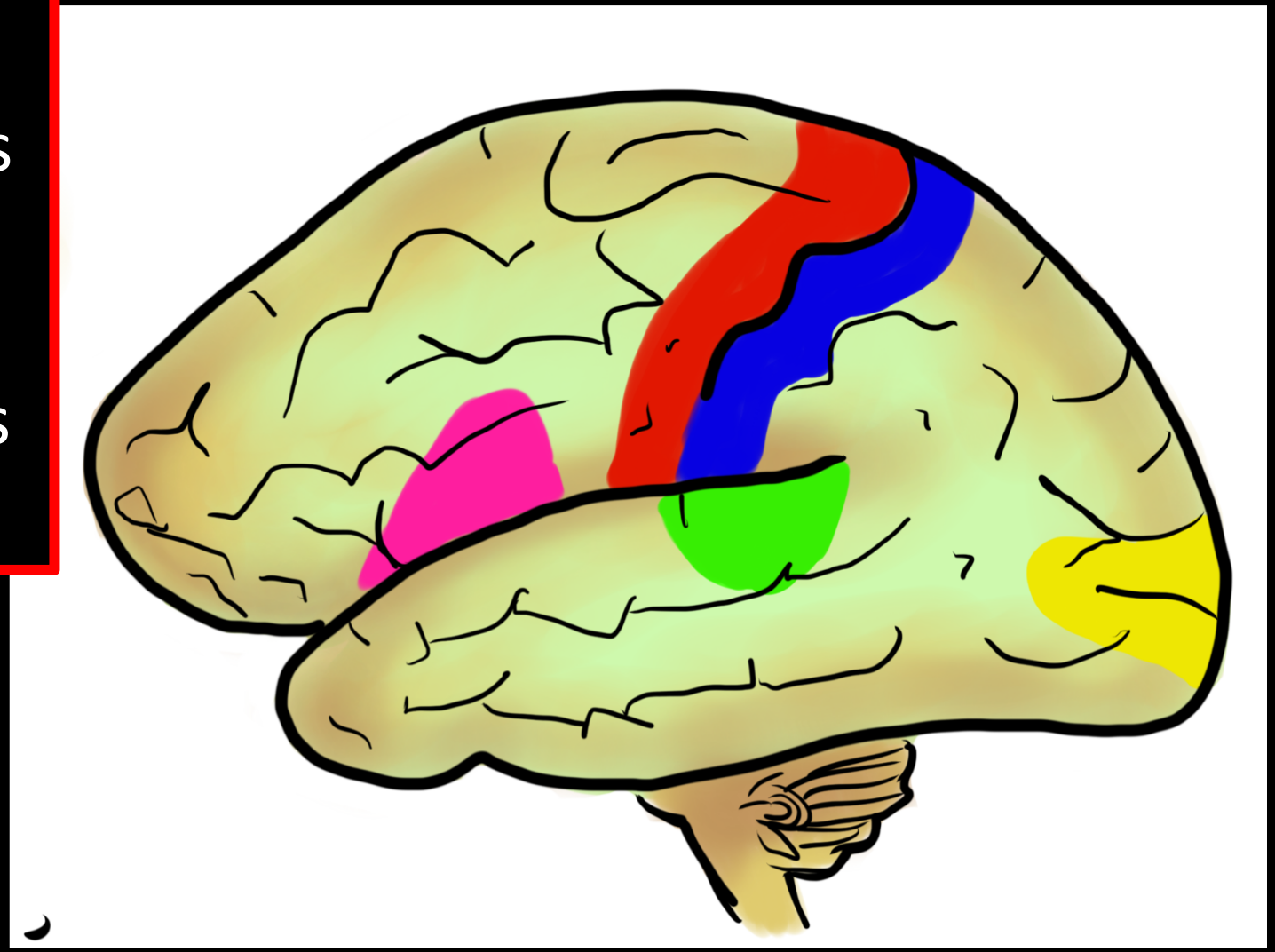


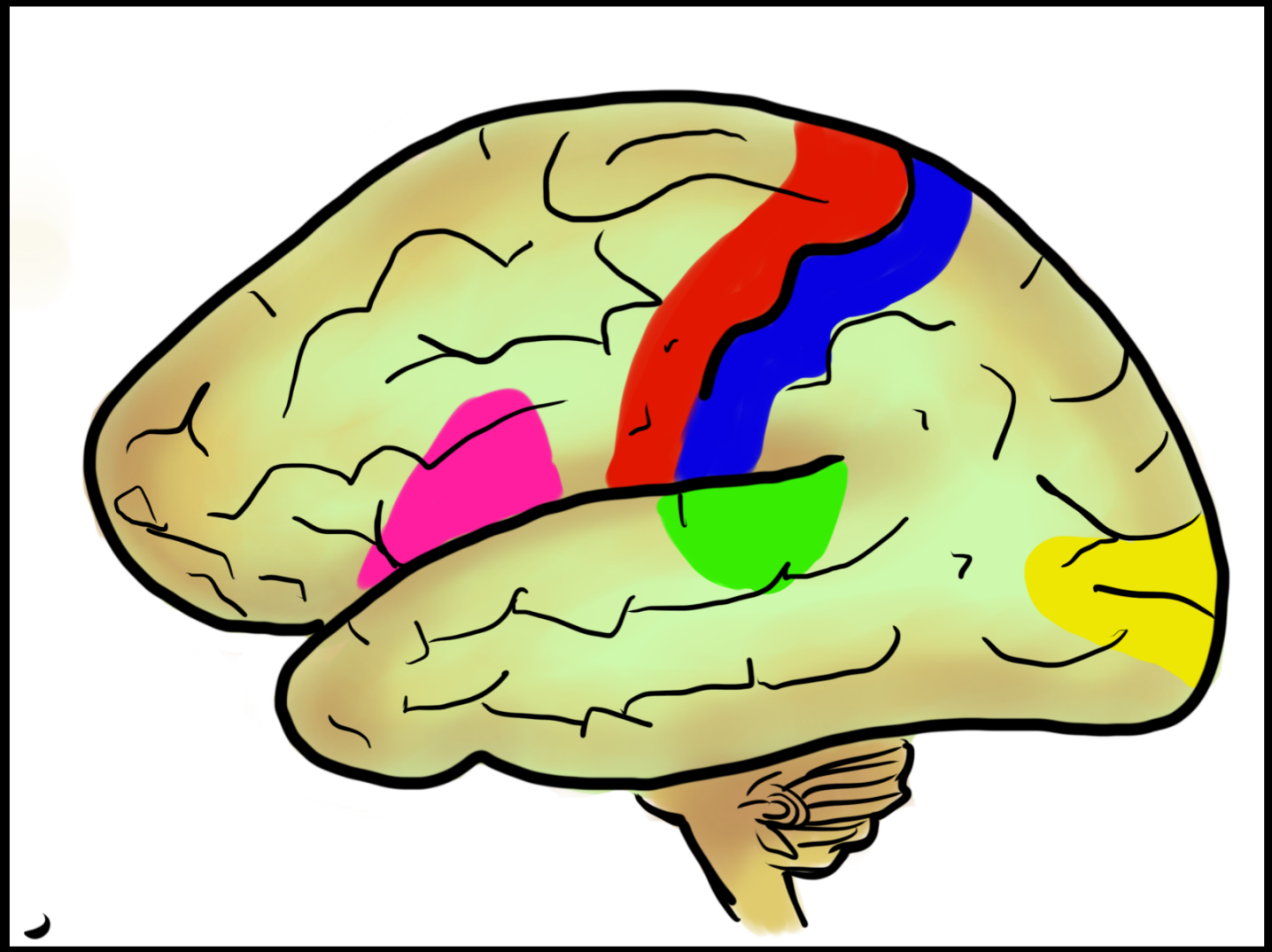
Dominant (usually left) Hemisphere Functions

- Language
- Skilled motor formulation (praxis)
- Attention to the right side of the world

FRONTAL LOBE

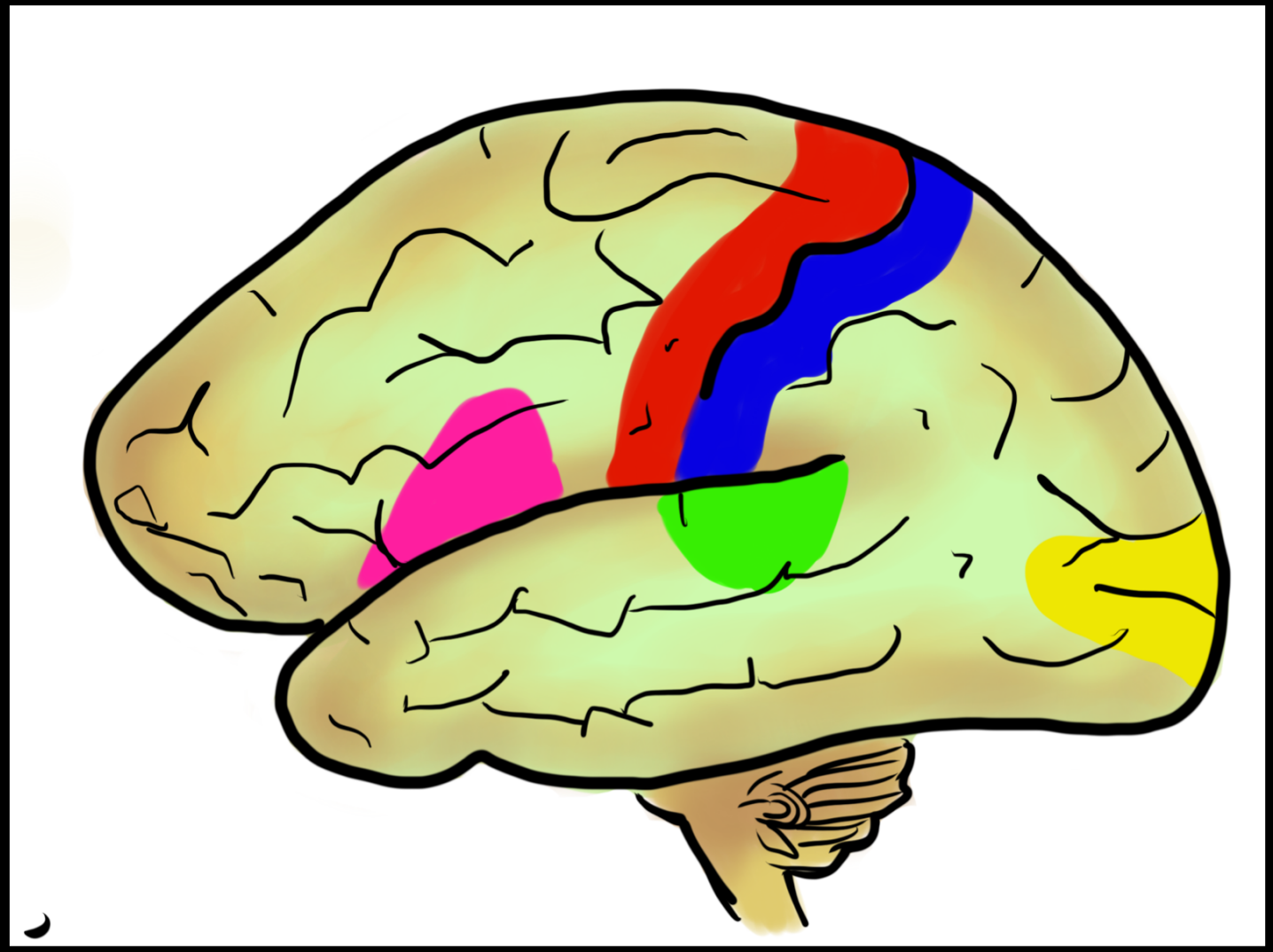
- “Action & inaction”
- Primary motor cortex
- Motor association areas
- Motivation
- Inhibition of inappropriate behaviors
- Expressive language (L)





PARIETAL LOBE

- "Surveys the Environment"
- Primary sensory cortex
- Sensory association area
- Attention (R>L)
- Praxis



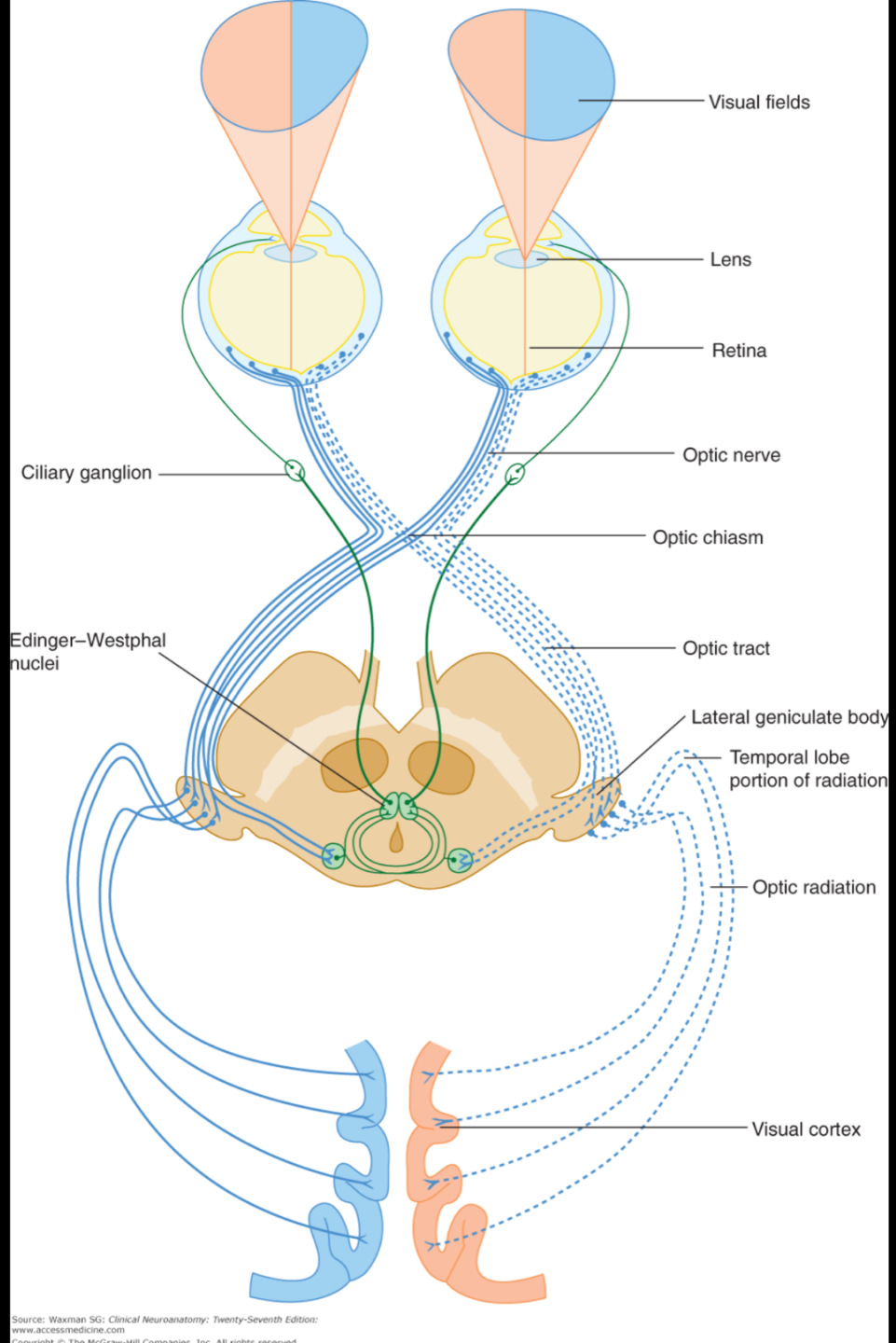
OCCIPITAL LOBE

- “Vision”
- Primary visual cortex

Primary Visual Cortex

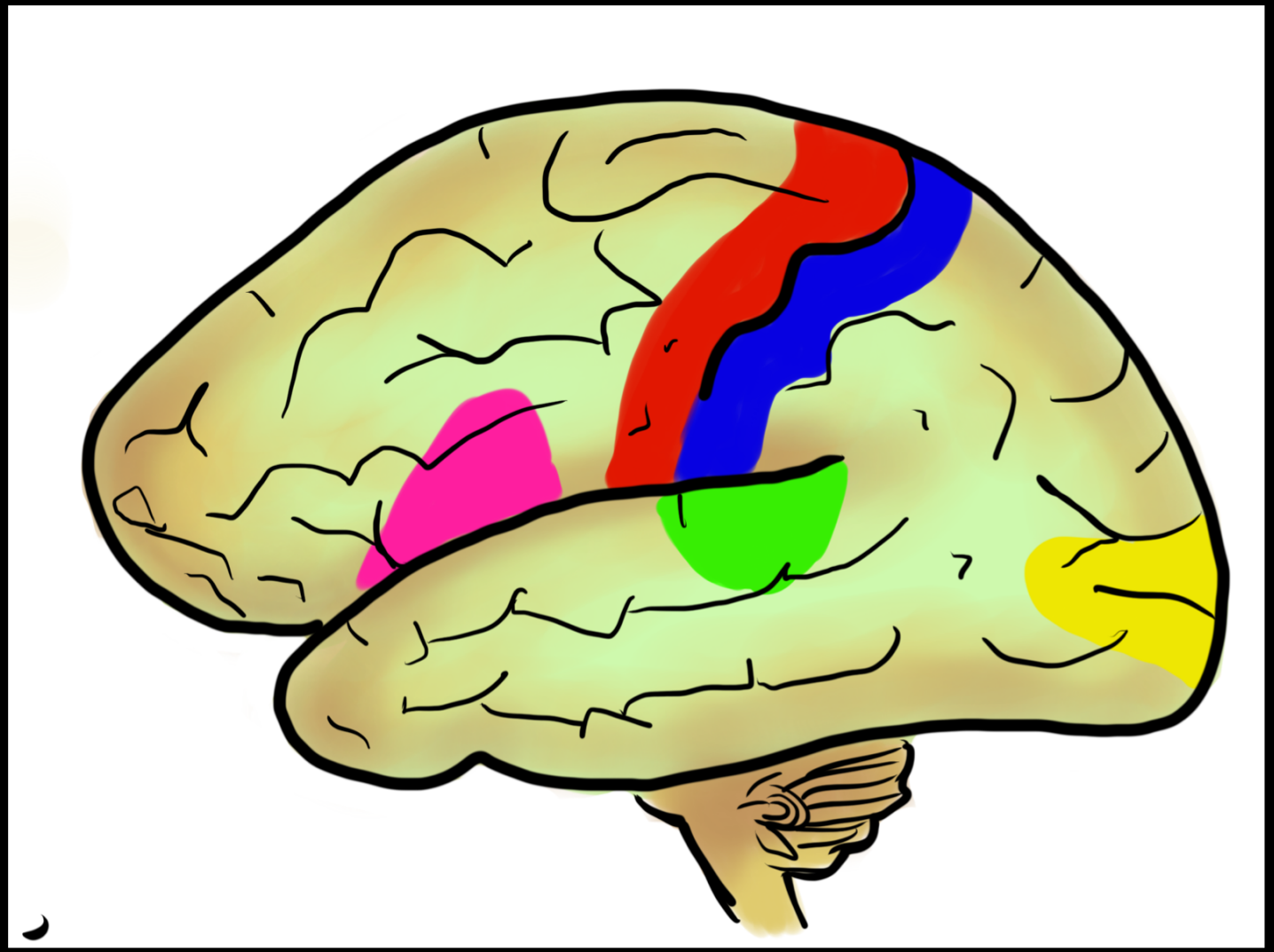
- Receives inputs from the retina
- → optic nerves
- → thalamus (lateral geniculate body)
- → white matter tracts (optic radiations)
- To the primary visual cortex

- Lesion of **unilateral primary visual cortex causes contralateral hemianopia**



TEMPORAL LOBE

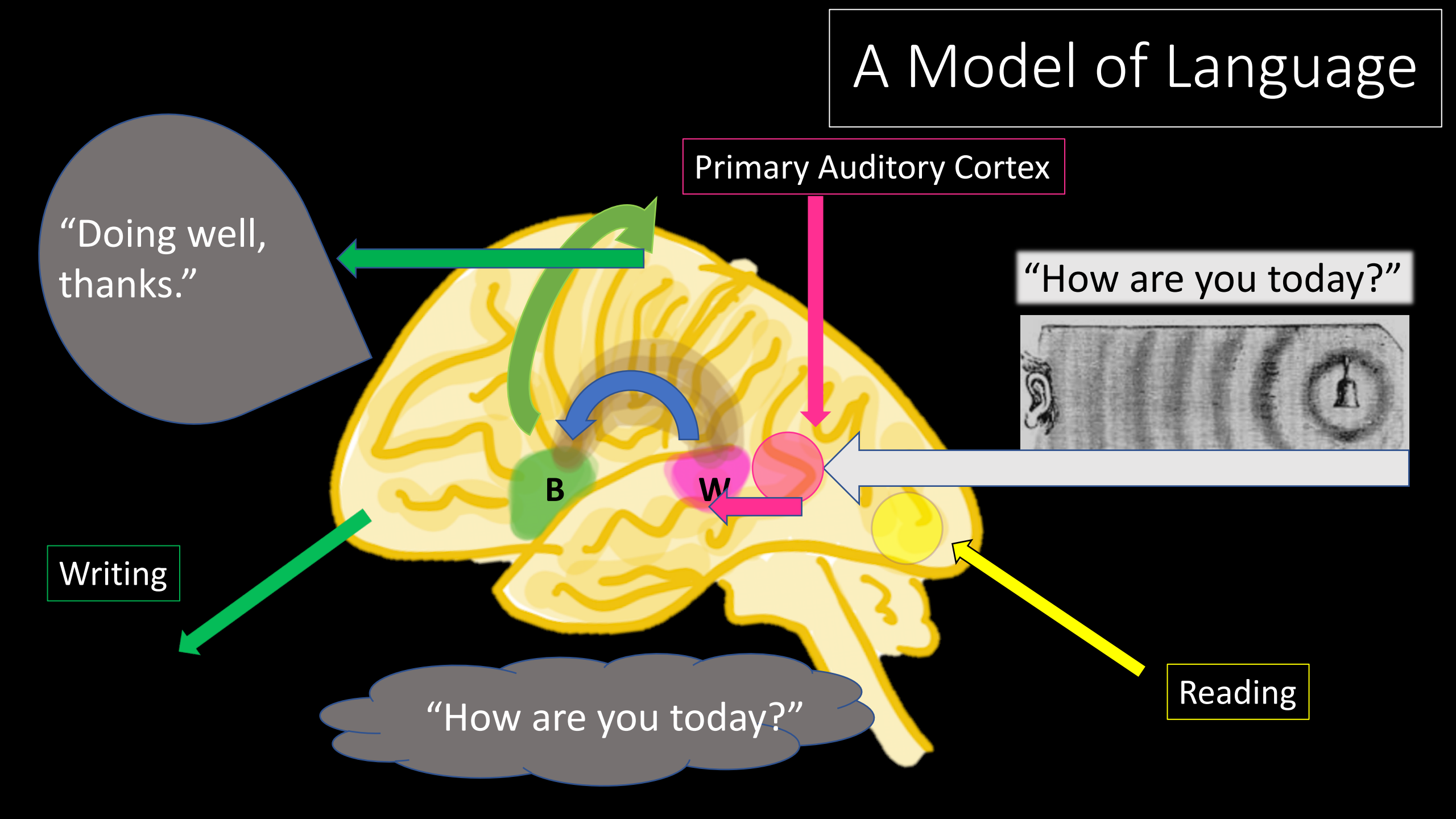
- "Special"
- Special senses bilaterally represented:
  - Smell, taste, sound
- Language comprehension (L)
- Memory
- Limbic system – emotions, homeostasis



Areas involved in language

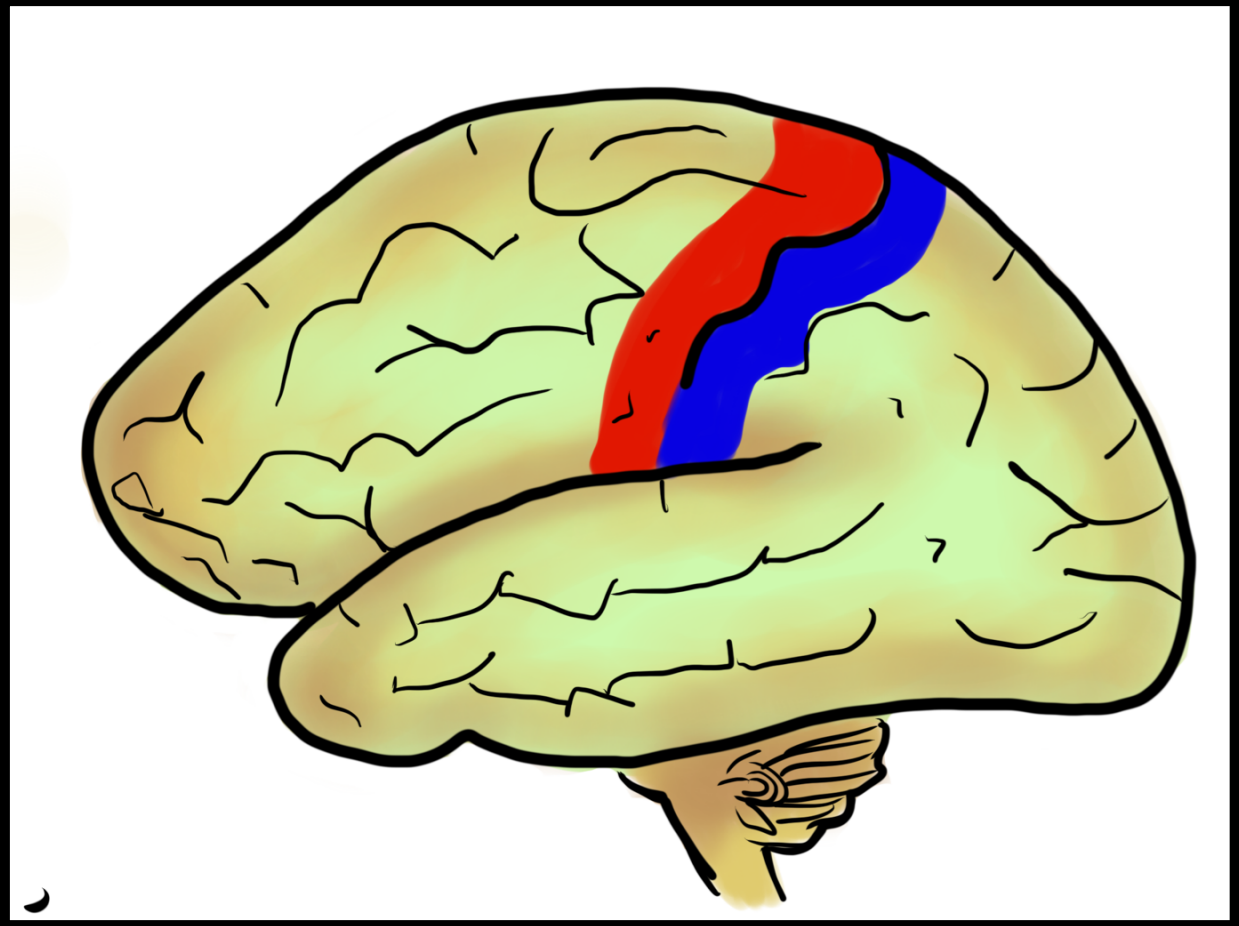
- Broca’s area – language production
- Wernicke’s area – language comprehension
- Arcuate fasciculus – connects the two

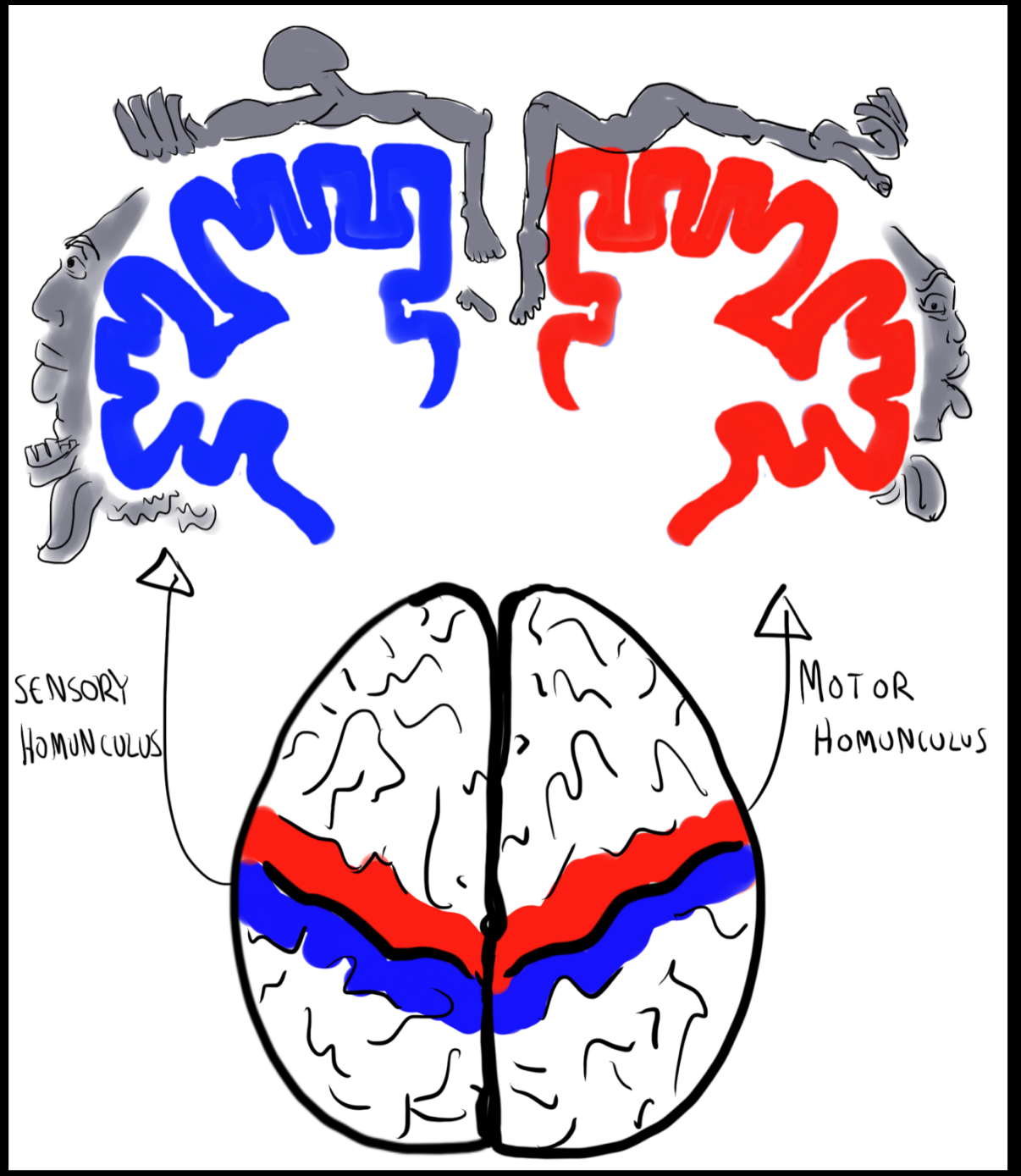
A Model of Language



Language Domain	Broca's Aphasia	Wernicke's Aphasia
SPONTANEOUS SPEECH	Nonfluent	Fluent with paraphasic errors
COMPREHENSION	Intact	impaired
NAMING	Impaired	Impaired
REPETITION	Impaired	Impaired
READING	Often impaired	Impaired for comprehension
WRITING	Impaired	Normal
ASSOCIATED SIGNS	Right hemiparesis, right hemisensory loss	Right hemianopia

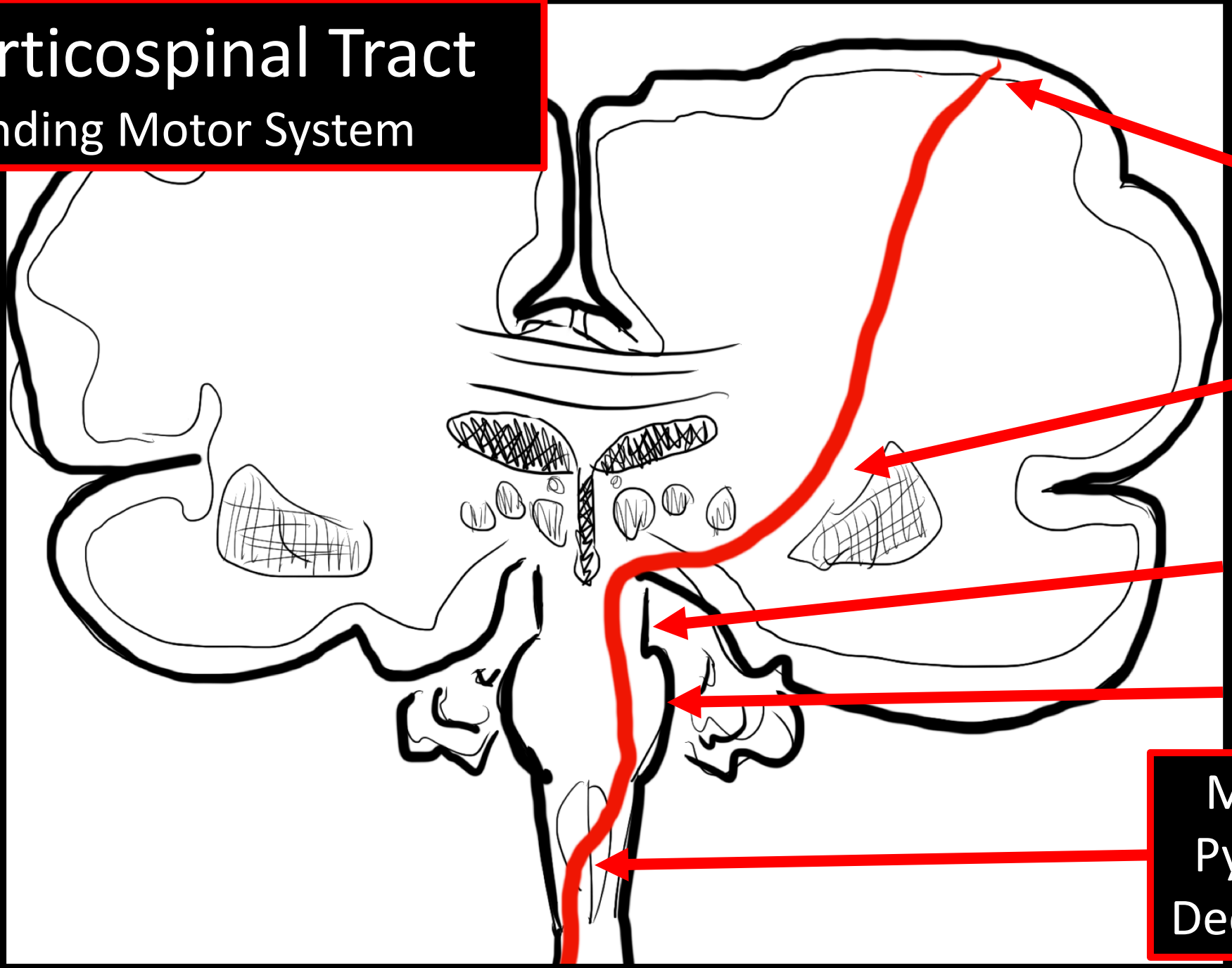
Motor and Sensory Systems

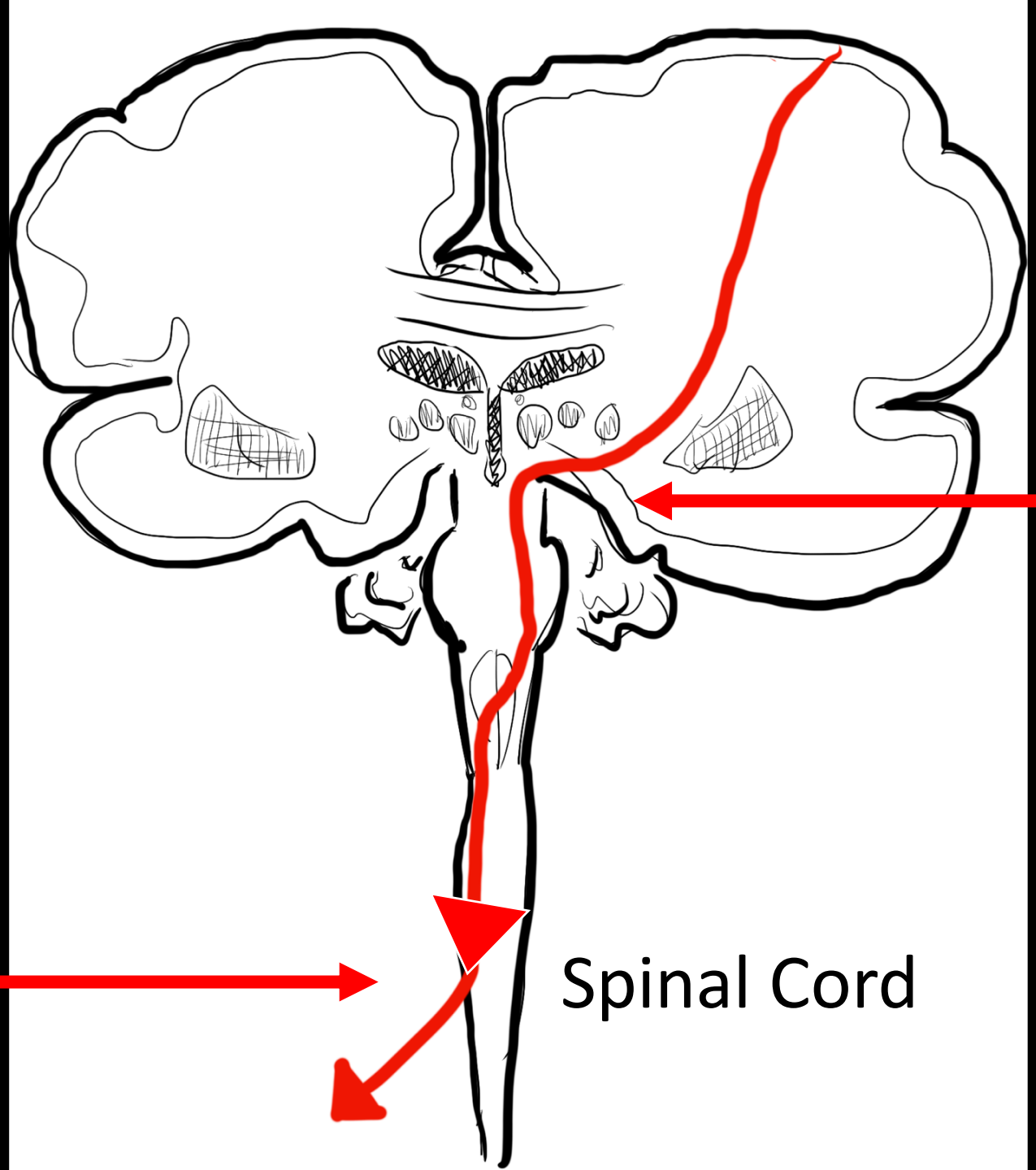




The Corticospinal Tract

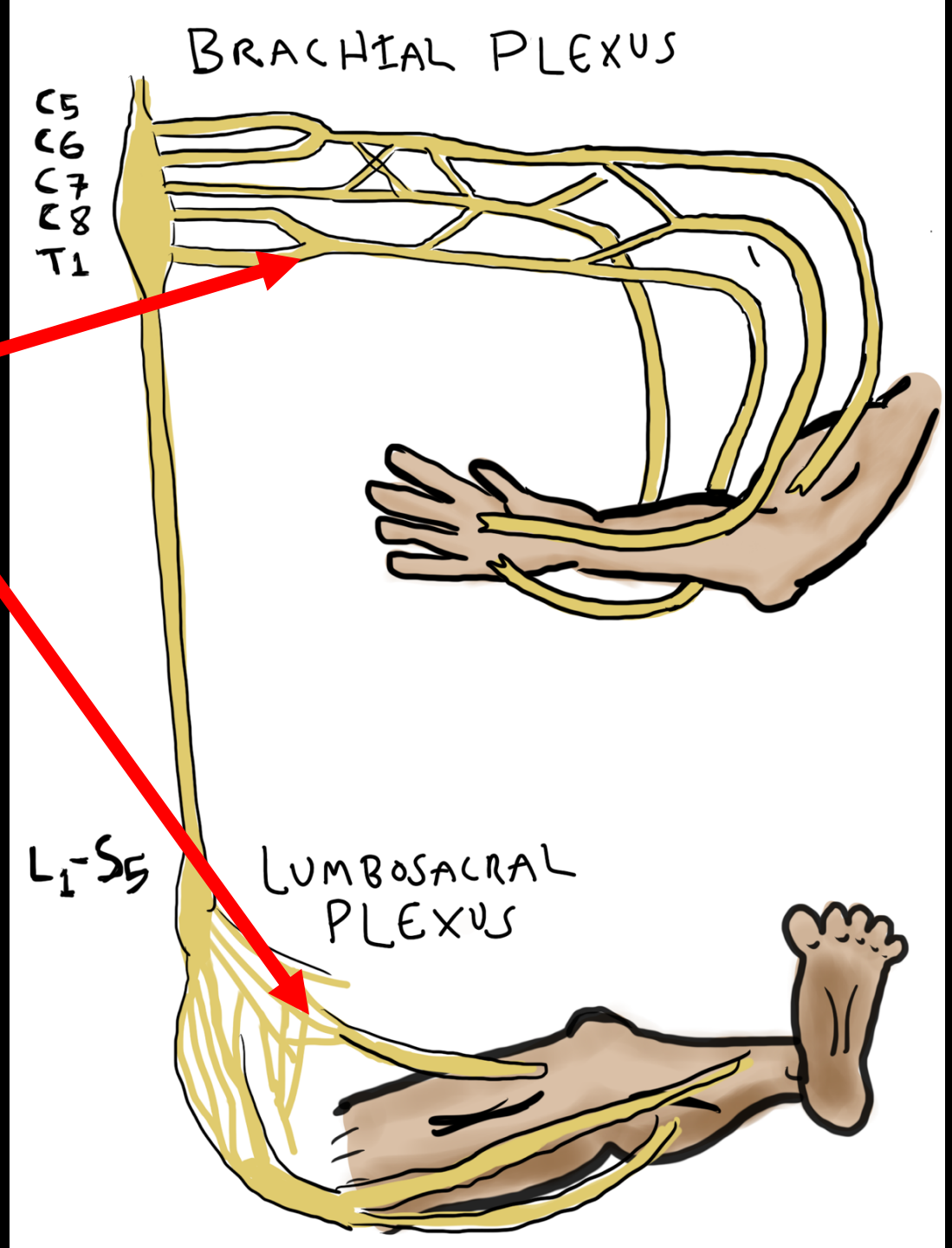
Descending Motor System

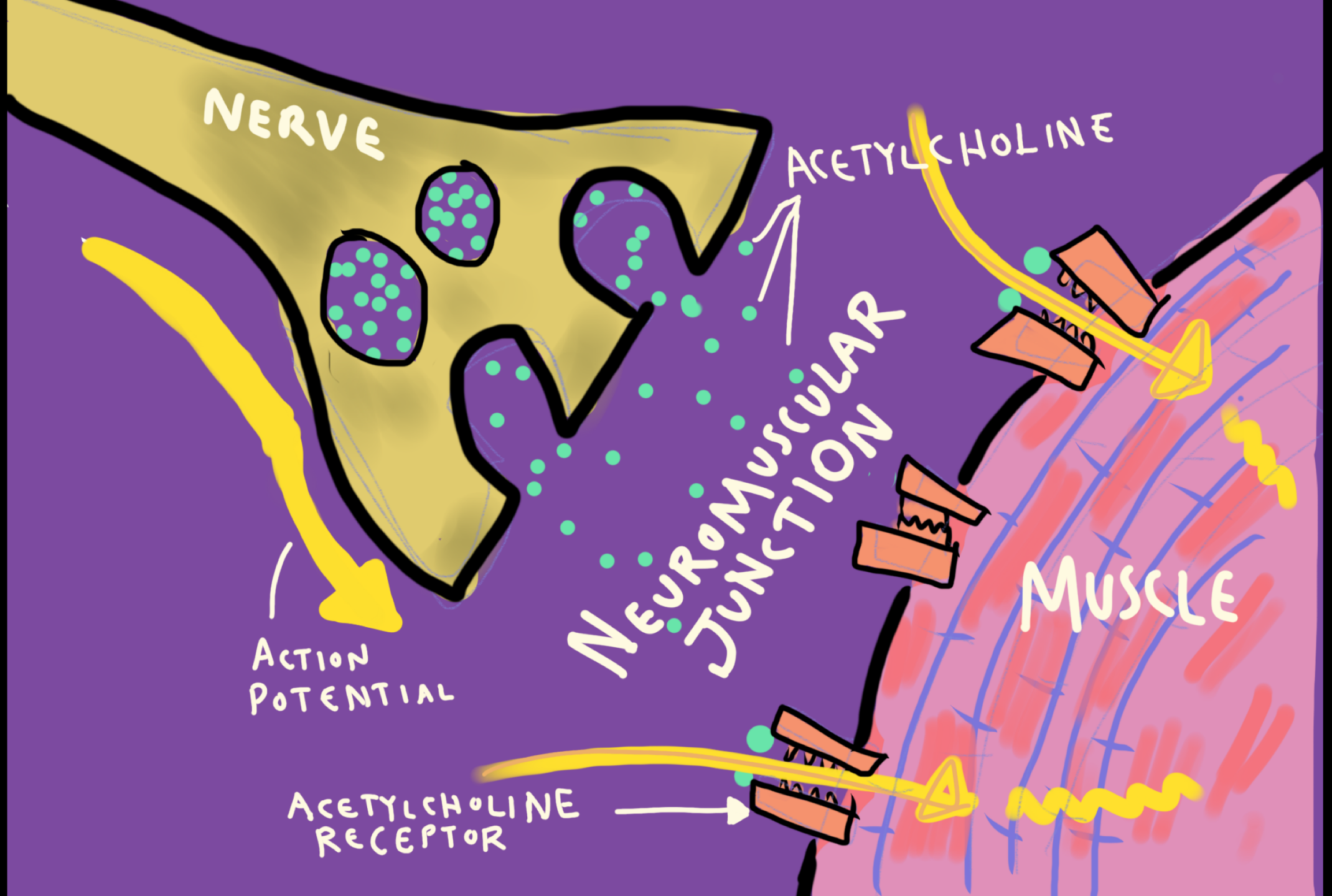



Upper
Motor
Neuron
Lower
Motor
Neuron
Spinal Cord

Lower Motor Neurons

Connect the spinal cord to the muscle

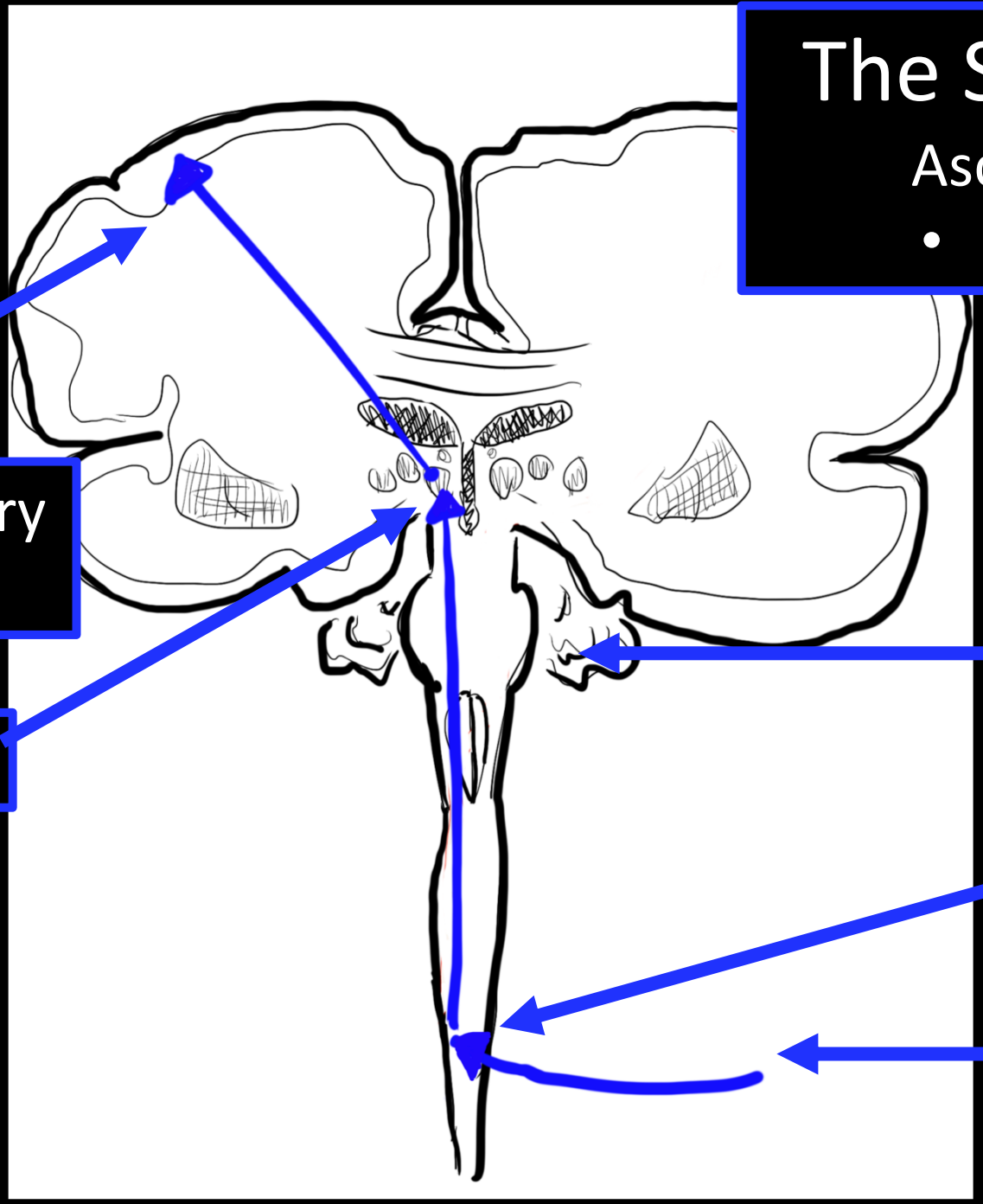



NERVE
ACETYLCHOLINE
NEUROMUSCULAR JUNCTION
MUSCLE
ACTION POTENTIAL
ACETYLCHOLINE RECEPTOR

The Spinothalamic Tract

Ascending Sensory System

- Pain and Temperature



Somatosensory Cortex

Thalamus

Ascends in spinal cord

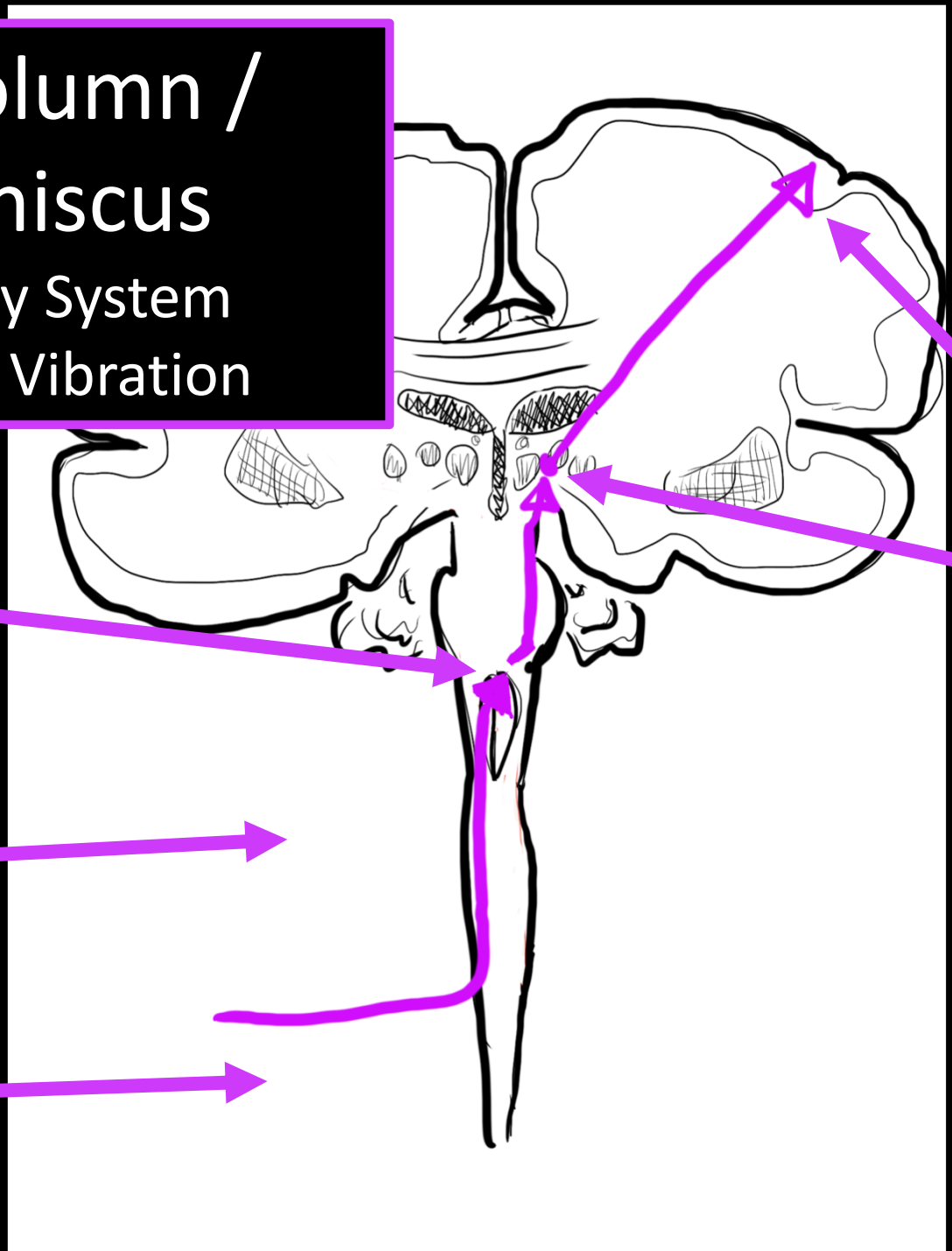
Decussation in Spinal Cord

Sensory Nerve

The Dorsal Column / Medial Lemniscus

Ascending Sensory System

- Proprioception, Vibration



Somatosensory Cortex

Thalamus

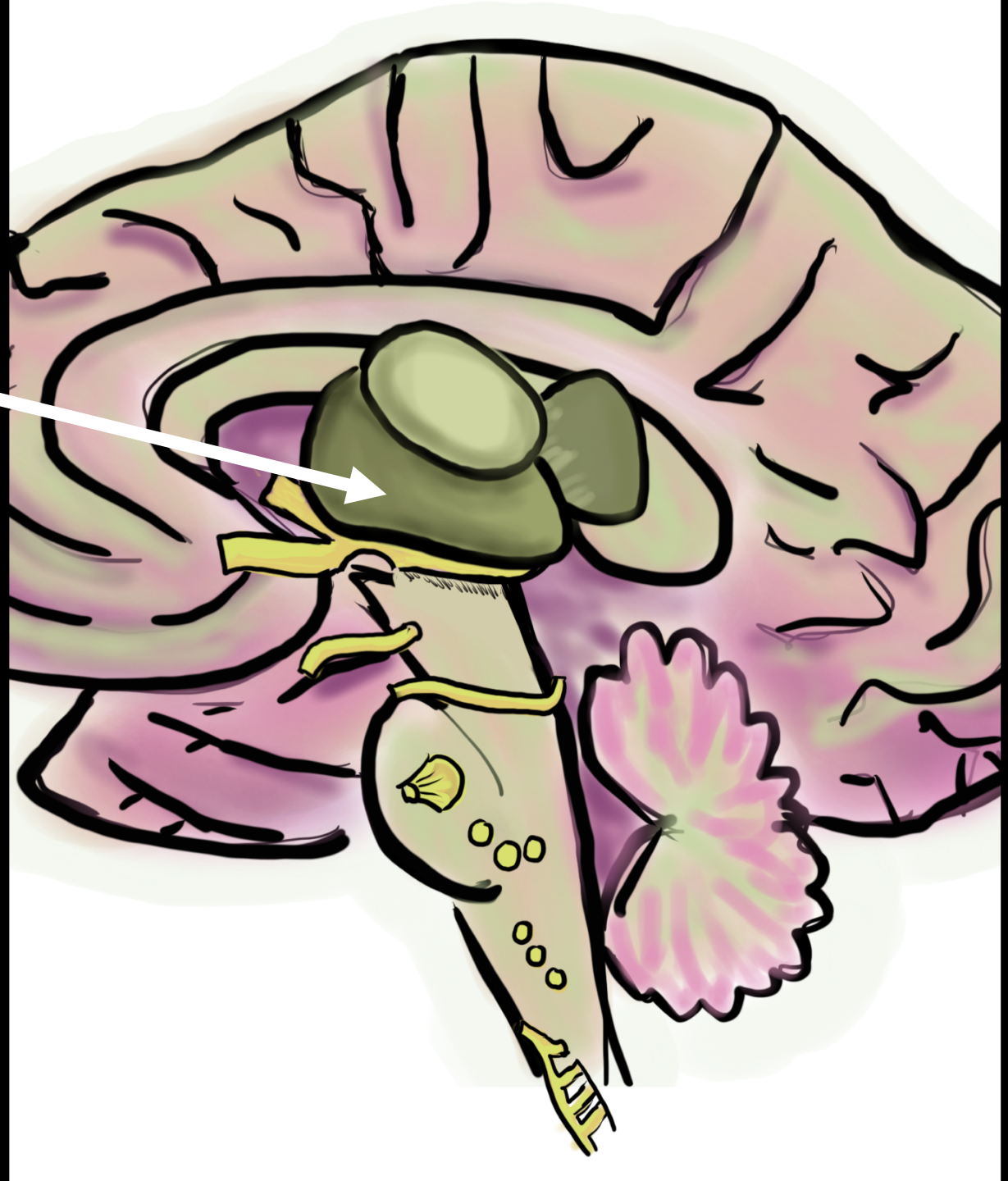
Decussation in Superior Medulla

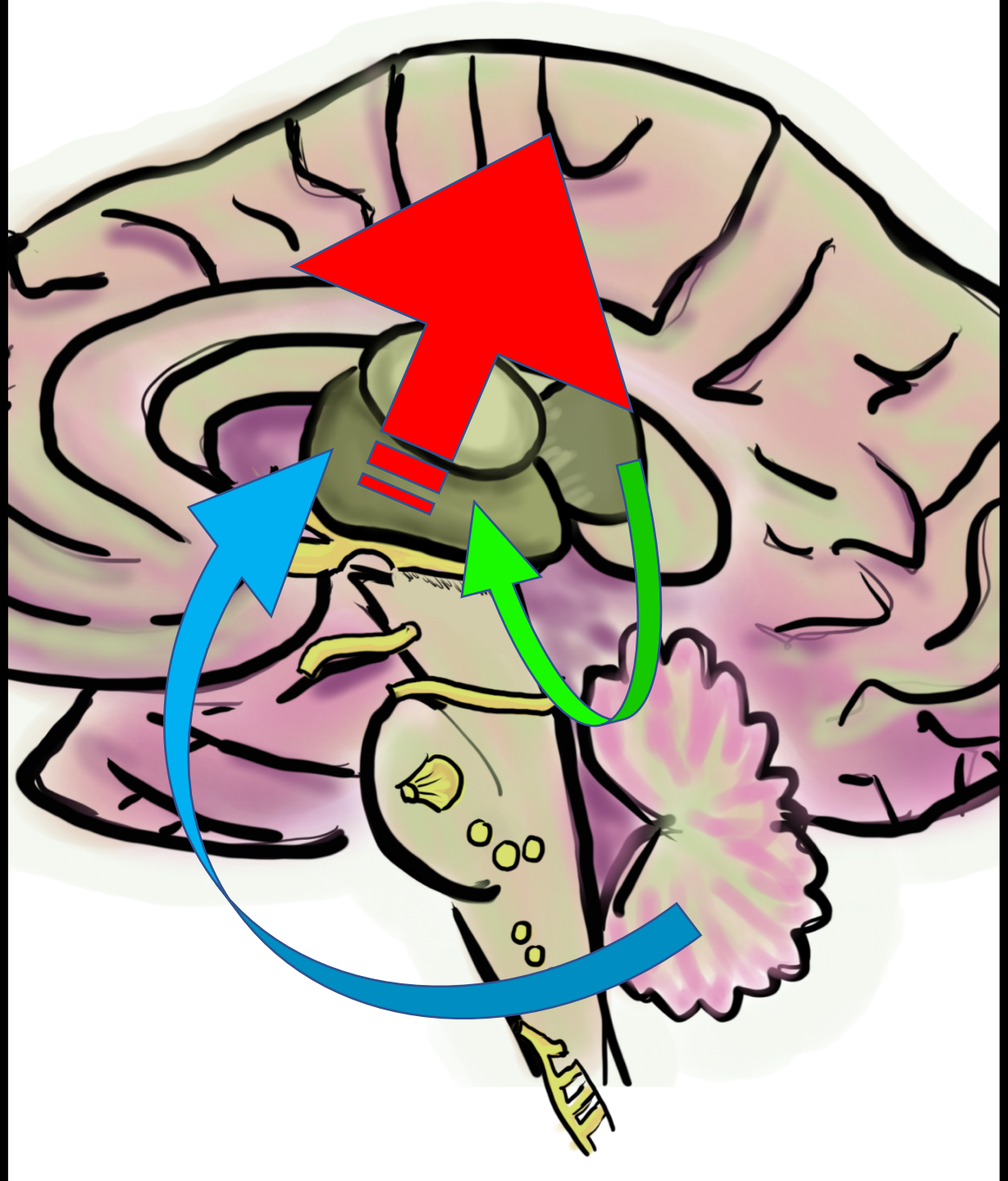
Ascends in ipsilateral spinal cord

Sensory Nerve

Thalamus

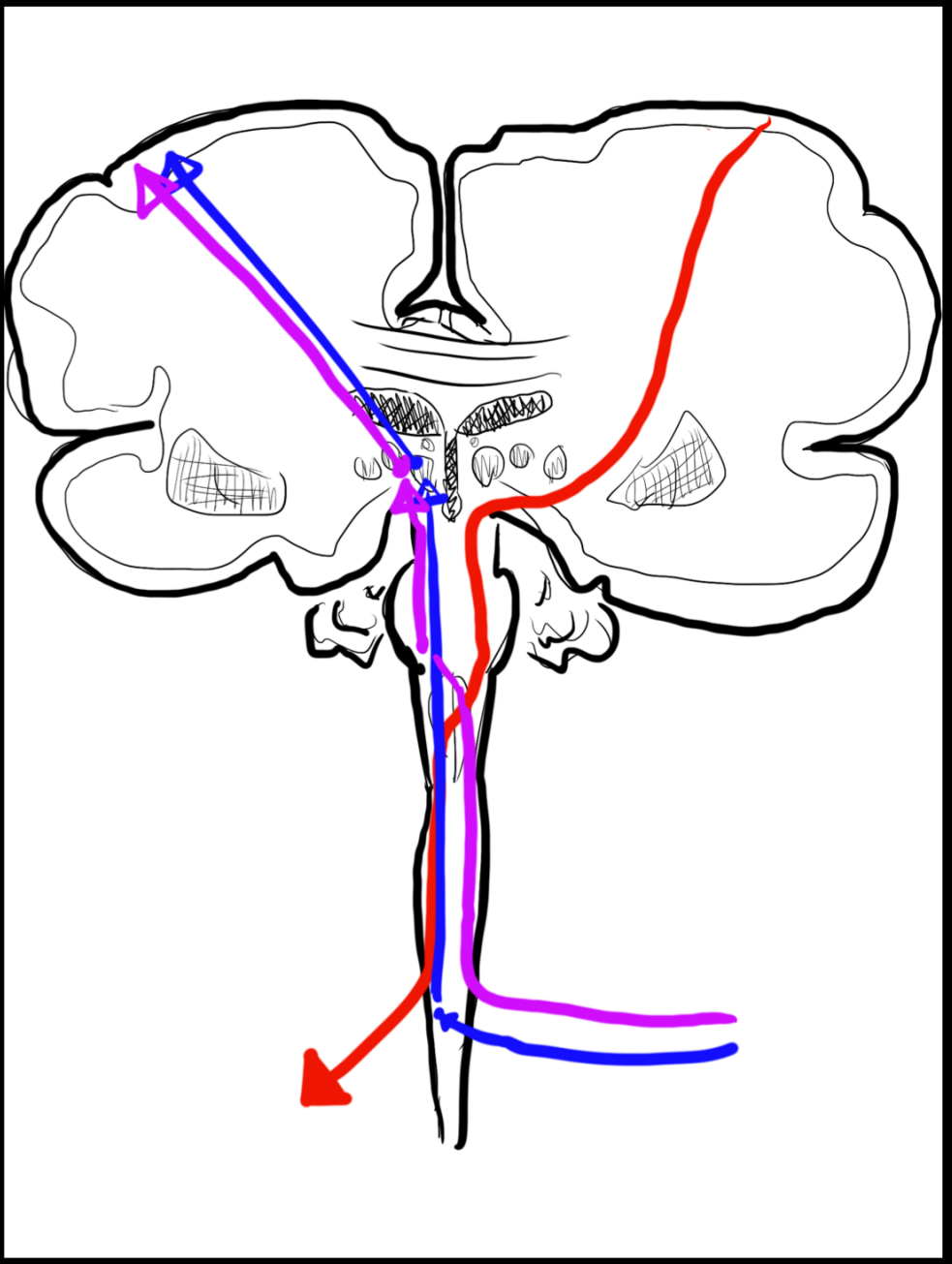
- ‘Secretary’ for cerebral cortex
- Receives sensory input & passes it to the cortex
- Involved in consciousness
- Involved in motor control



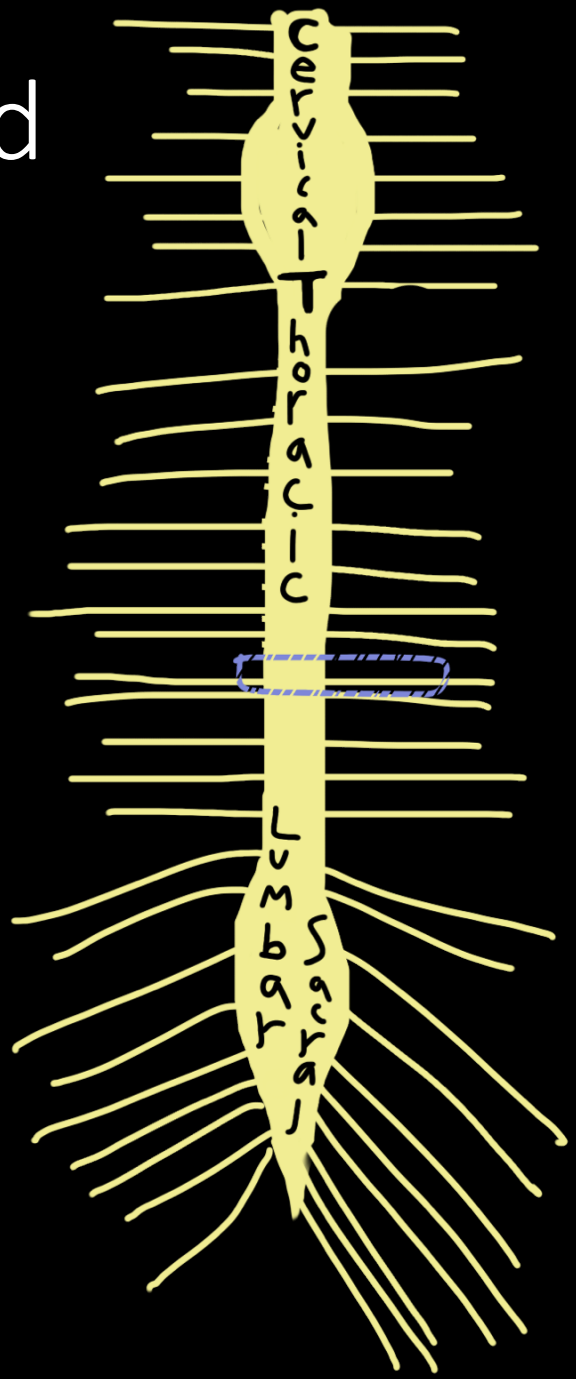


Motor Control

- Thalamus receives input from
  - Cerebellum
  - Basal ganglia
  - Relays information to motor cortex
- Basal ganglia
  - Complex circuit
  - Involved in motor initiation



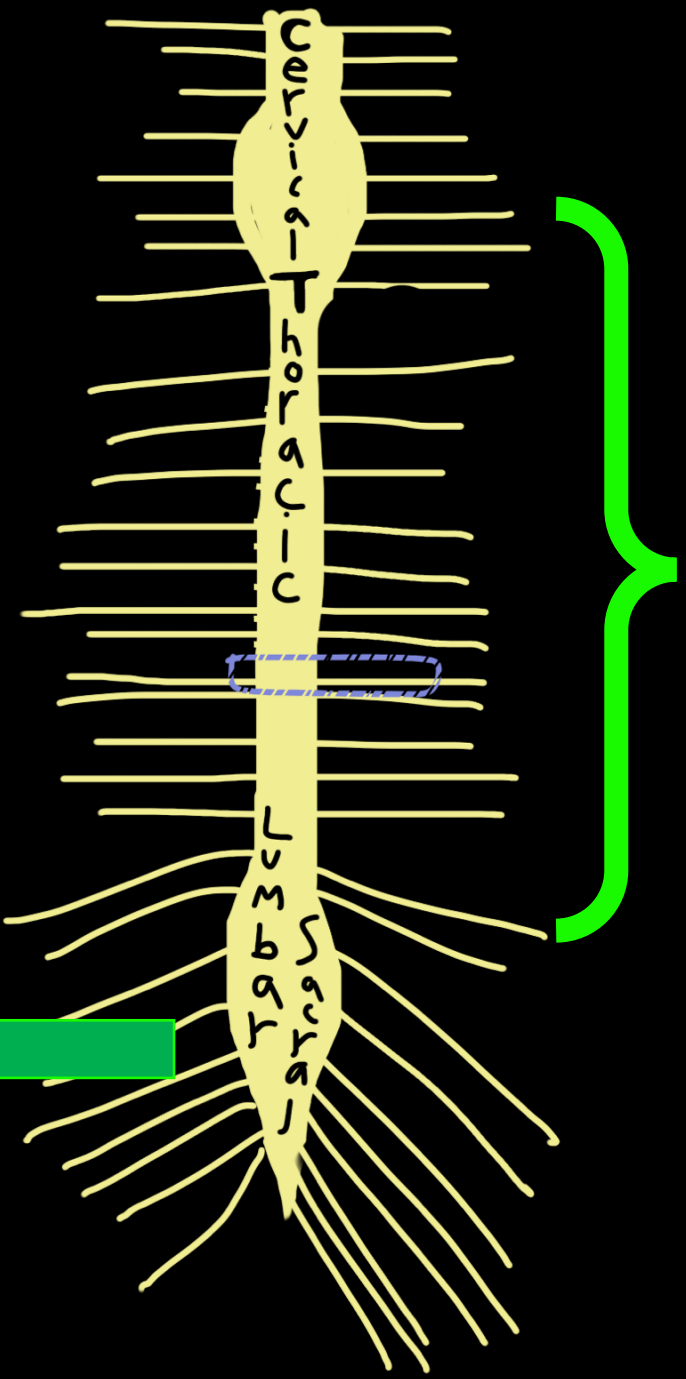
The Spinal Cord



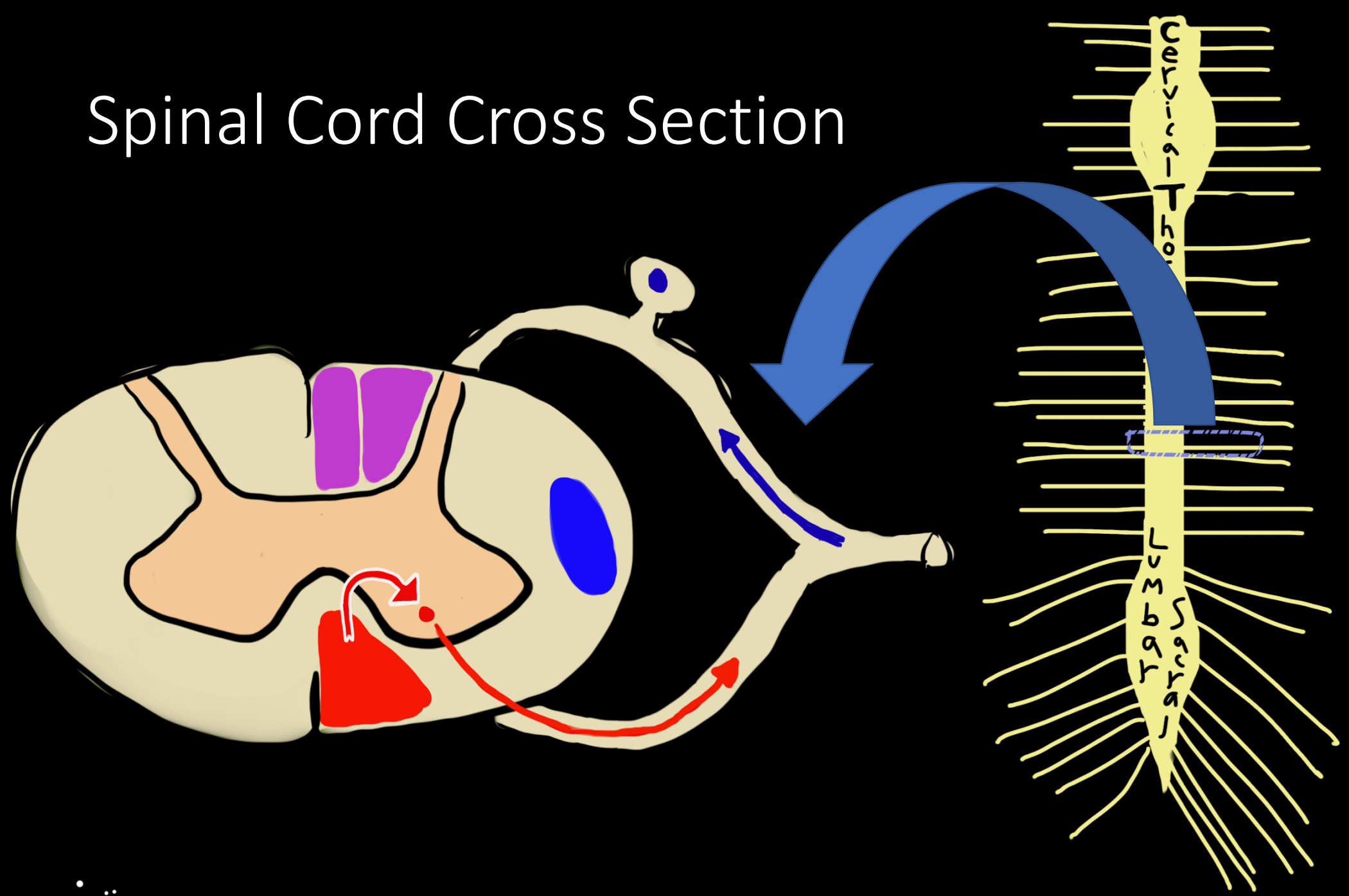
The Spinal Cord – Autonomic output

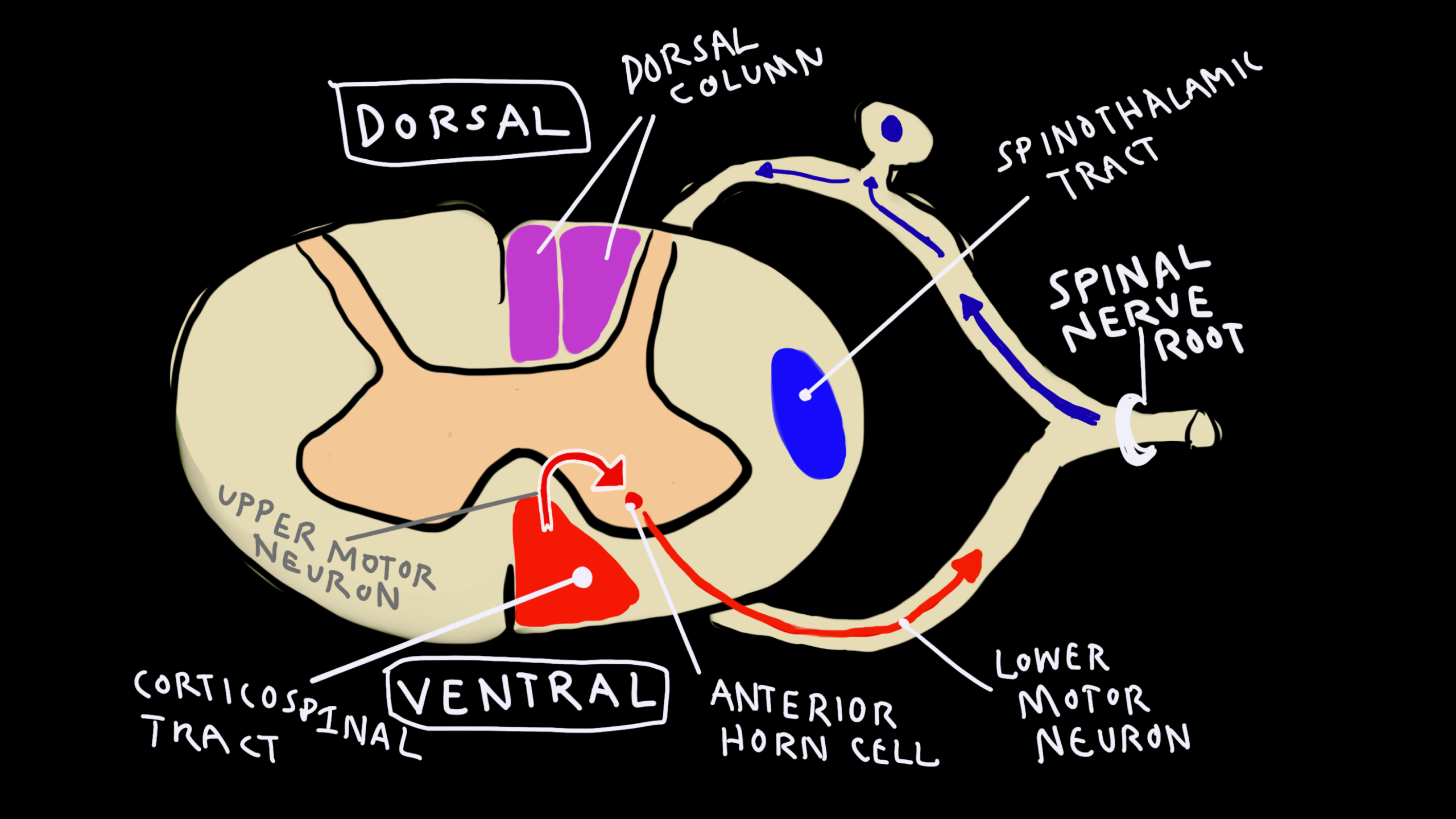
Sympathetic Output

Parasympathetic:
GI / GU

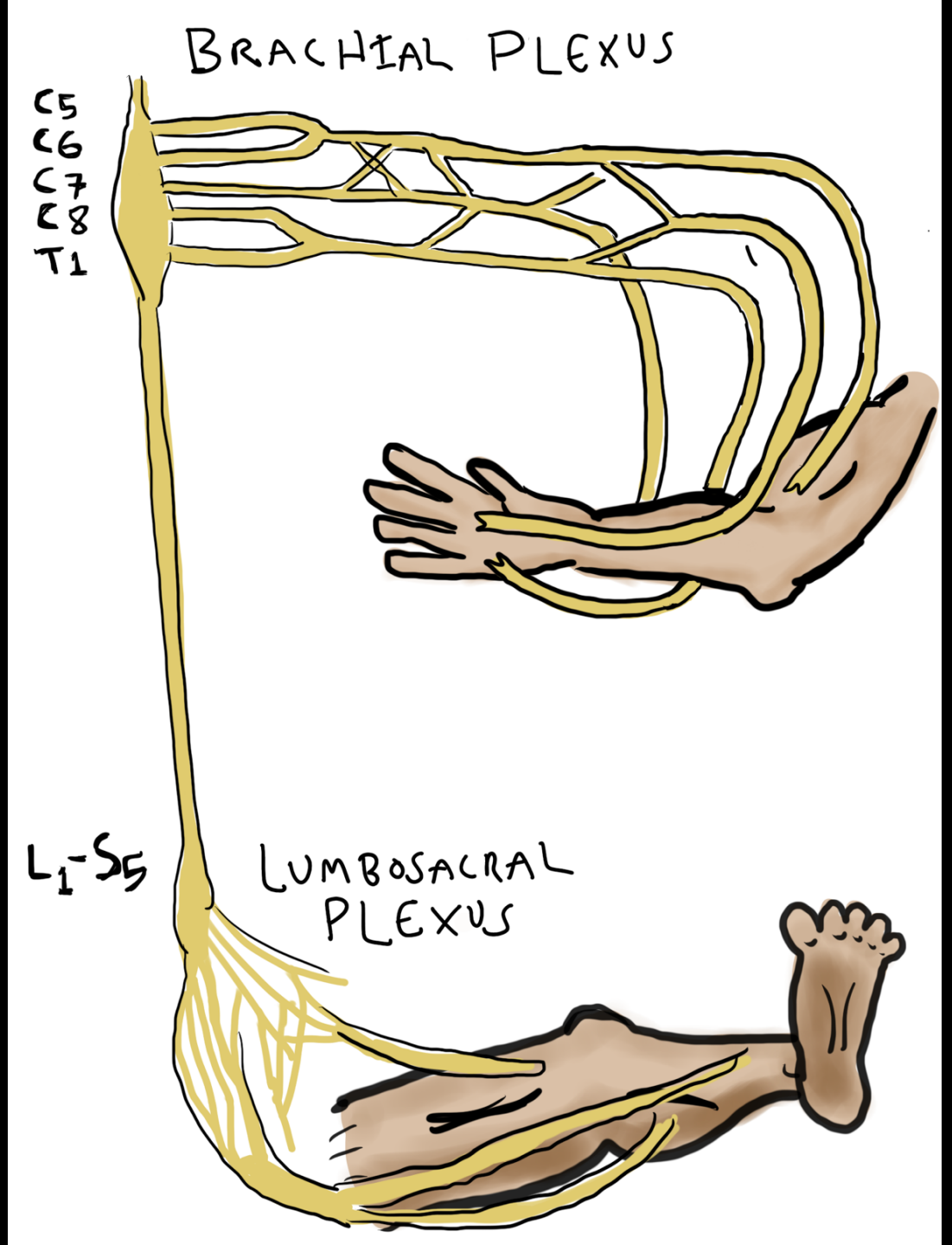


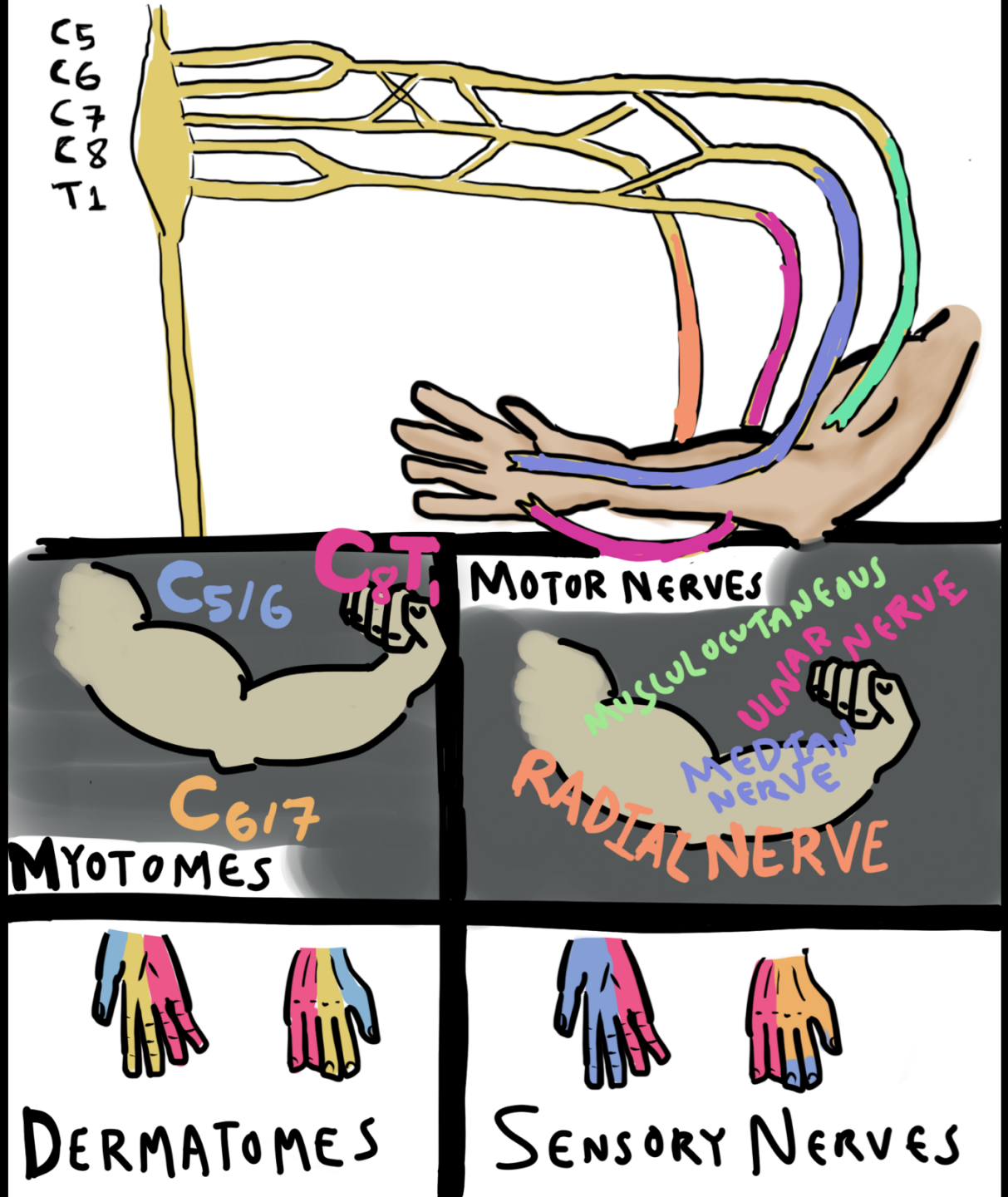
Spinal Cord Cross Section



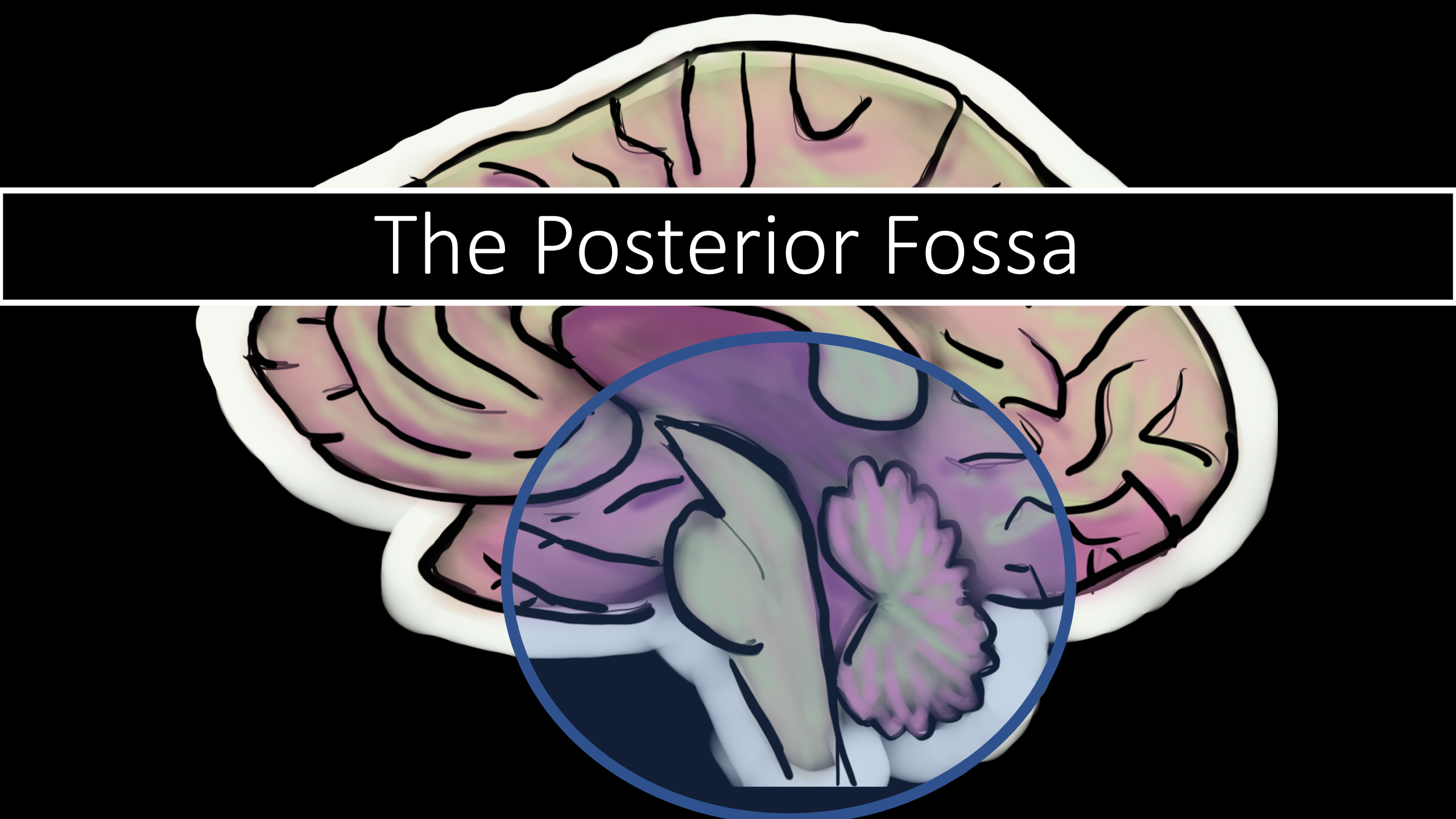

DORSAL
DORSAL COLUMN
SPINOTHALAMIC TRACT
SPINAL NERVE ROOT
UPPER MOTOR NEURON
CORTICOSPINAL TRACT
VENTRAL
ANTERIOR HORN CELL
LOWER MOTOR NEURON

Spinal Cord Outputs



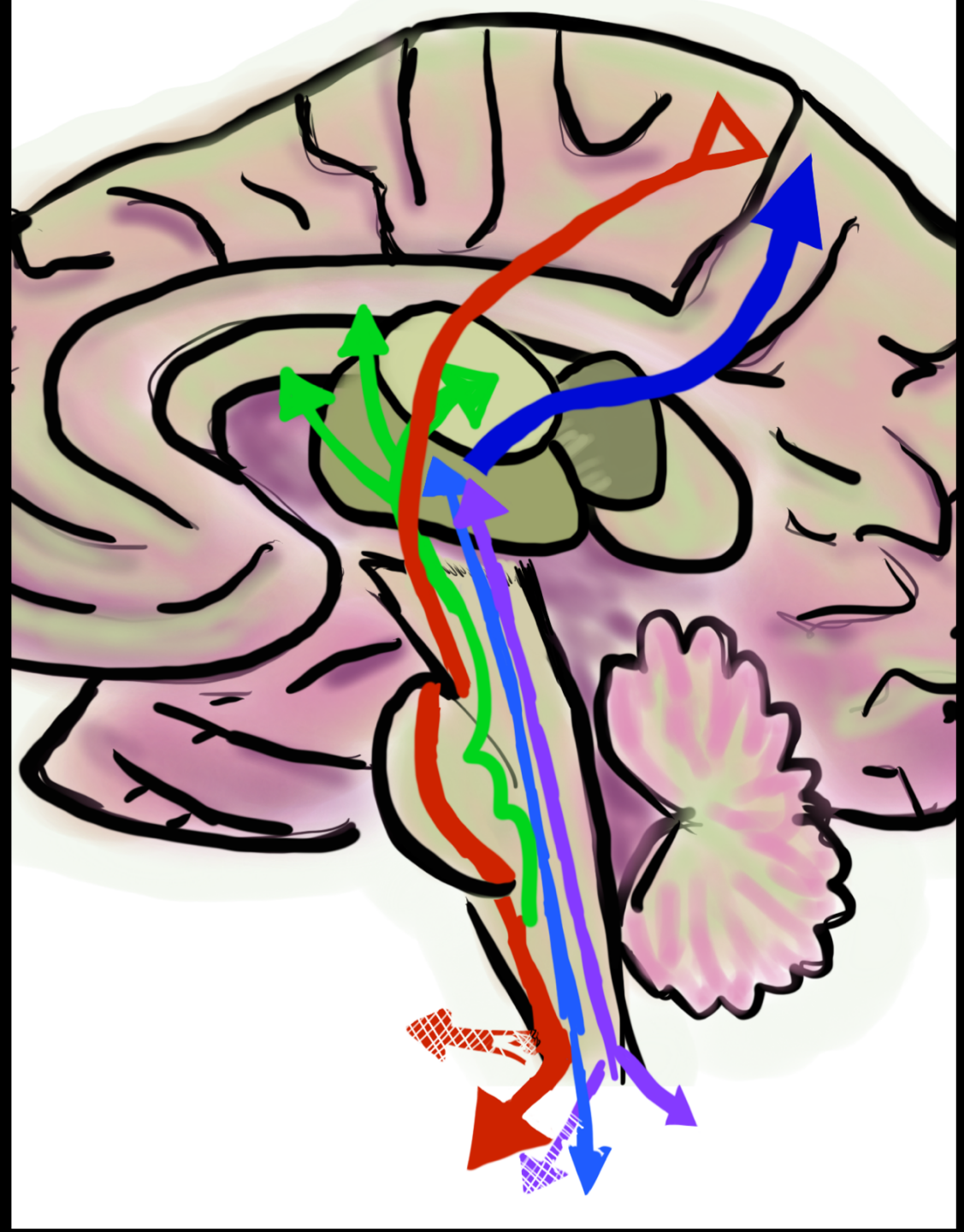

C5
C6
C7
C8
T1
C5/6
C8T1
C617
MYOTOMES
MOTOR NERVES
MUSCULOCUTANEOUS
ULNAR NERVE
MEDIAN NERVE
RADIAL NERVE
DERMATOMES
SENSORY NERVES

The Posterior Fossa

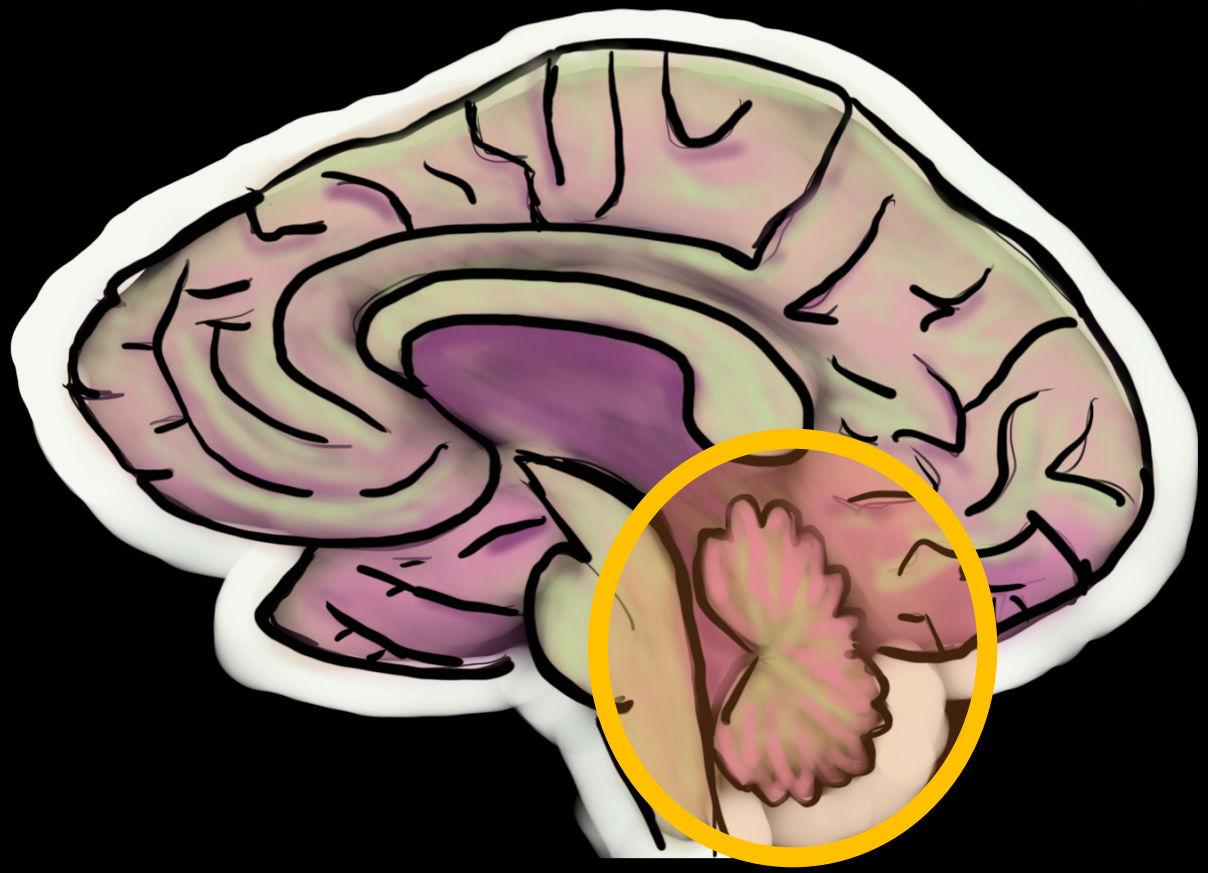


- Pathways running through the brainstem:

- Corticospinal tract
- Medial lemniscus
- Spinothalamic tract
- Reticular activating system
  - Consciousness
- Cerebellar pathways

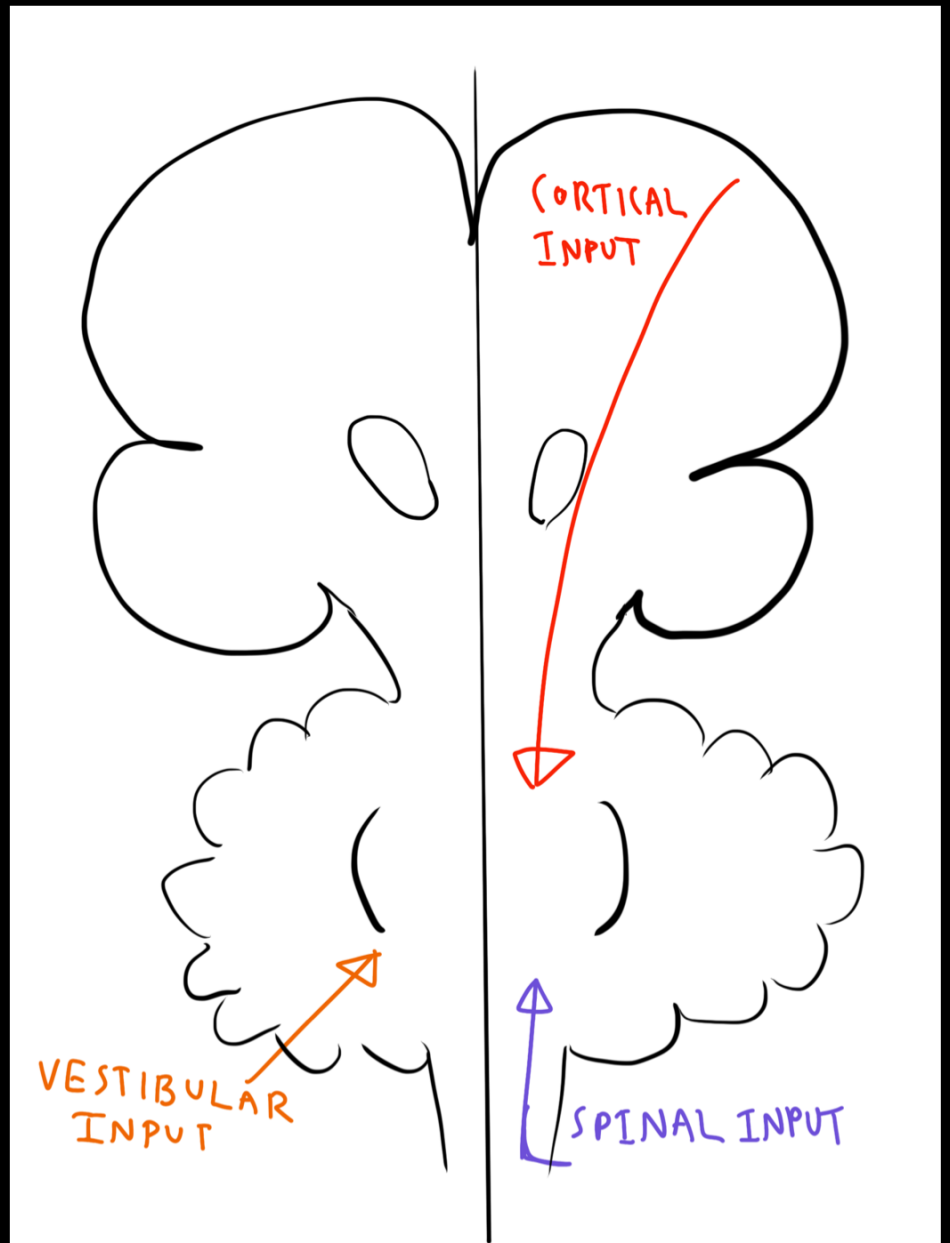


The Cerebellum

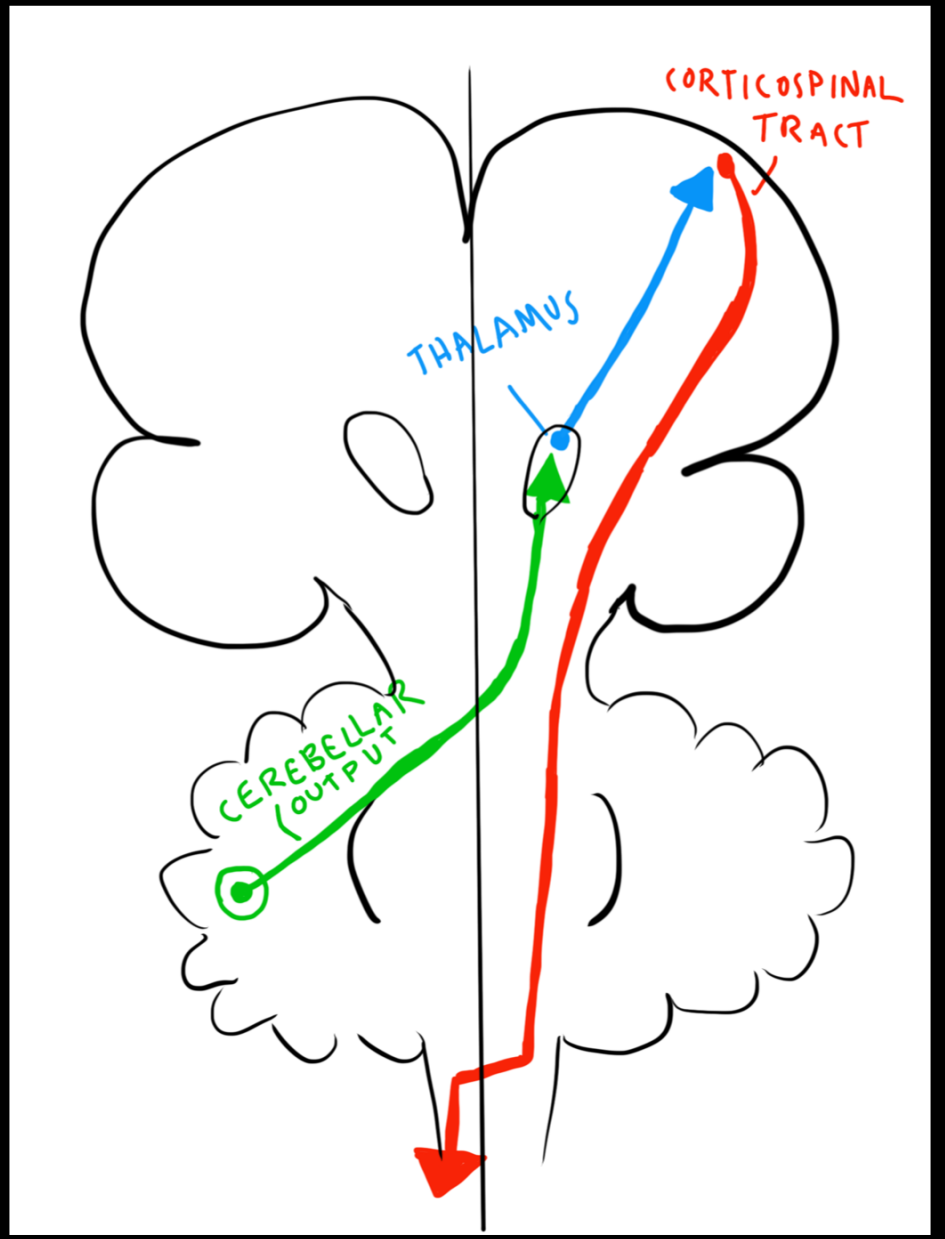


- Coordination of movements
- Lesion of the cerebellum causes IPSILATERAL ataxia

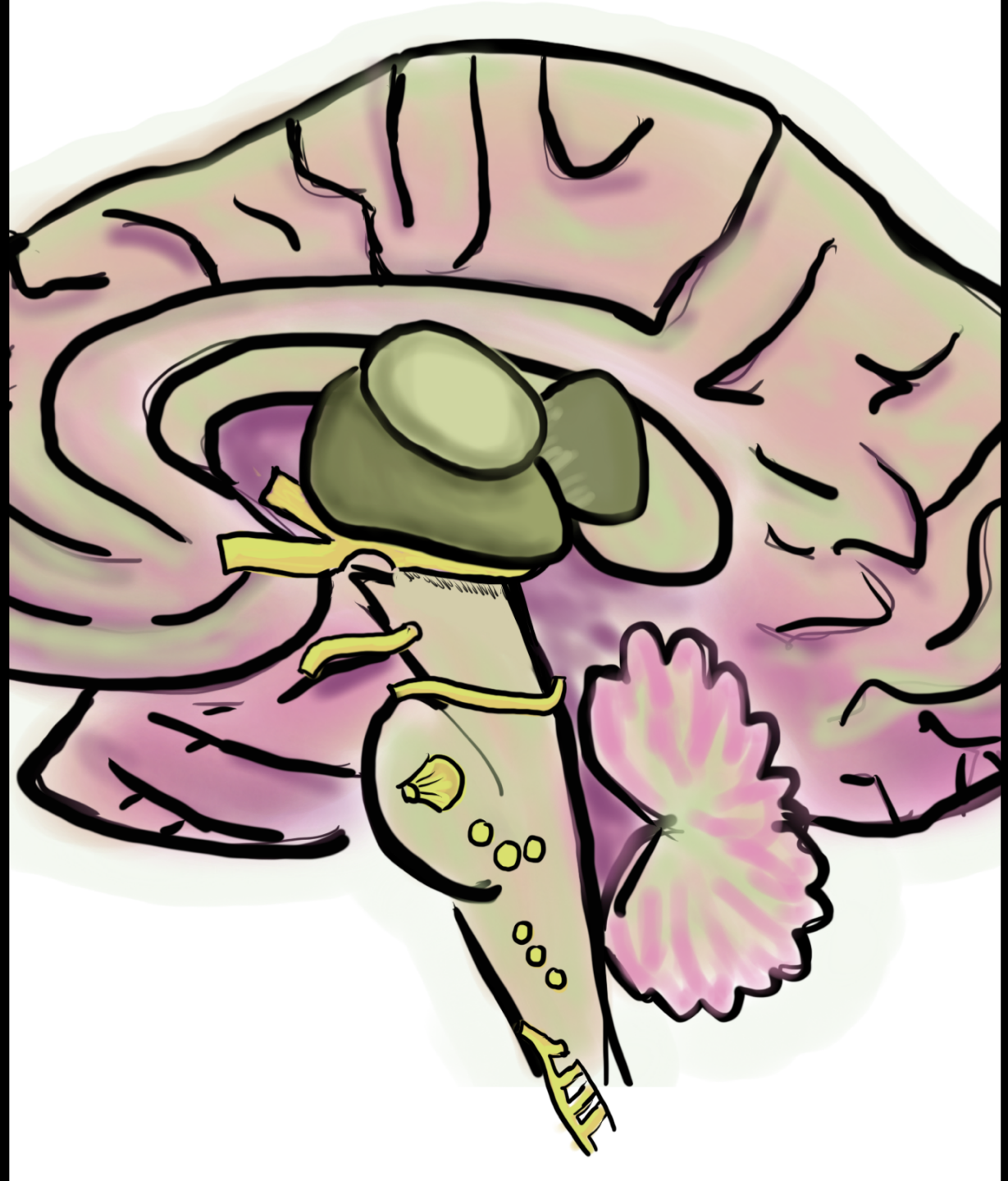
Cerebellar Inputs



Cerebellar Outputs

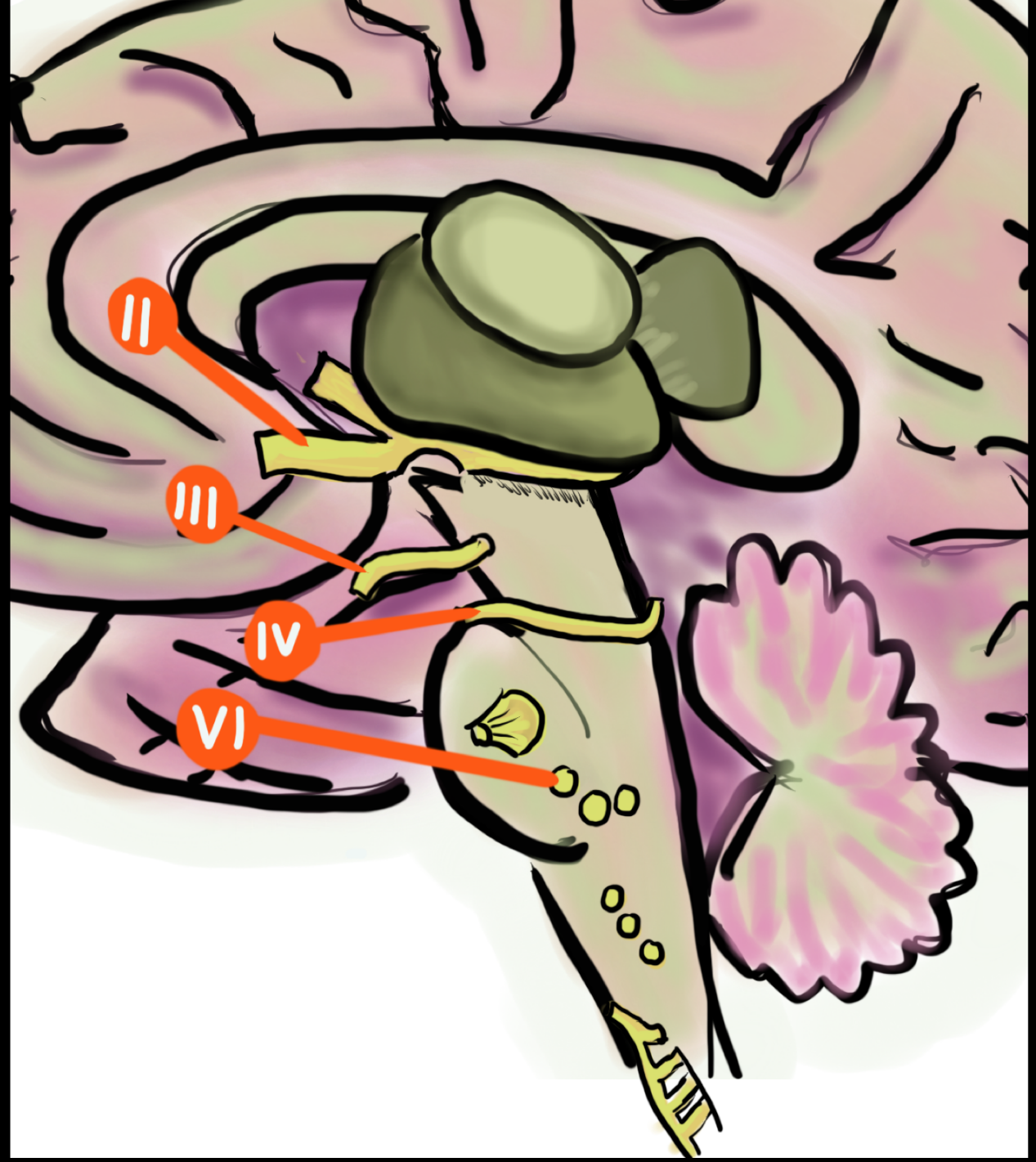


Brainstem Anatomy



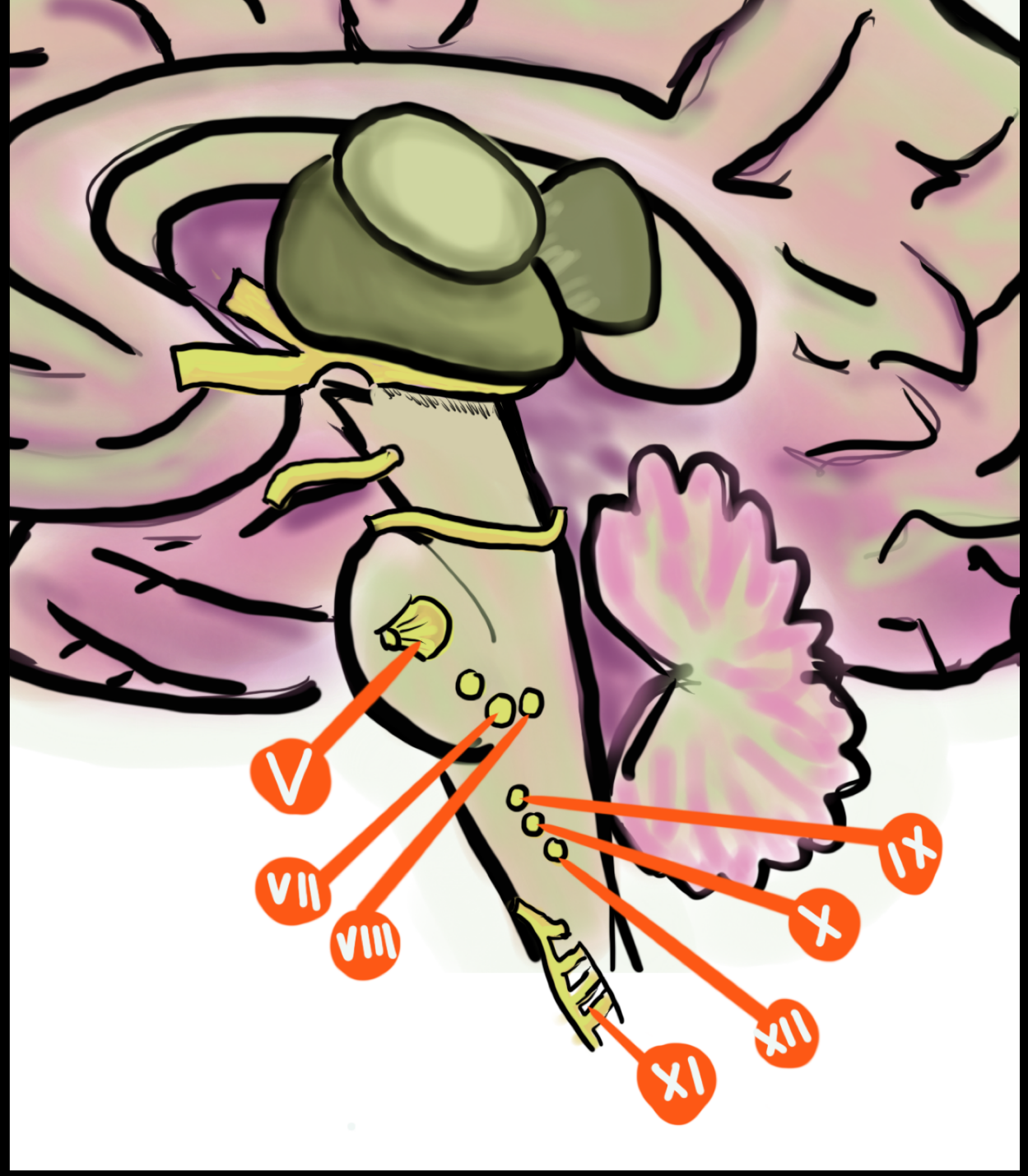
Upper Brainstem:

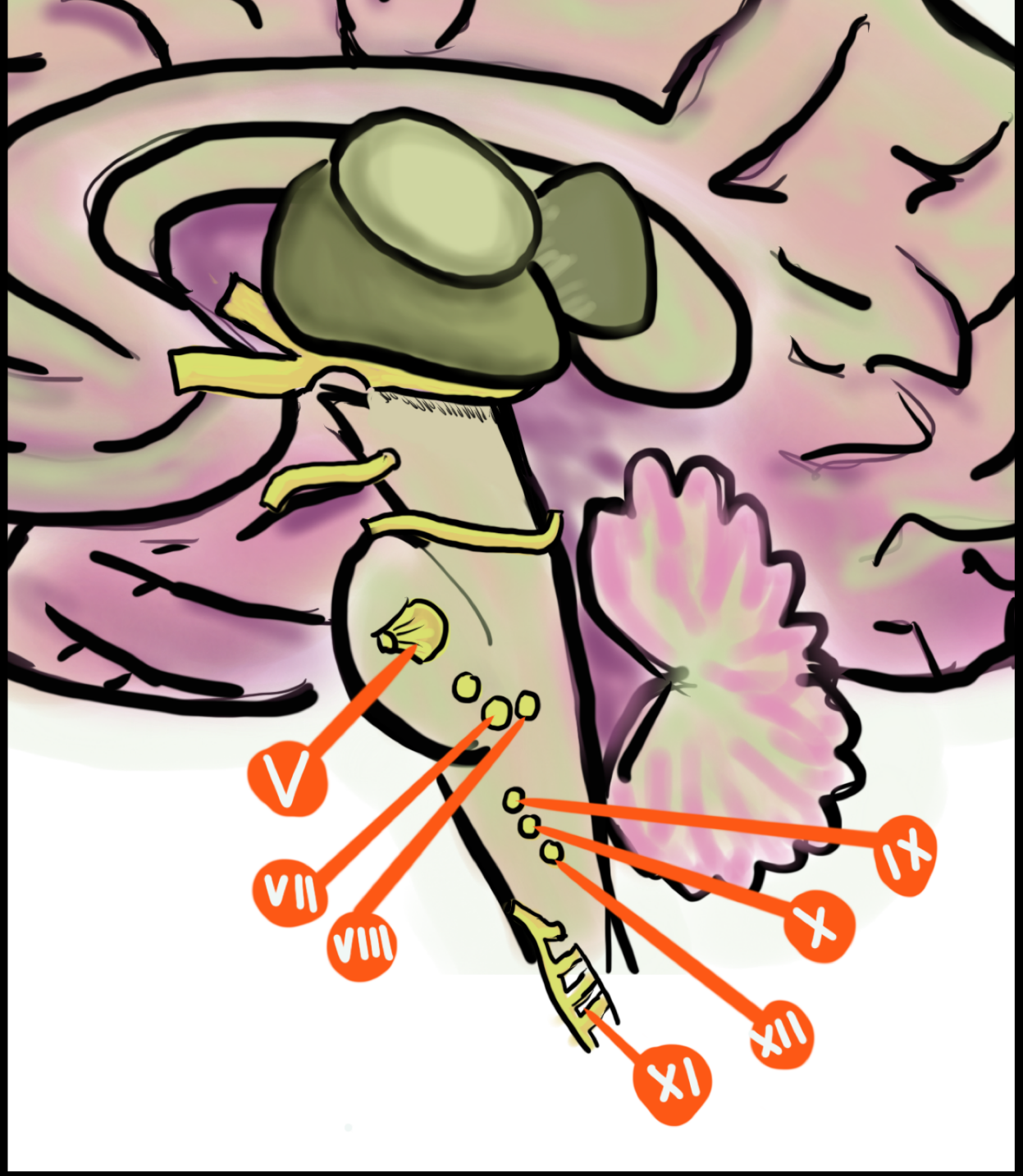
- Optic nerve (II)
  - Bypasses brainstem en route to thalamus
- Oculomotor nerves (III, IV, VI)
  - Move eyes
  - Originate in midbrain and pons



Mid-brainstem / Pontine:

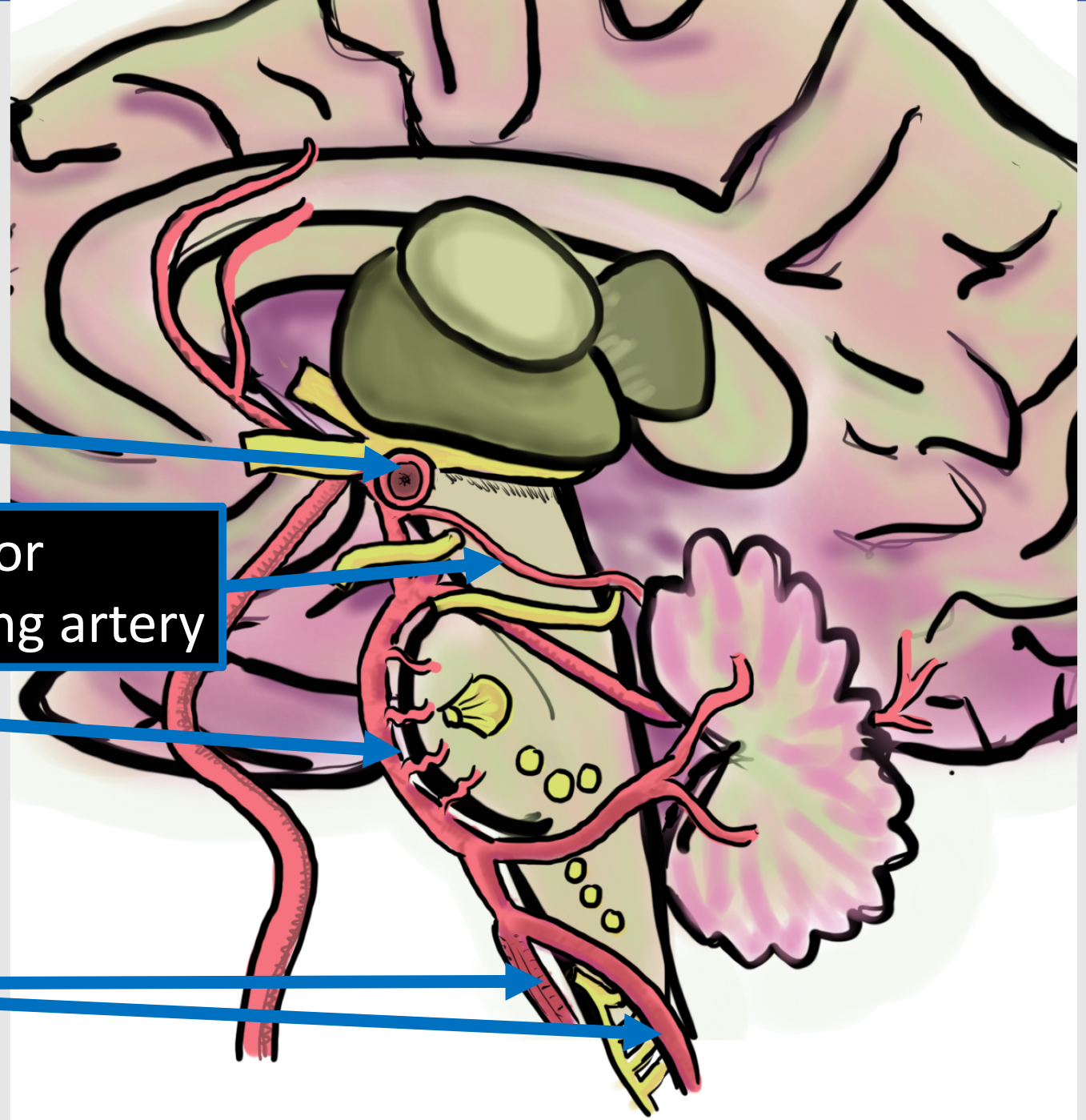
- Trigeminal nerve (V)
  - Facial sensation
- Facial nerve (VII)
  - Facial expression
- Vestibulocochlear nerve (VIII)
  - Hearing
  - Vestibular
  - Near facial nerve



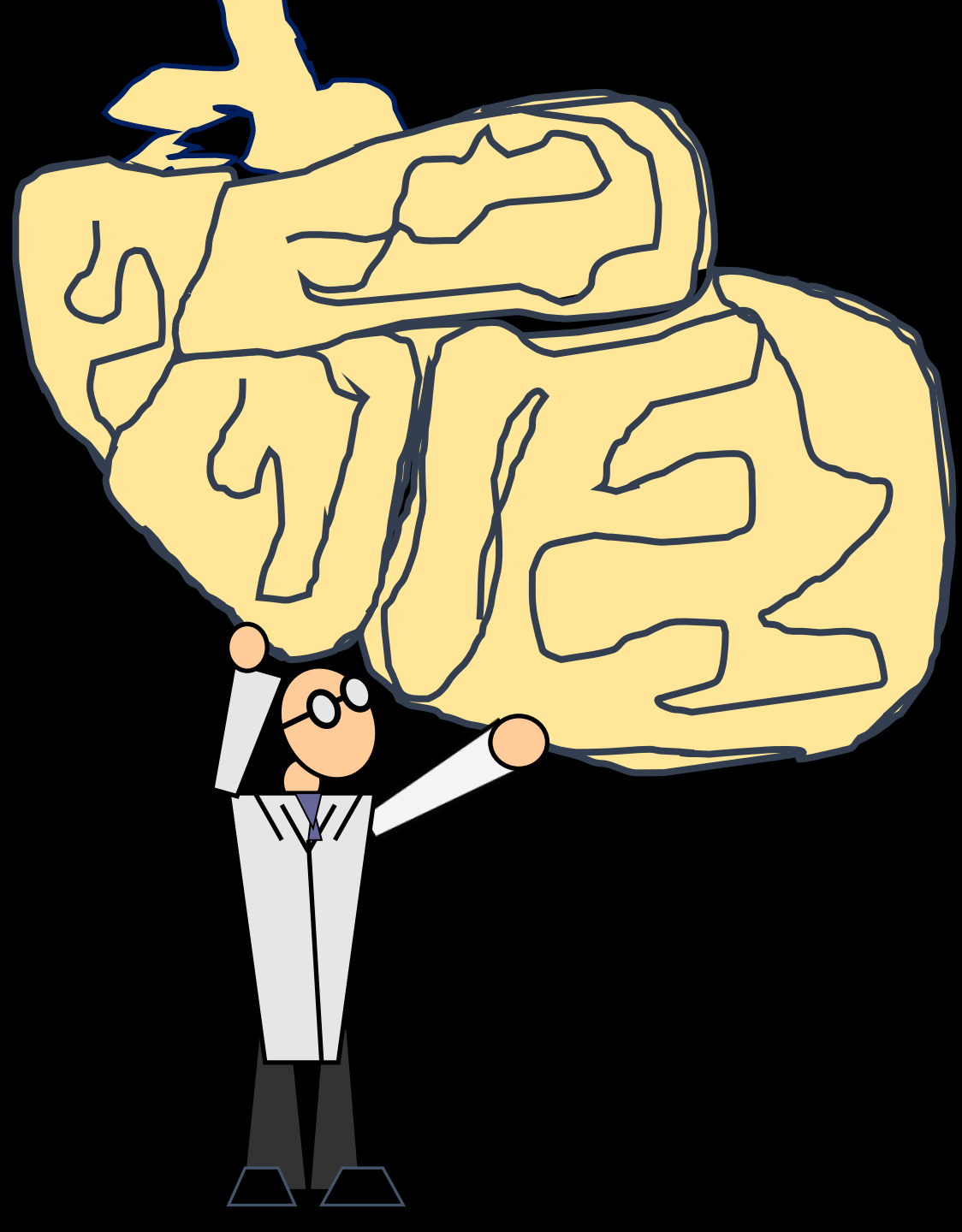


In the Medulla:

- IX & X
  - Swallowing
  - Parasympathetic function
- Spinal accessory (XI)
  - moves neck and trapezius
- Hypoglossal (XII)
  - tongue


Middle Cerebral Artery
Posterior Communicating artery
Basilar artery
Vertebral arteries

Putting it to work



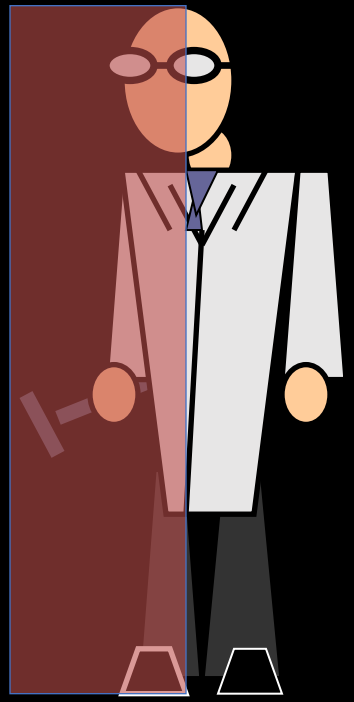
Case 1

- A 65 year old smoker presents with acute onset right face, arm and leg weakness and numbness
- On exam :
  - Normal language and visual fields
  - Normal eye movements, tongue, palate
  - Right facial droop, right arm and leg weakness (grade 4/5)
  - Right hemianesthesia to pinprick and vibration
  - Hyperreflexia in right arm and leg, right Babinski sign

- Where are the possible localizations?

Unilateral Weakness and Numbness Clues to localization:

- Tracts involved:
  - Corticospinal tract
  - Both sensory tracts
- All symptoms on the same side
  - Must be above decussations of motor and sensory tract
  - Above medulla, right side



Unilateral Weakness and Numbness Right Face, Arm and Leg

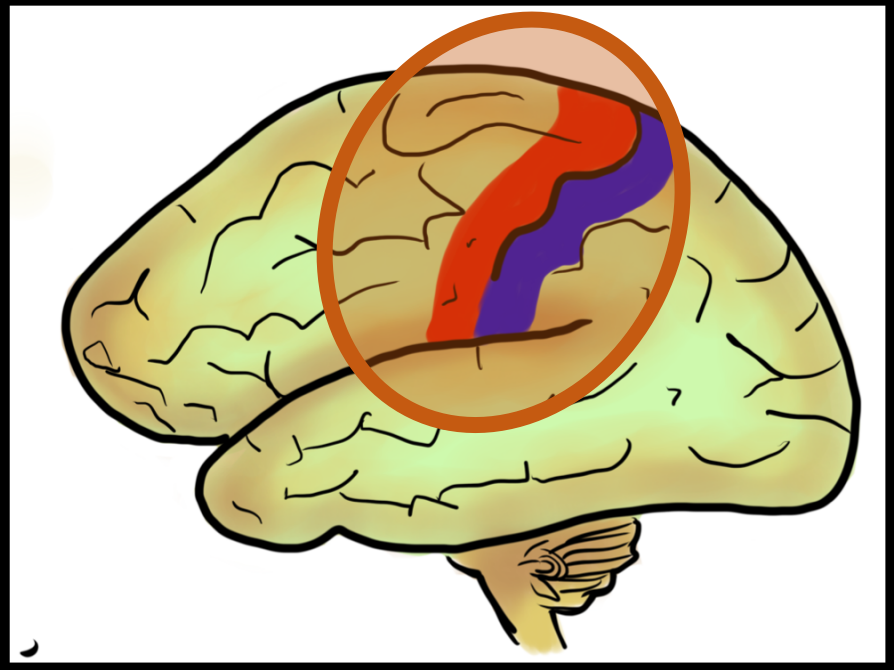
Possible locations:

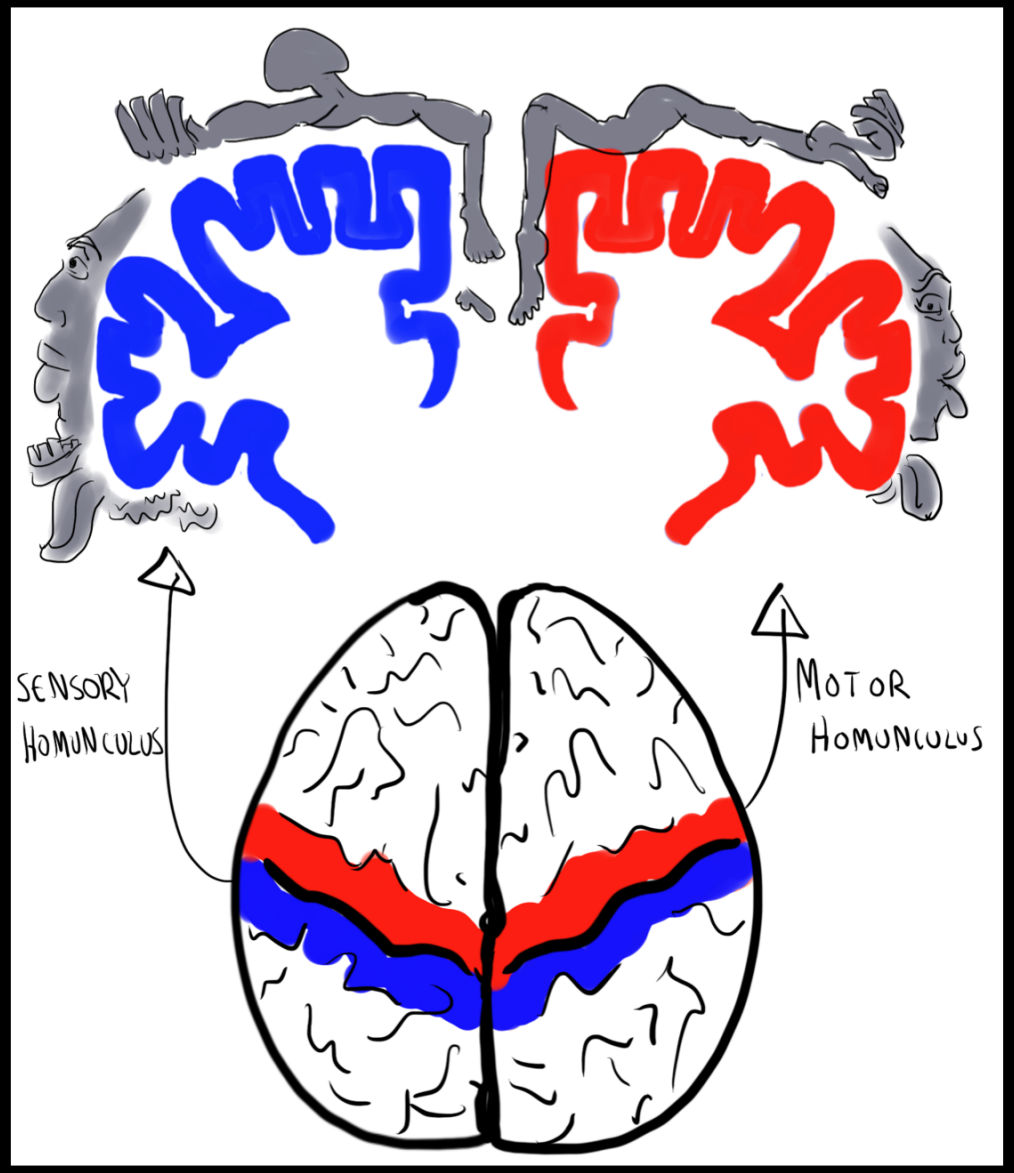
- Cortex
- Corona Radiata
- Internal capsule
- Midbrain
- Pons

Which of these can we rule out?

Not the Cortex

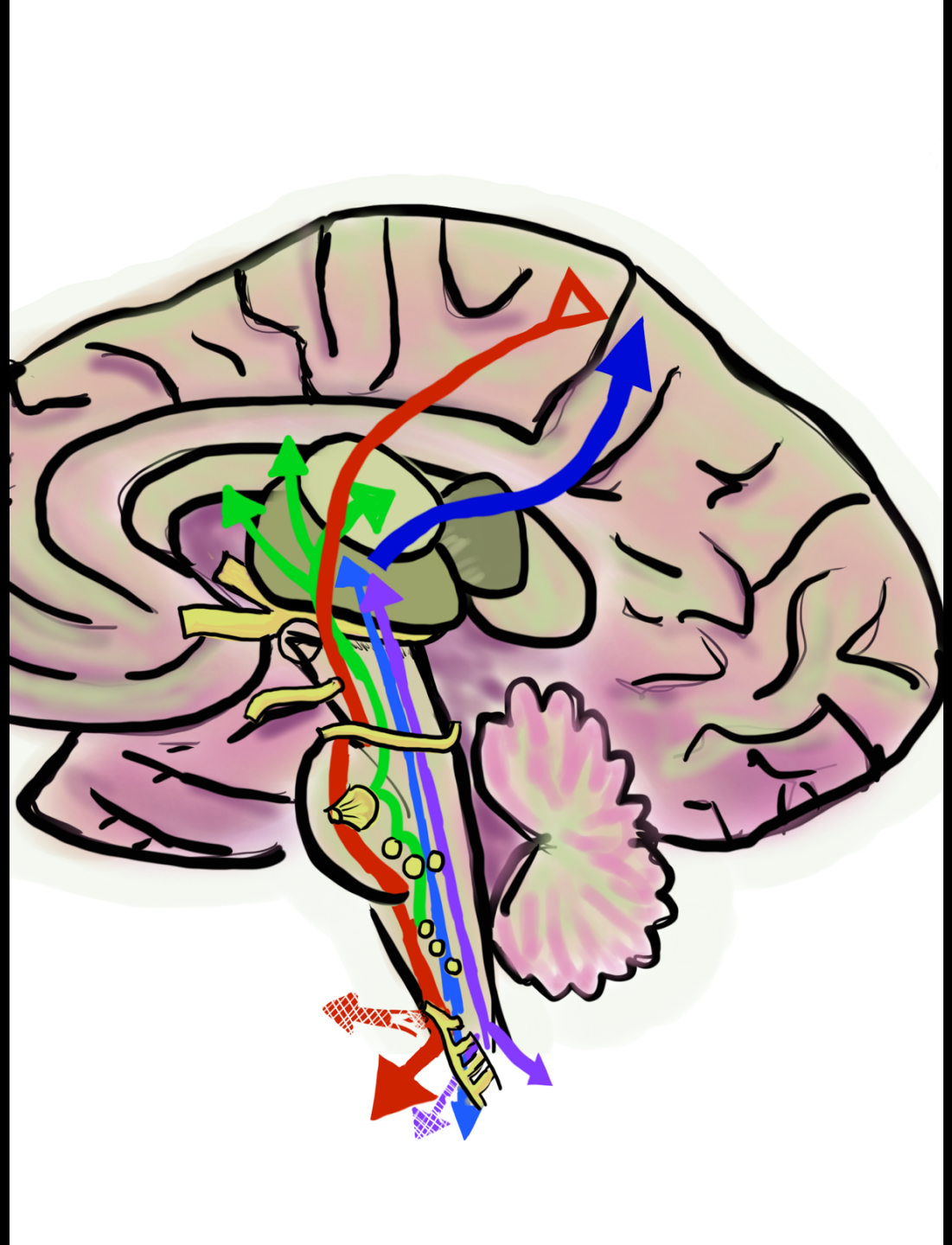
A lesion that big would affect language (left brain) and/or vision





Not the Brainstem

Sparing of cranial nerves

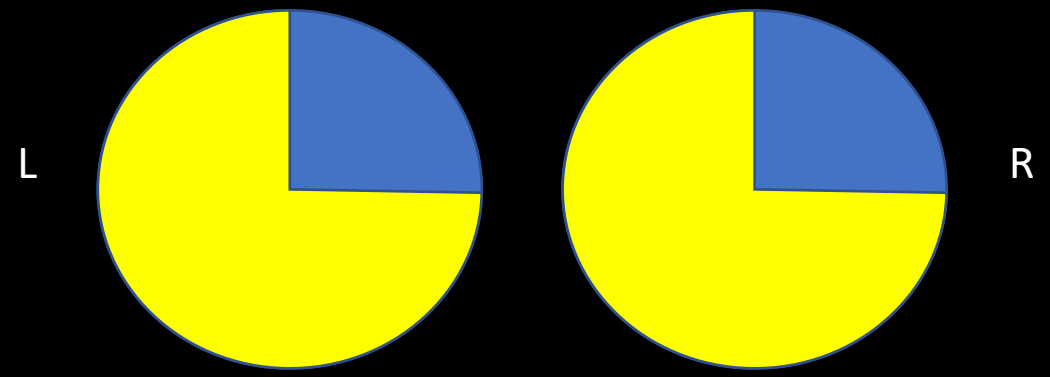


Case 1 - Diagnosis

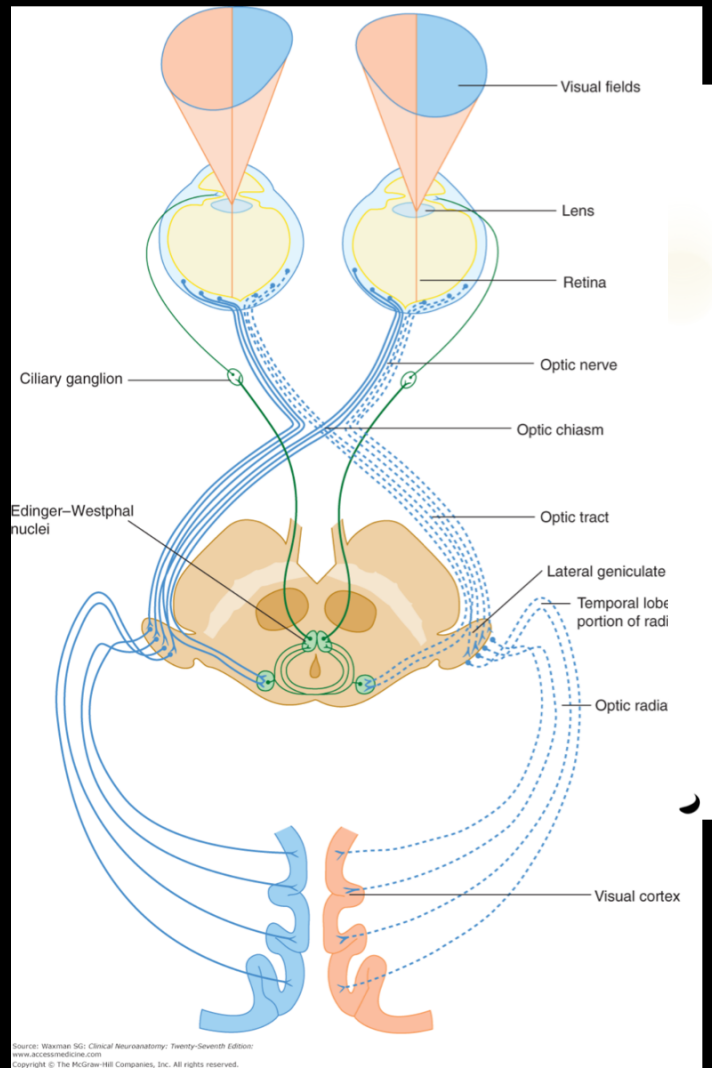
- Sensorimotor lacunar stroke:
  - Lesion of contralateral internal capsule (motor) and thalamus (sensory)
- Classic lacunar stroke syndrome

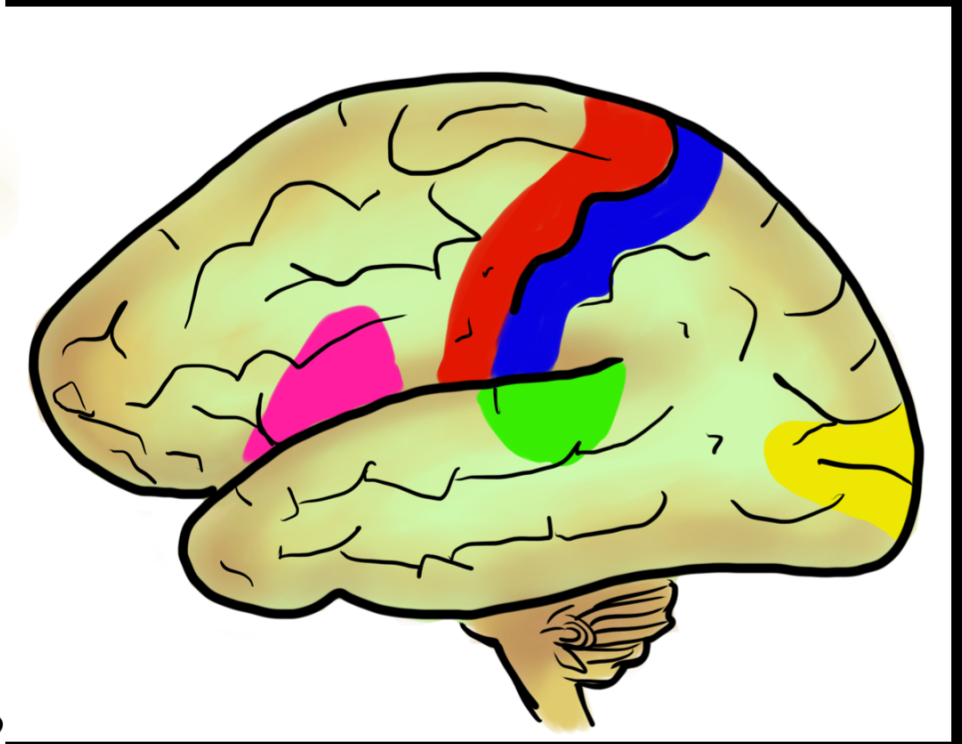
Case 2

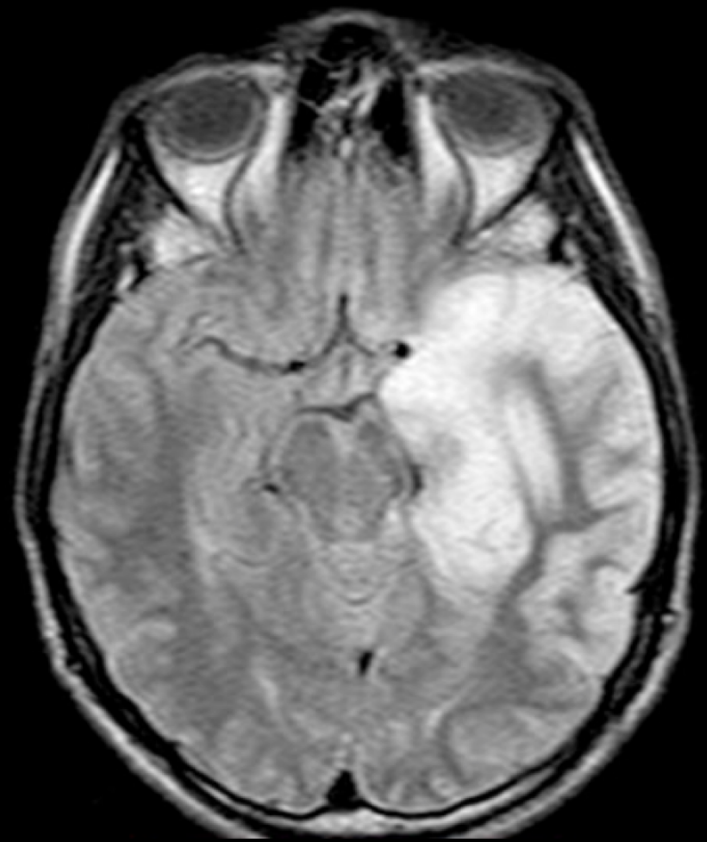
- 55 year old man presents with 2 days of ‘increasing confusion’
- Presents to your clinic
- Normal neurological exam except:
  - Nonsensical speech – rambling, using made up words
  - Trouble understanding simple commands
  - Febrile – 38.2 dC
  - Right superior quadrantanopia
- Plain CT brain is normal
- Where is the localization?
- Now what?



Case 2 – Receptive Aphasia, Right superior visual field deficit & fever







Suspect herpes encephalitis, start acyclovir

Case 3

- 65 year old smoker presents with right facial weakness and left arm and leg weakness

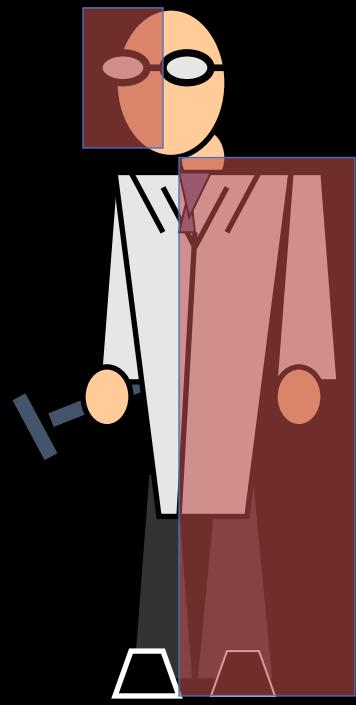
- On exam:
  - Right facial droop
  - Left arm and leg weakness
  - Normal sensory exam

Right facial weakness, left body weakness Clues to localization:

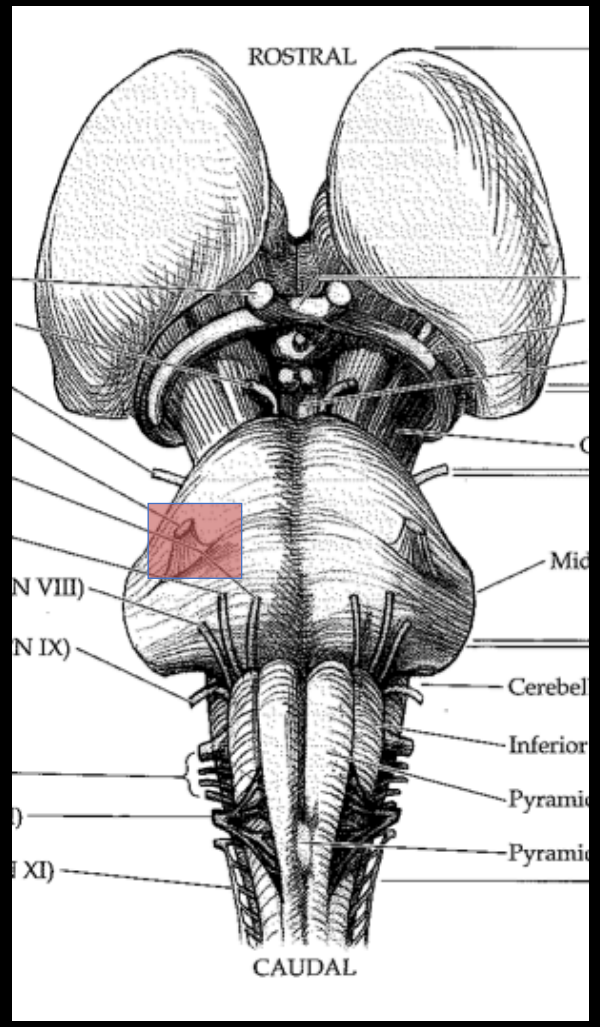
- “Crossed sign”

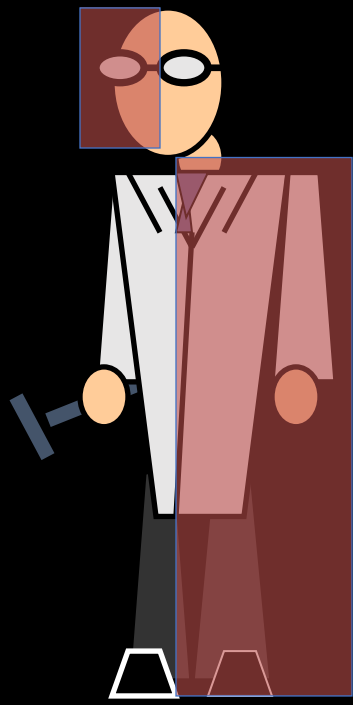
Tracts involved

- Right corticospinal tract (left body weakness)
- Right cranial nerve VII (right facial weakness)



Where is the Lesion?
Right facial weakness, left body weakness





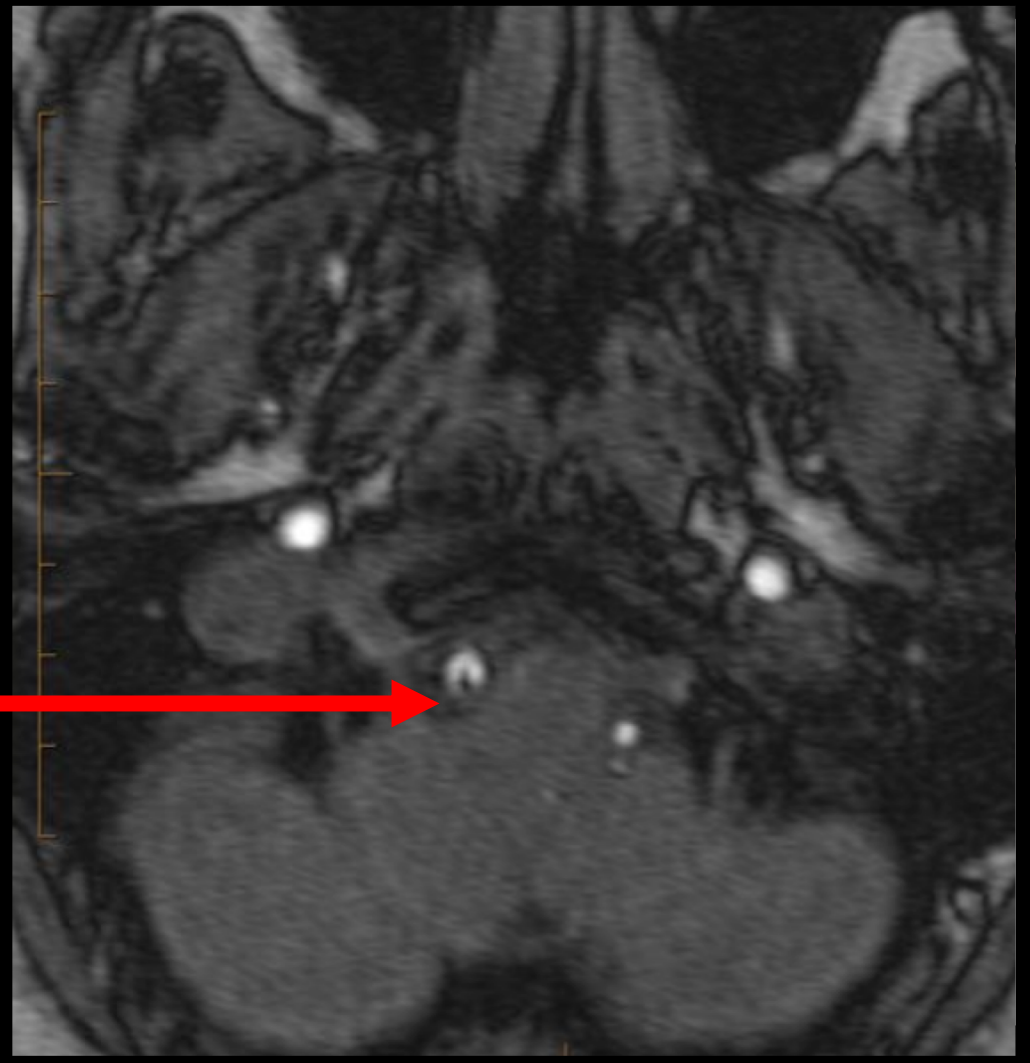
Case 3
Right facial weakness, left body weakness

- You suspect a pontine stroke
- CT scan of the brain is normal
- Carotid ultrasound shows no stenosis
- What now?

Brainstem Lesions

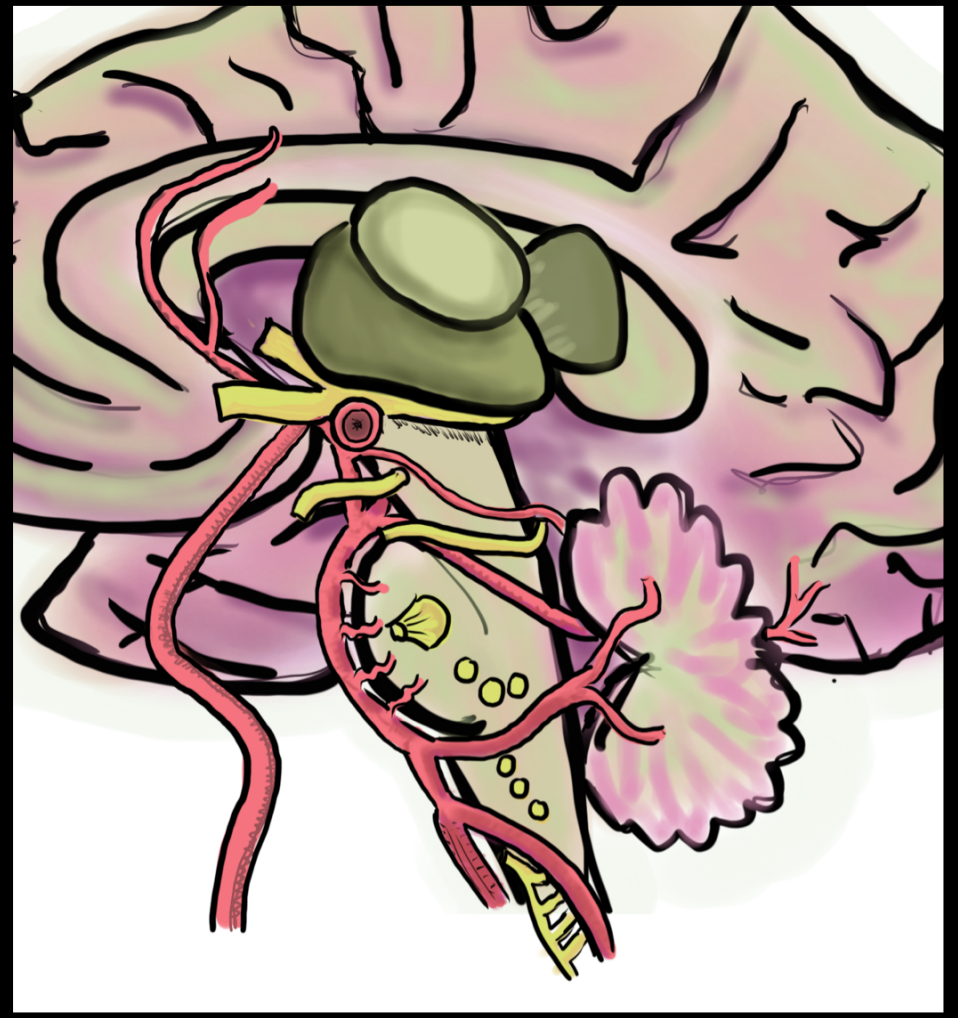
- Small hit, big damage
- Lesion may be too small to be seen on CT
- MRI more sensitive
- Remember to image the posterior circulation!

Vertebral Artery Dissection



Suggestive of Brainstem Lesions

- Crossed signs (motor or sensory)
- Diplopia / Ophthalmoplegia (CN III, IV, VI)
- Dysarthria (CN VII, XII)
- Vertigo (CN VIII)
- Dysphagia (CN IX, X)



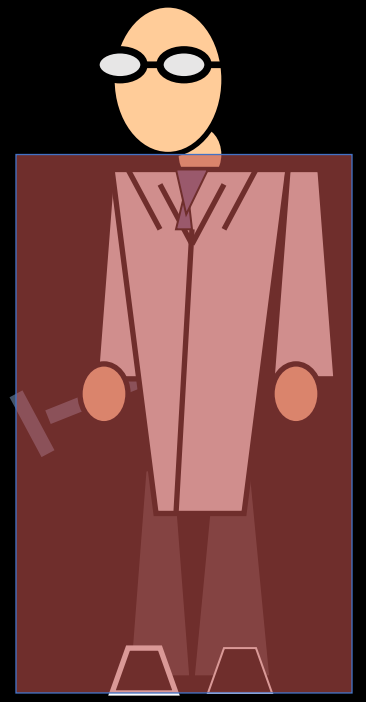
Case 4

- A 45 year old woman presents with 4 days of progressive numbness and weakness of all four limbs
- Cranial nerves unaffected

- Where are the possible localizations for these symptoms?

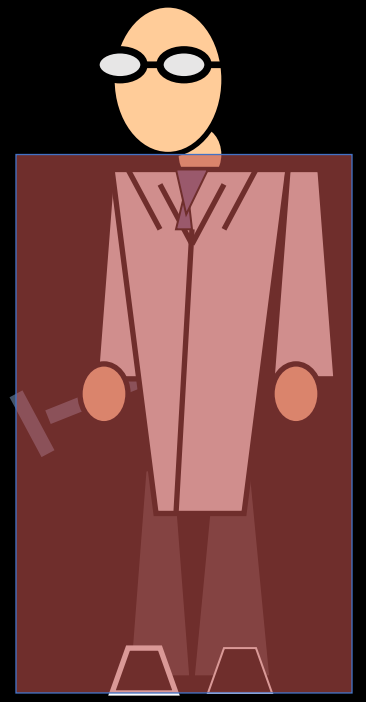
Symmetrical numbness and weakness of all four limbs, face normal

- Muscle? Unlikely (numbness)
- NMJ? Unlikely (numbness)
- Nerve? Likely (many nerves involved)
- Plexus or root? Unlikely (4 limbs)
- Spinal cord? Likely (spares the face)
- Brainstem? Unlikely (no signs above neck)
- Brain? Unlikely (no signs above neck)



Symmetrical numbness and weakness of all four limbs, face normal

- Muscle? Unlikely (numbness)
- NMJ? Unlikely (numbness)
- **Nerve? Likely (many nerves involved)**
- Plexus or root? Unlikely (4 limbs)
- **Spinal cord? Likely (spares the face)**
- Brainstem? Unlikely (no signs above neck)
- Brain? Unlikely (no signs above neck)



Clues to Look For

Spinal Cord:

- Bowel or bladder abnormalities
- Autonomic dysfunction
- Sensory level
- Upper motor neuron signs: spasticity, hyperreflexia, upgoing toes

Peripheral Nerve:

- Lower motor neuron signs: Arreflexia, flaccidity, fasciculations

Note – arreflexia may occur in acute spinal cord lesions

Differential Diagnoses

- Subacute spinal cord lesion
  - Compressive
  - Demyelinating (MS)
  - Infectious
  - Other inflammatory
  - Neoplastic
  - **Need MRI!**
- Subacute polyneuropathy
  - Rule out guillain barre syndrome!
  - **Need Lumbar Puncture!**

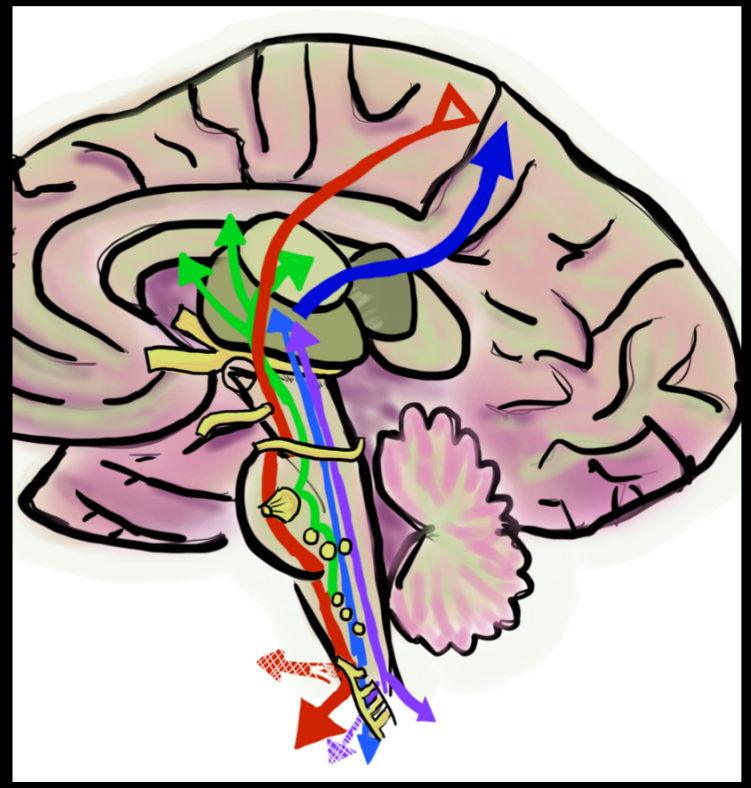
Case 5

- 45 year old woman presents with drooping of the eyelids, double vision, slurred speech
- Normal level of consciousness
- Mild weakness of proximal arm and leg muscles
- Normal sensation and coordination
- Decreased reflexes

- Possible localizations?

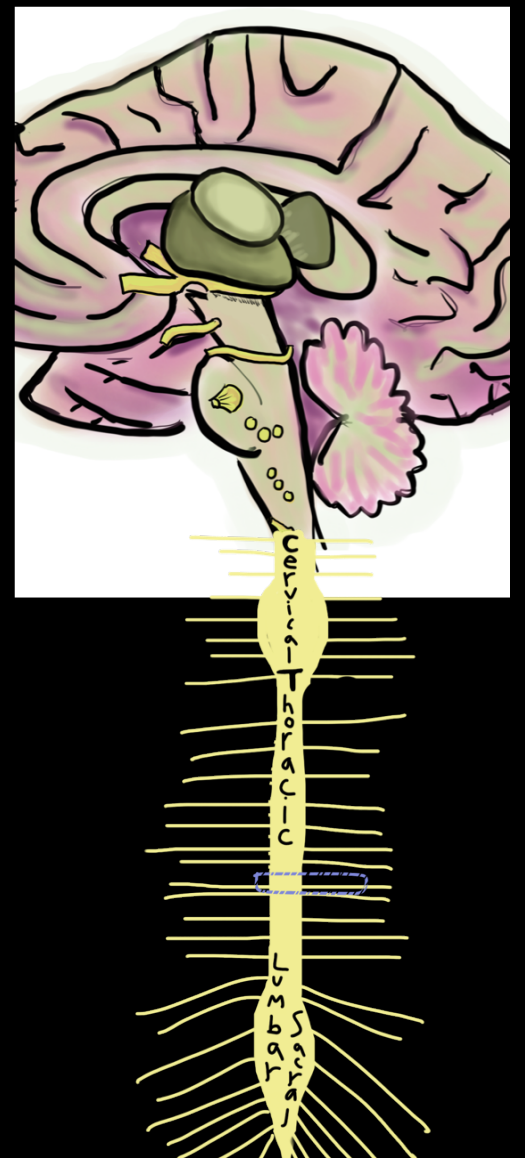
Ptosis, diplopia, dysarthria, limb weakness

- Brainstem?
  - Must involve cranial nerve III (ptosis and diplopia)
  - Must involve cranial nerve VII, IX or X (slurred speech)
  - Must involve corticospinal tract (limb weakness)
  - But normal level of consciousness?
  - Decreased reflexes?



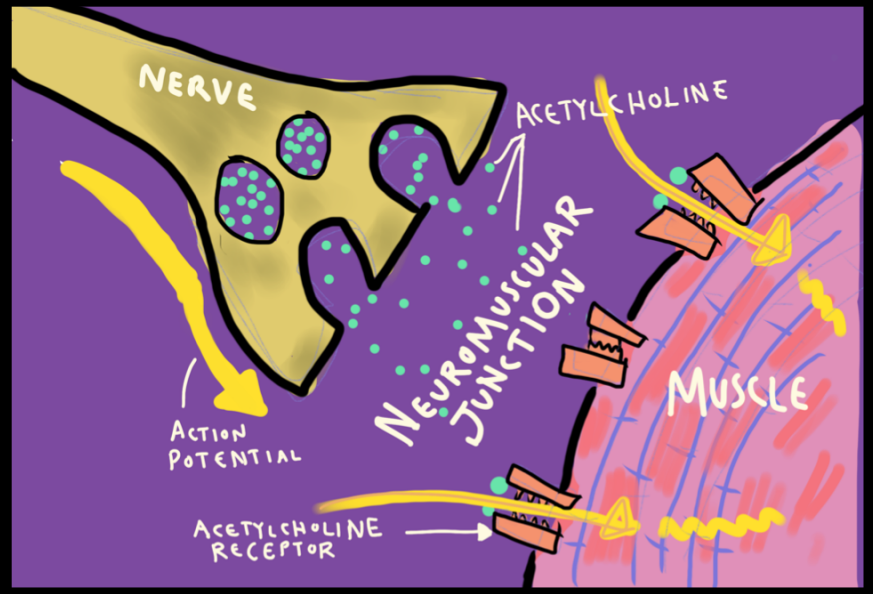
Ptosis, diplopia, dysarthria, limb weakness

- Multiple nerves?
  - Cranial nerves III, VII, IX, X
  - Motor nerves to arms and legs
  - But sensation intact?



Ptosis, diplopia, dysarthria, limb weakness

- Neuromuscular junction
  - Myasthenia gravis
  - Commonly presents with cranial nerve findings and motor weakness
  - Fatiguability – symptoms worse with use of muscles
  - Acetylcholine receptor antibodies (at the neuromuscular junction)



Objectives

- To review the anatomy of the nervous system
- To understand the relationship between clinical symptoms and signs and neuroanatomy
- To develop an approach to localization within the nervous system

- My goal – to help you refine neurological localization skills in 25 minutes
- Your goal – to keep up