Neuroscience 101 II

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University of Minnesota

Coffee Hour

Tuesday (Sept 11) 10:00-11:00am
Friday (Sept 14) 8:30-9:30am

Surdyk’s Café in Northrop Auditorium

Stop by for a minute or an hour!

Input and Output Systems

Input - Sensory Systems:

- Somatosensory
- Visceral sensory
- Special sensory
  - Vision
  - Auditory
  - Vestibular
  - Gustatory (taste)
  - Olfactory (smell)

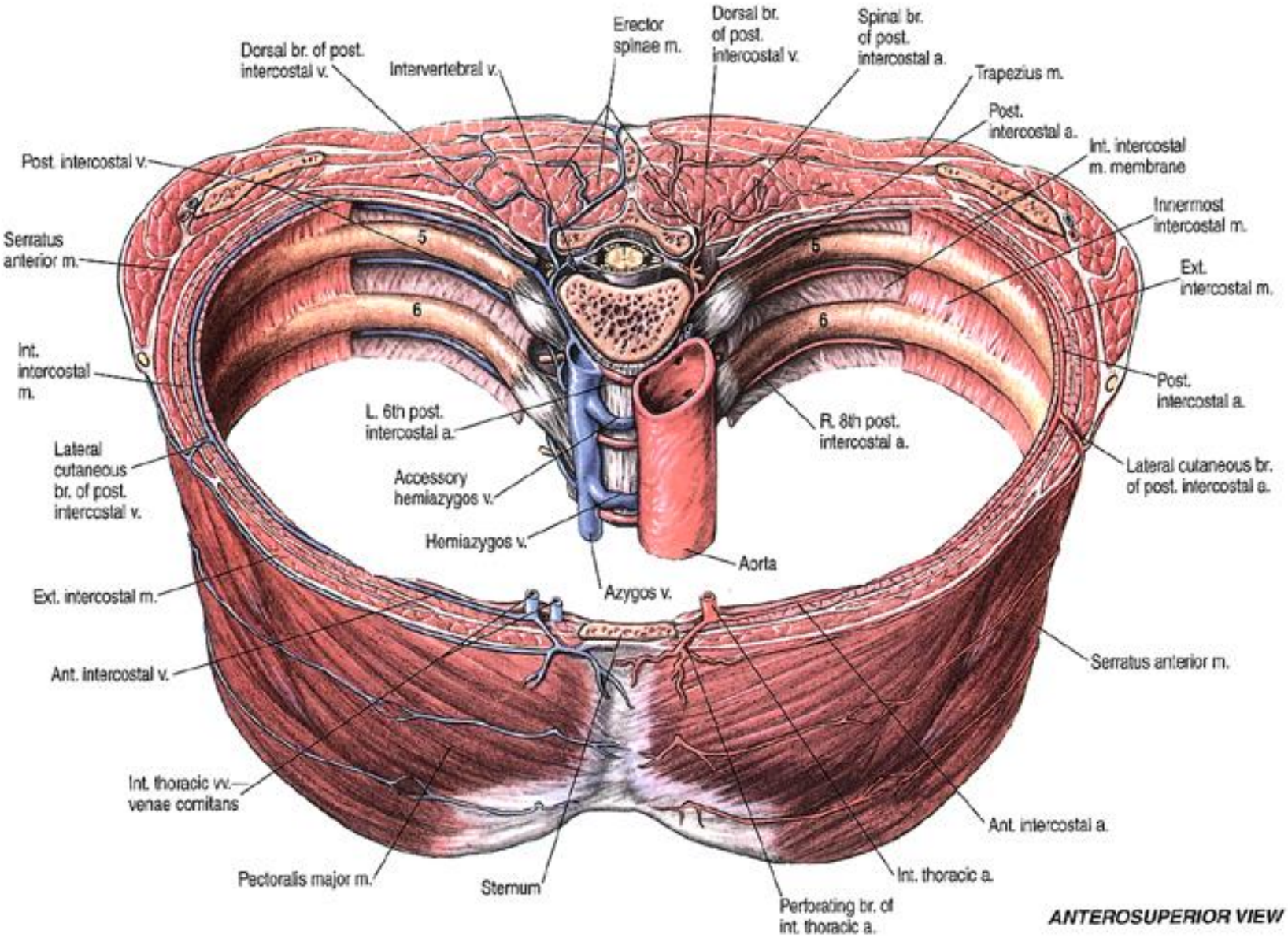
> general sensory

Output – Motor & Endocrine Systems:

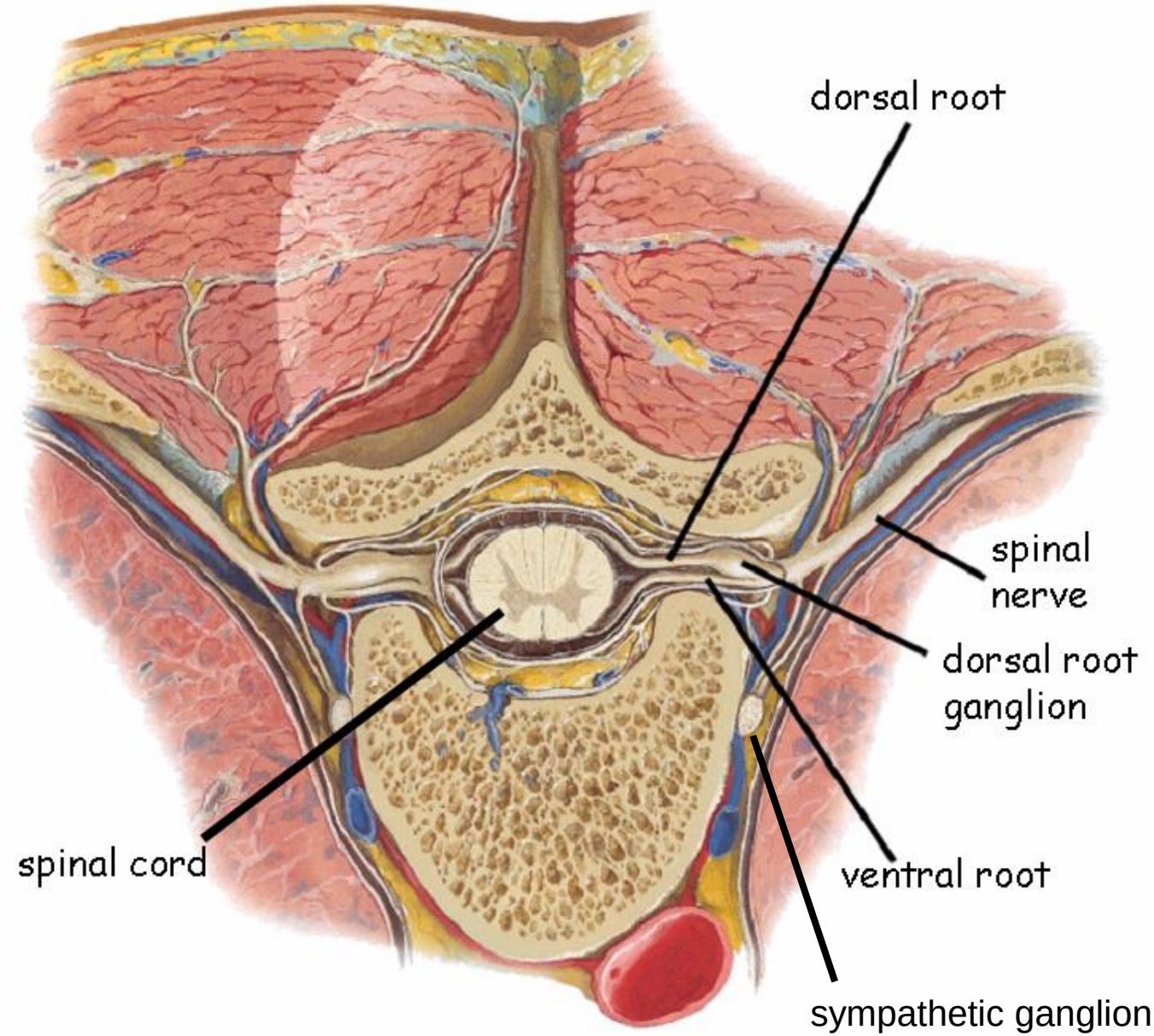
- Somatomotor
- Branchial motor
- Autonomic (visceral) motor
  - Parasympathetic
  - Sympathetic
  - Enteric
- Neuroendocrine systems (hormones)
  - Hypothalamus / Pituitary
  - Pineal gland
  - Adrenal medulla

> general motor

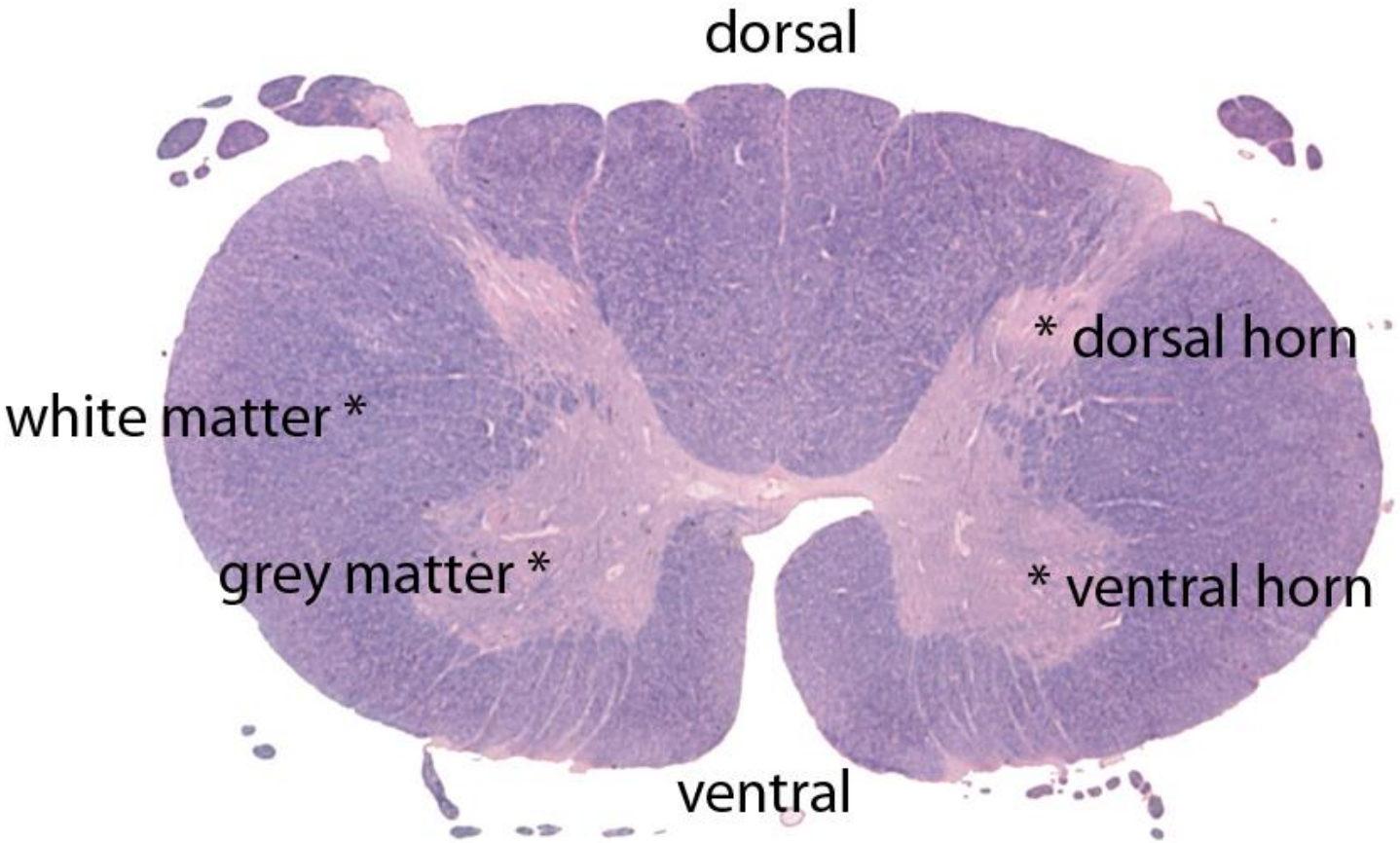
Spinal Cord


Erector spinae m.
Dorsal br. of post. intercostal v.
Spinal br. of post. intercostal a.
Dorsal br. of post. intercostal v.
Intervertebral v.
Trapezius m.
Post. intercostal a.
Int. intercostal m. membrane
Post. intercostal v.
Innermost intercostal m.
Serratus anterior m.
Ext. intercostal m.
Int. intercostal m.
Post. intercostal a.
L. 6th post. intercostal a.
R. 8th post. intercostal a.
Lateral cutaneous br. of post. intercostal v.
Accessory hemiazygos v.
Lateral cutaneous br. of post. intercostal a.
Hemiazygos v.
Aorta
Azygos v.
Ext. intercostal m.
Serratus anterior m.
Ant. intercostal v.
Int. thoracic vv.— venae comitans
Ant. intercostal a.
Int. thoracic a.
Pectoralis major m.
Sternum
Perforating br. of int. thoracic a.
ANTEROSUPERIOR VIEW

Spinal Cord

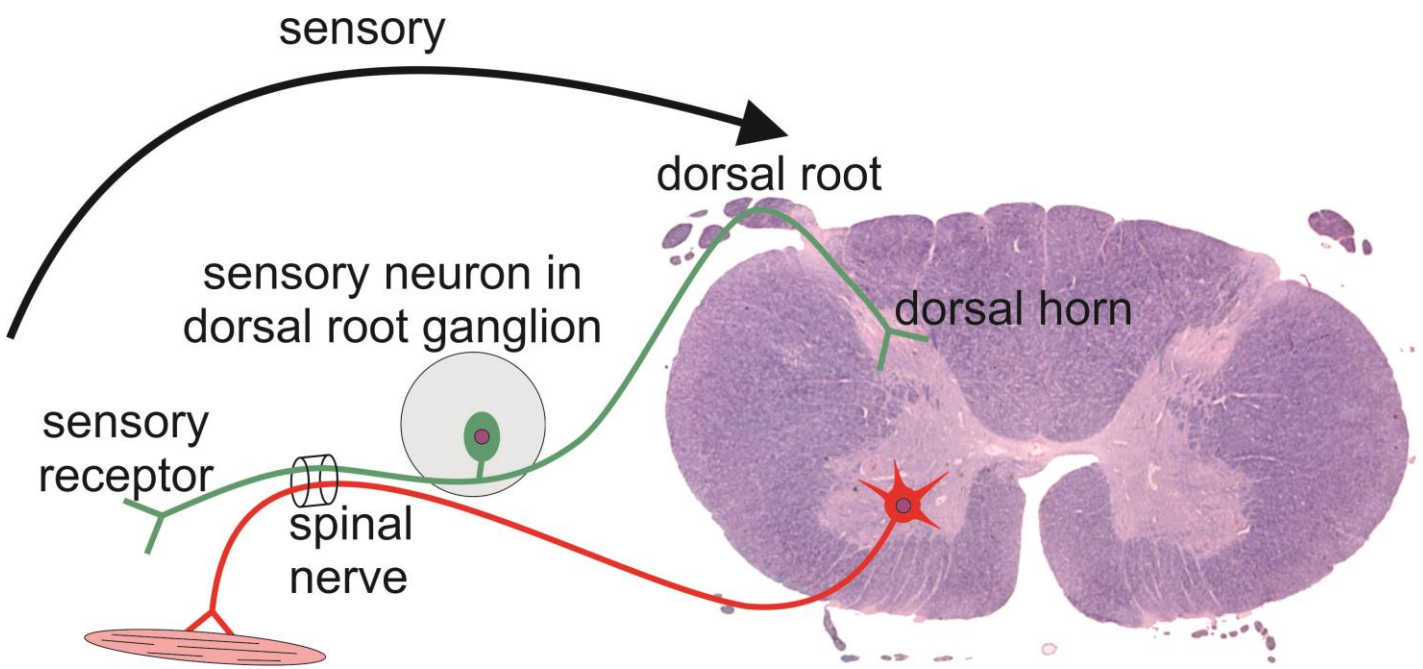

dorsal root
spinal nerve
dorsal root ganglion
spinal cord
ventral root
sympathetic ganglion

Spinal Cord


dorsal
* dorsal horn
white matter *
grey matter *
* ventral horn
ventral

Primary Somatosensory Neurons

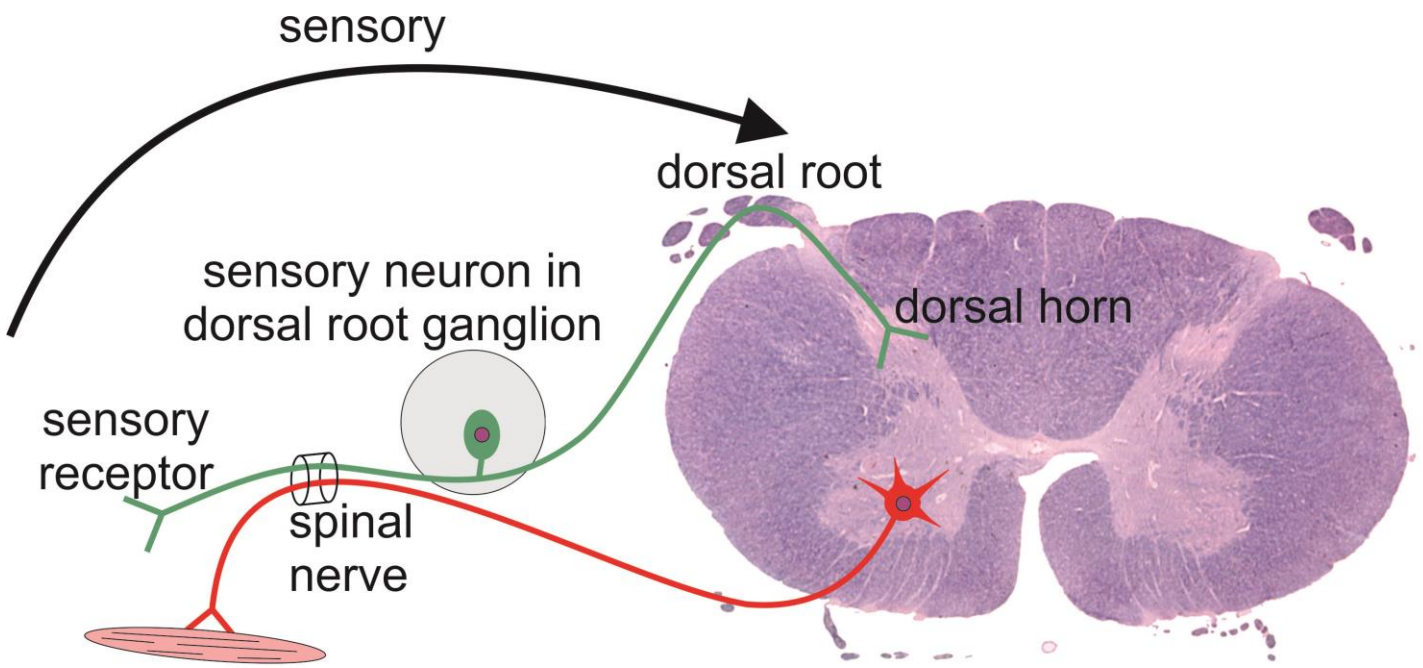
- The somas of primary somatosensory neurons are in:
  - cranial nerve sensory ganglia
  - dorsal root (spinal) ganglia



Primary Somatosensory Neurons

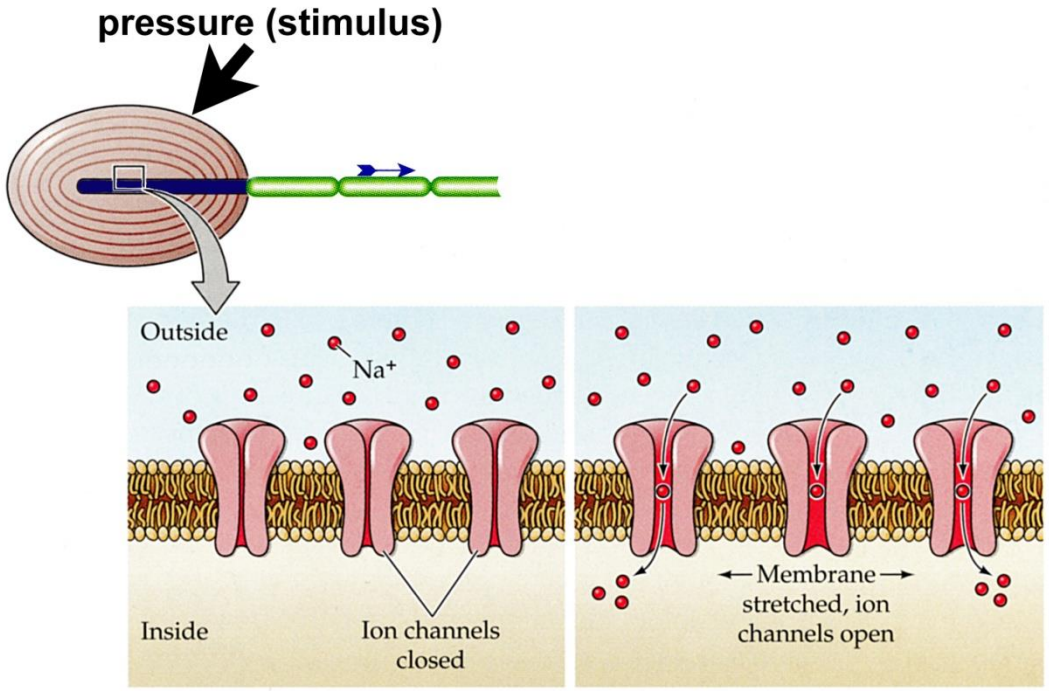
- The terminal end of the peripheral process of the sensory neuron functions is the receptor.

- Each sensory neuron's receptors are specialized to respond to a single type of stimulus.



Somatosensory Receptors

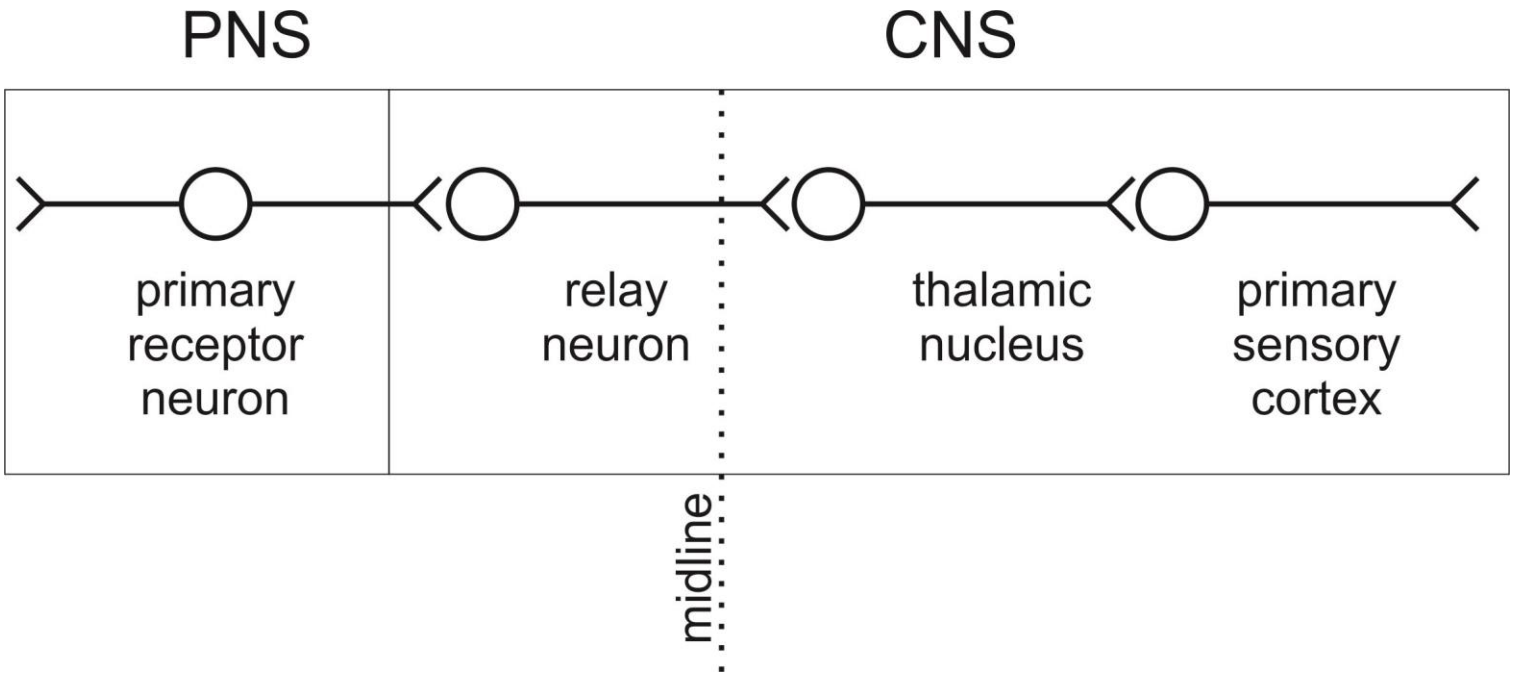
- An appropriate stimulus results in sodium channels opening and an influx of sodium into the nerve ending. This results in a graded depolarizing membrane potential.



The somatosensory system detects multiple sensations.

- Touch
  - fine touch
  - pressure
  - vibration
  - movement against the skin
- Proprioception
  - limb & trunk position
  - movement
  - load
- Thermoception (temperature)
  - heat
  - cold
- Nociception (pain – tissue damage)
- Pruritic reception (itch)

Somatosensory Projection to Cortex



Somatosensory Projection to Cortex

Two pathways:

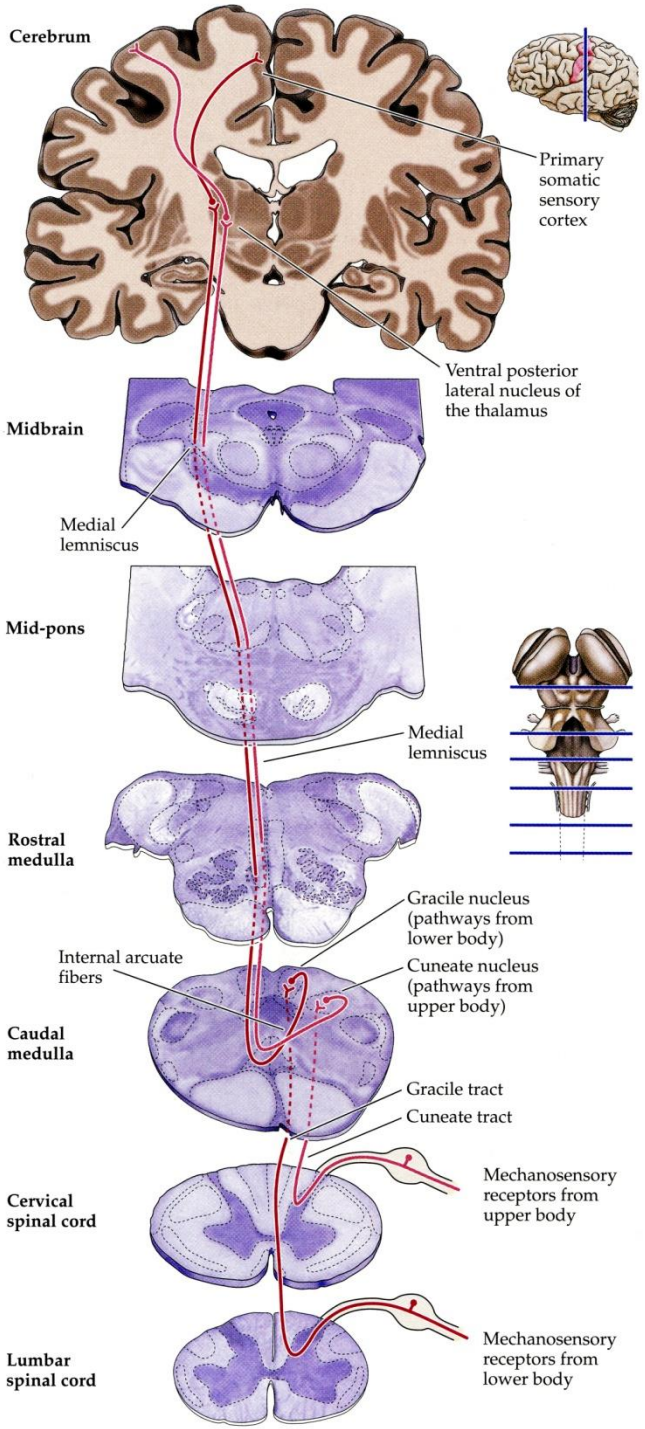
- Proprioception and most touch via the dorsal columns.

- Pain, temperature and some touch via the spinothalamic tracts.

Somatosensory Projection to Cortex

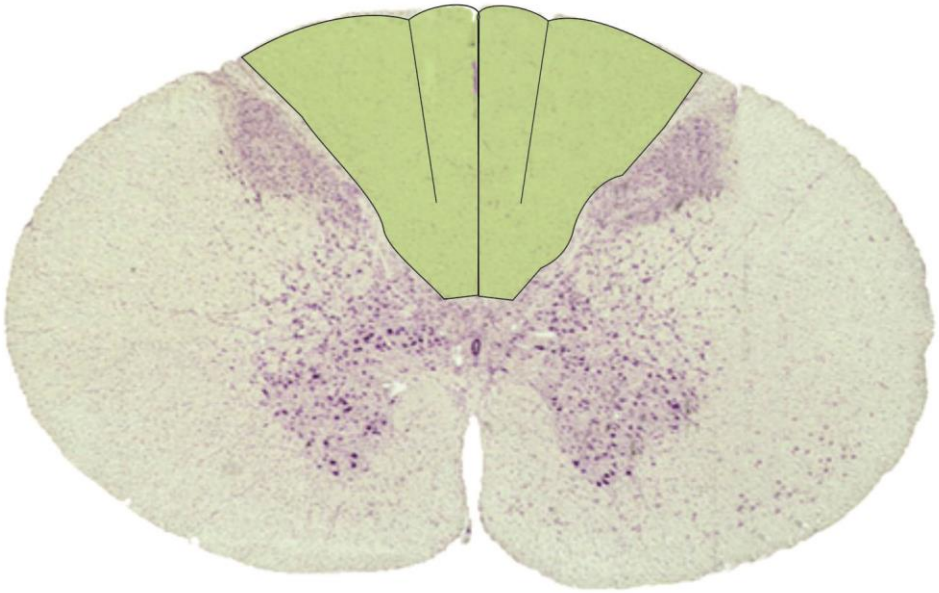
Dorsal column projection:

- Primary sensory axons for proprioception and most touch enter the dorsal horn and ascend in the dorsal columns.
- These axons synapse in nucleus gracilis (from lower body) and nucleus cuneatus (from upper body) in the medulla.
- Axons from these nuclei cross the midline and ascend to synapse in the ventral posterolateral nucleus (VPL) of the thalamus.
- Axons from the VPL neurons ascend through internal capsule to synapse in primary somatosensory cortex.



Somatosensory Projection to Cortex

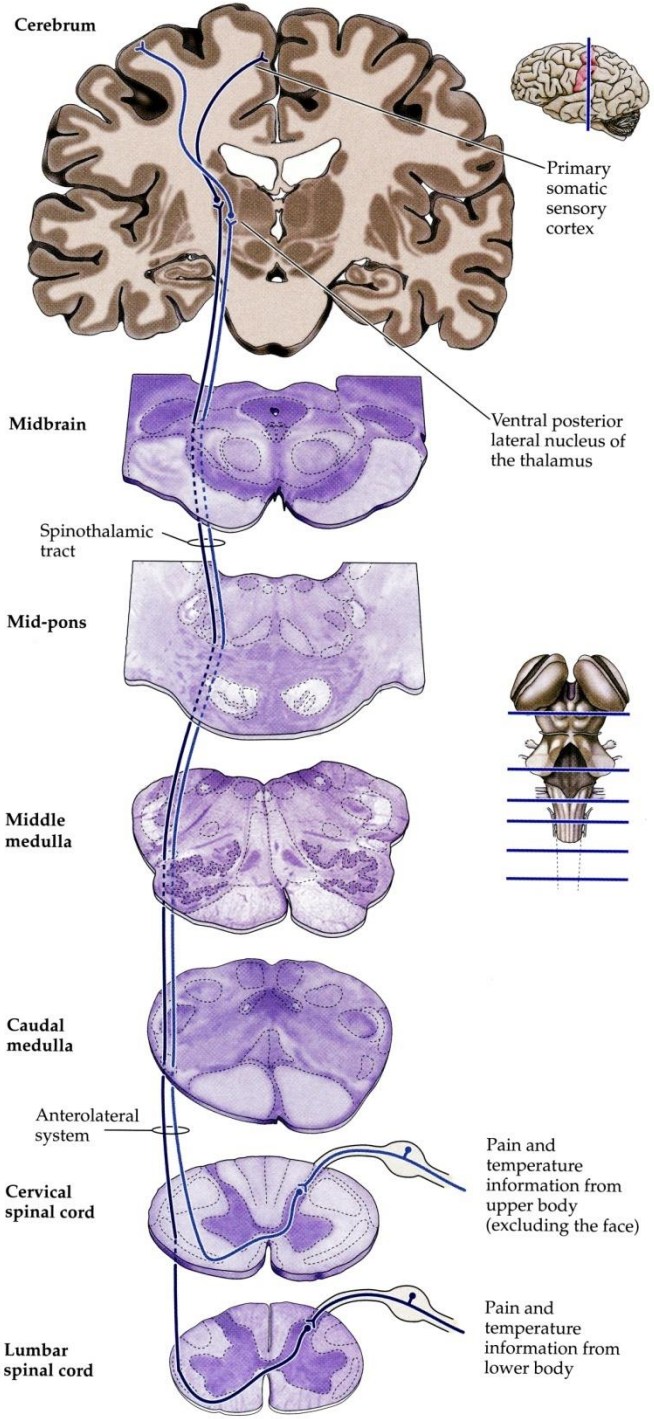
- The dorsal columns are in the dorsal funiculus of the spinal cord.



Somatosensory Projection to Cortex

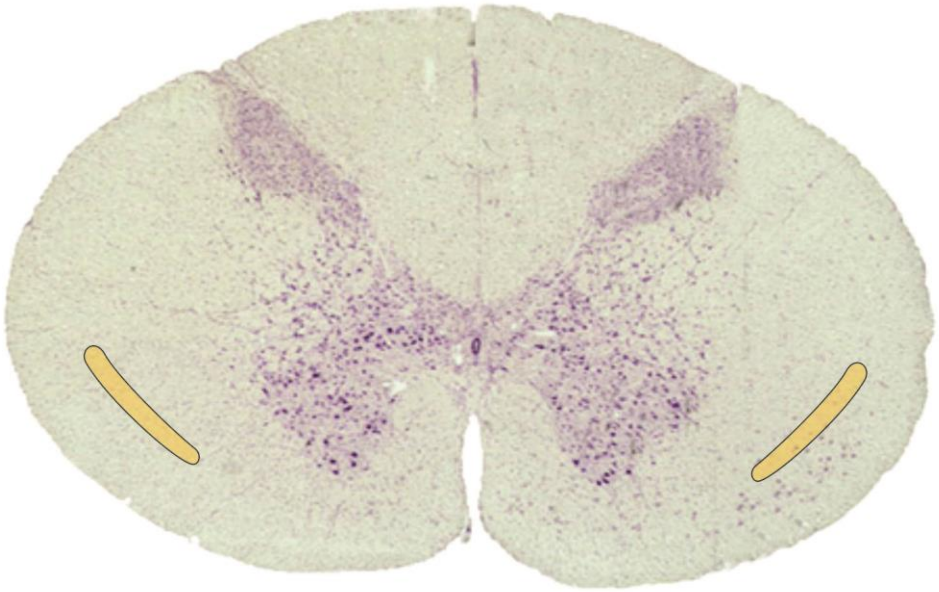
Spinothalamic projection:

- Primary sensory axons for pain, temperature and some touch synapse on neurons in the dorsal horn.
- Axons of these dorsal horn neurons cross the spinal cord and ascend in the spinothalamic tract.
- They synapse in the ventral posterolateral nucleus (VPL) of the thalamus.
- Axons from the VPL neurons ascend through internal capsule to synapse in primary somatosensory cortex.



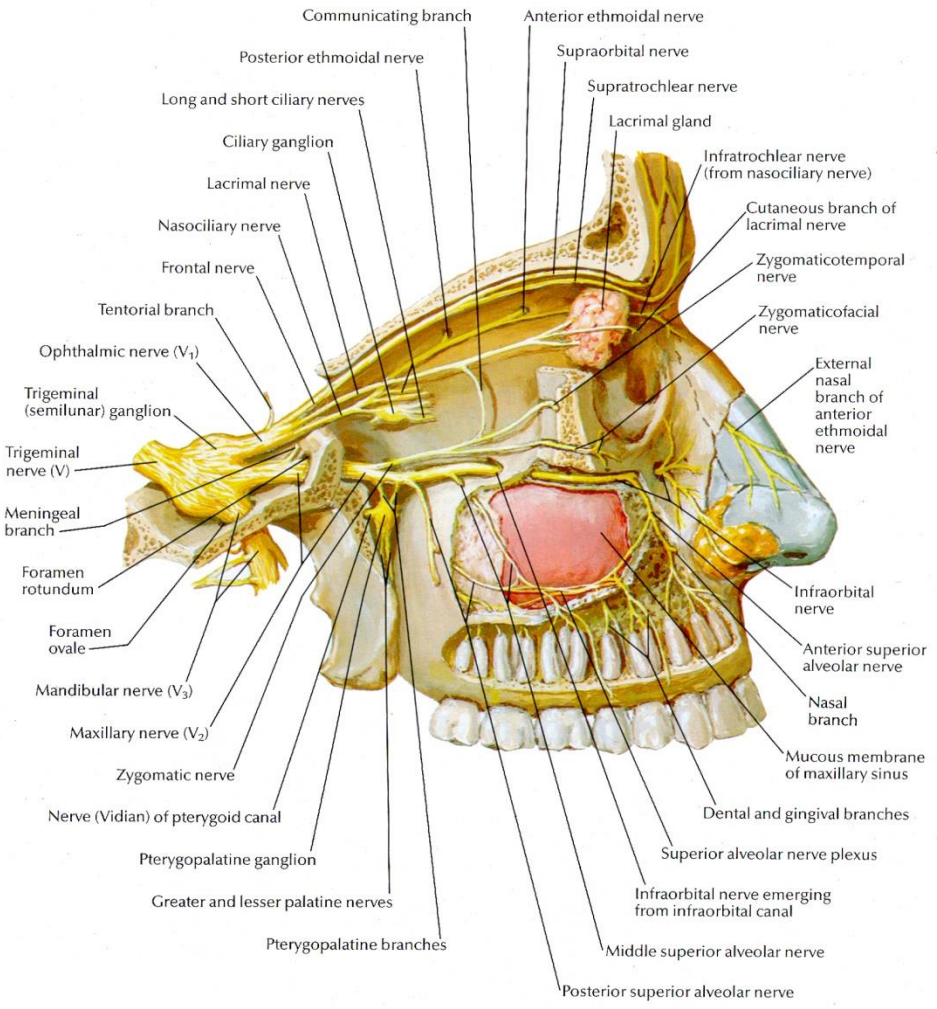
Somatosensory Projection to Cortex

- The spinothalamic tracts are in the lateral funiculus of the spinal cord.



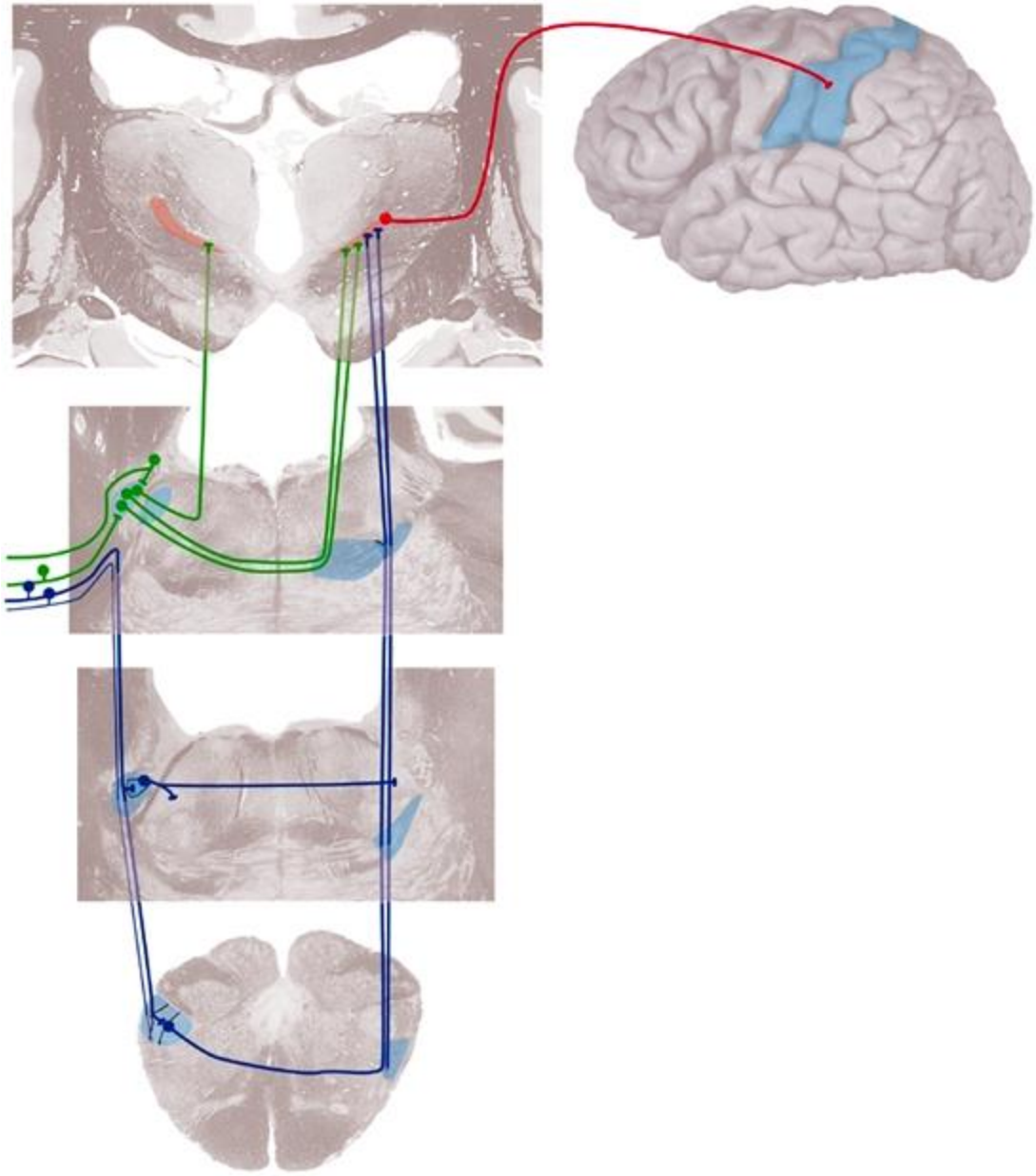
Primary Somatosensory Neurons

- The main somatosensory nerve for the head is the trigeminal nerve (cranial nerve V).
- The trigeminal ganglion is in the skull near where the trigeminal nerve joins the pons.



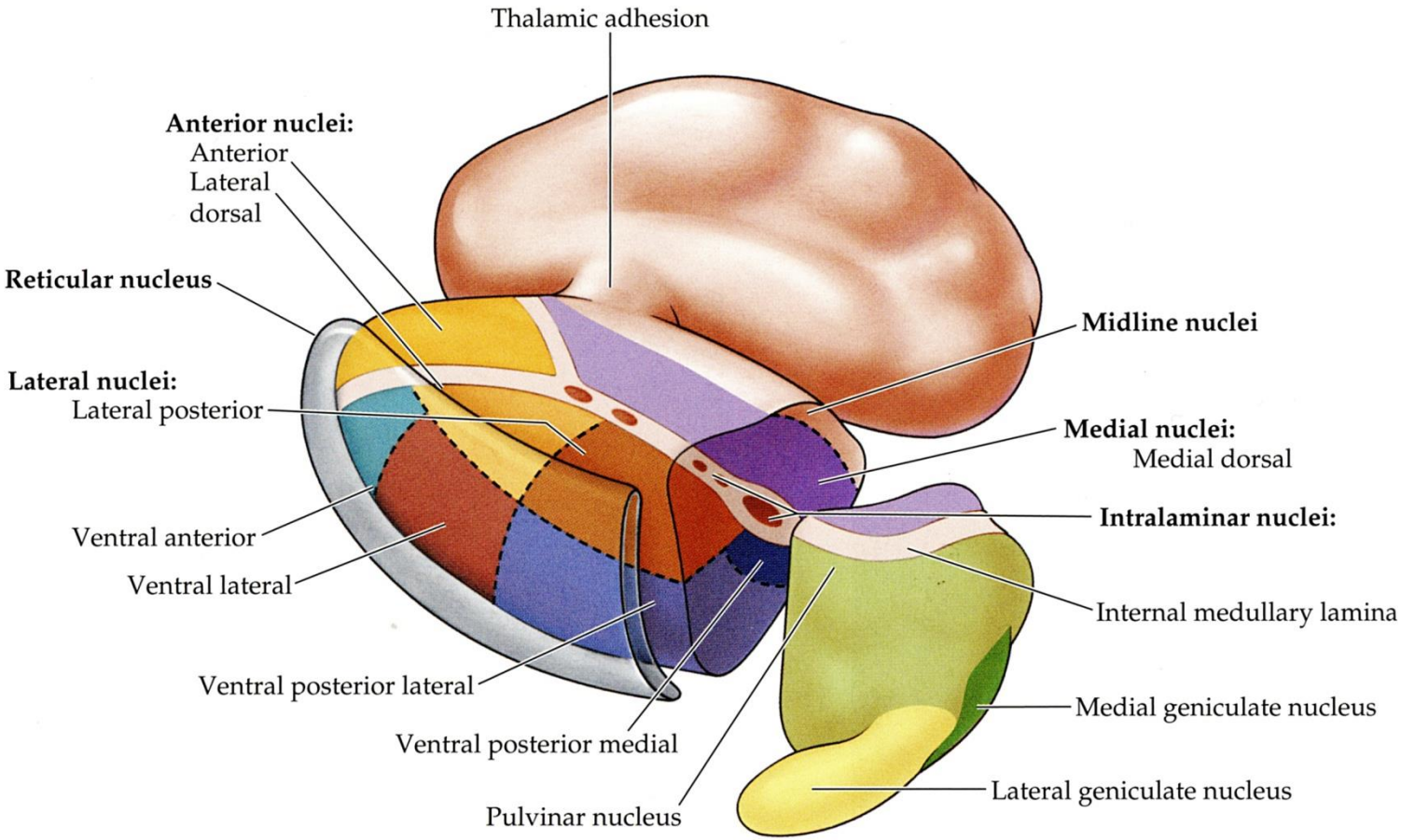
Somatosensory Projection to Cortex

- Trigeminal sensory pathways in the brain are similar to that for the rest of the body.
- Somatosensory information from the trigeminal nerve goes to the ventral posteromedial nucleus (VPM) of the thalamus.



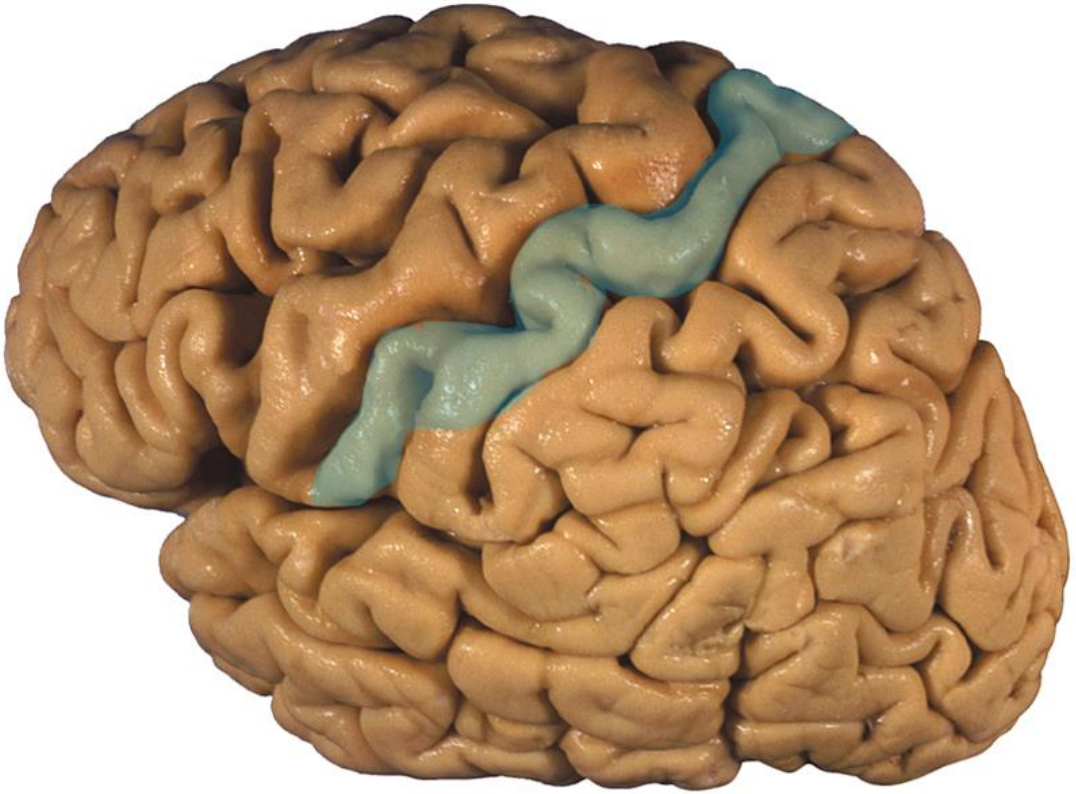
Somatosensory Projection to Cortex

Somatosensory information is relayed via the ventral posterior nucleus (medial and lateral divisions) of thalamus to primary somatosensory cortex.

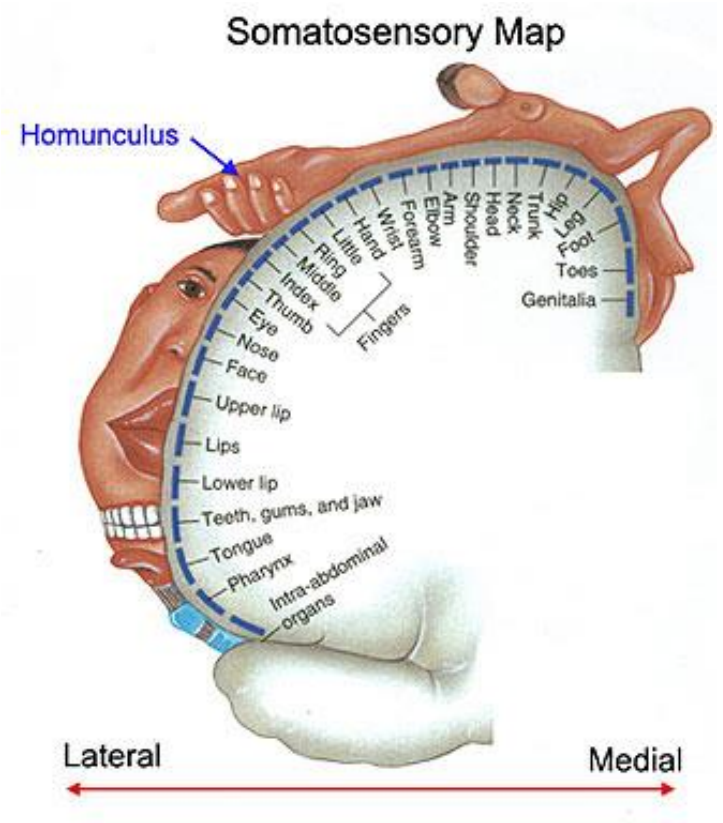


Somatosensory Projection to Cortex

- Primary somatosensory cortex (S1 cortex) is in the postcentral gyrus of the parietal lobe.



- The somatosensory projection has a somatotopic organization throughout the pathway.



Input and Output Systems

Input - Sensory Systems:

- Somatosensory
- Visceral sensory
- Special sensory
  - Vision
  - Auditory
  - Vestibular
  - Gustatory (taste)
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> general sensory

Output – Motor & Endocrine Systems:

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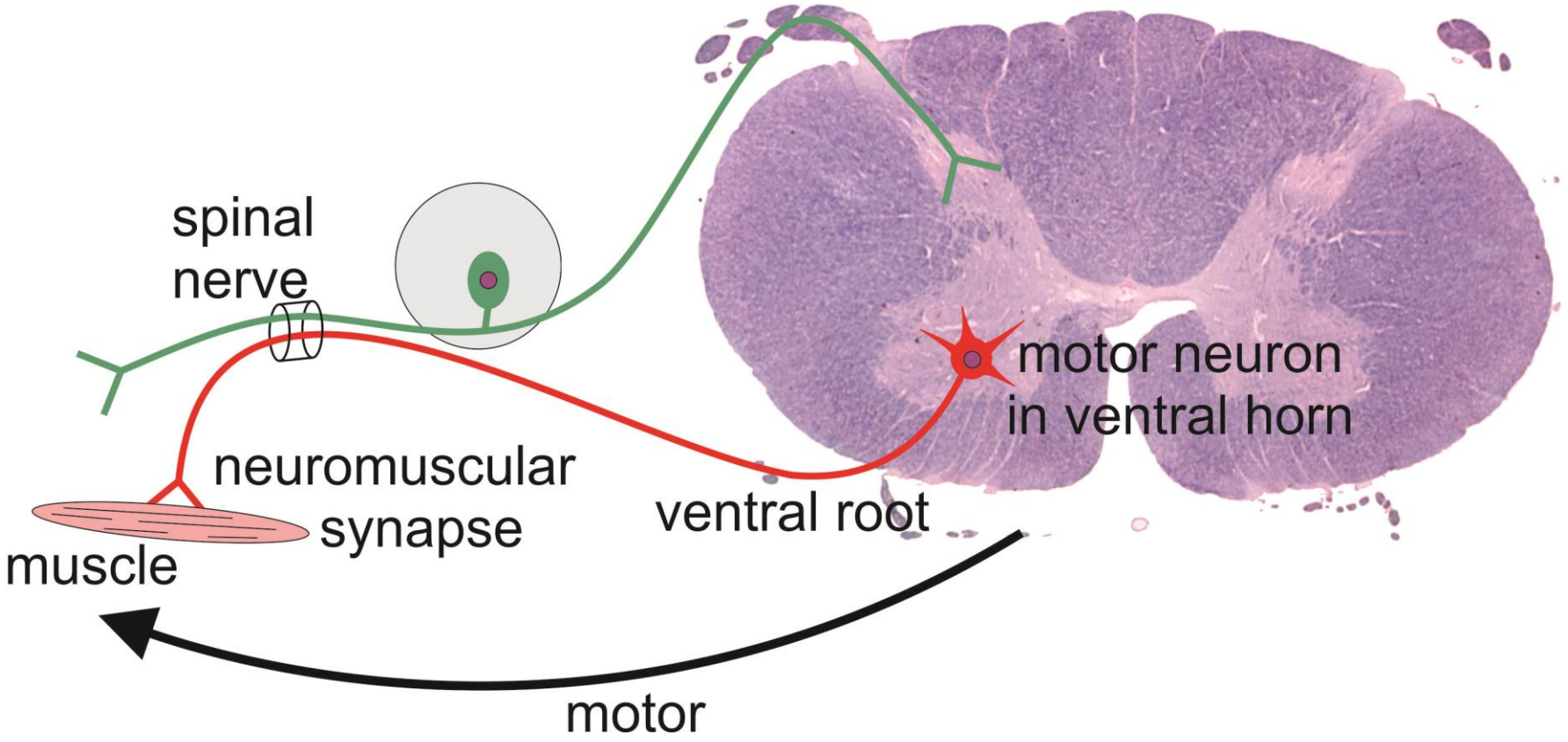
> general motor

General Motor System



Neuromuscular Junction

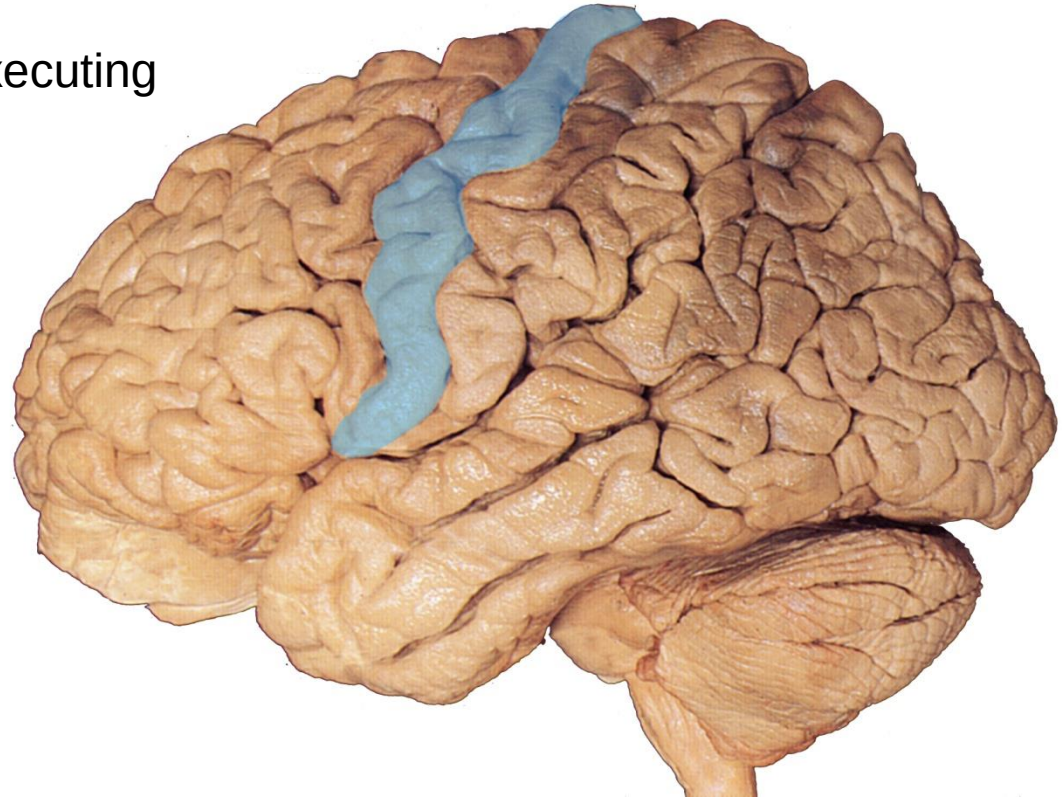
- Each muscle fiber (myofiber) has a synapse with a single motor neuron in the adult.
- A motor neuron can synapse with more than one myofiber.
- Acetylcholine is the neurotransmitter used at neuromuscular junctions.
- Activation by a motor neuron initiates contraction of the myofiber.

Motor Cortex

- The largest descending input to motor neurons is from primary motor cortex in the precentral gyrus of the frontal lobe.

- Axons descending from motor cortex are from upper motor neurons in cortical layer V.

- Motor cortex is essential for executing voluntary movements.



General Motor System

- Upper motor neuron in motor cortex

  (most axons cross to the opposite side of the body)

  -synapses with-

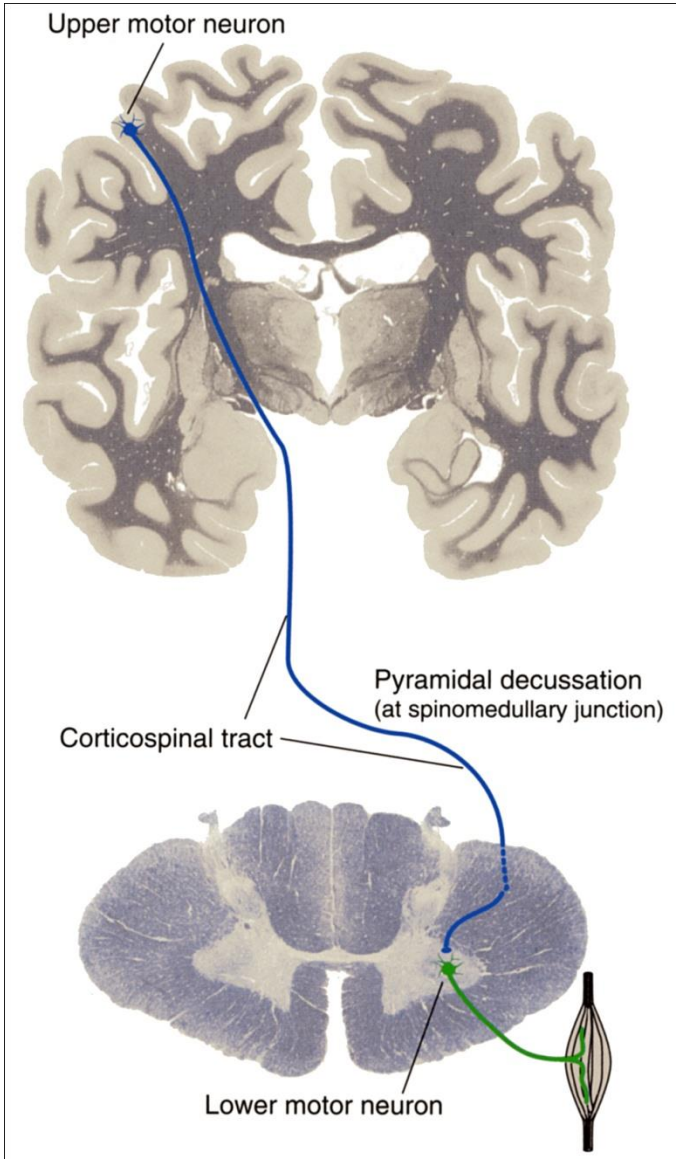
- (Lower) motor neuron in a cranial nerve nucleus in the brainstem or the ventral horn of the spinal cord

  (axons exit CNS via a cranial nerves or ventral roots)

  -synapses with-

- Muscle fiber

  (each muscle fiber has a single neuromuscular synapse; a single motor neuron can innervate multiple muscle fibers)



General Motor System

Other pathways to motor neurons:

- Rubrospinal tract – from red nucleus in midbrain, runs close to lateral corticospinal tract to all levels of the spinal cord for fine tuning limb movements

- Vestibulospinal tract – from vestibular nuclei to all levels of the spinal cord for balance and adjusting head position

- Reticulospinal tract – from reticular formation in pons and medulla to all levels of the spinal cord for automatic control of trunk muscles for posture and limb muscles for learned movements

- Tectospinal tract – from superior colliculus to cervical spinal cord for coordination of head & eye movements

- Reflex circuits – from other local spinal neurons including some sensory neurons

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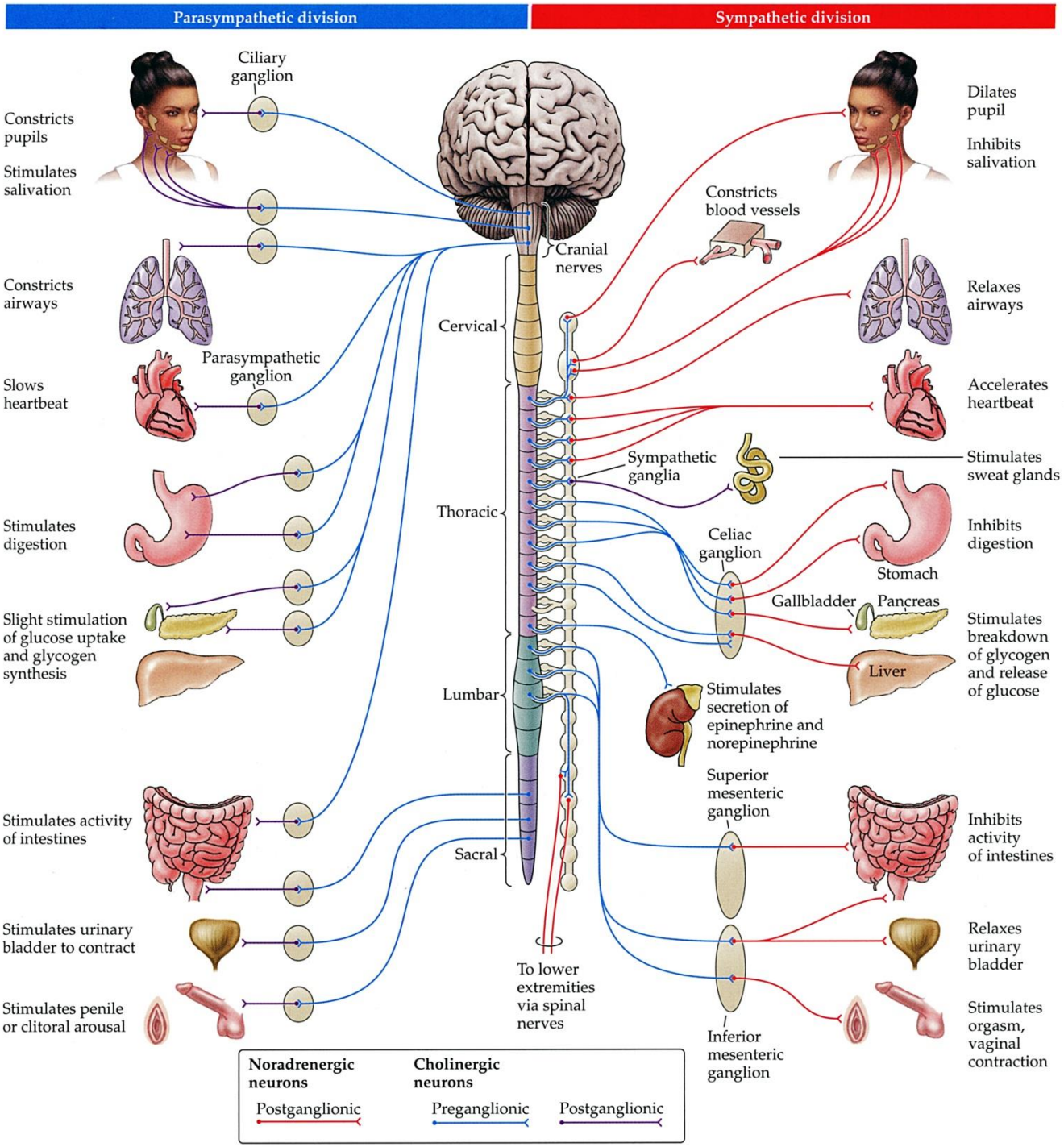
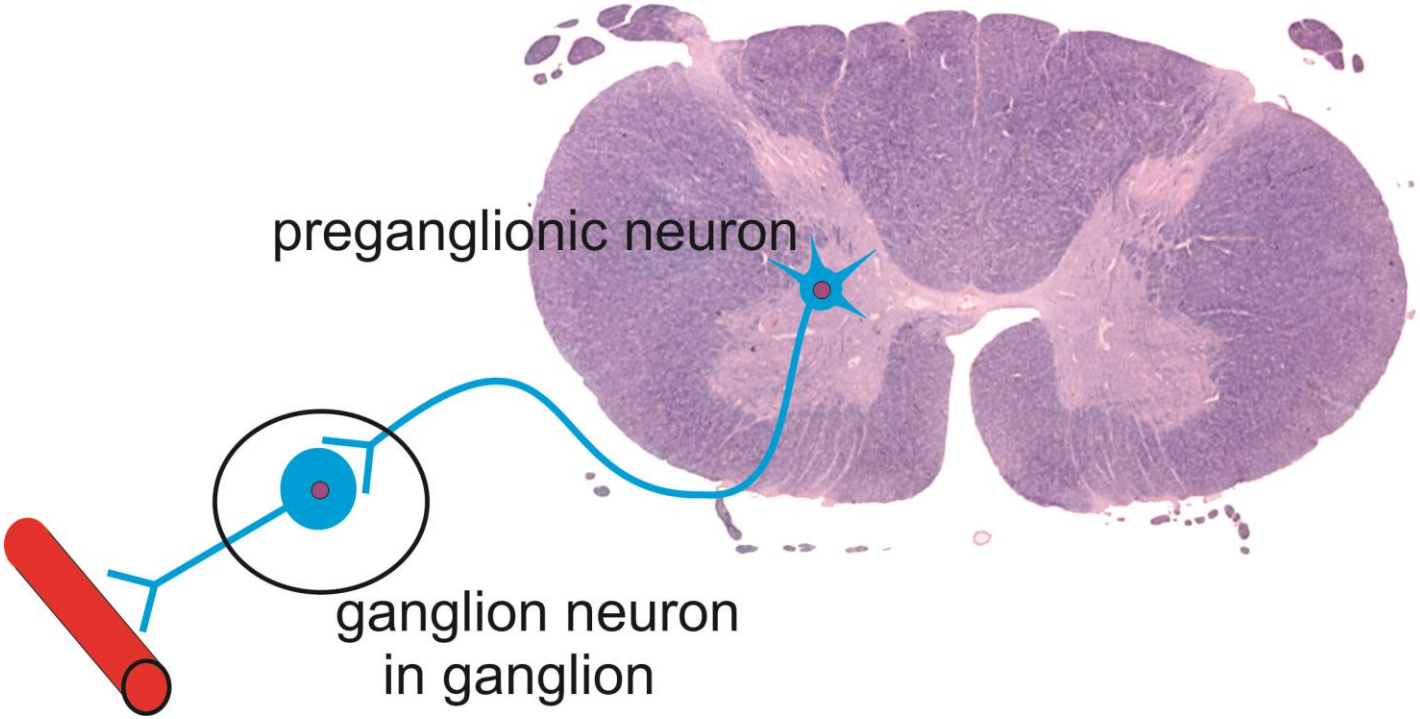
> general motor


Parasympathetic division
Sympathetic division
Ciliary ganglion
Constricts pupils
Stimulates salivation
Constricts airways
Parasympathetic ganglion
Slows heartbeat
Stimulates digestion
Slight stimulation of glucose uptake and glycogen synthesis
Stimulates activity of intestines
Stimulates urinary bladder to contract
Stimulates penile or clitoral arousal
Cranial nerves
Cervical
Thoracic
Lumbar
Sacral
To lower extremities via spinal nerves
Dilates pupil
Inhibits salivation
Constricts blood vessels
Relaxes airways
Accelerates heartbeat
Sympathetic ganglia
Stimulates sweat glands
Celiac ganglion
Inhibits digestion
Stomach
Gallbladder
Pancreas
Stimulates breakdown of glycogen and release of glucose
Liver
Stimulates secretion of epinephrine and norepinephrine
Superior mesenteric ganglion
Inhibits activity of intestines
Relaxes urinary bladder
Inferior mesenteric ganglion
Stimulates orgasm, vaginal contraction
Noradrenergic neurons
Postganglionic
Cholinergic neurons
Preganglionic
Postganglionic

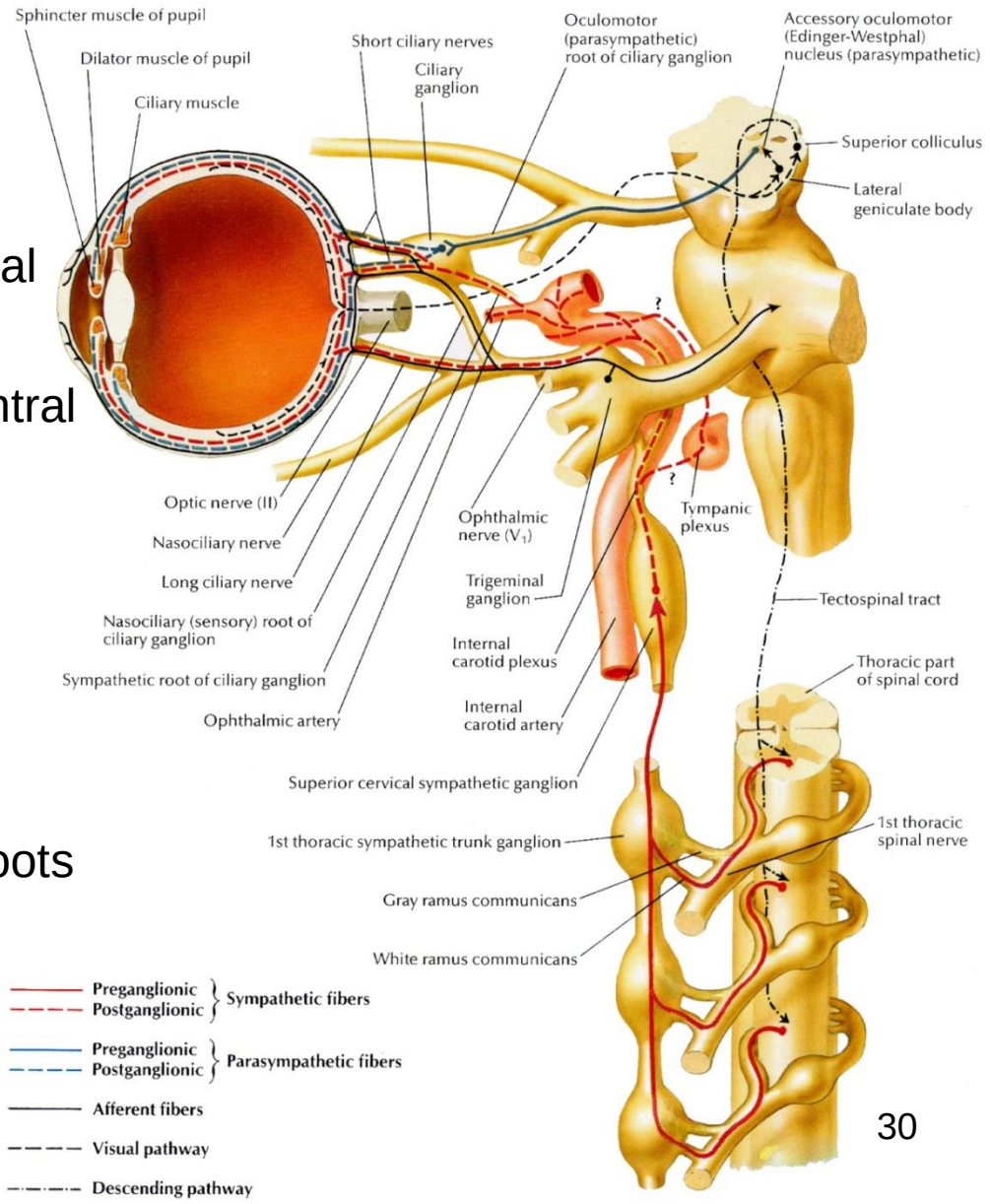
Autonomic Nervous System

- Two neuron chain:
  - Preganglionic neuron in brainstem or spinal cord
  - Ganglion neuron in PNS ganglion



Autonomic System (motor)

- Parasympathetics
  - Cranial (brainstem) and sacral spinal cord preganglionic neuron
  - Axons exit via cranial nerves or ventral roots
  - Ganglion near target
- Sympathetics
  - Thoracic and lumbar spinal cord preganglionic neuron
  - Axons exit spinal cord via ventral roots
  - Ganglion along vertebral column



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> general motor

cranial nerve		*function*				
		general motor	*parasympathetic*	*general sensory*	*special sensory*	
I	Olfactory				X (olfaction)	
II	Optic				X (vision)	
III	Oculomotor	X[a]	X			
IV	Trochlear	X[a]				
V	Trigeminal	X[b]		X[c]		
VI	Abducens	X[a]				
VII	Facial	X[b]	X	X	X (taste)	
VIII	Vestibulocochlear				X (auditory & vestibular)	
IX	Glossopharyngeal	X[b]	X	X[c]	X (taste)	
X	Vagus	X[b]	X	X[c]	X (taste)	
XI	Accessory *	X[a]				
XII	Hypoglossal	X[a]				

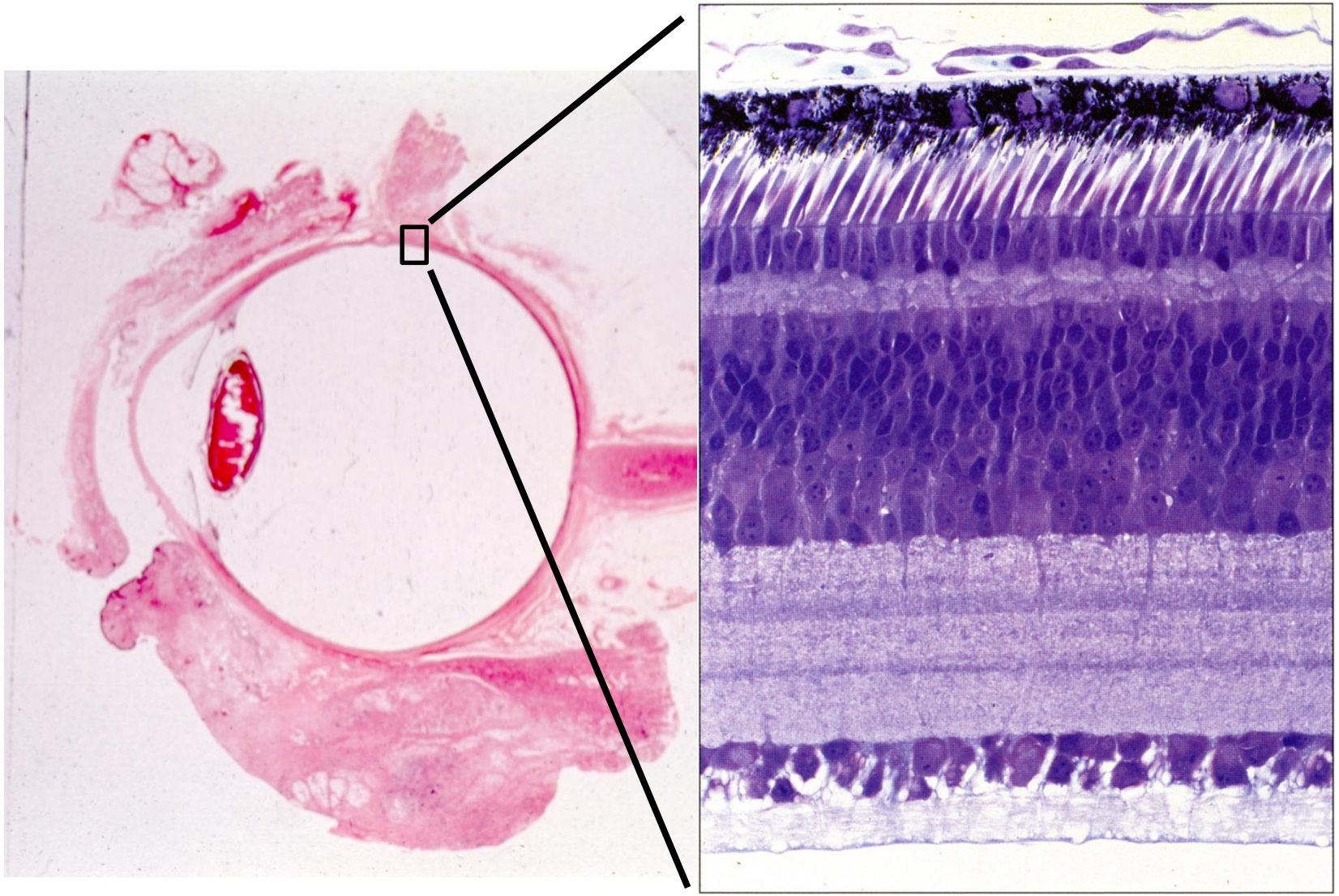
* cervical component; cranial component included with vagus

[a] somatic motor – innervates muscles that develop from somites

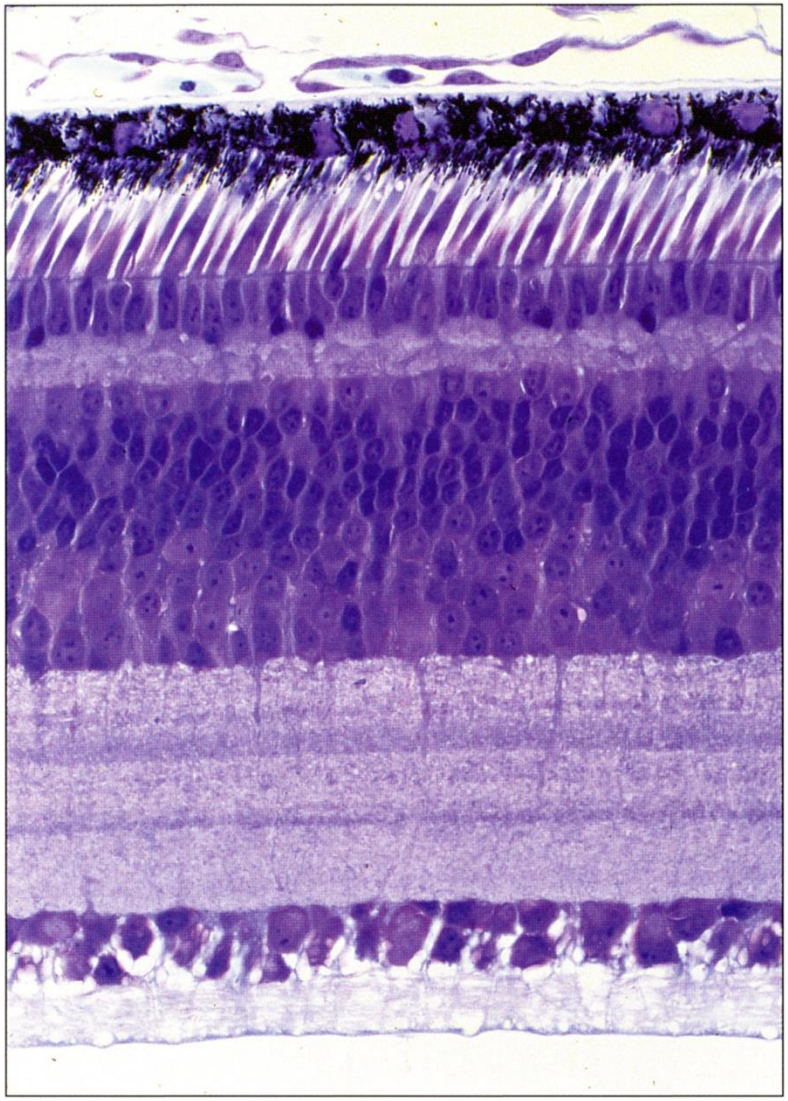
[b] branchial motor – innervates muscles that develop from pharyngeal (branchial) arches

[c] includes visceral sensory as well as somatosensory

Retina



Retina



retinal pigment epithelium (RPE)

inner & outer segments
(receptor apparatus)

outer nuclear layer

outer plexiform layer

inner nuclear layer

inner plexiform layer

ganglion cell layer

optic fiber layer
(axons of ganglion cells)

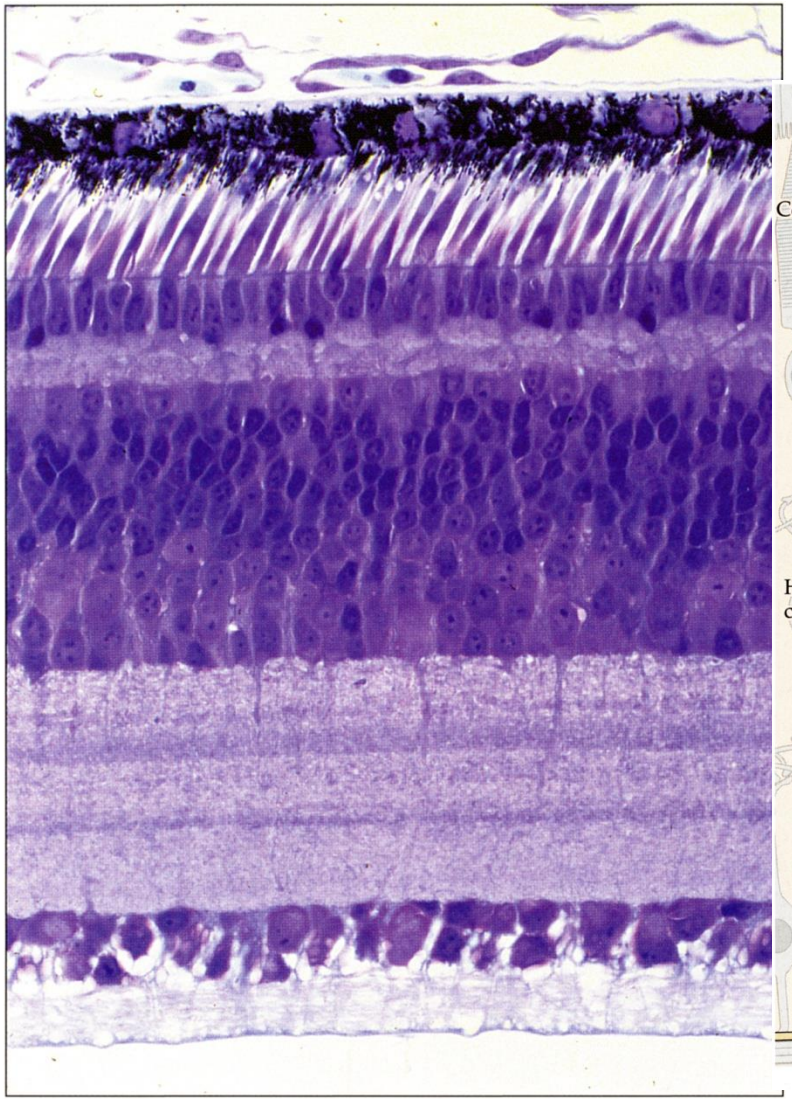
Retina

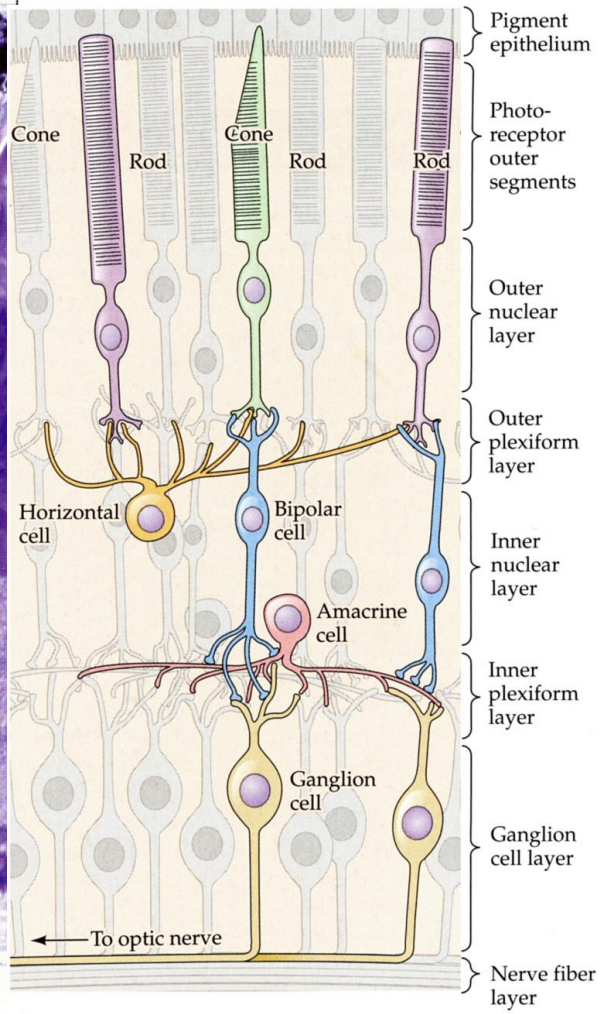
pigment epithelial cells

photoreceptor neurons (rod and cone cells)

interneurons and glial cells (horizontal, amacrine, bipolar and Muller cells)

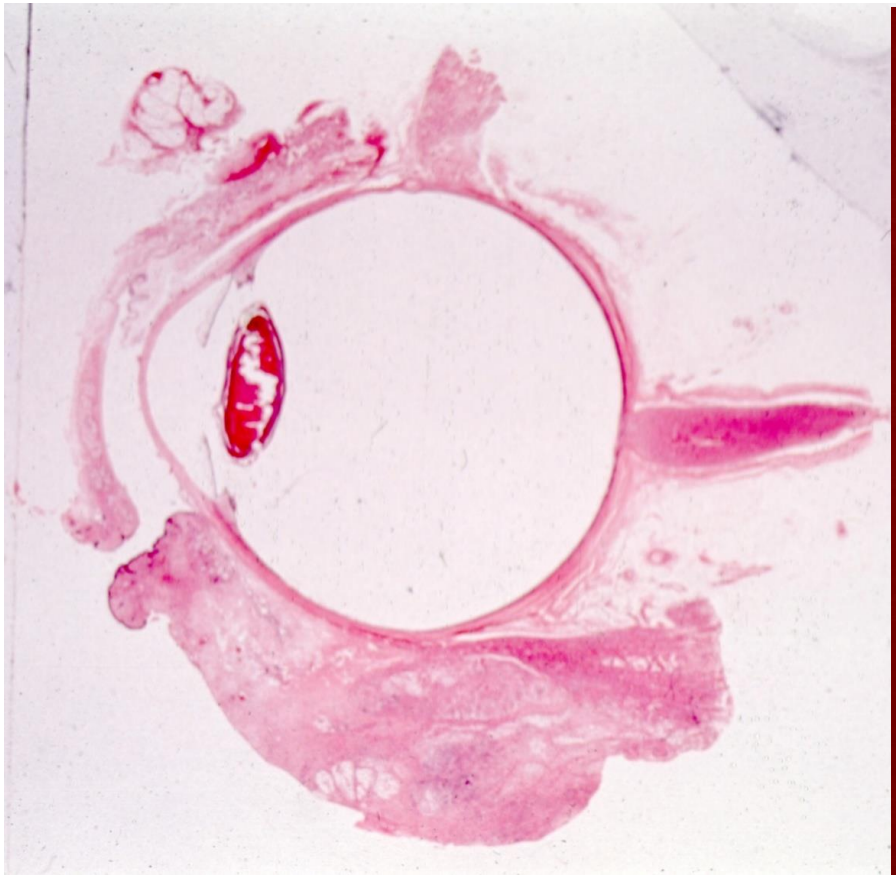
ganglion cells



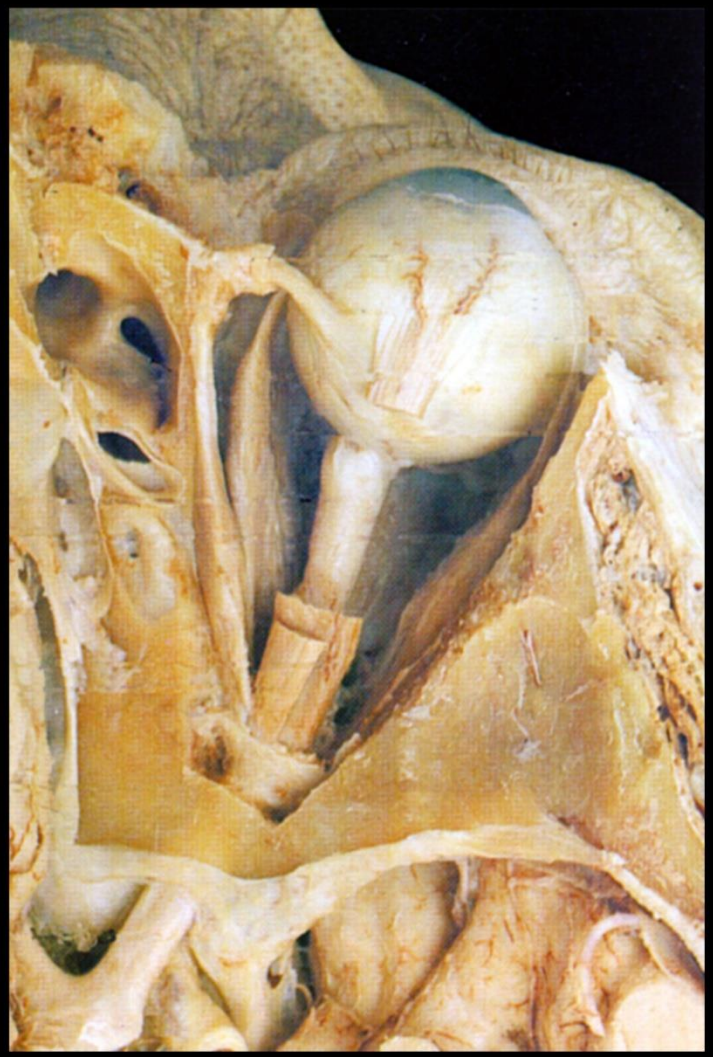


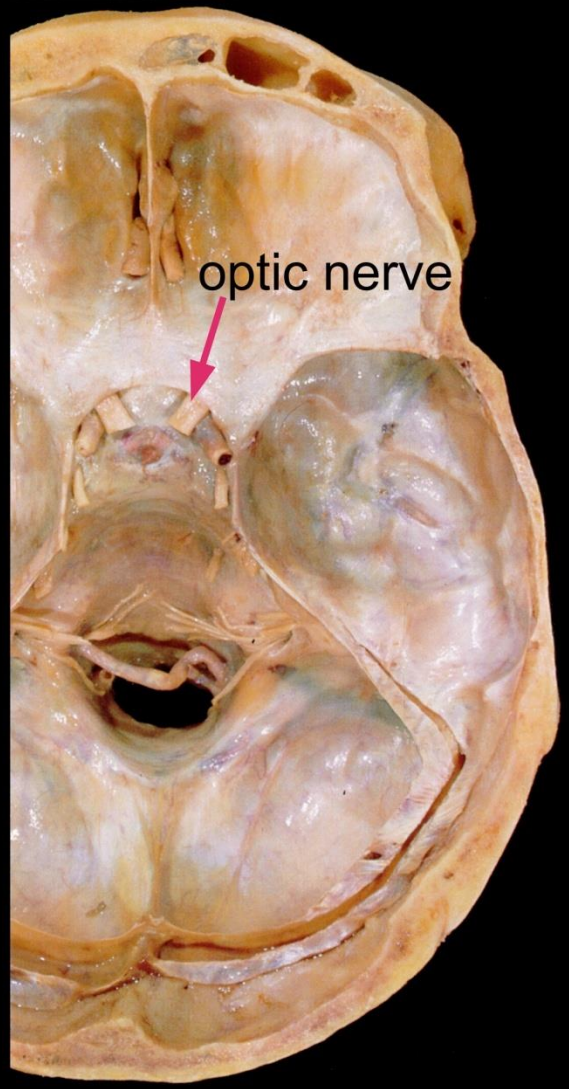
Optic Nerve (CN II)

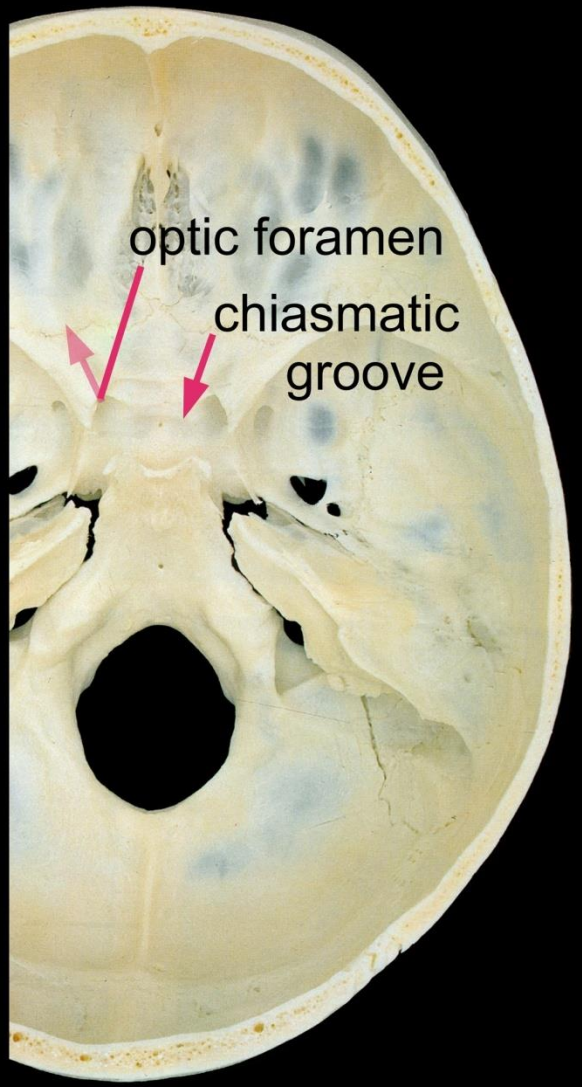
- The axons from retinal ganglion cells across the retina run to the optic nerve head.
- The optic nerve head is the start of the optic nerve.
- There is no retina at the optic nerve head (blind spot).



Optic Nerve (CN II)

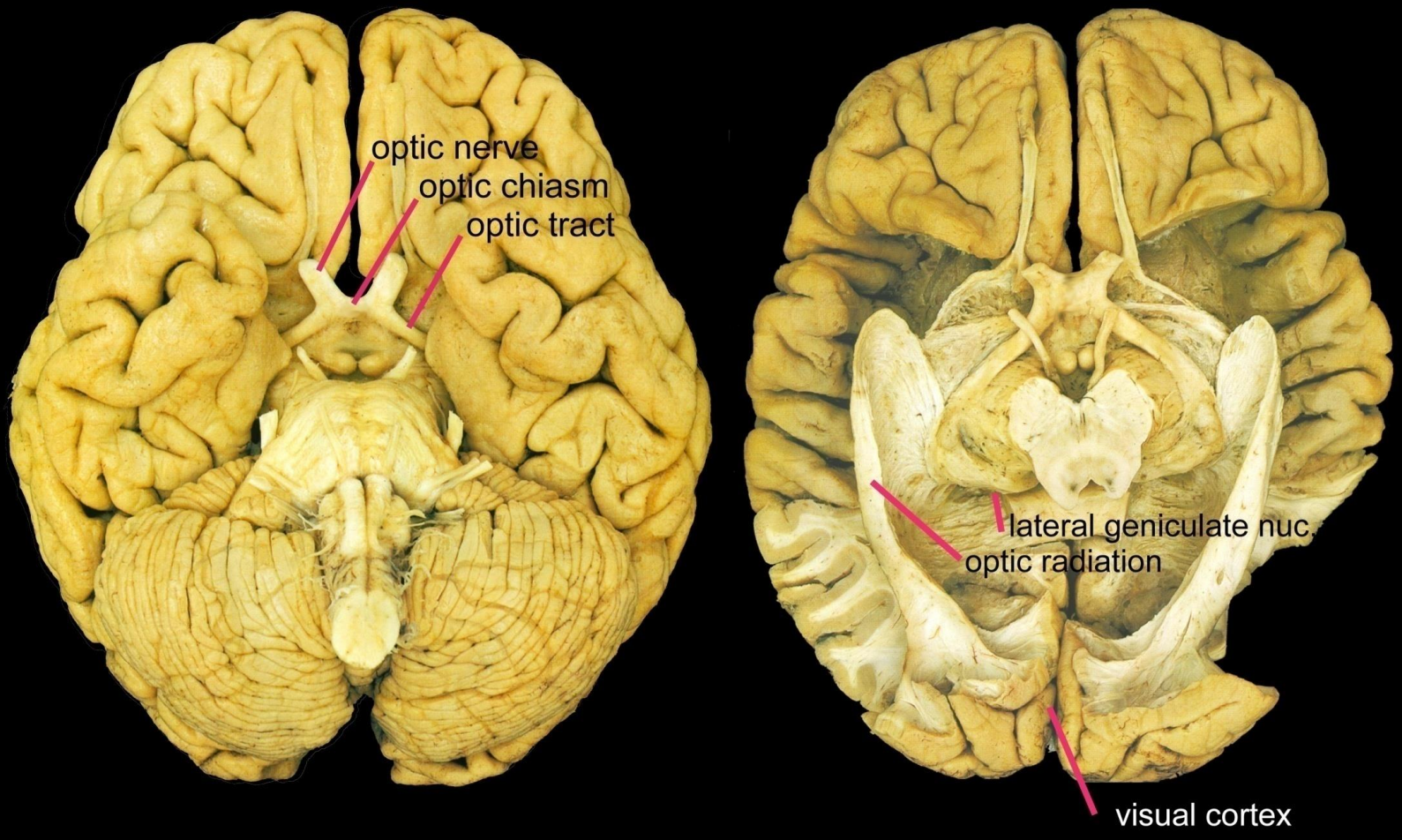




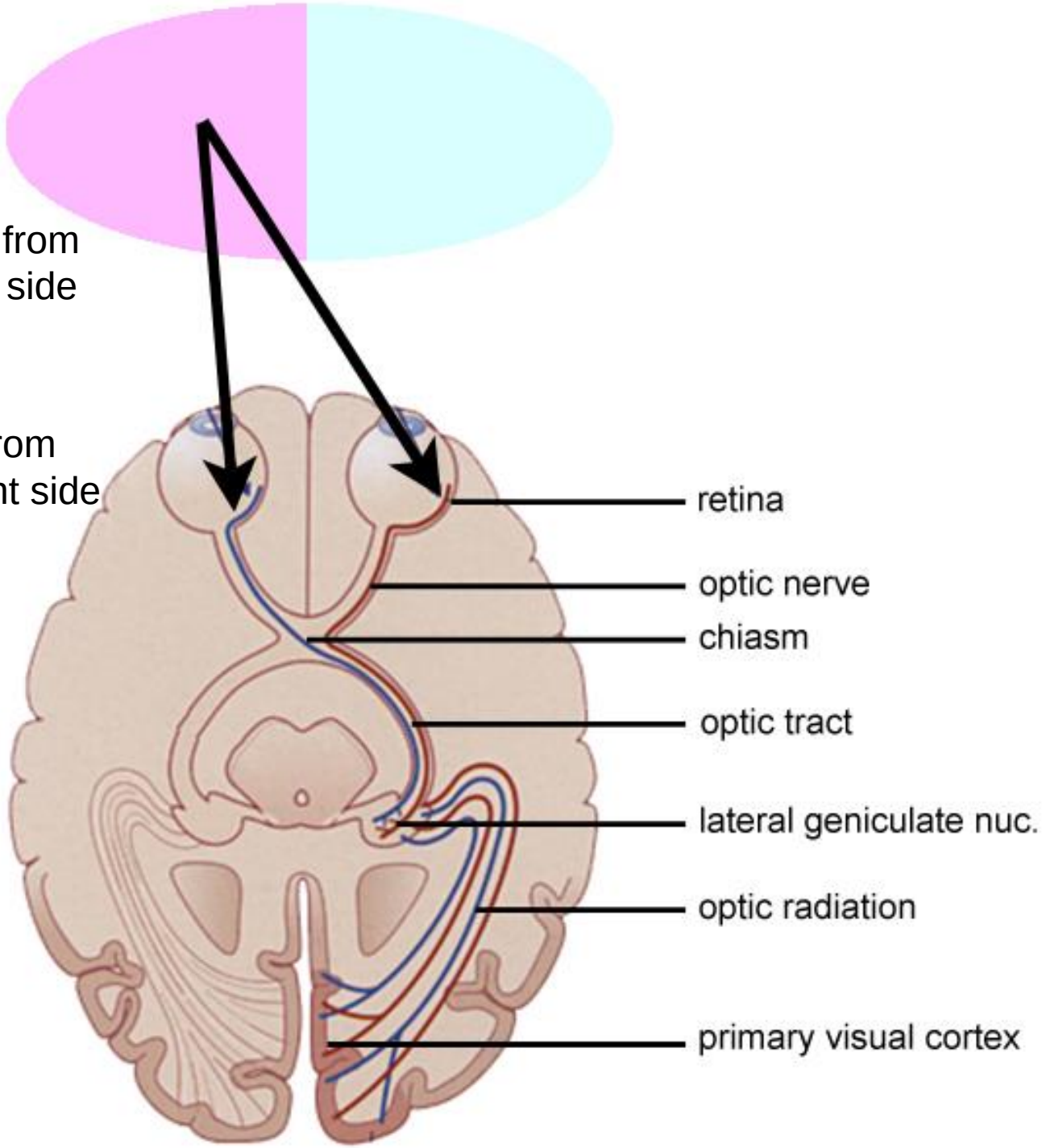


Central Visual Pathways

- The optic nerve attaches to the brain at the optic chiasm.
- The retinal axons continue in the optic tract.

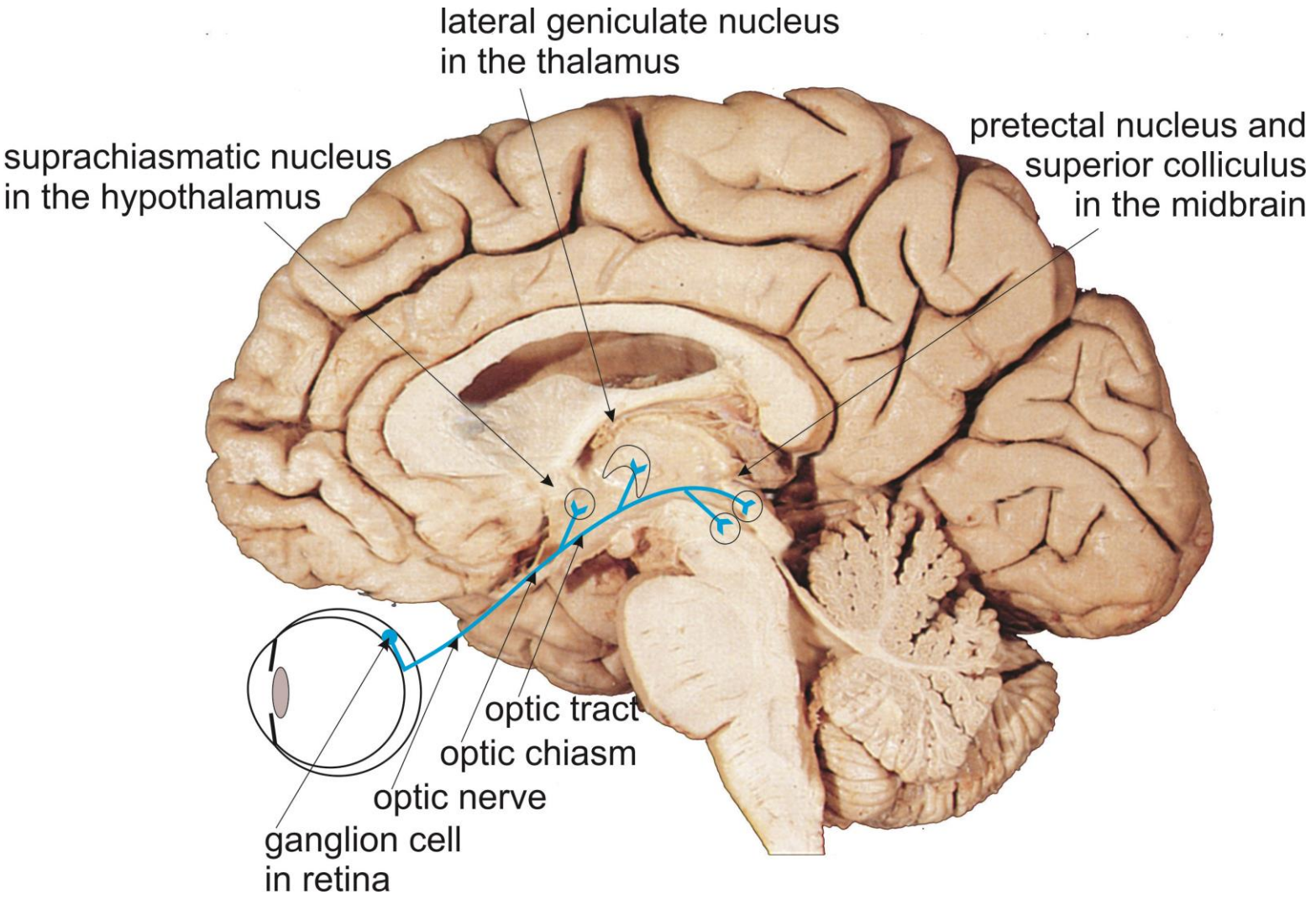


- The right visual hemifield from both eyes goes to the left side of the brain.
- The left visual hemifield from both eyes goes to the right side of the brain.



Central Visual Pathways

- Retinal axons synapse in several visual centers in the brain.



Central Visual Pathways

Retinal axons synapse in several visual centers in the brain including:

- Suprachiasmatic nucleus in the hypothalamus for regulation of circadian rhythms.

- Lateral geniculate nucleus in the thalamus for relay to visual cortex for conscious perception of vision.

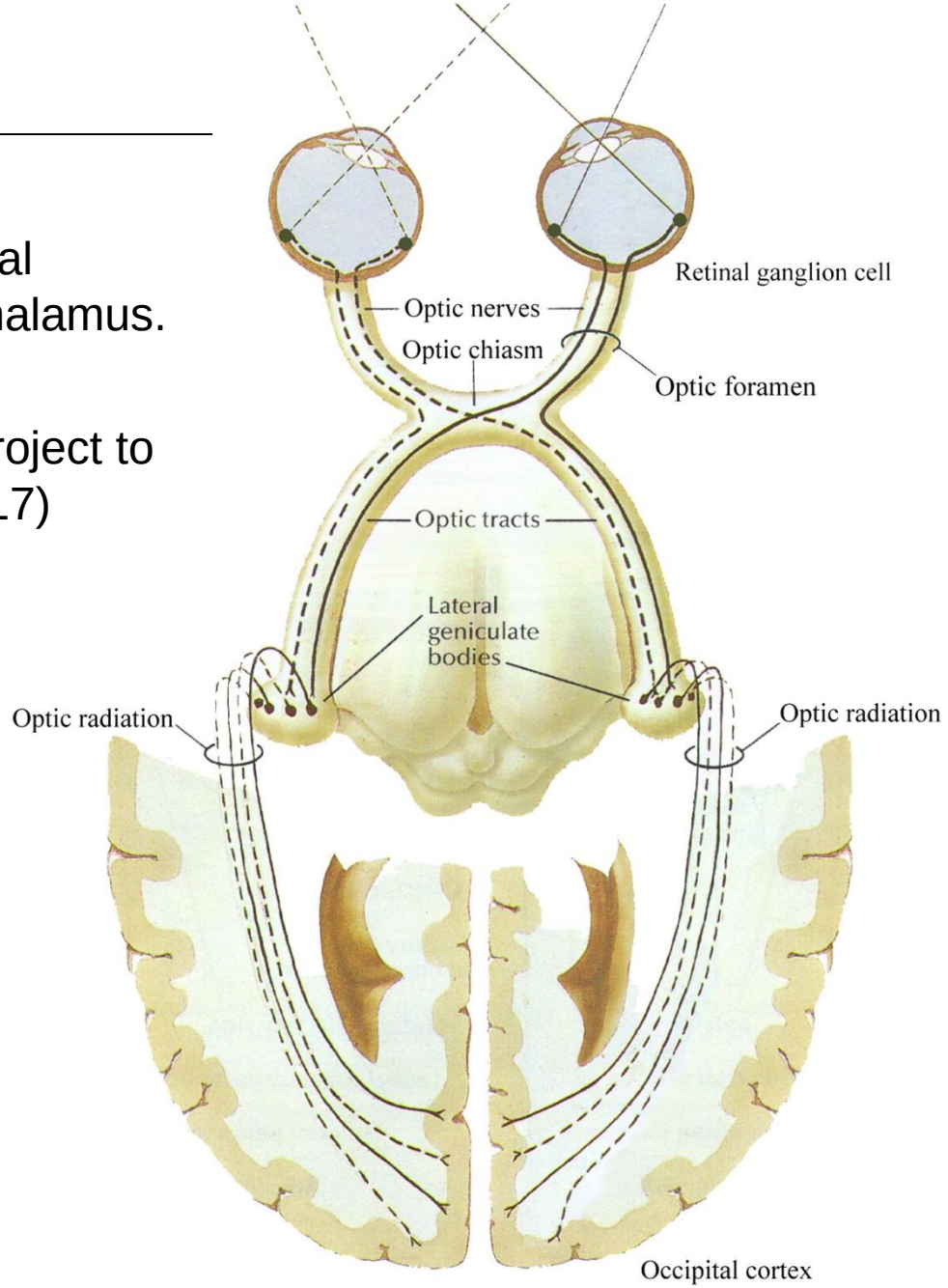
- Pretectal nucleus for the pupillary light reflex and other reflexes.

- Superior colliculus in the midbrain for oculomotor control.

Different axons go to different targets; no axon goes to all these visual centers.

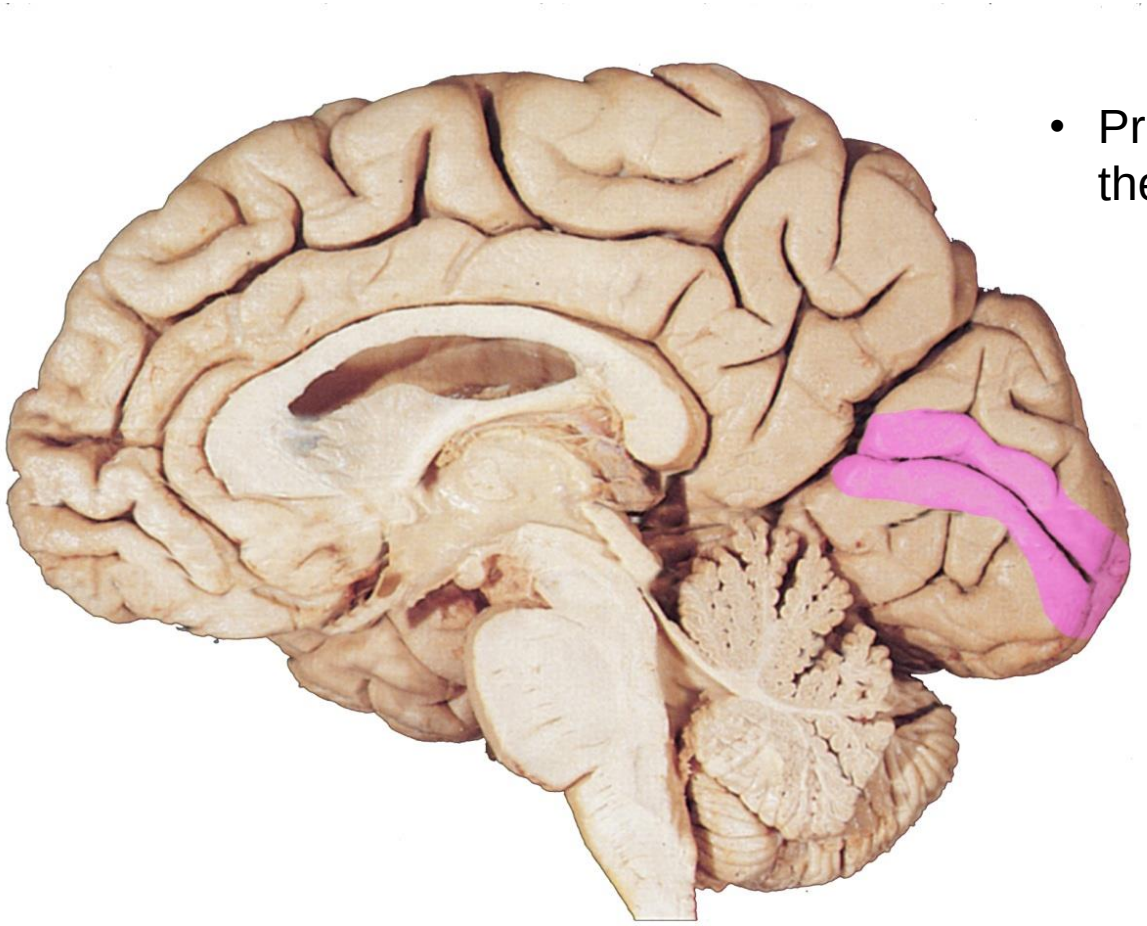
Central Visual Pathways

- Retinal axons synapse in the lateral geniculate nucleus (LGN) of the thalamus.
- Axons from neurons in the LGN project to primary visual cortex (V1 or area 17)



Central Visual Pathways

- Primary visual cortex is essential for conscious visual perception.



- Primary visual cortex is in the occipital lobe.