COGS 17 Week 7

Spring 2024, A03

Slides Adapted From Previous Quarter

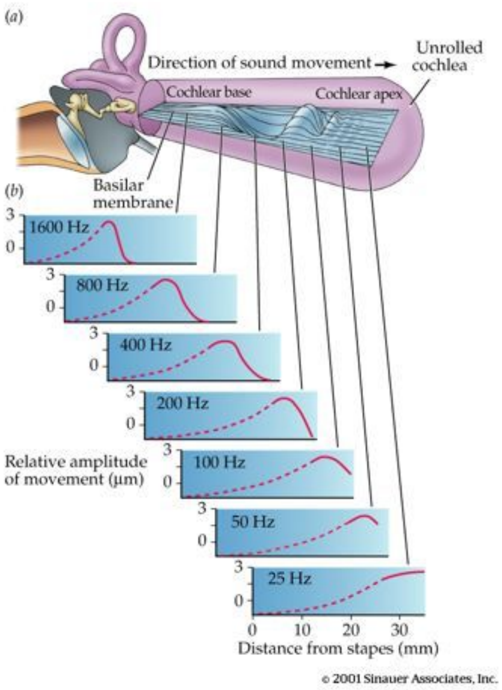
By: Jason Chen

Announcement

- Midterm On May 16, 2024 (Thursday) 3:30 - 4:50 pm
- 26 Questions, most of them require multiple responses
- 80 Minutes to complete
- One attempt
- You can revisit and change answers
- No section Next Monday

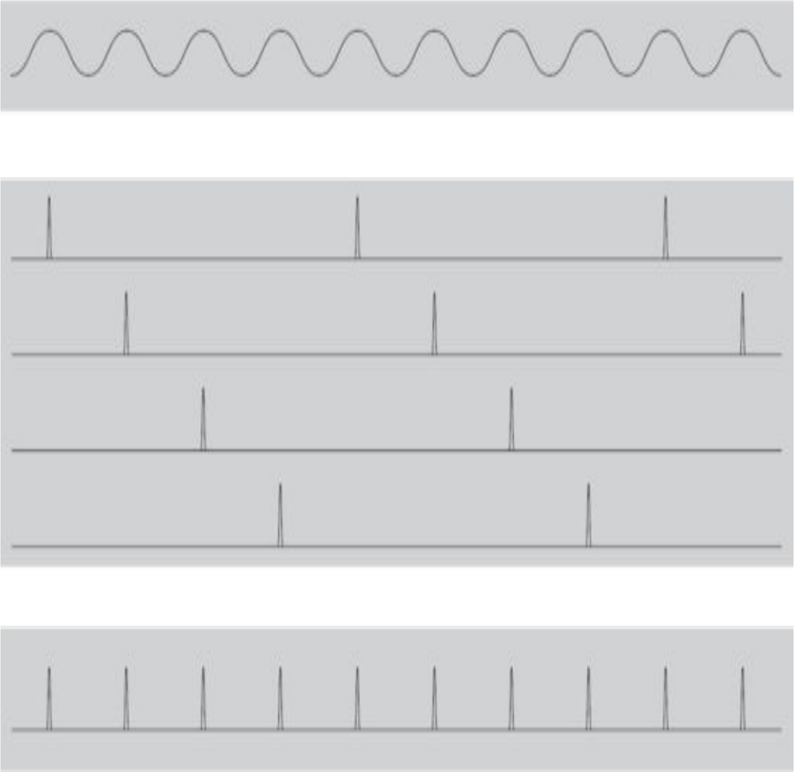
Audition

Place Coding



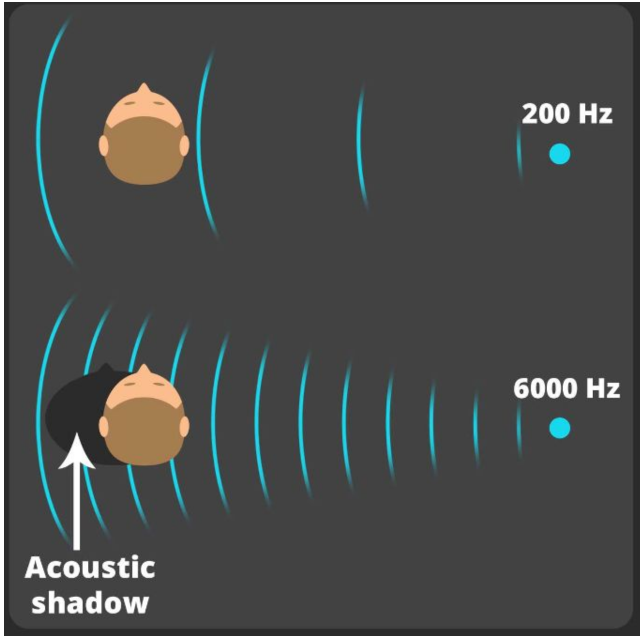
- The **BASE** of the basilar membrane is narrow and stiff >> resonates to **HIGH** frequencies
- The **APEX** of the basilar membrane is wide and floppy >> resonates to **LOW** frequencies
- The more the Basilar Membrane resonates, the farther it moves >> the farther the Cilia will bend >> more NT release
- The **DISTRIBUTION** of NT release along Basilar Membrane that codes for Frequency

Temporal Coding



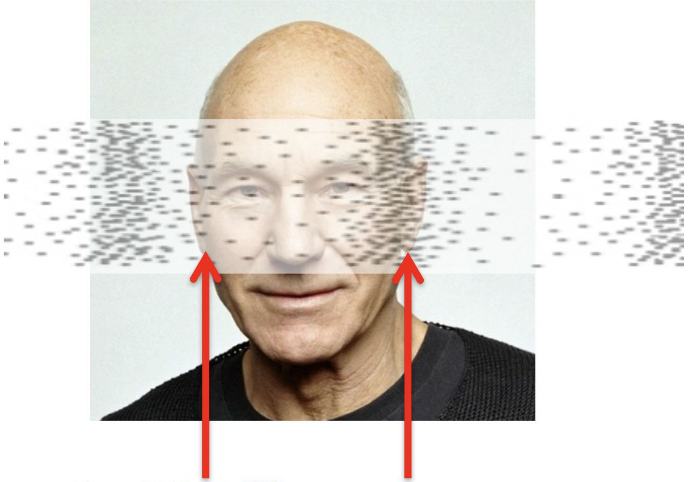
- The whole basilar membrane will vibrate at the rate of input
- However, Hair Cells communicate to Spiral Ganglions, which fire **ACTION POTENTIAL**, which limits the rate spiral ganglions can fire (due to the **refractory period**)
- Maximum frequency ~1000 Hz
- Solution: Volley Principle -- No single Ganglion cell can code for a high rate, but a group of them working together can

Localization via Intensity differences



- Sound at ear closer to source is slightly more intense than at other ear, because of the head shadow
- Works best for **higher** frequencies, since these most likely to be absorbed by head

Localization via phase differences

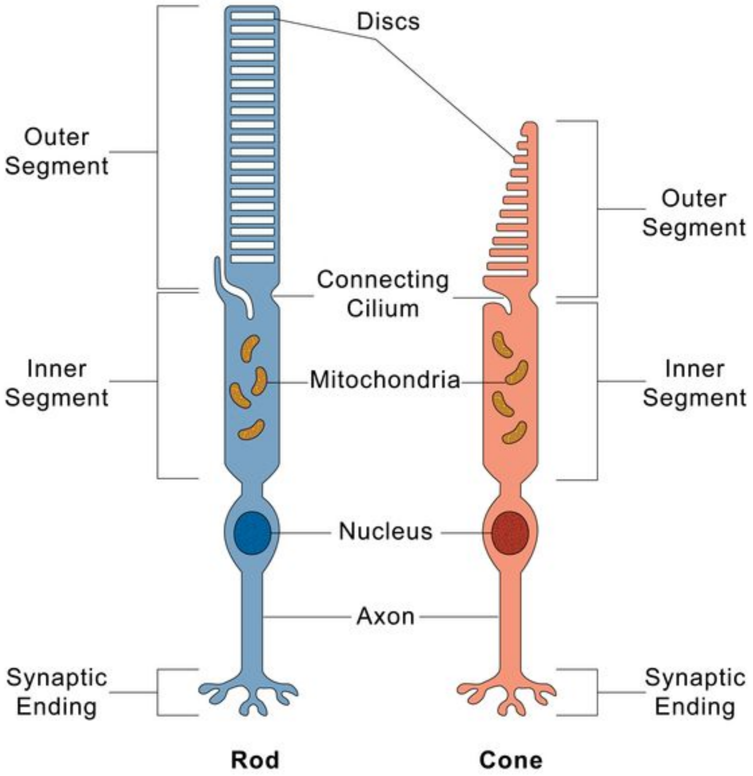


Note PHASE difference at two ears

- For **lower** frequencies (longer wavelength), can detect difference in peak vs. trough of wave reaching two ears

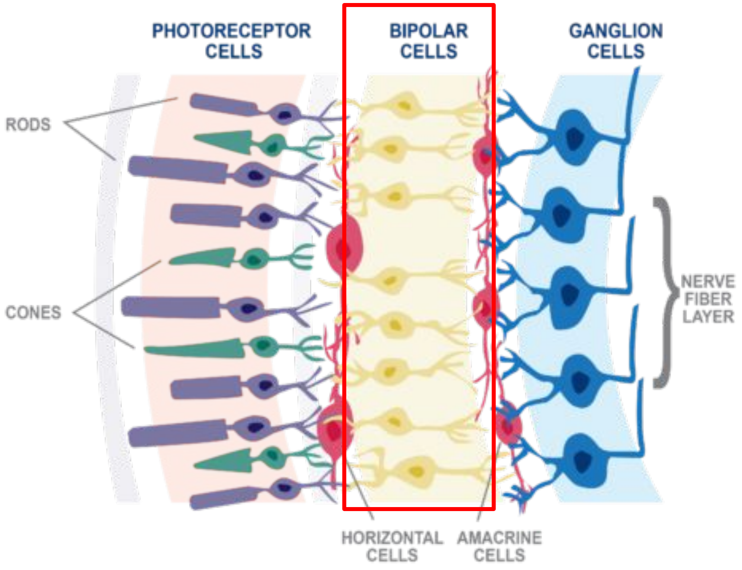
Vision

Visual Receptors



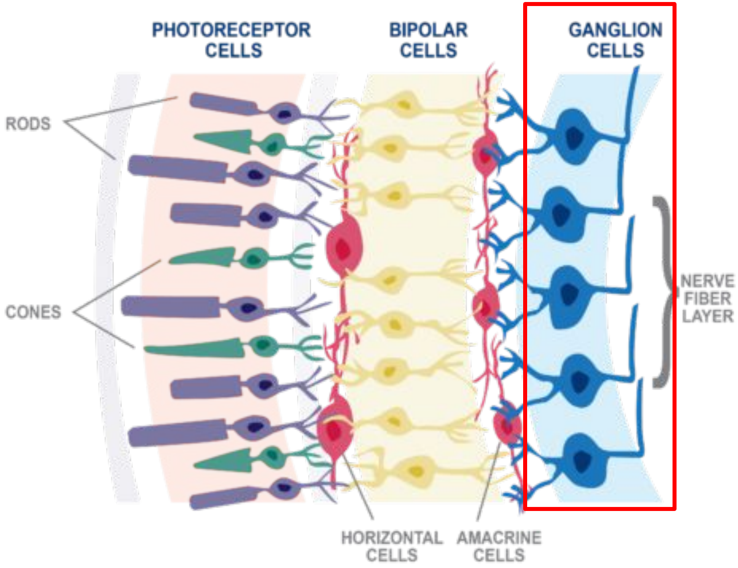
- Rods -- being larger, have MORE photopigment but only 1 kind >> **DO NOT** code color; **high** sensitivity; **poor** acuity; **excellent** for motion detection
- Cones -- smaller, have 3 kinds of photopigments >> **DO** code color; **low** sensitivity; **excellent** acuity; **poor** for motion detection
- Receptors show **Spontaneous** firing, **Graded** potentials, release **Inhibitory** NT

Bipolar Cells



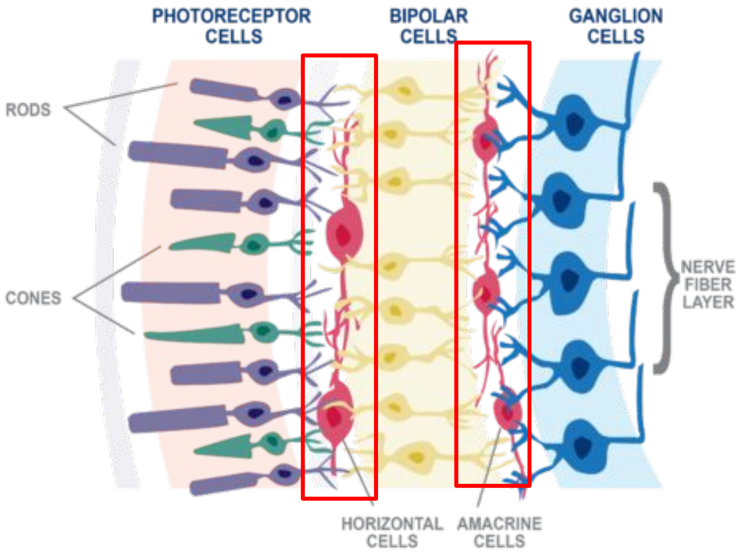
- Postsynaptic to Receptors, show **Spontaneous** firing, **Graded** Potentials, release **Excitatory** NT

Ganglion Cells



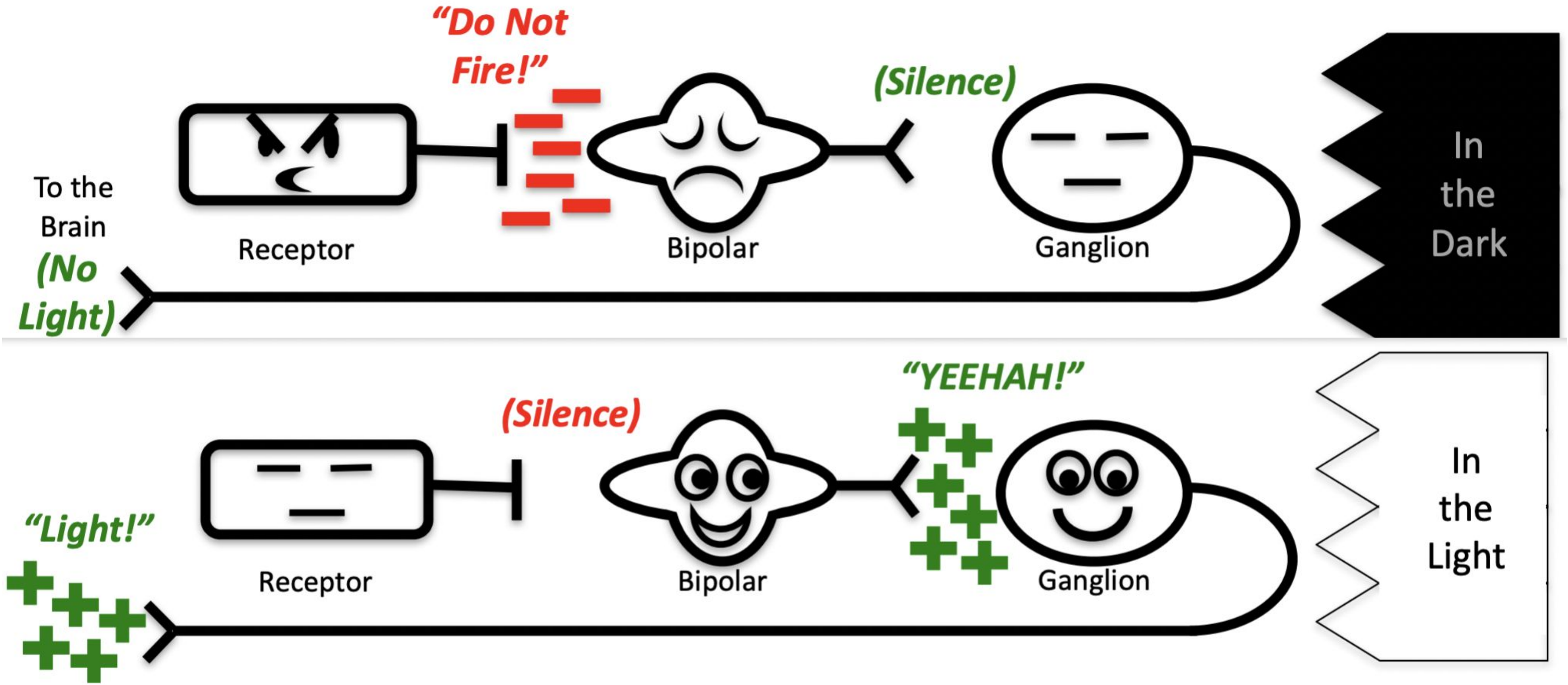
- Postsynaptic to Bipolars, show **Action** Potentials, release **Excitatory** NT

Interneurons



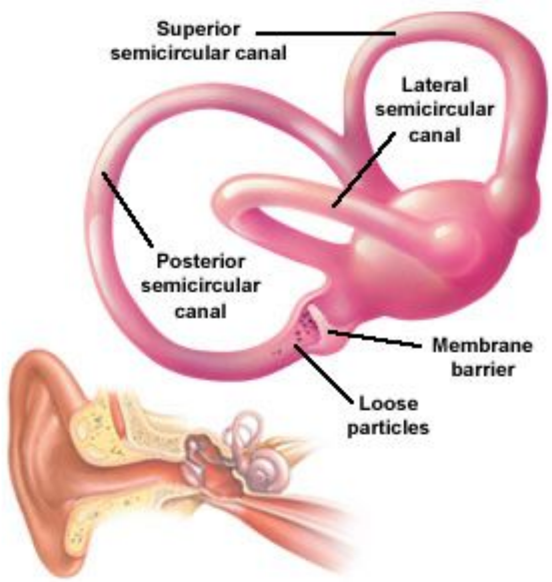
- Horizontal Cells -- **Graded** Potentials, mostly **Inhibitory** NT, modify interface of Receptors and Bipolars
- Amacrine Cells -- **Graded** Potentials, mostly **Inhibitory** NT, modify interface of Bipolars and Ganglions

Receptors Are Turned OFF By Light



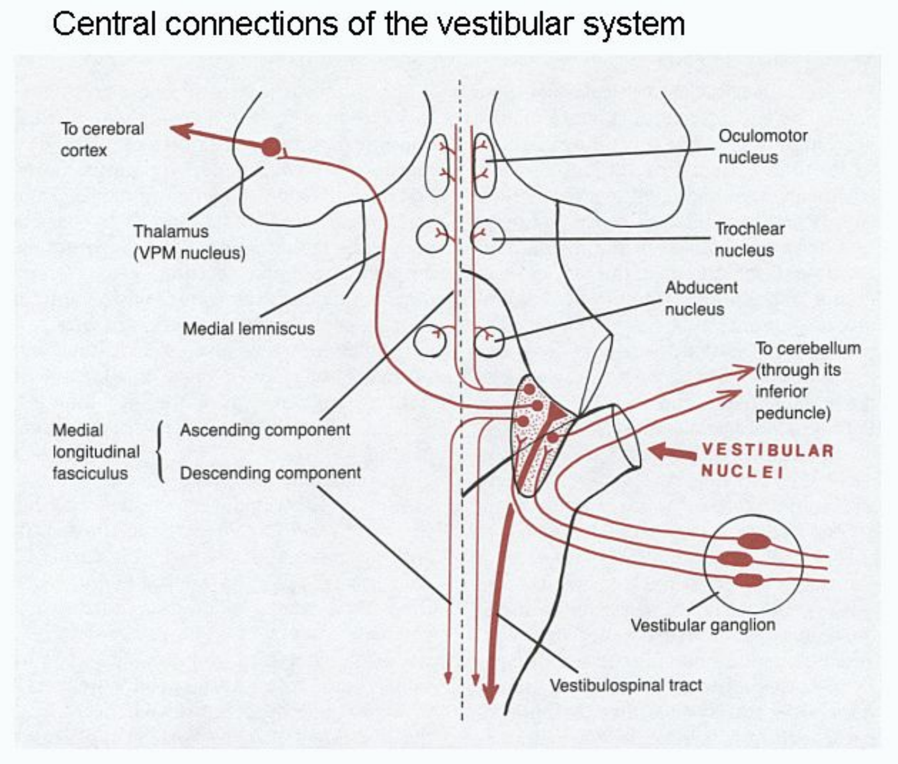
Somatosensory

Vestibular System



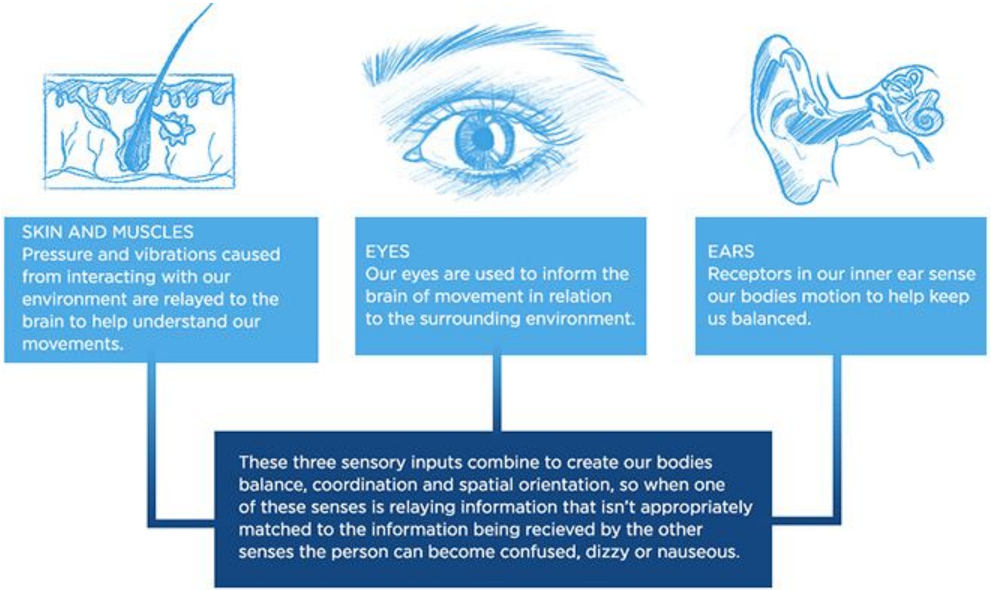
- consists of two complex structures that provide info for movement, balance
- Semi-Circular Canals: Detect angular ac/deceleration – i.e. Rotation
- Otolith (“Ear stone”) Organs: Detect changes in head tilt relative to body
- In all of the above, deforming Hair Cells results in **graded** responses to subtle, 3D changes

Vestibular Pathways



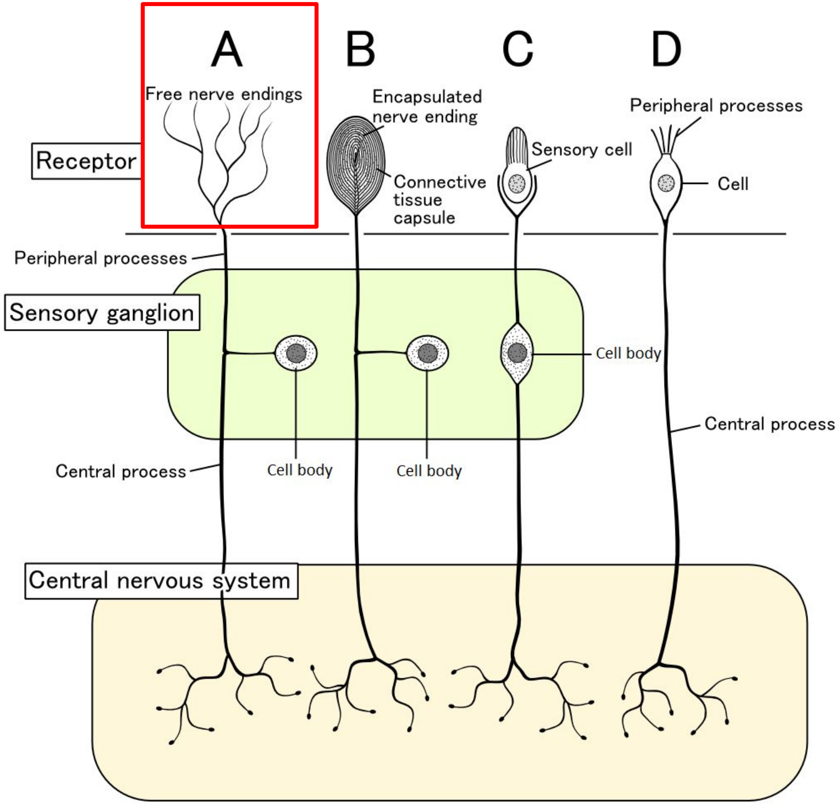
- **Hair Cells** => **Vestibular Ganglions**, whose axons form tract within 8th Cranial Nerve (nerve shared w/Audition) => **Vestibular Nuclei of Medulla**, some directly to **Cerebellum** => **Spinal Cord and many Brain Stem nuclei**, including Pons, & Midbrain's Red Nucleus, and to **Superior Colliculus** to coordinate with vision, and to **Cranial Nerves** (3,4,6) that control Eye Movement, to compensate for head

Motion Sickness



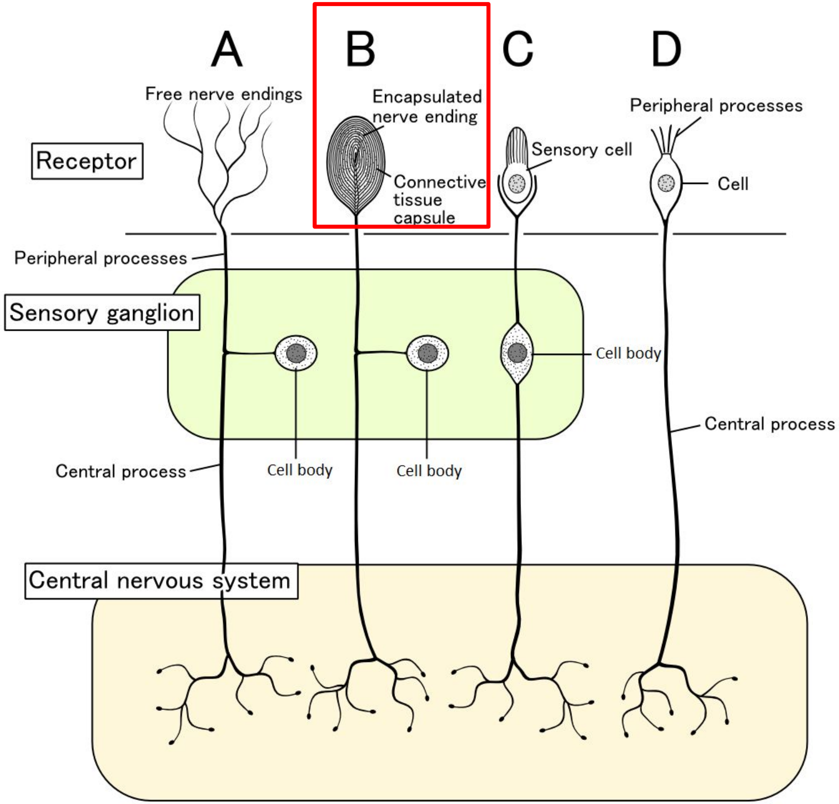
- When visual and/or motor feedback **inconsistent** with vestibular info, Medulla connections cause nausea

Free Nerve Endings



- respond to change in **Temperature** (Thermoreceptors) and **pain & itch** (Nociceptors)

Encapsulated Nerve Endings

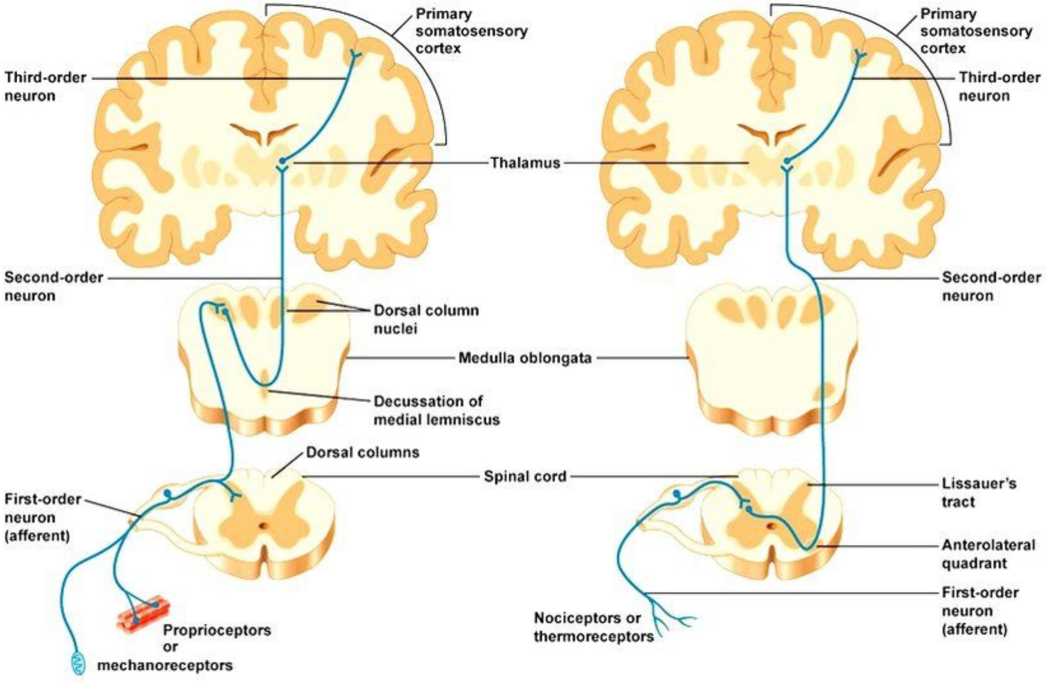


- respond to 1) various types of **Touch** and 2) Proprioception = internal **muscle & organ movement**
- Meissner's have **small** Receptive Fields & are **fast** adapting - respond to rapid change
- Merkel's have **small** Receptive Fields & are **slow** adapting - for detail discrimination
- Pacinians have **large** Receptive Fields & are **fast** adapting -respond to large scale changes
- Ruffinni's have **large** Receptive Fields & are **slow** adapting - respond to sustained, large-scale events

Across-fiber Coding

- Two types of temperature receptors: Warm Best & Cool Best
- Temperature coded by the distribution of activity across both types of receptors
- 89 ℉ -- physiological zero” (does not feel either cold or hot) = Produces equal response from Warm Best (WB) and Cool Best (CB) receptors (WB = CB)
- Exposing the skin to a warmer temperature (such as 105 ℉) produces a different code: “WB > CB”
- Chilling the hand (as by putting it in ice water) will selectively adapt the CB receptors more than the WB receptors, producing an aftereffect such that tepid water (89 ℉) will now feel warmer (more like 105 ℉) (Now CB < WB instead of CB = WB)

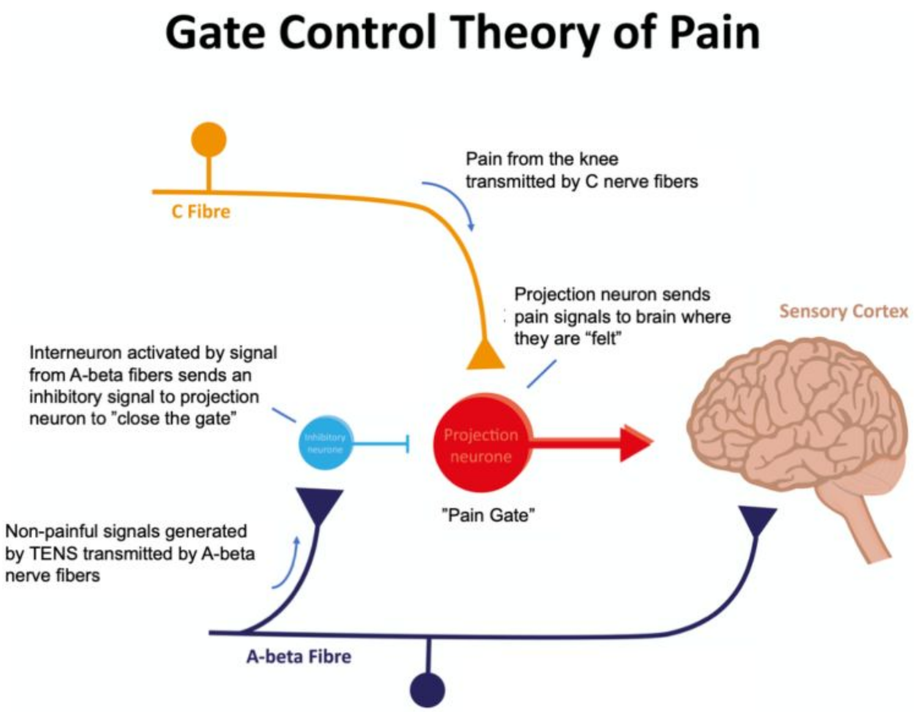
Somatosensory Pathways



(a) Dorsal column–medial lemniscal pathway (b) Spinothalamic tract

- Medial Lemniscal pathway -- "Second-order" cells cross over in Brain Stem (tract called "Medial Lemniscus") to synapse in contralateral VPN
- Spinothalamic pathway -- "Second-order" neurons cross over in Spinal Cord, ascend on contralateral side to synapse in contralateral VPN

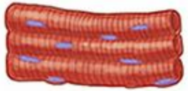
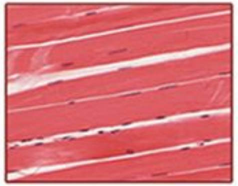
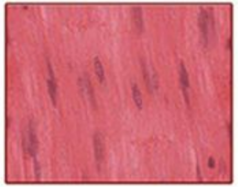
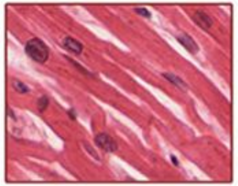
Gate Theory



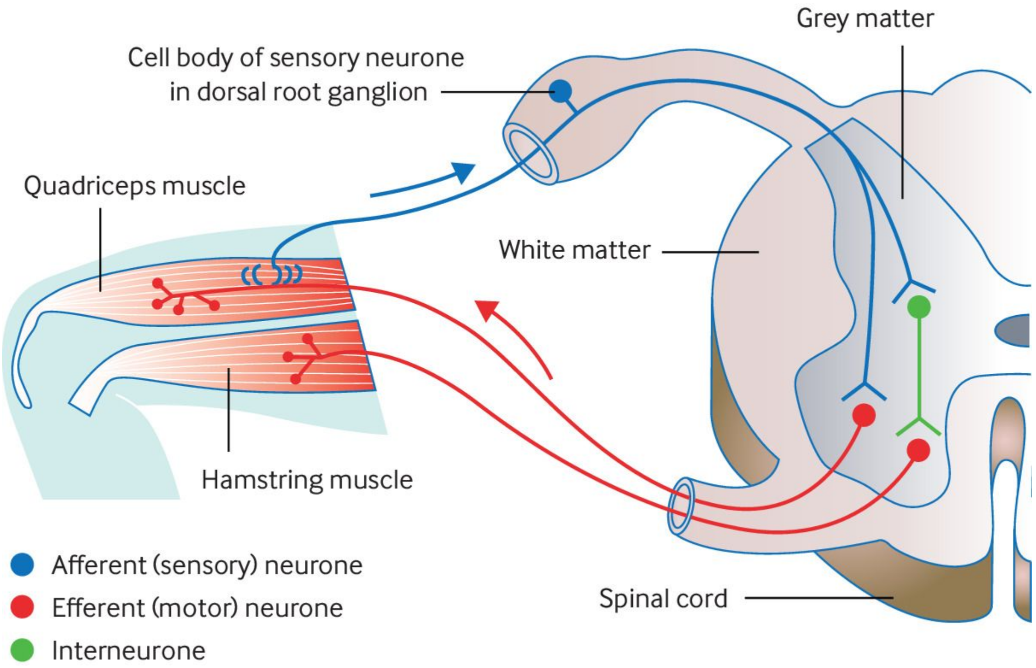
- Touch Receptors near source of pain are stimulated
- Periaqueductal Grey Area (PAG in Midbrain) releases Inhibitory Endorphins
- Within brain, some cells that release Substance P have NT receptor sites on their Terminals that respond to inhibiting Endorphins

Motor

3 Types of Muscles

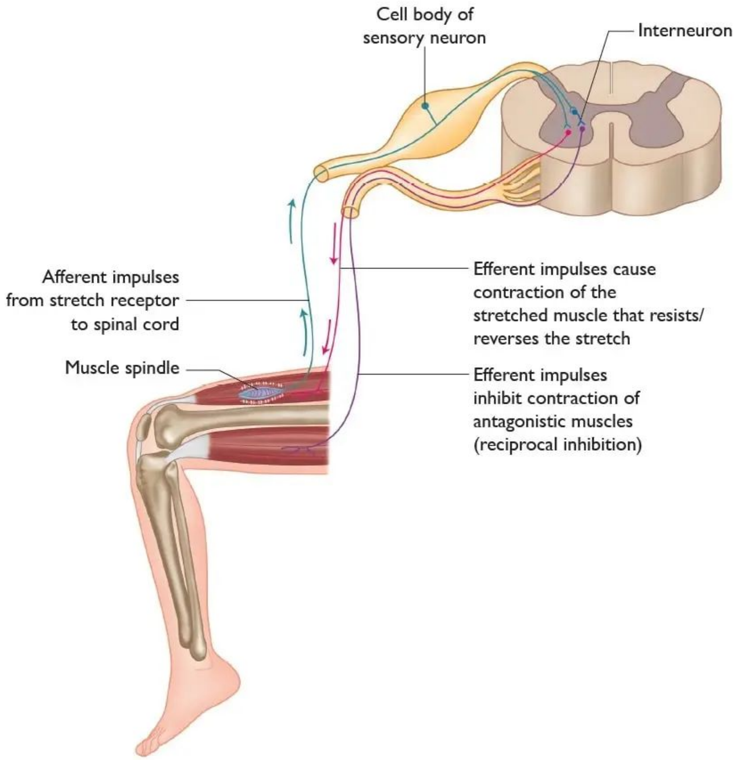
	Main features	Location	Type of cells	Histology
Skeletal muscle	- Fibers : striated, tubular and multi nucleated - Voluntary - Usually attached to skeleton			
Smooth muscle	- Fibers : non-striated, spindle-shaped, and uninucleated. - Involuntary - Usually covering wall of internal organs.			
Cardiac muscle	- Fibers : striated, branched and uninucleated. - Involuntary - Only covering walls of the heart.			

Reflexes



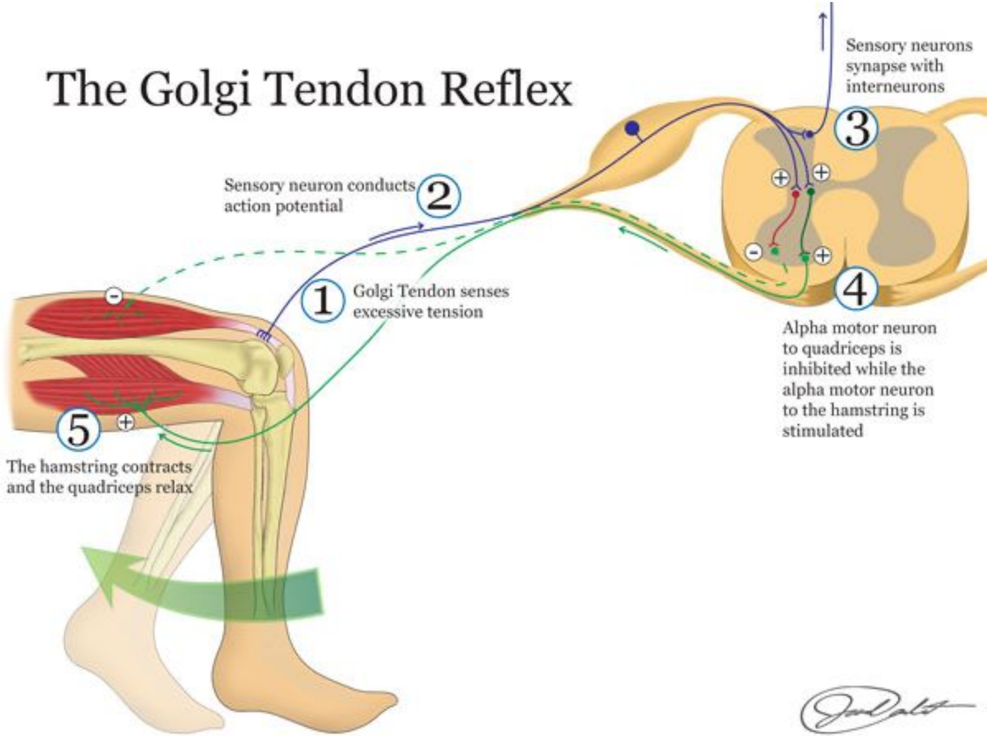
- **Involuntary**, unplanned sequence or action and nearly instantaneous response to a stimulus
- Most involve Spinal Cord circuits (i.e. without brain participation)

Stretch Reflex



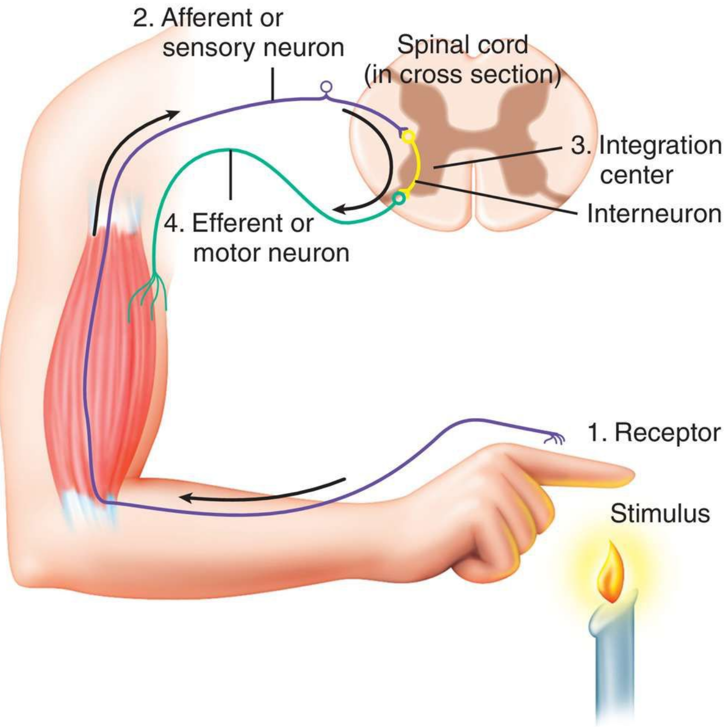
- Proprioceptors called Spindles in muscle detect passive stretch of muscle
- Axon of Spindle to Spinal Cord, excites Motor Neuron back to same muscle, contracts to counter stretch

Golgi Tendon Reflex



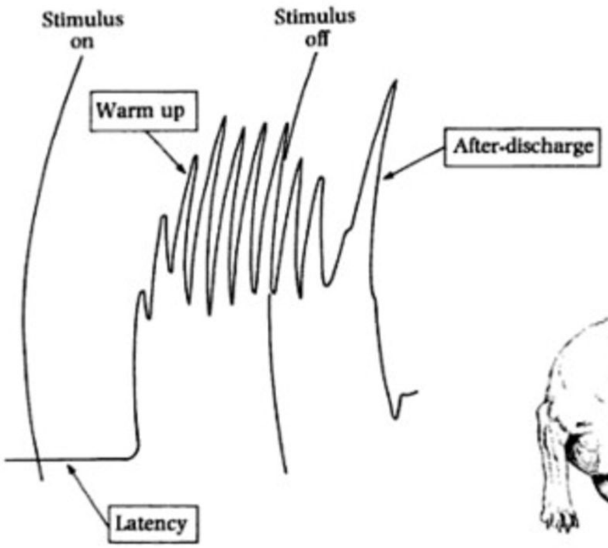
- Proprioceptors called Golgi Tendon Organs in tendons detect intensity of muscle contraction
- If contraction is too strong (threatens to tear muscle apart) sends signal to Interneurons in Spinal Cord that inhibit the Motor Neurons causing that contraction, lessening their rate of firing

Pain Withdrawal Reflex



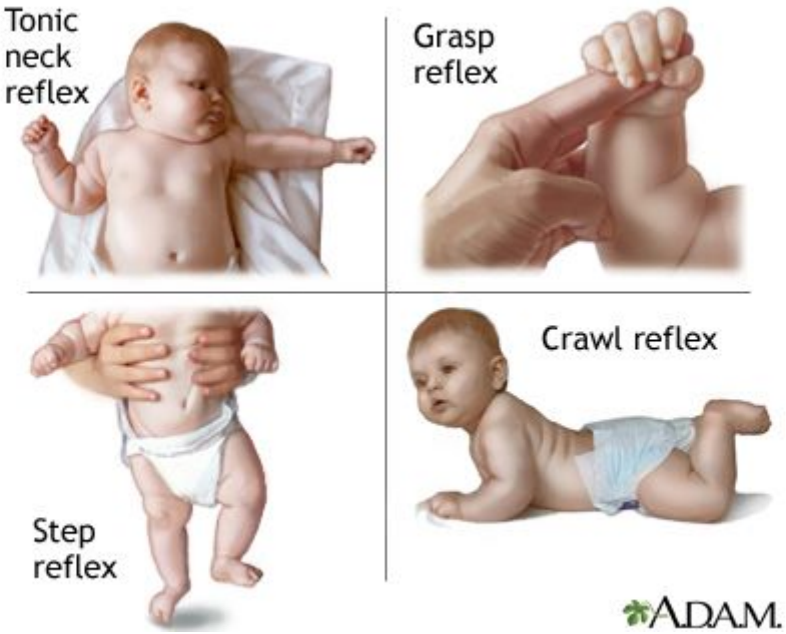
- Stimulated Nociceptors signal Interneurons in Spinal Cord to excite Motor Neurons that synapse back onto relevant Flexor muscles to move body part way from noxious stimulus
- Signals sent along myelinated Motor Neurons reach muscle **before** Pain signal even reaches brain

Scratch reflex



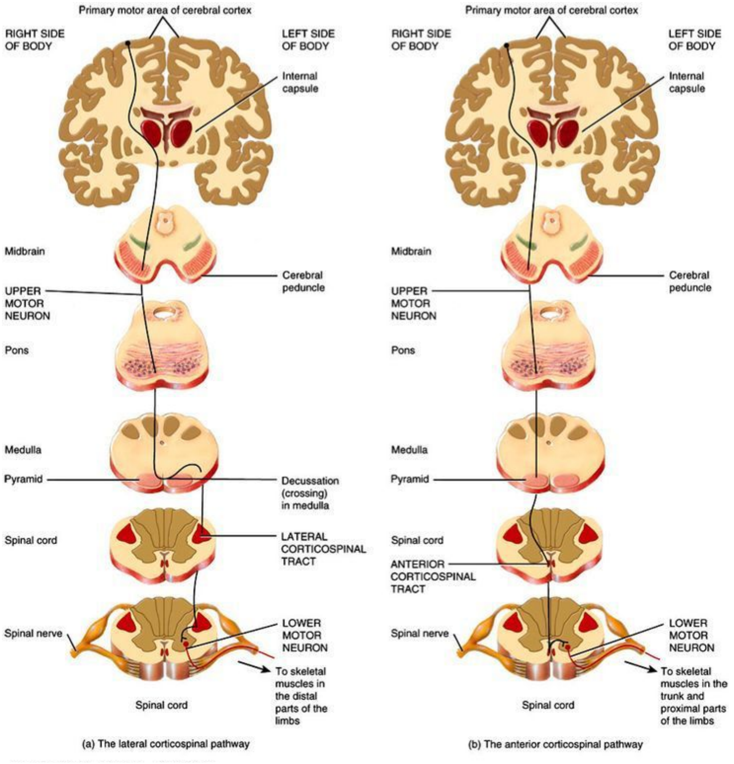
- An Oscillator Circuit
- Rate is relatively fixed, mediated by Spinal Cord
- Such Oscillator circuits, produced by Central Pattern Generators, in Cord, Cerebellum, & elsewhere, in humans probably involved many learned “motor programs” including dance, speech, writing, etc.

Infant Reflexes



- These can reappear in drunken (or brain damaged) adults in part mediated by Cerebellum

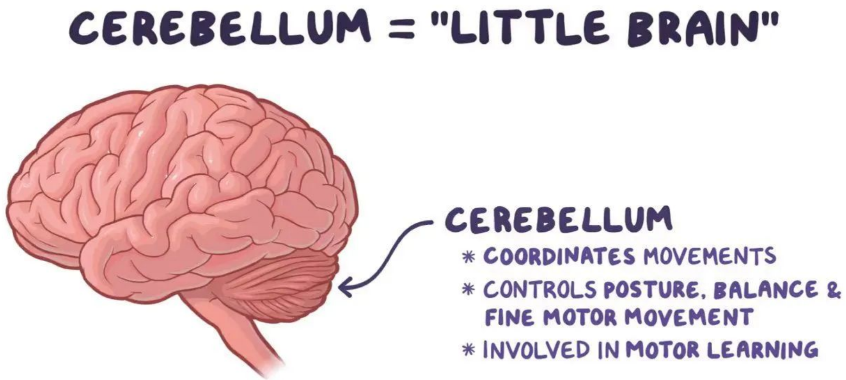
Motor Pathways



- Corticospinal ("Pyramidal") Tracts -- mainly to contralateral periphery, crossover at Pyramids of Medulla

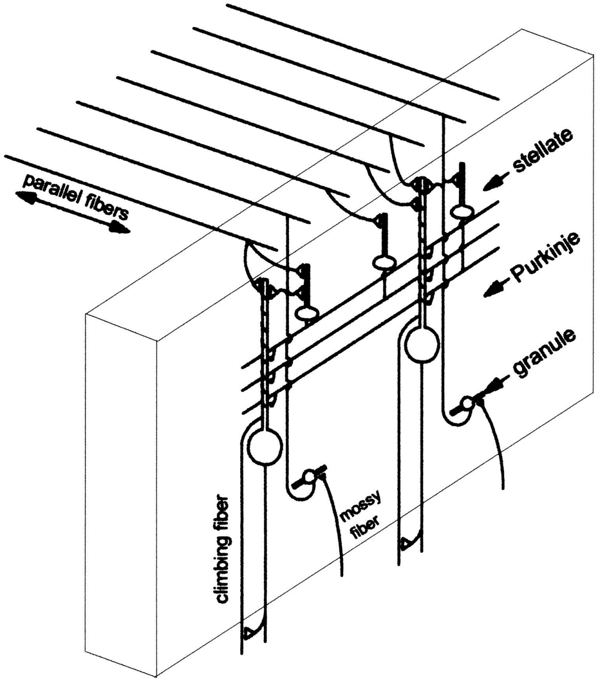
- Ventro-Medial Tracts -- Mainly for bilateral midline control (both sides of central body & coord'd limbs)

Cerebellum



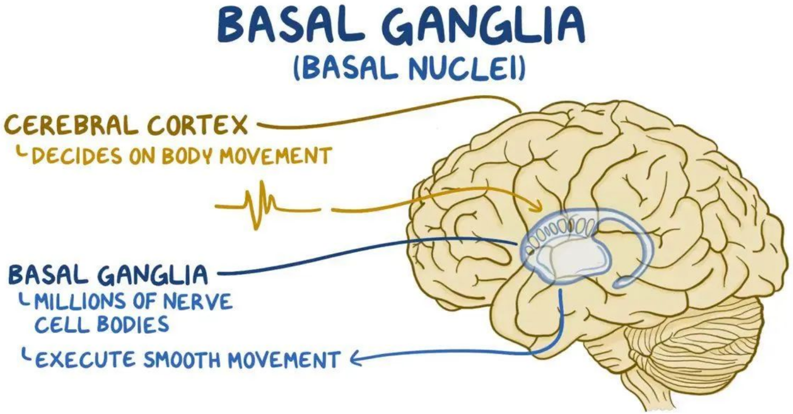
- 13% of brain mass, contains more neurons (~50 billion) than rest of brain combined
- For rapid, coordinated and/or ballistic movements requiring precise aiming and timing
- Receives proprioception from Spinal Cord & sensory info(esp Visual and Vestibular) via Cranial Nerves
- Projects to all major motor structures in brain; Including Ventrolateral Thalamus (VLN) to Cortex

Cerebellum



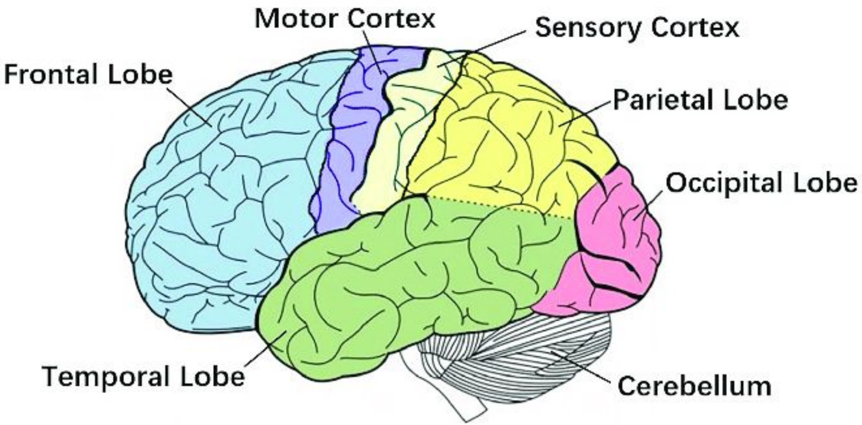
- In Cerebellar Cortex, Parallel Fibers like wires along long rows of “telephone poles” called Purkinje Cells
- Action potentials in Parallels travel along, exciting Purkinjes, who send Inhibition down to Deep Nuclei
- Deep Nuclei, when released from Inhibition, spontaneously command motor nuclei in brain
- Timing of such outputs is coded per distance the signals travel along the Purkinjes

Basal Ganglia



- Organizes Behavior, esp (tho not only) learned, task-based sequences
- Involved in direction and amplitude of slow, smooth-changing, voluntary movements (e.g. posture, walking)
- May also be implicated in "automating" complex sequential processes (e.g. driving) & in "selecting" use
- Pathology includes Parkinson's Disease

Motor Cortex



- Primary Motor Cortex in Frontal Lobe on Precentral Gyrus just anterior to Central Sulcus
  -- Includes topological "Map" of body;
  -- No direct connection to muscles, but send commands to Motor Neurons in Brain Stem and Spinal Cord
- Secondary Motor Cortex involved in Planning movement, which includes:
  -- Premotor Cortex in Frontal Lobe anterior to Primary Motor Cortex
  -- Supplementary Motor Cortex in Frontal Lobe anterior to Primary Motor & dorsal to Premotor Cortex

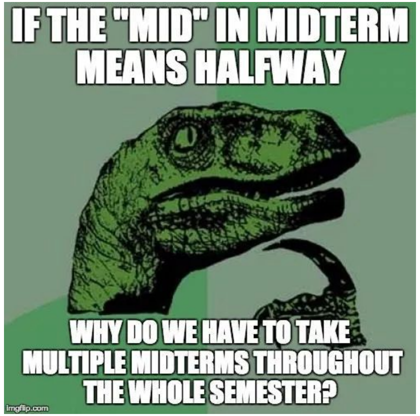
Problem Set for Today (Midterm 2 Review)

- Link: https://docs.google.com/document/d/1UmhKsK1FcDGQ8xPQ96tbwus5XG_PwIBVizwrnxjtQpQ/edit?usp=sharing

SCAN ME


"I'M FREE AFTER MIDTERM SEASON."
BUT IT'S ALWAYS MIDTERMS SEASON.
imgflip.com

GOOD LUCK!


IF THE "MID" IN MIDTERM MEANS HALFWAY
WHY DO WE HAVE TO TAKE MULTIPLE MIDTERMS THROUGHOUT THE WHOLE SEMESTER?
imgflip.com

Questions?

Office Hours: Mon 5-6 pm

To get the section slides: https://github.com/JasonC1217/COGS17-A03-Sp24

OR:

SCAN ME