Nervous Systems

Basics of Life Science

Thursdays 9-10:30

Ray Luo

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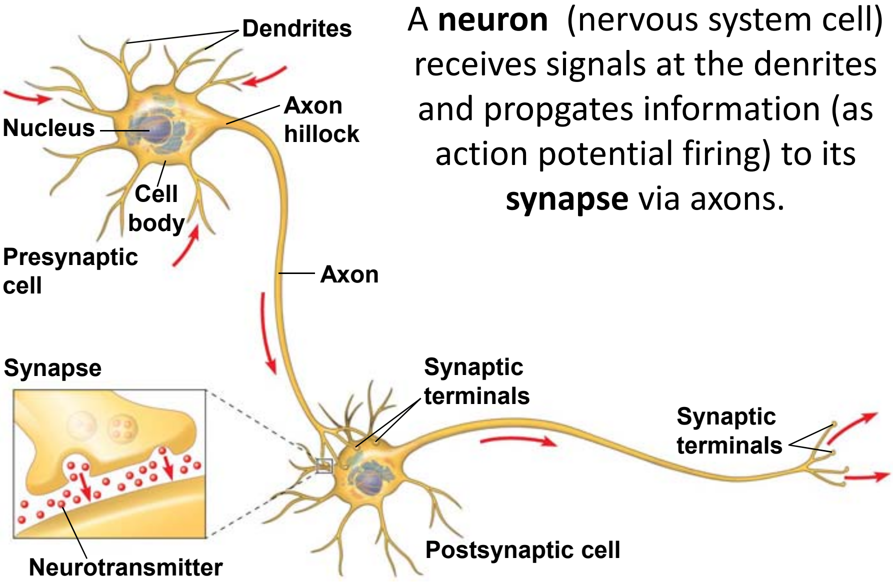

A **neuron** (nervous system cell) receives signals at the denrites and propgates information (as action potential firing) to its **synapse** via axons.

Nervous systems originated from systems of sensory and motor neurons.

- Sea jelly nerve nets control contraction/expan.
- Sea star radial nerves for each arm contracts, connected to central nerve ring.
- Central nervous system integrate at anterior end & spine, peripheral system nerves ganglia.
- Glial cells (non-neurons) protect and nourish neurons, e.g. Schwann cells produce myelin sheats surrounding axons in PNS for speed.

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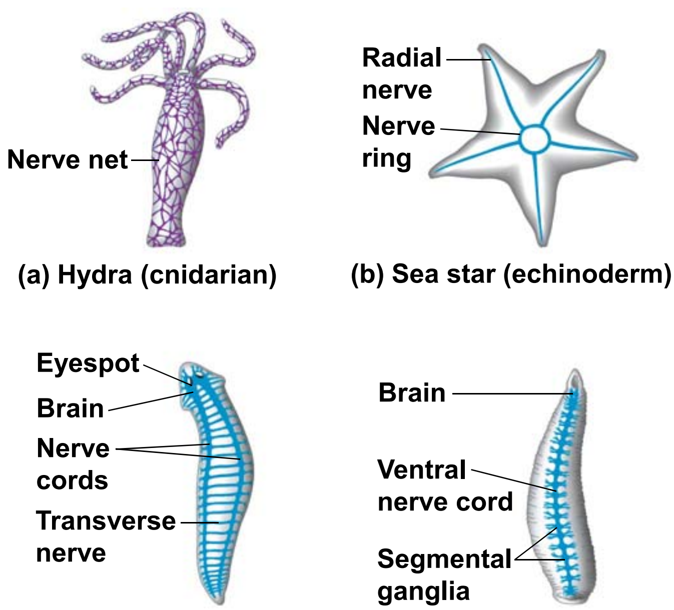
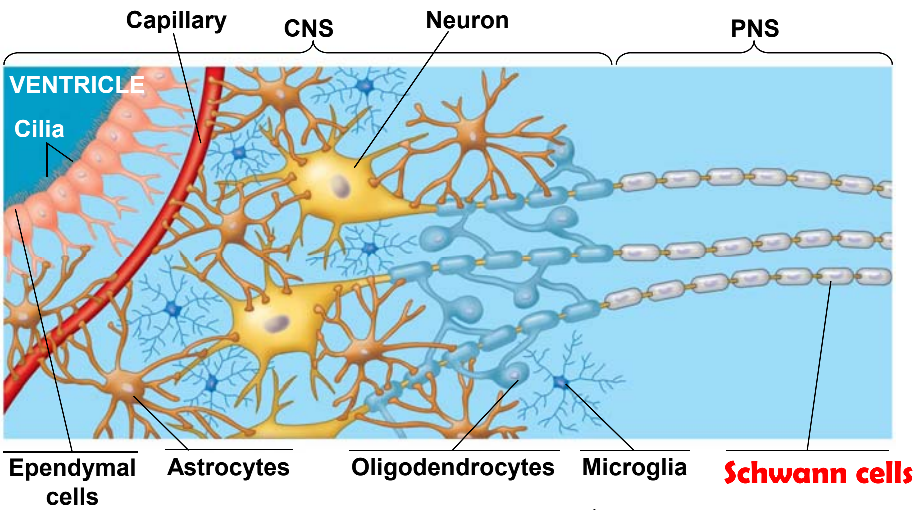


(a) Hydra (cnidarian) (b) Sea star (echinoderm)
(c) Planarian (flatworm) (d) Leech (annelid)



Line ventricle, Promote circ.

Regulate O2, glucose, Ionic balance

Myelinate CNS axons

Immune system protectors

Myelinate PNS axons

Vertebrate nervous systems are grouped into circuits.

- Cavity of embryonic nerve cord becomes central canal of spinal cord and brain ventricles, filled with cerebrospinal fluid.
- Gray matter: neuron cell bodies.
- White matter: axon bundles myelinated, exterior in periphery, interior in CNS for region signaling.
- Spinal cord communicates CNS and PNS, but also indep in reflexes (bypassing CNS).
- Knee jerk reflex function at only spinal cord level.

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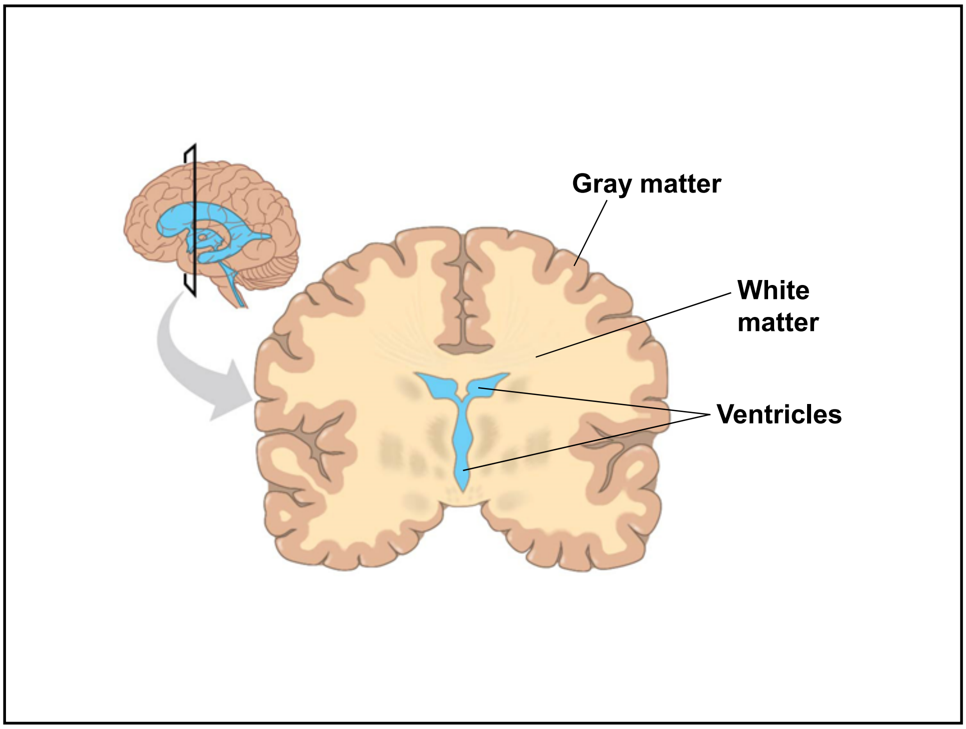
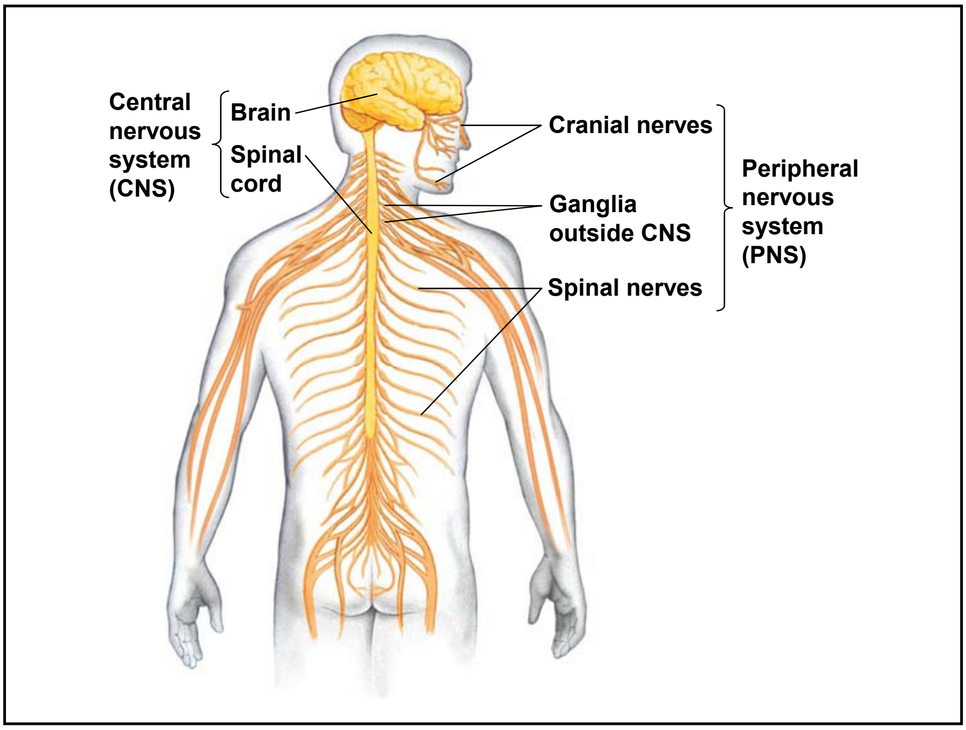
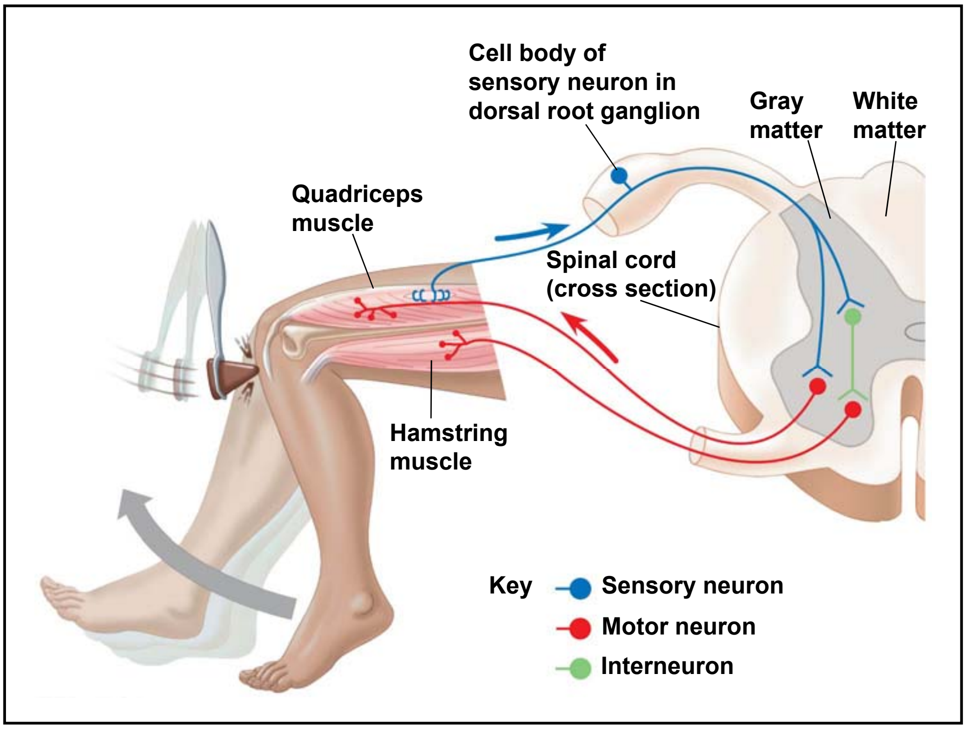

Gray matter
White matter
Ventricles


Central nervous system (CNS)
Brain
Spinal cord
Cranial nerves
Ganglia outside CNS
Spinal nerves
Peripheral nervous system (PNS)



Peripheral nervous system consists of motor and autonomic systems.

- Afferent: PNS to CNS, efferent: CNS to PNS
- PNS motor system: signal to skeletal muscles
- PNS autonomic: involuntary, cardiac and smooth muscles, enteric digestive glands
- PNS autonomic sympathetic: arousal, digestion down, glucose conv, just outside spinal cord ganglia, post ganglia norephinephrine
- PNS autonomic parasympathetic: rest digest, glycogen prod, sex functions up along symp, base of brain to ganglia near organ, post ganglia ACh

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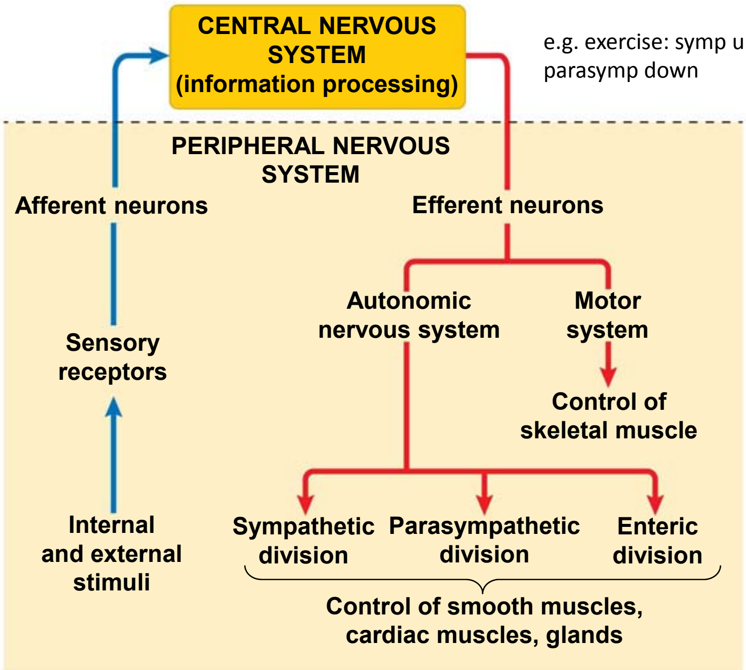
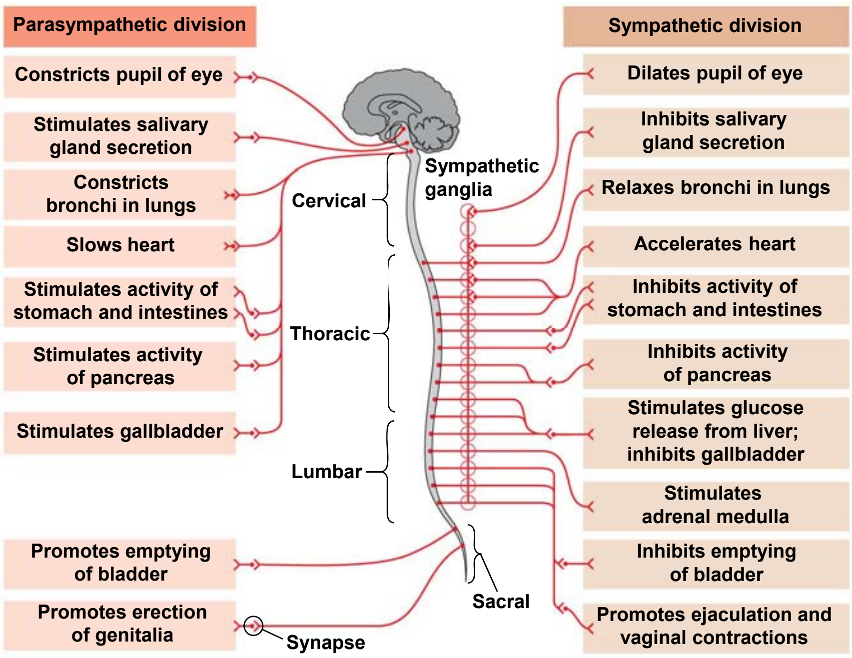
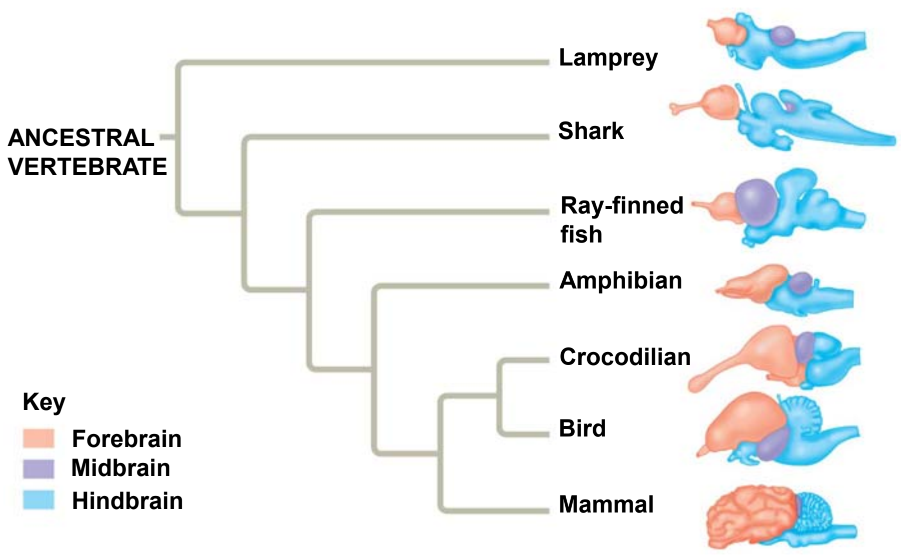


e.g. exercise: symp up, parasymp down



Regional specific components of evolved brain structures.

- Forebrain: complex processing, midbrain: routing inputs, hindbrain: involuntary activity movement
- Forebrain got bigger in evolution, region specific
- Human cerebral cortex: left control right, corpus callosum cross-over, learning perception etc
- Cerebellum: error check move, eye-hand coord
- Diencephalon: thalamus relay sensory info, hypothalamus hunger thirst, body temperature, bio clock, pituitary control, pineal gland: melatonin CSF
- Brainstem: pons and medulla, relay, breathing, heart, swallowing vital functions, cross-over, vis reflex



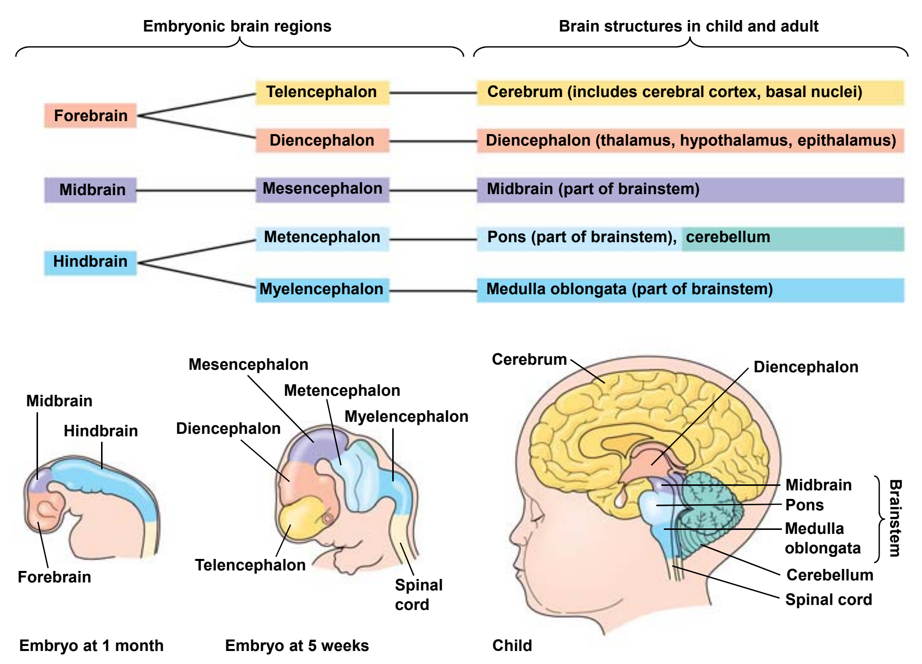
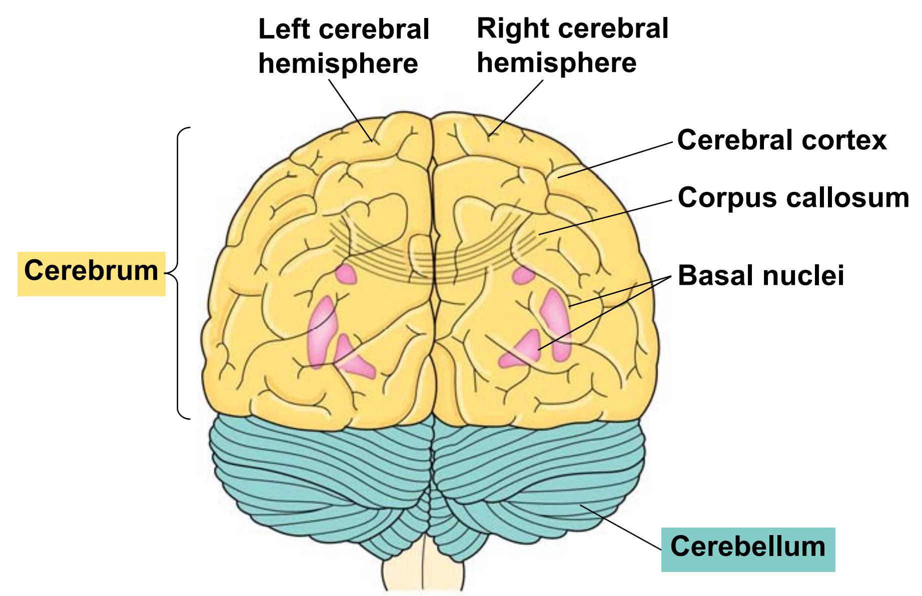
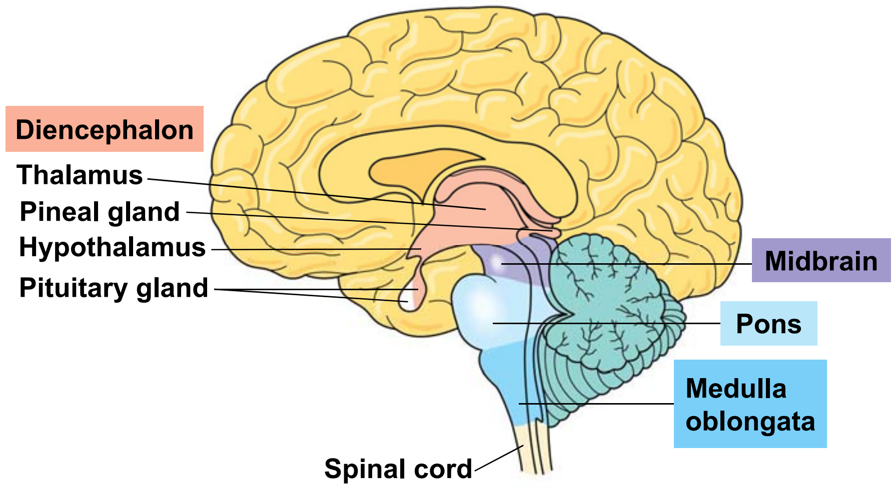


Figure 49.11c



Adult brain viewed from the rear

Figure 49.11d



Sleep, arousal, and circadian rhythms are regulated by midbrain control.

- Sleep: recording EEG waves, evidence for con-solidation replay, midbrain reticular formation control REM rapid eye move dream filter input
- Dolphin: sleep one hemisphere at a time
- Biological clock sync to light and dark: hypothalamus
- Hypothalamic suprachiasmatic nucleus SCN transplant b/t 20 and 24 hr hamster strains - SCN as pacemaker

Figure 49.12

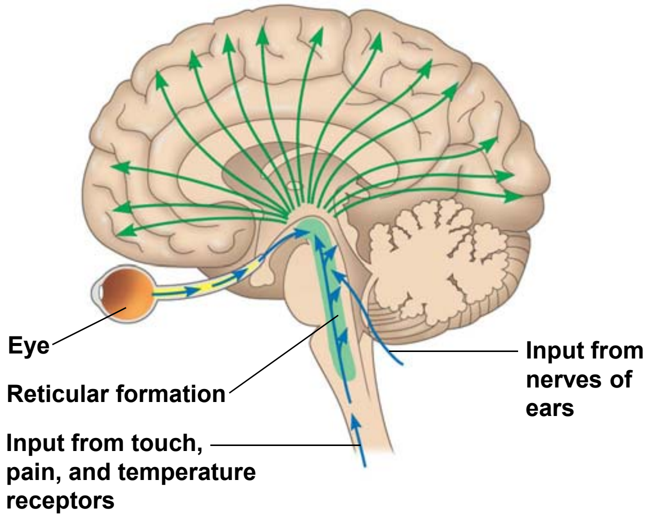
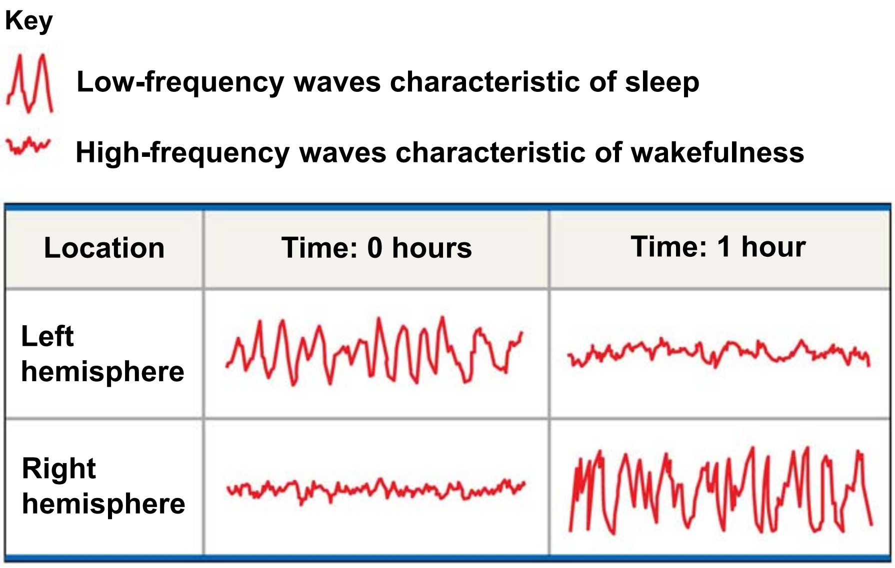


Figure 49.13



Emotions rely on interplay within limbic system: amygdala, hippocampus

- Image followed by shock lead to autonomic arousal heart rate sweating, but amygdala damage -> no arousal but can recall image
- fMRI of human tracks change in local oxygen level, listen to happy or sad music: happy -> nucleus accumbens activated, sad -> amygdala

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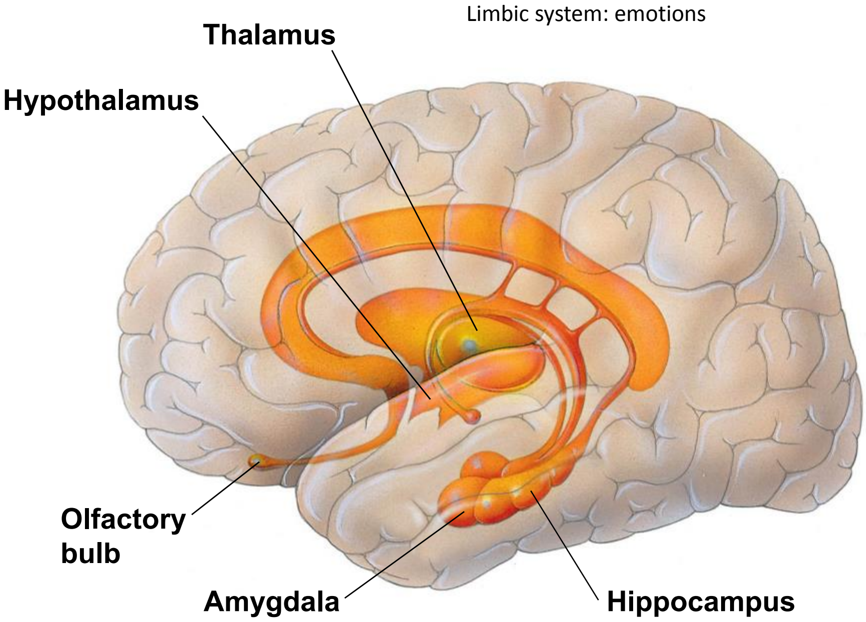
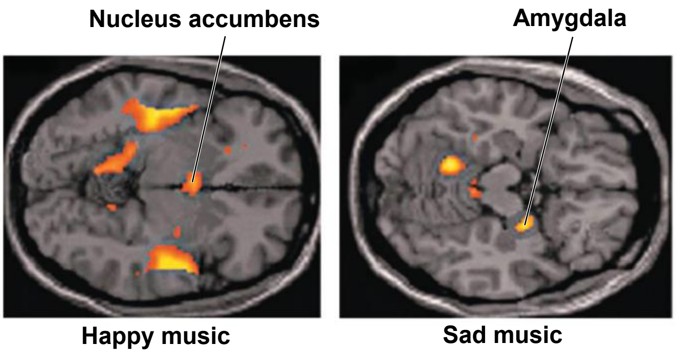
Limbic system: emotions





Team activity

Myelinated neurons are especially abundant in the _____.

- A) white matter of the brain and the gray matter of the spinal cord
- B) white matter in the brain and the white matter in the spinal cord
- C) gray matter of the brain and the gray matter of the spinal cord
- D) gray matter of the brain and the white matter of the spinal cord

If a patient has an injury in the brain stem, which of the following would be observed?

- A) an inability to regulate body temperature
- B) an inability to regulate heart function
- C) auditory hallucinations
- D) visual hallucinations

Cerebral cortex consists of sensory, association, and motor areas.

- Visual auditory somatosensory receptors -> thalamus -> primary sensory area (particular feature) -> association area (recognition faces) -> prefrontal (action planning) -> motor cortex -> brainstem -> spinal cord -> motor neurons
- Topographical organization in sensory and motor cortices, proportional to amount of processing needed for that body part
- Broca's area damage: can understand - not speak, Wernicke's damage: can't comprehend - can talk

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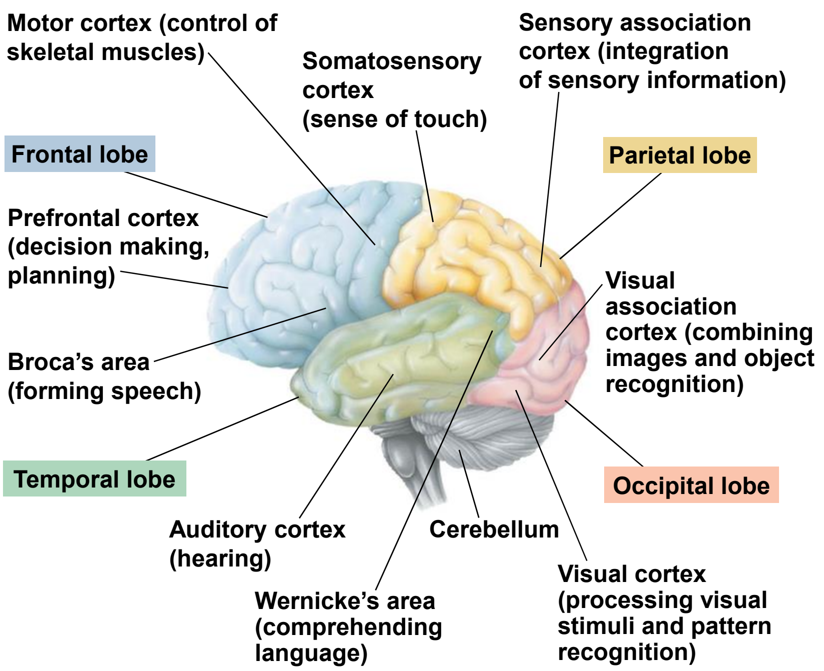
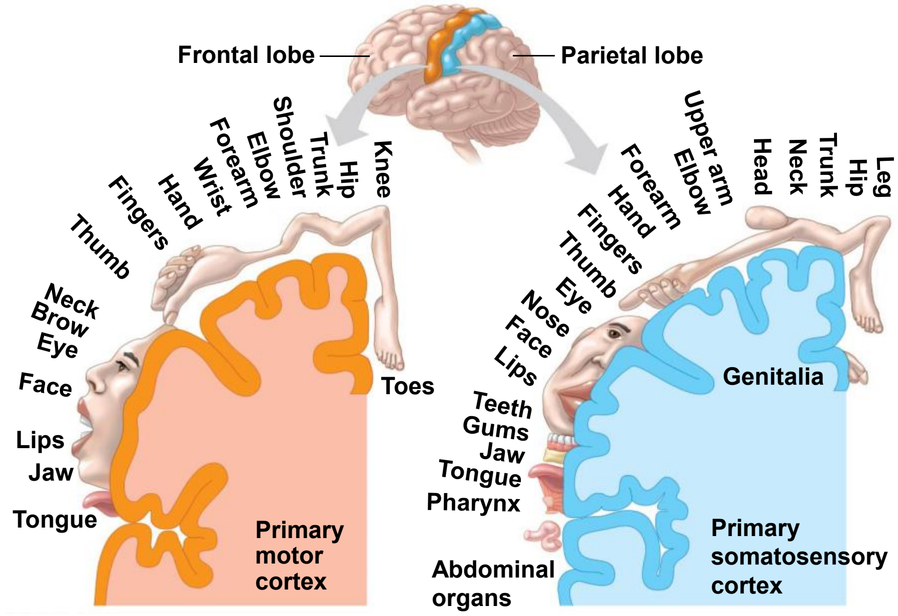
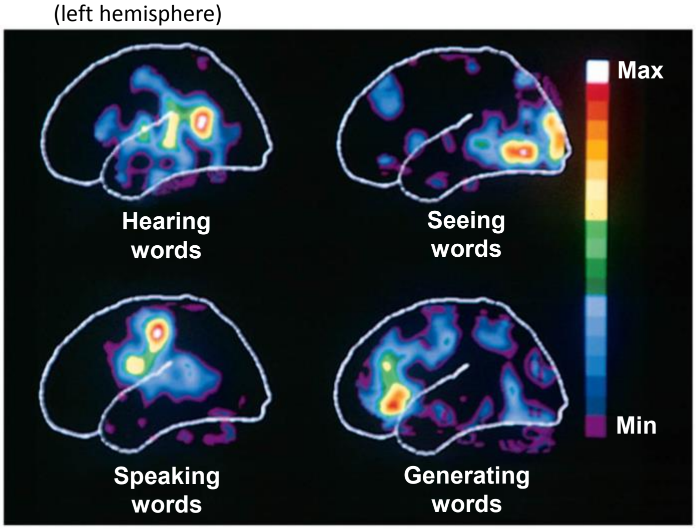




Wernicke's area
(left hemisphere)

Visual cortex

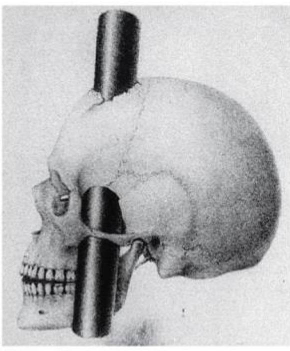


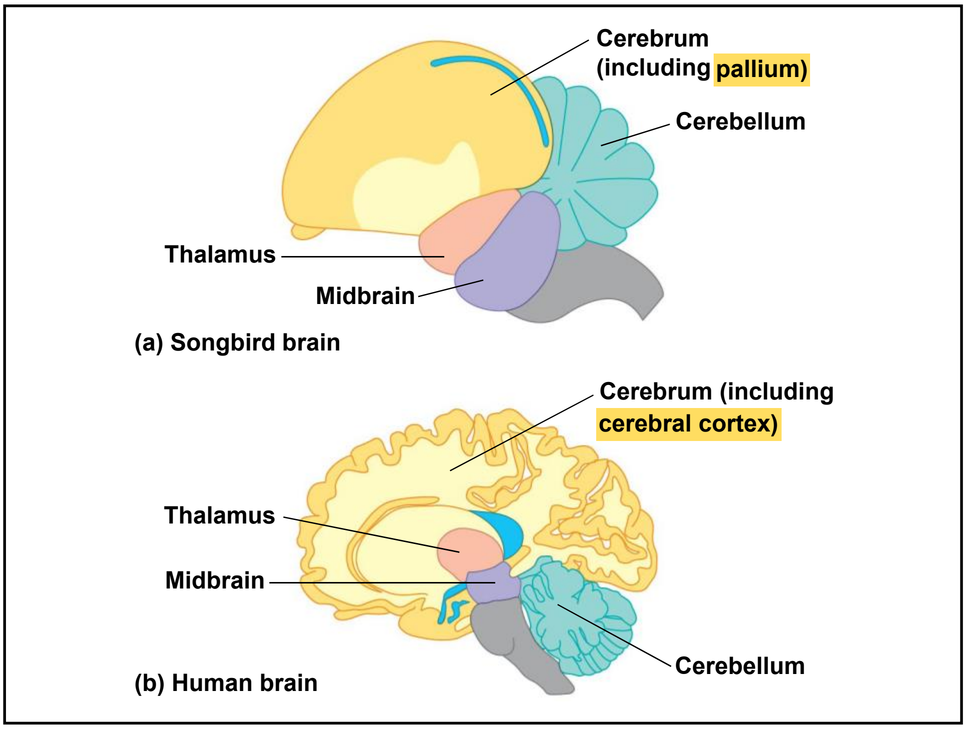
Broca's area
(left hemisphere)

Frontal (not speaking)

- Left hemisphere: language, logic, math
- Right hemisphere: recognition, spatial, pattern
- Split brain severing of corpus callosum: cannot read word in left visual field since info cannot go from right hemisphere to language area
- Frontal lobe: Phineas Gage explosion caused iron rod behind left eye recovered, detached personality erratic behavior, no exec control
- Evolution: unconvoluted pallium in birds and convoluted cortex in humans from same ancestor? Birds can remember, tools, abstract

Skull of Phineas Gage, railroad construction crew





Learning and memory are formed by changes in cell, synaptic connections.

- Competition for growth factors: **cell** death for half of cells who don't reach proper location.
- Competition for right connections: half of **synapses** for a cell are eliminated in develop.
- Neuronal plasticity: activity of cell -> remodel, fire together -> wire together, autism defect.
- Hippocampus short term memory, cortex long term memory, damage to hippocampus: can recall past but not form new memories.

Changes in synpatic strength at the hippocampus via LTP.

- More connections with existing knowledge the new knowledge is, easier it's to remember
- New skill: new connects, new fact: use existing
- Long term potentiation in hippocampus: high freq presyn firing coincides with postsyn depolarization -> unblock NMDAR -> insertion of AMPAR glutamate receptors -> bigger postsyn potential with the usual presyn stim

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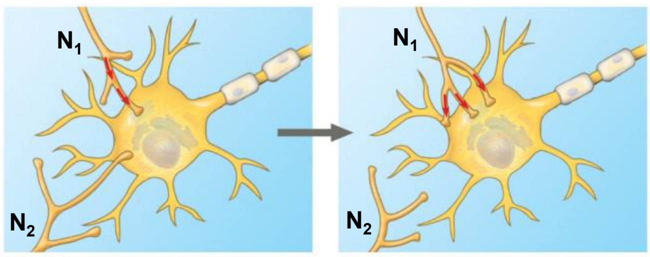
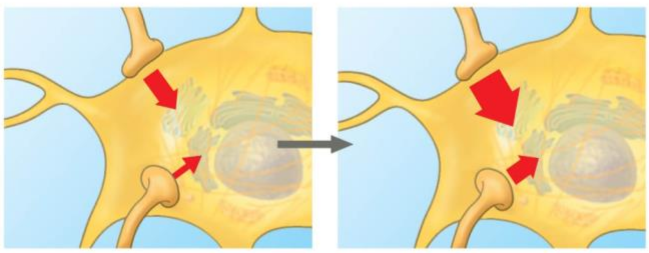
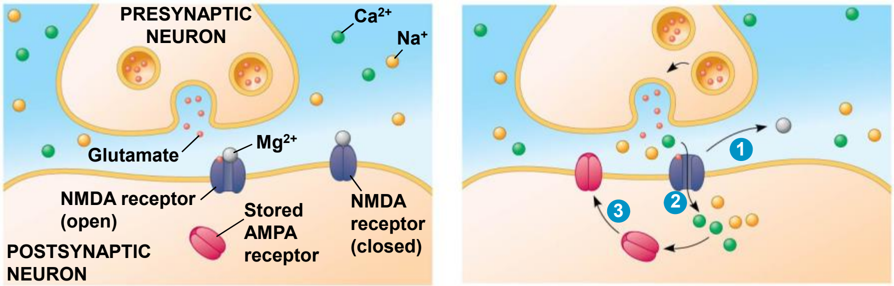


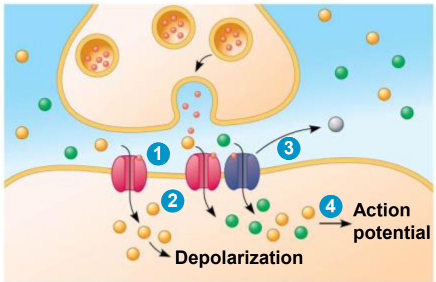
(a) Connections between neurons are strengthened or weakened in response to activity.



(b) If two synapses are often active at the same time, the strength of the postsynaptic response may increase at both synapses.



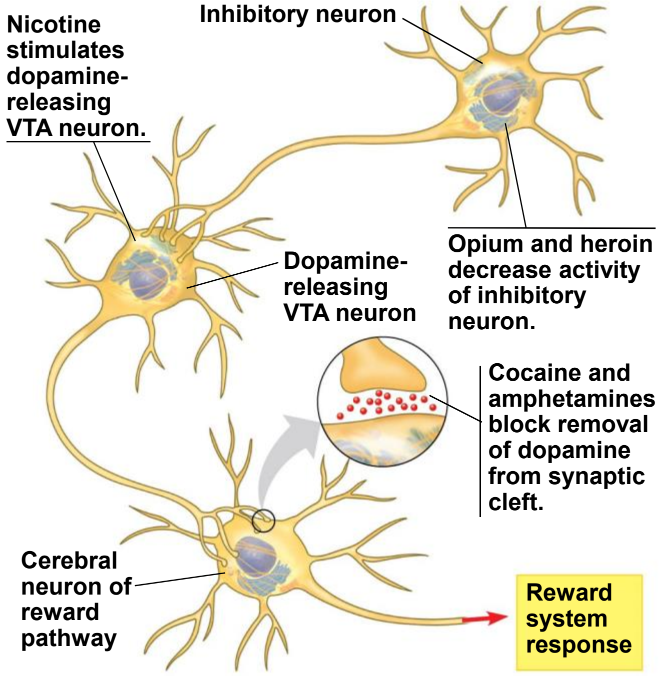
(a) Synapse prior to long-term potentiation (LTP)
(b) Establishing LTP


(c) Synapse exhibiting LTP

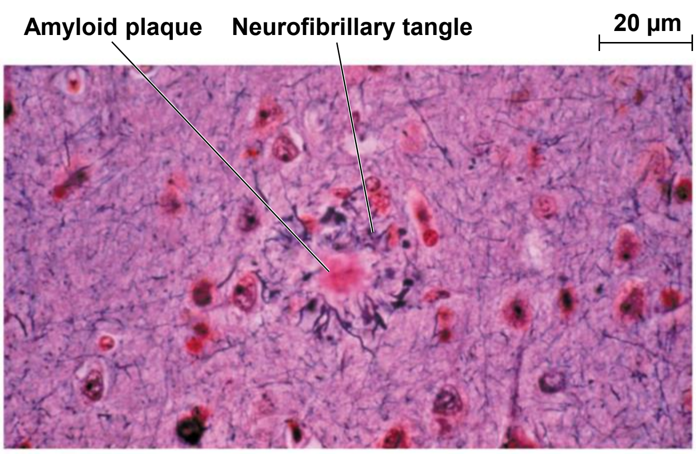
Nervous system disorders can affect anyone.

- Family studies to identify genetic factors
- Schizophrenia: disordered reality, hallucinates, delusions, dopamine block alleviates symptom
- Depression: major depressive, bipolar manic phase suicidal phase, Prozac amines up
- Addiction: manipulate VTA dopamine pathway
- Alzheimer's: can't function can't recognize, accumulate beta amyloid plagues that kill cells nearby, neurofibrillary tau tangles (early onset)
- Parkinson's: tremors rigid shuffling, mitochondria genetic defect?, L-Dopa and deep brain stim

Addiction



Alzheimer's disease: molecular aspects.



Team activity

The motor cortex is part of the ______.

- A) spinal cord
- B) cerebrum
- C) medulla oblongata
- D) cerebellum

Exercise and emergency reactions include ______.

- A) decreased activity in the sympathetic, and increased activity in the parasympathetic divisions
- B) increased activity in all parts of the peripheral nervous system
- C) increased activity in the enteric nervous system
- D) increased activity in the sympathetic, and decreased activity in the parasympathetic divisions