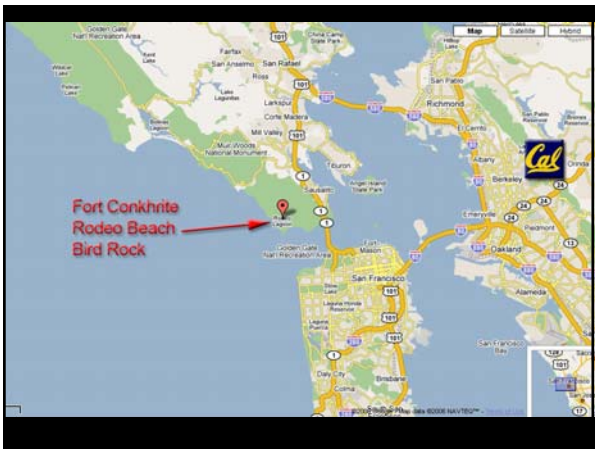
Notes

- Exam scores will be posted this weekend.
- Extra credit assignment will be posted this weekend (follow the directions).
- Field trip to Fort Conkhrite & Bird Rock.
  (Details to be announced next week)



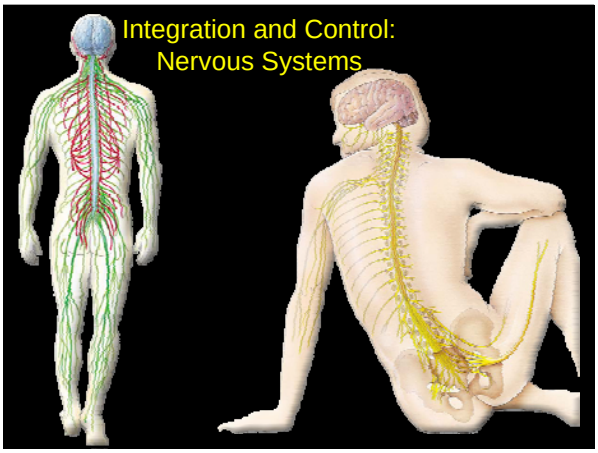
Questions

How do herbivores get B12?

- Ruminant bacteria produce B12.
- Gorillas eat insects.
- Hind gut fermenters – bacterial fermentation produces B12.
- Rabbits eat their feces to get B12 produced in cecum.
- Some herbivores ingest soil with cobalt, which is required by some bacteria to produce B12.
- Humans cannot get B12 from their bacteria because absorption of B12 occurs before the cecum.

True vegans must supplement diet with B12!

www.veganhealth.org/b12/int
www.veganhealth.org/b12/animal



Components of Nervous System

- Neurons – transmit signals.
- Neuroglia – collection of cells supporting neurons.
- Ganglia – collection of nerve cell bodies.
- Nerves – bundled neurons.
- Spinal cord – connection between brain and periphery.
- Brain – primary control center.

Neurons

- Basic units of communication in nearly all nervous systems.
- Monitor information in and around the body and issue commands for responsive actions.

Three Classes of Neurons

- **Sensory neurons** – detect and relay information form stimuli to the brain and spinal cord.
- **Interneurons** - communicates with other neurons. Often links sensory and motor neurons. Involved in memory and other complex brain functions.
- **Motor neurons** - delivers information from other neurons to muscles and glands.

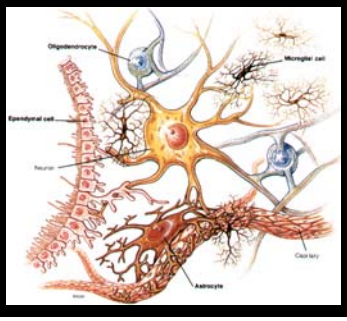
Neuroglia

- Make up more than half the volume of the vertebrate nervous system.
- A variety of cells that metabolically assist, structurally support, and protect the neurons.

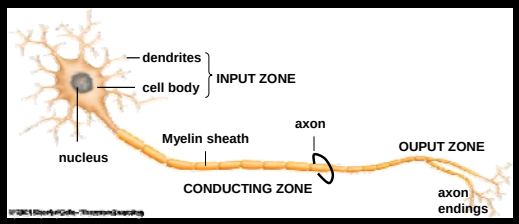
Neuroglia

Support cells

- **Astrocytes - support**
- **Microglia - cleaners**
- **Ependymal Cells - circulation**
- **Oligodendrocytes – myelin maintenance**



Structure of a Neuron



Signal transmission

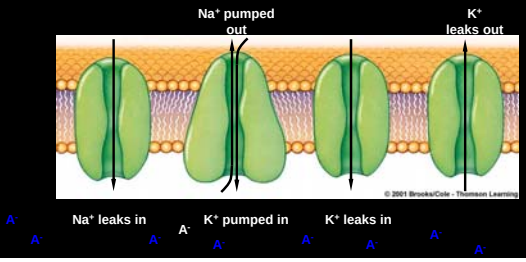
- How do neurons transmit information?
- An electrical pulse called an Action Potential starts when a signal is received at the dendrites and then propagates down the axon to the end of the neuron.

Resting Potential

- Charge difference across the plasma membrane of a neuron.
- Fluid just outside cell is more negatively charged than fluid inside.
- Potential is measured in millivolts
- Resting potential is usually about -70mv

Maintaining Resting Potential

K^+ and Na^+ can't diffuse across bilayer.
They must pass through transmembrane protein channels.



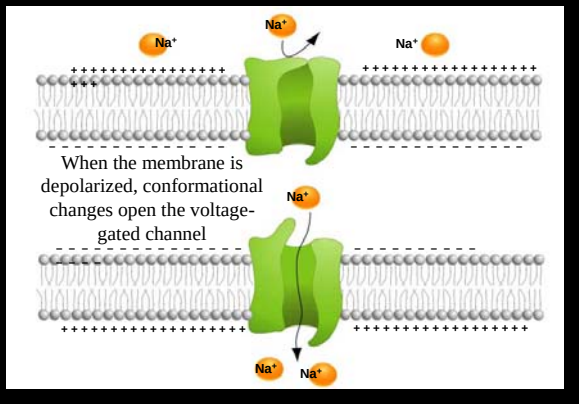
Ion Concentrations at Resting Potential

- Potassium (K^+)
  - Concentration inside the neuron is higher than the concentration outside.
- Sodium (Na^+)
  - Concentration inside the neuron is lower than the concentration outside.

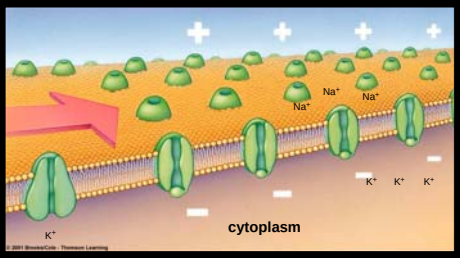
Action Potential

- A transitory reversal in membrane potential (depolarization).
- Voltage change causes voltage-gated channels in the membrane to open.
- As a result of ion flow through these channels, the inside of neuron briefly becomes more positive than outside.

At the resting potential, voltage-gated Na^+ channels are closed.

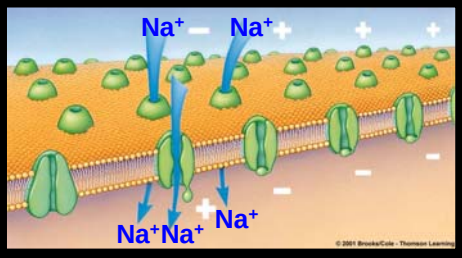


Action Potential



Depolarization of memebrane

Action Potential

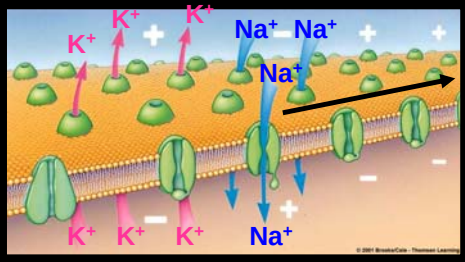


Voltage-gated channels open – Na^+ flows in

Repolarization

- Once peak depolarization is reached, Na^+ gates close and K^+ gates open.
- Movement of K^+ out of cell repolarizes the cell.
- The inside of the cell once again becomes more negative than the outside.

Action Potential

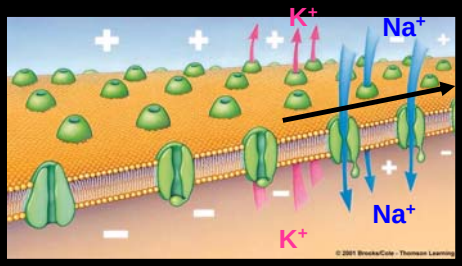


Causes depolarization of downstream voltage-gated channels and repolarization of upstream K+ channels.

Propagation of Action Potentials

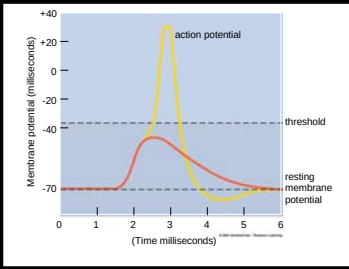
- An action potential in one part of an axon brings a neighboring region to threshold.
- Action potential occurs in one patch of membrane after another.

Action Potential



Action potential propagates down the axon

Recording of Action Potential



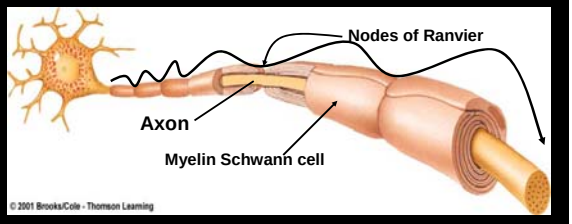
All or Nothing

- All action potentials are the same size.
- If stimulation is below threshold level, no action potential occurs.
- If it is above threshold level, cell is always depolarized to the same level.

Action Potential

Action Potential

Myelin Sheath

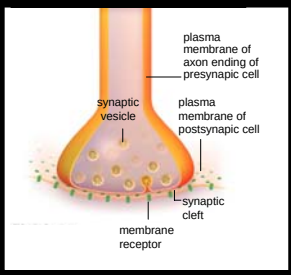


- A series of Schwann cells
- Sheath blocks ion movements
- Action potential must “jump” from node to node

Action Potential Saltatory Propagation

Chemical Synapse

- Gap between the terminal ending of an axon and the input zone of another cell.
- Chemical transmission of signals from one cell to another.



Synaptic Transmission (1)

- When action potential reaches the end of the presynaptic cell, voltage-gated calcium channels open.
- Flow of calcium into presynaptic cell causes release of neurotransmitter into synaptic cleft via vescicles.

Synaptic Transmission (2)

- Neurotransmitter diffuses across cleft and binds to receptors on membrane of postsynaptic cell.
- Binding of neurotransmitter to receptors opens ion channels in the membrane of postsynaptic cell, which stimulates a new action potential in the postsynaptic cell.

Action potential animated

Initiation of an action potential

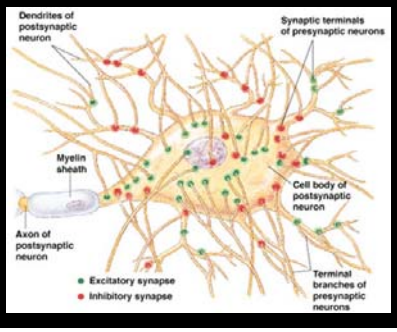
Types of Neural Circuits

- Convergent circuit - Signals from many neurons are sent on to just a few.
- Divergent circuit - Signals from one neuron are sent out to many others.
- Reverberating circuit - A circular circuit that returns a signal to its source

Synaptic Integration (signal control)

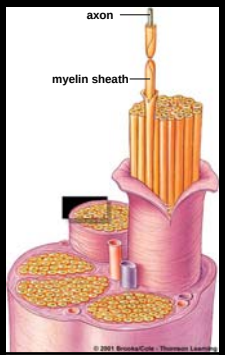
- **Neurotransmitters can be excitatory or inhibitory.**
- **Neurons involved in convergent circuits receive suppressive, inhibitory, excitatory or reinforced signals from different neurons.**
- **These signals influence the neural response of the receiving neuron.**

Convergent Circuit & Integration



Nerves

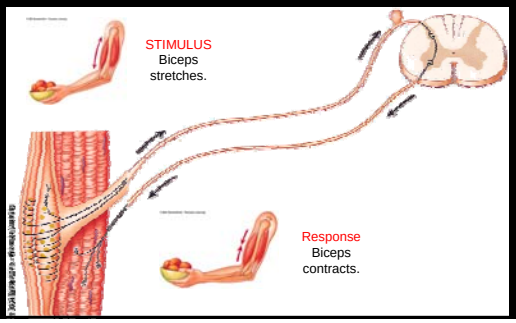
- A nerve is a bundle of axons enclosed within a connective tissue sheath.
- Permit long-distance communication between the brain or spinal cord and the rest of the body.



Reflexes

- Automatic movements made in response to stimuli.
- In the simplest reflex arcs, sensory neurons synapse directly on motor neurons.
- Most reflexes involve an interneuron

Stretch Reflex



Multiple Sclerosis

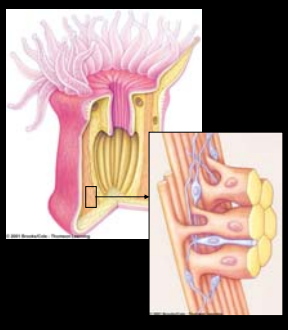
- A condition in which nerve fibers lose their myelin.
- This slows conduction in these fibers.
- Symptoms include visual problems, numbness, muscle weakness, and fatigue.

Invertebrate Nervous Systems

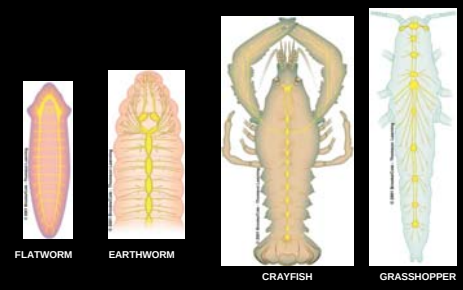
- All animals except sponges have some sort of nervous system.
- Nerve cells are oriented relative to one another in signal-conducting and information-processing highways.

Nerve Net

- Diffuse mesh of nerve cells that take part in simple reflex pathways
- Nerve cells interact with sensory and contractile cells



Bilateral Nervous Systems



Evolution of Nervous Systems

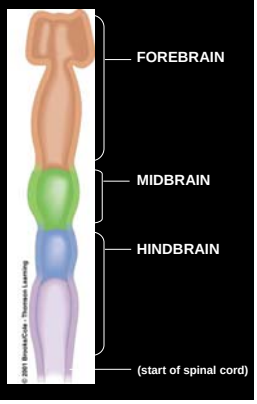
- Bilateral nervous system may have evolved from nerve nets.
- Most bilateral animals have local nerve nets in some parts of the body.
- The bilateral planula larva of some Cnidarians resembles a flatworm

Vertebrate Nervous Systems

- Earliest fishlike vertebrates had a hollow, tubular nerve cord.
- Modification and expansion of the nerve cord produced the spinal cord and brain.
- Nerve cord persists in vertebrate embryos as a neural tube.

Functional Regions

- Expansion and modification of the dorsal nerve cord produced functionally distinct regions



Central and Peripheral Nervous Systems

- Central nervous system (CNS)
  - Brain
  - Spinal cord
- Peripheral nervous system
  - Nerves that thread through the body

Peripheral Nervous System

- Somatic nerves
  - Motor functions
  - Carry signals to and from skeletal muscle, tendons, and skin.
- Autonomic nerves
  - Visceral functions
  - Carry signals to and from internal organs and glands.

Two Types of Autonomic Nerves

- Sympathetic nerves
- Parasympathetic nerves
- Most organs receive input from both
- Usually have opposite effects on organ

Sympathetic Nerves

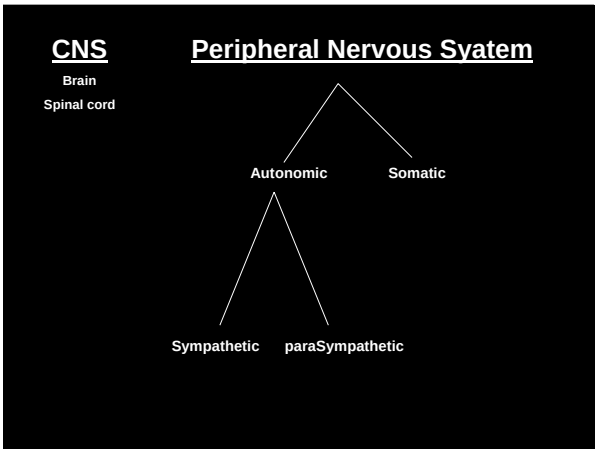
- Originate in the thoracic and lumbar regions of the spinal cord.
- Ganglia are near the spinal cord.
- Promote responses that prepare the body for stress or physical activity (fight-or-flight response)

Parasympathetic Nerves

- Originate in the brain and the sacral region of the spinal cord
- Ganglia are in walls of organs
- Promote housekeeping responses, such as digestion

Both Systems Are Usually Active

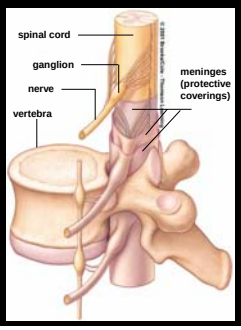
- Most organs are continually receiving both sympathetic and parasympathetic stimulation.
- For example, sympathetic nerves signal heart to speed up and parasympathetic stimulate it to slow down.
- Which dominates depends on situation.



Function of the Spinal Cord

- Expressway for signals between brain and peripheral nerves.
- Sensory and motor neurons make direct reflex connections in the spinal cord.
- Spinal reflexes do not involve the brain

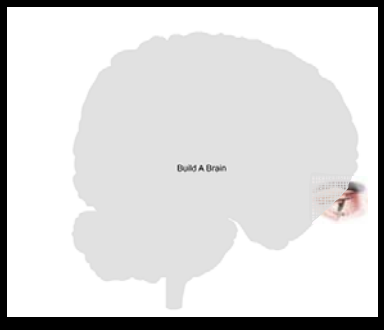
Structure of the Spinal Cord



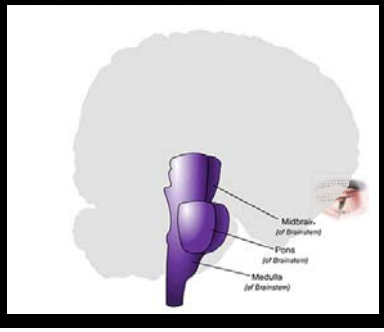
Development of the Brain

- Brain develops from a hollow neural tube.
- Forebrain, midbrain, and hindbrain form from three successive regions of tube.
- Brain stem is tissue that evolved first and develops first in all three regions.

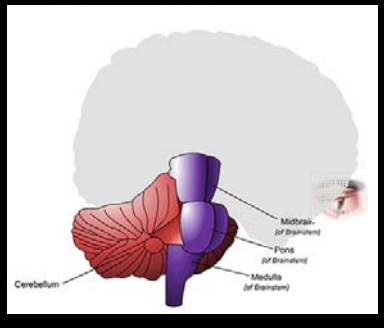
Let's build a brain



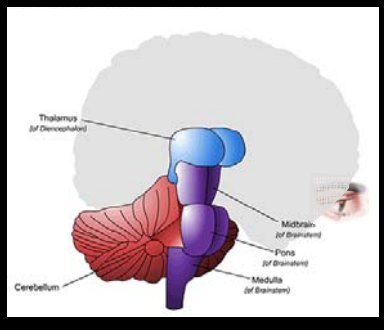
Brainstem



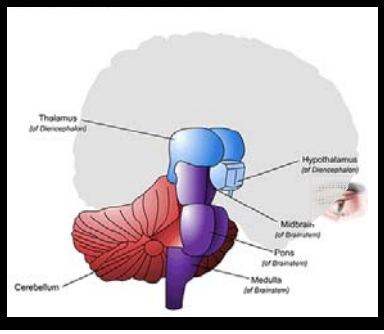
Hindbrain & Midbrain



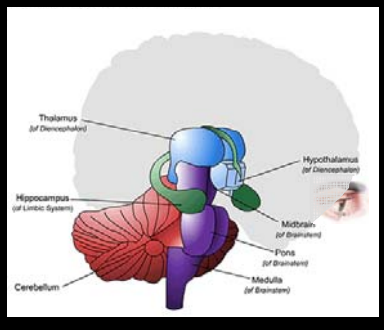
Hindbrain & Midbrain



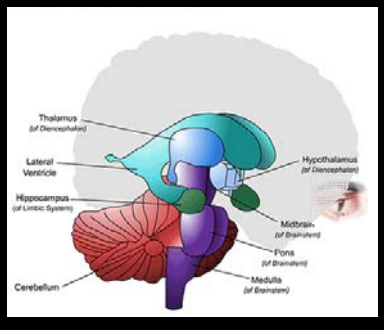
Hindbrain & Midbrain



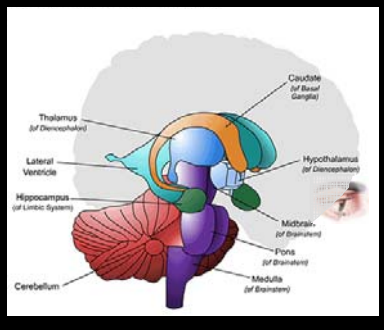
Hindbrain, Midbrain & Limbic



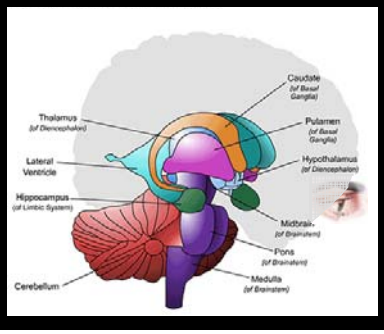
Hindbrain, Midbrain & Limbic



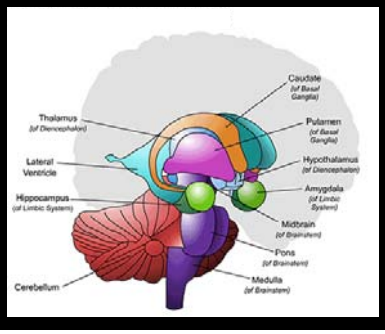
Hindbrain, Midbrain & Limbic



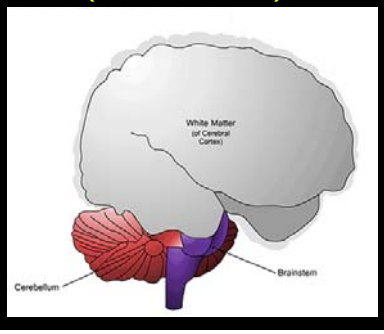
Hindbrain, Midbrain & Limbic



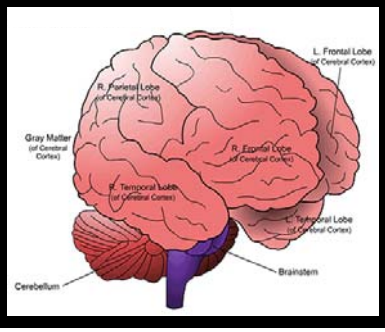
Hindbrain, Midbrain & Limbic



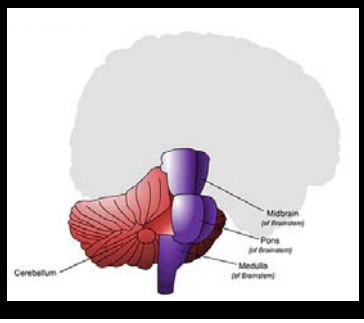
Hindbrain & cerebral cortex (white matter)



Cerebral cortex



Hindbrain & Midbrain



Hindbrain

- Medulla oblongata
- Cerebellum
- Pons

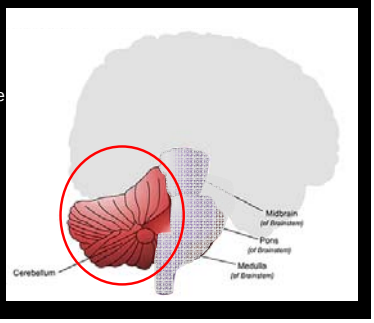
Hindbrain

Medulla oblongata

- Respiration
- Circulation
- Coughing
- Sleep

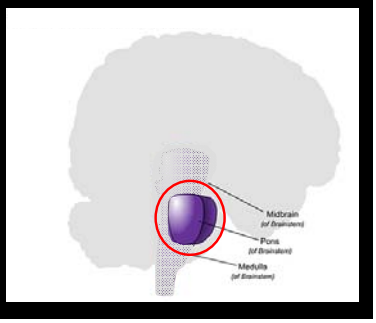
Hindbrain

Cerebellum
Receives info from eyes, ears, muscles & forebrain to control motor skills & posture



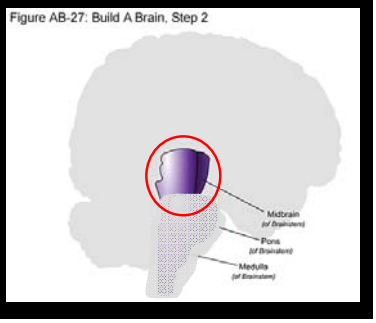
Hindbrain

Pons
Traffic control between cerebellum and forebrain

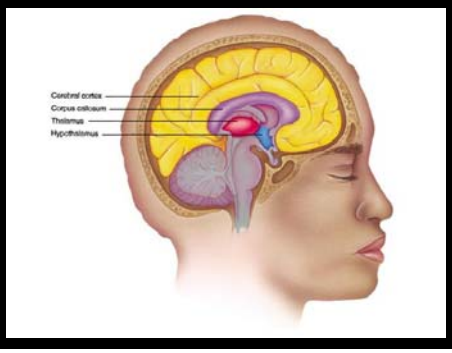


Midbrain

- Coordinates reflex responses to sight and sounds.
- Roof of midbrain is the tectum.



Forebrain



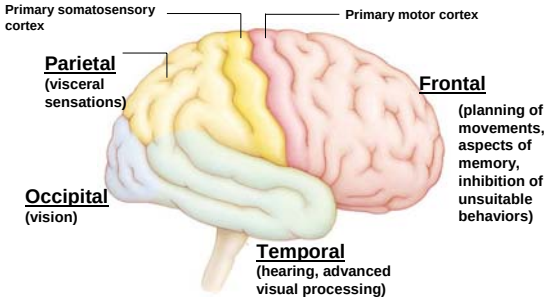
Forebrain

- Olfactory lobes
- Cerebrum
- Thalamus
- Hypothalamus and pituitary gland

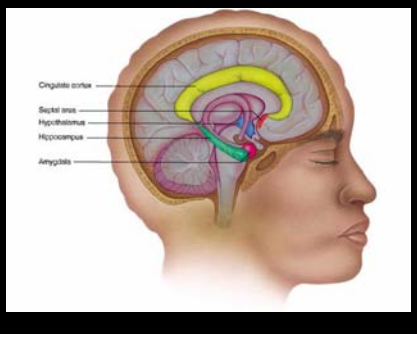
Anatomy of the Cerebrum

- Largest and most complex part of human brain.
- Outer layer (cerebral cortex) is highly folded.
- A longitudinal fissure divides cerebrum into left and right hemispheres.

Lobes of the Cerebrum



Limbic System

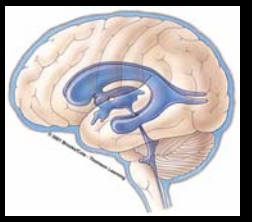


Limbic System

- Controls emotions and has role in memory. Links emotions with memory, like smell, sex, fear, anxiety, thrills, …
- Includes
  - Hypothalamus - Parts of the thalamus
  - Amygdala
  - Cingulate gyrus
  - Hippocampus

Cerebrospinal Fluid

- Surrounds the spinal cord.
- Fills ventricles within the brain.
- Blood-brain barrier controls which solutes enter the cerebrospinal fluid, but some undesirable chemicals can pass through – alcohol, nicotine, THC, caffeine, some bacteria, which can cause meningitis.



Memory

- Brain's capacity to store and retrieve information about past sensory input.
- Stored in stages
  - Temporary storage in cerebral cortex
  - Short-term memory
  - Long-term memory

Drugs and Addiction

- A drug is a substance introduced into the body to provoke a specific physiological response.
- In addiction, a drug assumes an "essential" biochemical role in the body.

Stimulants

- Increase alertness and body activity, then cause depression
  - Caffeine
  - Nicotine - mimics acetylcholine
  - Cocaine - blocks reabsorption of neurotransmitters (dopamine).
  - Amphetamines - induces dopamine release.

Depressants and Hypnotics

- Lower activity of nerves and parts of the brain.
  - Barbiturates
  - Alcohol - acts directly on the plasma membrane to alter cell function.

Hallucinogens and Marijuana

- Skew sensory perception by interfering with action of neurotransmitters.
- LSD affects action of serotonin.
- Marijuana is a depressant at low dose; it can also cause disorientation, anxiety, delusion, and hallucinations.