

The Human Brain

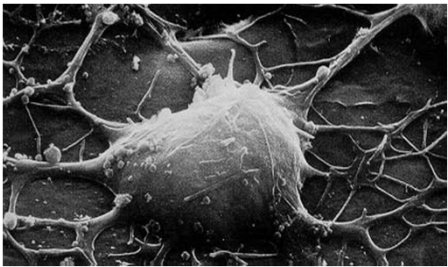
- Weighs about 3 pounds.
- Convoluted surface.
- Two hemispheres.
- ~100 billion neurons.
- ~1 trillion glial cells.

- Cerebral cortex ~80%.
- ~30 billion neurons in the cortex.
- ~10,000 connections for each cortical neuron.
- > 100 trillion connections...

Lecture Created by Jeffrey P. Toth, University of North Carolina Wilmington

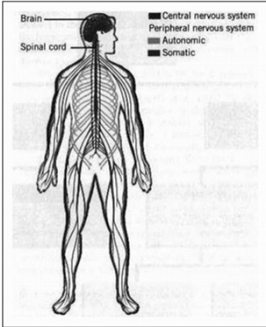
The Central Nervous System

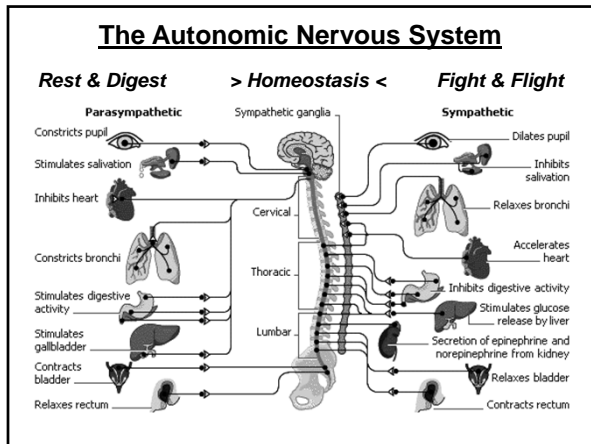
- Cellular Basis.
- Major Structures.
- Neural Communication.
- Principles & Methods.

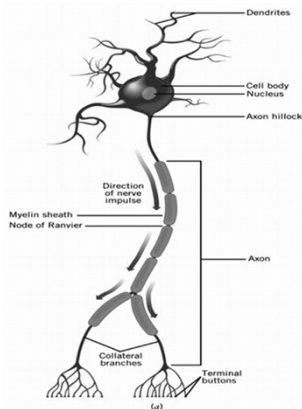
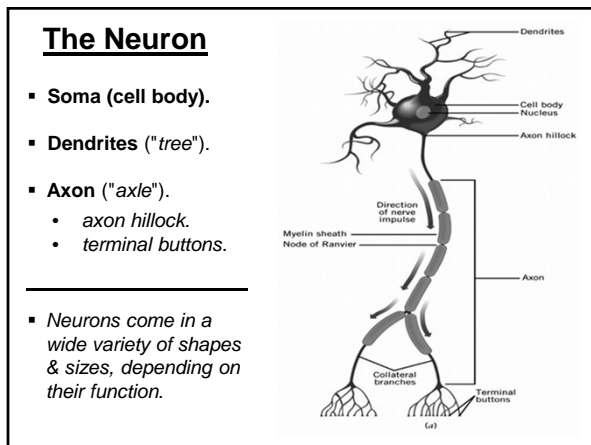


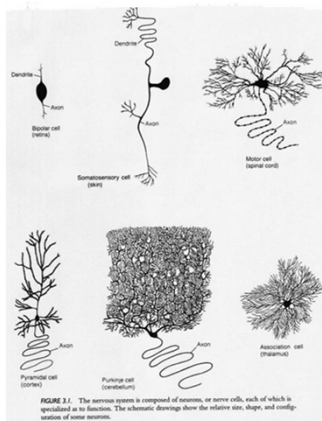
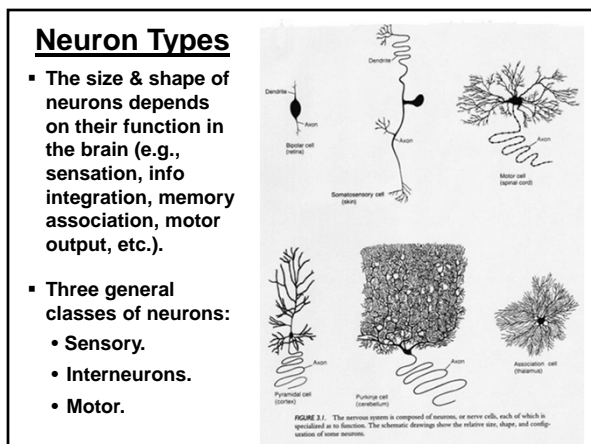
The Nervous System(s)

- The Central Nervous System (CNS).**
 - Brain and Spinal Cord.
- The Peripheral Nervous System.**
 - Somatic Nervous System.**
 - sense organs.
 - muscles.
 - Autonomic Nervous System.**
 - visceral structures.
 - sympathetic.
 - parasympathetic.









Neuron Types

Three Basic Types

- Sensory.
- Interneurons.
- Motor.

The Pain-Withdrawal Reflex
The pain-withdrawal reflex shown here involves only three neurons: a sensory neuron, a motor neuron, and an interneuron.

Motor cortex Somatosensory cortex

Motor neuron sends message to leg muscles before brain can register pain.

Sensory neuron sends message to spinal cord interneuron.

Interneuron sends message to motor neuron.

Sensory neuron sends pain message to brain.

Spinal cord

The Pain-Withdrawal Reflex - The shortest path through the nervous system.

The Synapse

The physical gap between neurons.

Pre-Synaptic Neuron

- terminal button.
- synaptic vesicles.
- synaptic cleft.

Post-Synaptic Neuron

- post-synaptic membrane.

Synapse

1. Dendrite

2. Cell body

3. Synaptic vesicles

4. Synaptic cleft

5. Post-synaptic membrane

6. Axon

7. Axon terminal

Glial Cells

Support the health and operation of neurons.

- Guide growing neurons.
- Transport nutrients.
 - blood-brain barrier.
- Repair damaged neurons.
- Facilitate neural transmission.
 - myelin sheath.

Motor receptive neuron

Axon

Dendrites

Synapse

Axon

Local circuit neuron

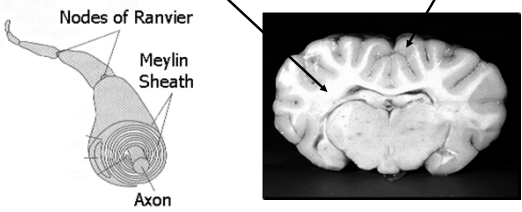
Capillary

Astrocytes (glia)

Myelin Sheath

Insulates axons for faster neural transmission.

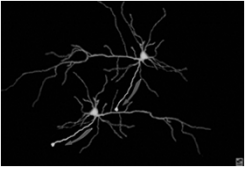
- **Myelin is a white fatty substance.**
- "White Matter"
- **Un-myelinated neurons are grey.**
- "Grey Matter"



Neural Communication

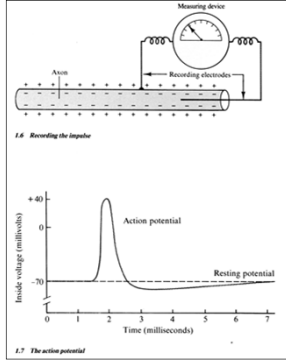
Neurons function to analyze and transmit information

- *neurons receive signals at dendrites.*
- *neurons send signals via axons.*
- *signals travel to end of axon (terminals), causing release of neurotransmitters.*
- *neurotransmitters travel across synapse and bind with the post-synaptic membrane.*
- *binding changes electrical properties, creating current.*



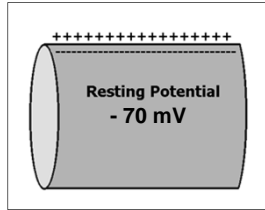
Three kinds of electrical events...

- ❑ **Resting potential.**
 - - 70 mV.
- ❑ **Graded potential.**
 - *passively spreading voltage change.*
- ❑ **Action potential (AP).**
 - *"firing" of a neuron.*
 - *actively propagated voltage change.*



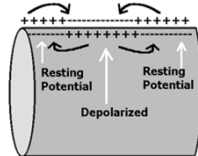
Resting Potential

- The state neurons are in when they are *not* firing.
- Selective permeability of cell membrane keeps potassium (K+) in and Sodium (NA+) out.
- This results in a voltage difference between inner and outer cell of -70 mV.
- A resting neuron is said to be *polarized*.



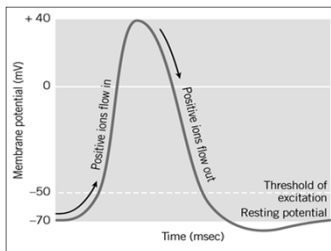
Graded Potential

- When the neuron receives a signal, there is a local change in electrical potential.
- More negative: *Hyperpolarized* - cell less likely to fire.
- More positive: *Depolarized* - cell more likely to fire.
- Signal spreads passively (*it is not actively propagated*).
- Amplitude decreases as the signal moves further away, but it may combine with other graded potentials...



Action Potential

- When *depolarization* reaches the excitation threshold, (-50 mV) an action potential is generated.
- Polarity reverses.
 - sodium flows in.
 - cell becomes positively charged.
- AP propagates along cell, ending at the terminal buttons.
- AP is all or none - there are no large or small AP's; they are all the same size.

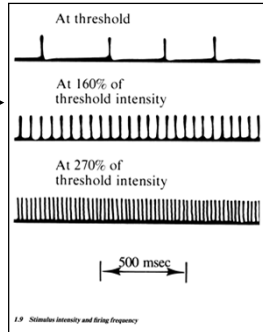


❖ **If Action Potentials are all-or-none, how do neurons code for different stimulus properties?**

➤ A number of coding mechanisms appear to be used, for example...

- **Frequency Coding.**
 - as stimulus intensity increases, so does the rate of firing.

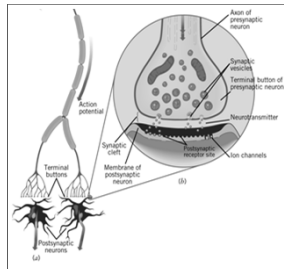
➤ Other coding mechanisms include Place Coding & Population Coding.



Synaptic Transmission

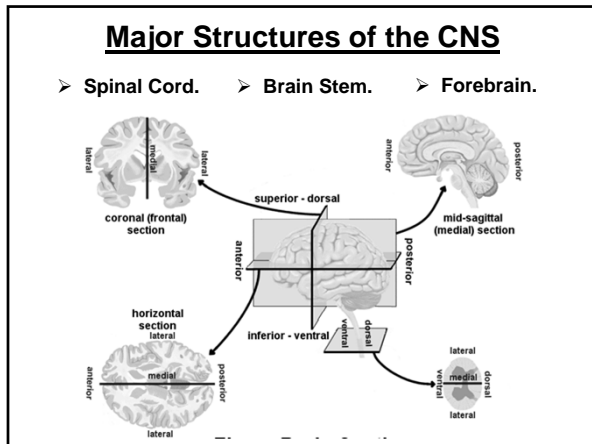
- Action potential arrives at terminal button, causing synaptic vesicles to fuse with cell membrane.

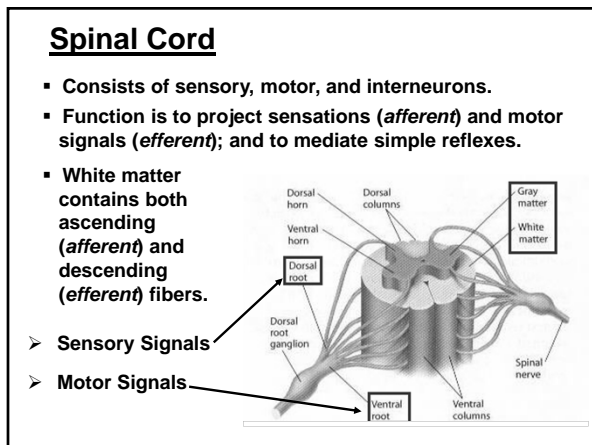
- Vesicles release neurotransmitters into synaptic cleft.
- Transmitters bind with membrane of post-synaptic neuron.
- Post-synaptic cell is thus depolarized or hyperpolarized.

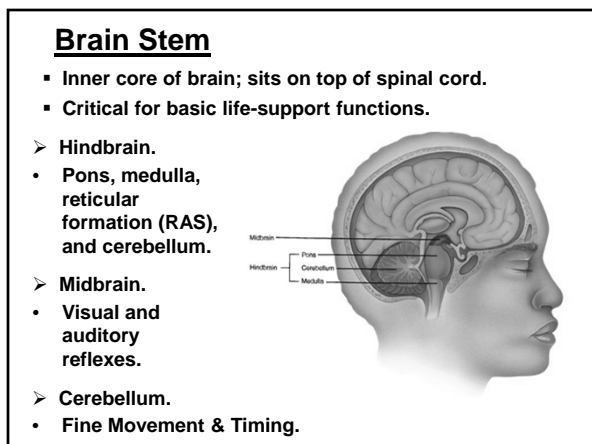


Neurotransmitters

- "Lock and Key" model.
 - only neurotransmitters that are the right "shape" will affect the post-synaptic membrane.
- **Acetylcholine** – widespread; excitatory; muscles.
- **Glutamate** – widespread; excitatory; memory & thought.
- **GABA** – widespread; inhibitory; mood/anxiety & memory.
- **Dopamine** – reward, motivation, movement, & cognition.
- **Serotonin** – sleep/arousal; mood/emotion (cf. SSRIs).
- **Endorphins** – pleasure/reward & pain (cf. opiates).







Forebrain

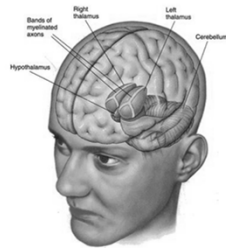
- Diencephalon.
- Basal Ganglia.
- Limbic System.
- Cortex.



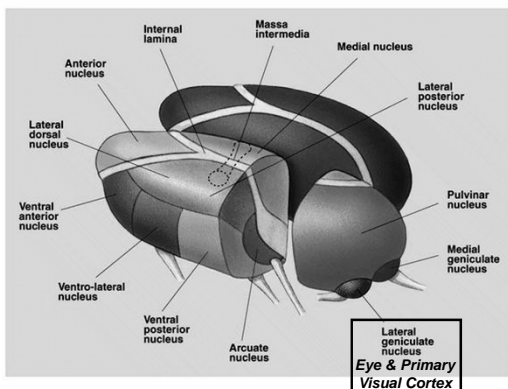
The Diencephalon

- Hypothalamus.
 - "Bio-motives"
 - The 4 F's.
 - Homeostasis.
 - Endocrine system.
- Thalamus.
 - Relay station for all sensory information.
 - Attention.

► Human Diencephalon



► Nuclei of the Thalamus



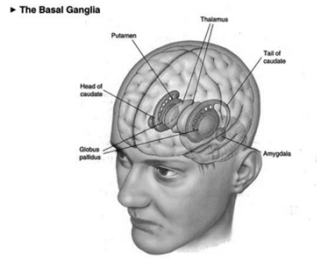
The Basal Ganglia

➤ **Movement.**

- Dopamine.
- Parkinson's Disease.

➤ **Cognition.**

- Motor learning.
- Sequencing.
- Problem solving.



The Limbic System

➤ **Amygdala.**

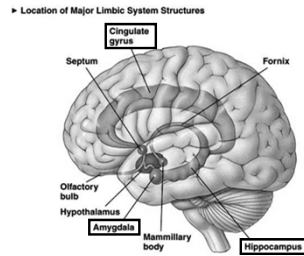
- Emotion.

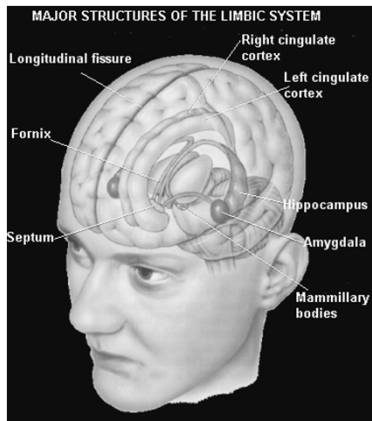
➤ **Hippocampus.**

- Learning and Memory.

➤ **Cingulate Gyrus.**

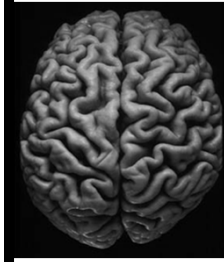
- Mediates between limbic system and cortex.
- Helps prefrontal cortex with "executive functions".



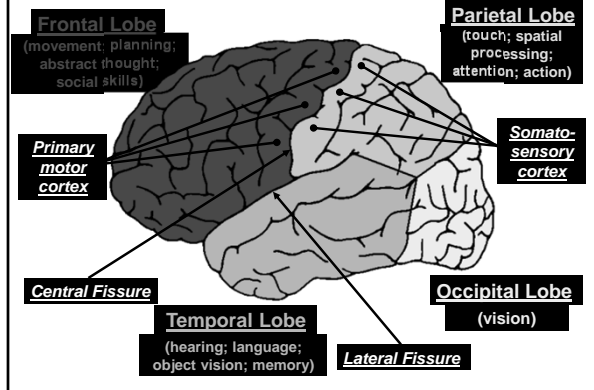


The Cerebral Cortex

- The outer layer ("bark") of the brain.
- Gyri (ridges) and Sulci (valleys).
- Cerebral Hemispheres (longitudinal fissure).
- Corpus Collosum.



Lobes of the Brain



The Central Nervous System

- ✓ Cellular Basis.
- ✓ Major Structures.
- ✓ Neural Communication.
- ☐ Principles & Methods.

