Introduction to the Nervous System

Lecture 2

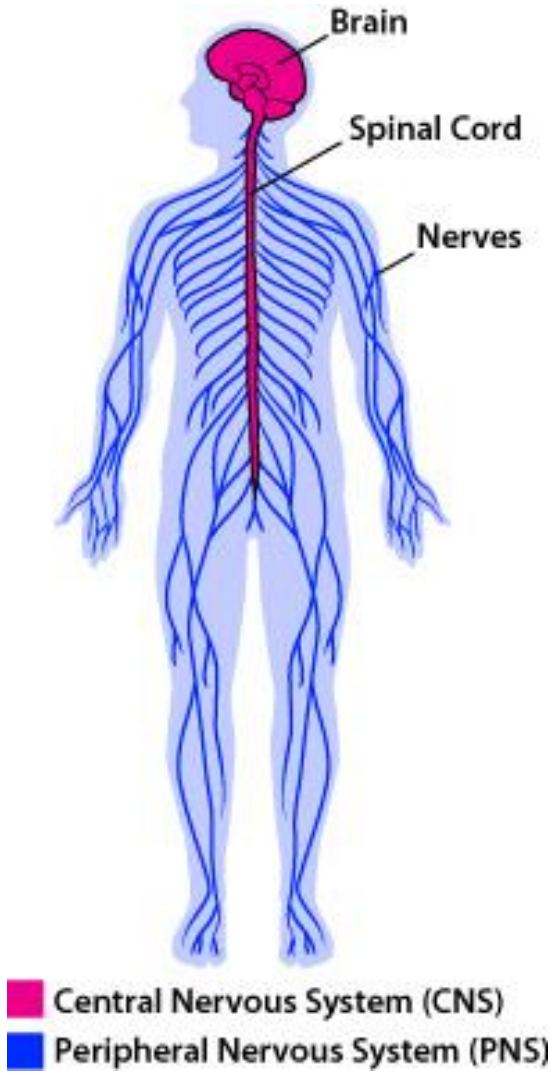
November 7, 2016

Nervous System

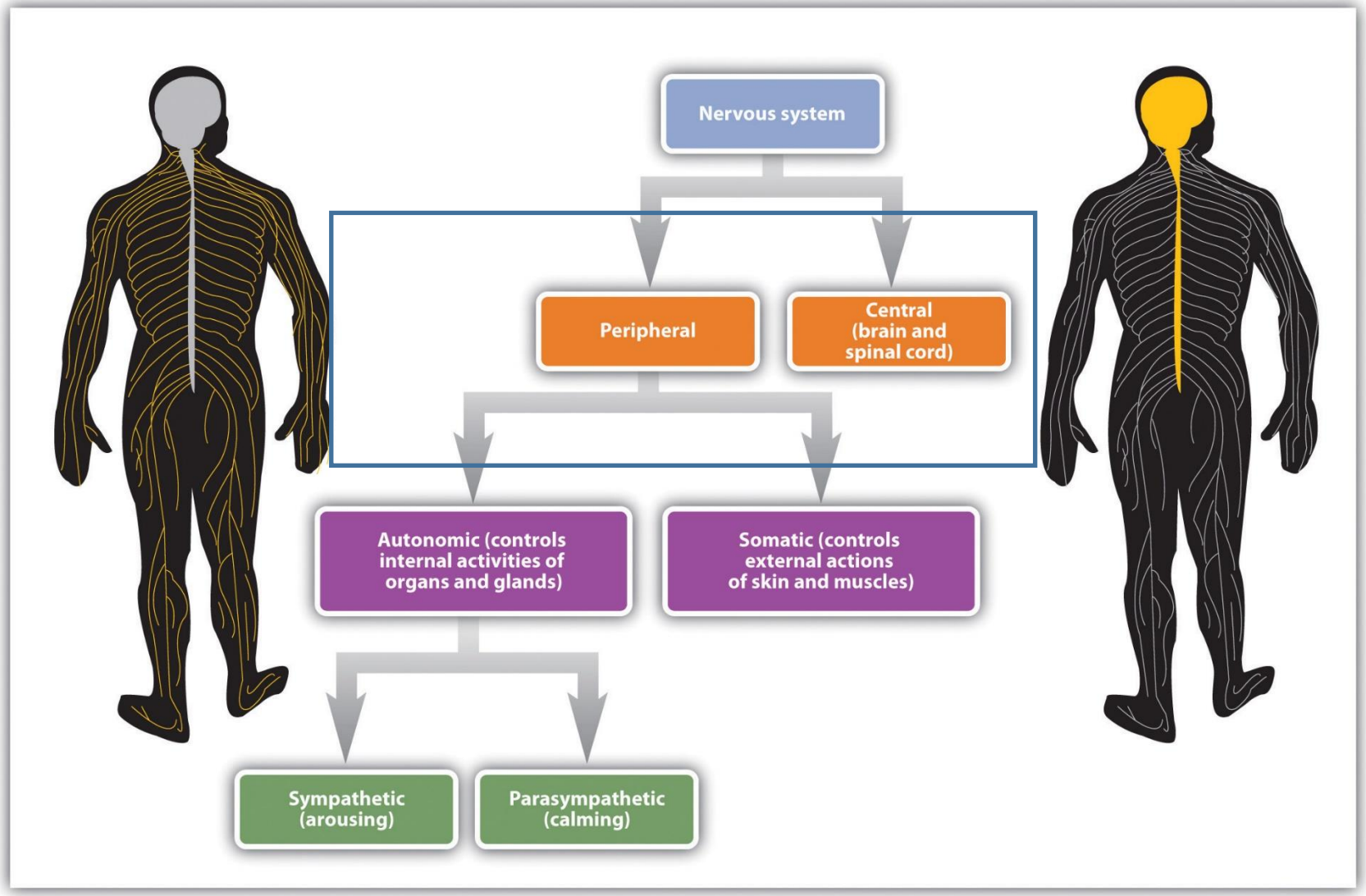
- Complex network of nerves and cells that carry messages and information to and from the brain and spinal cord to all parts of the body

- Responsible for the integration and control of all the body's functions

- Two major divisions, several subdivisions

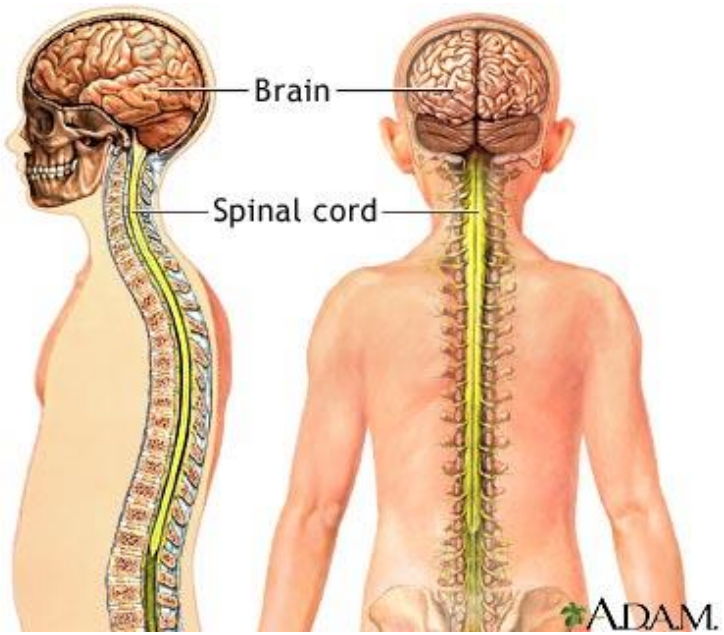


Divisions of the Nervous System



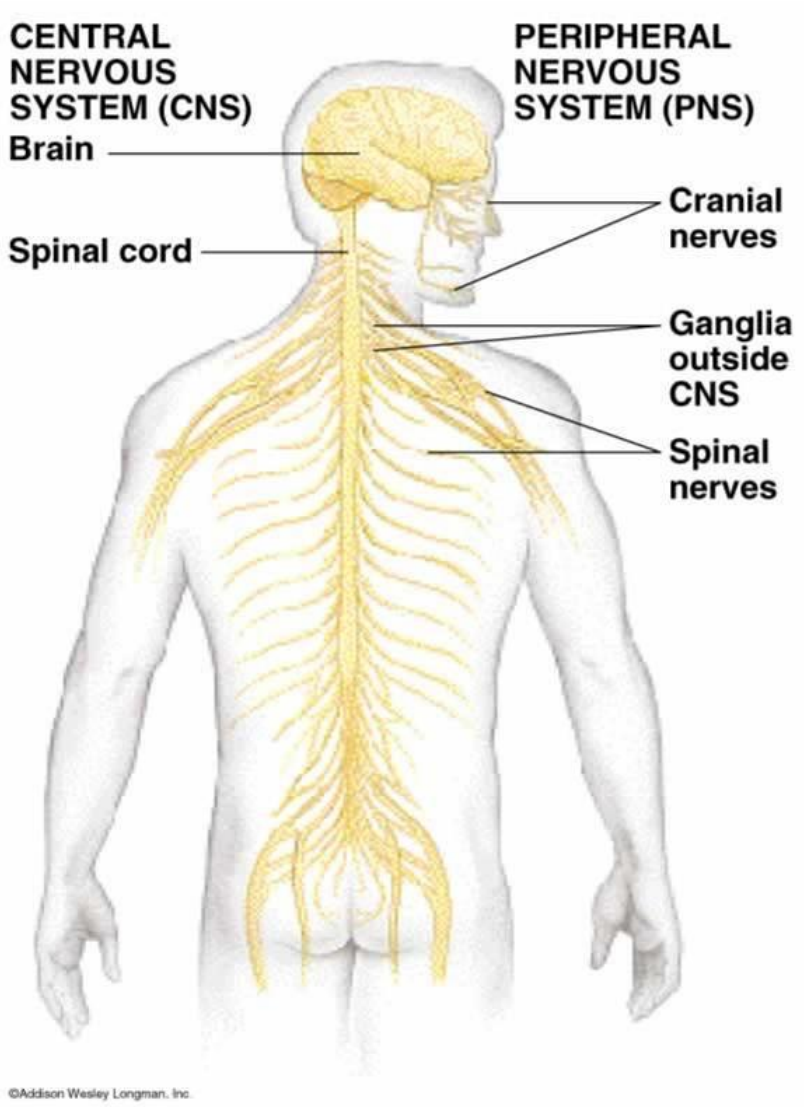
Central Nervous System (CNS)

- All nervous tissue enclosed by bone (brain & spinal cord)
- Allows the body to detect and respond to both internal and external stimuli

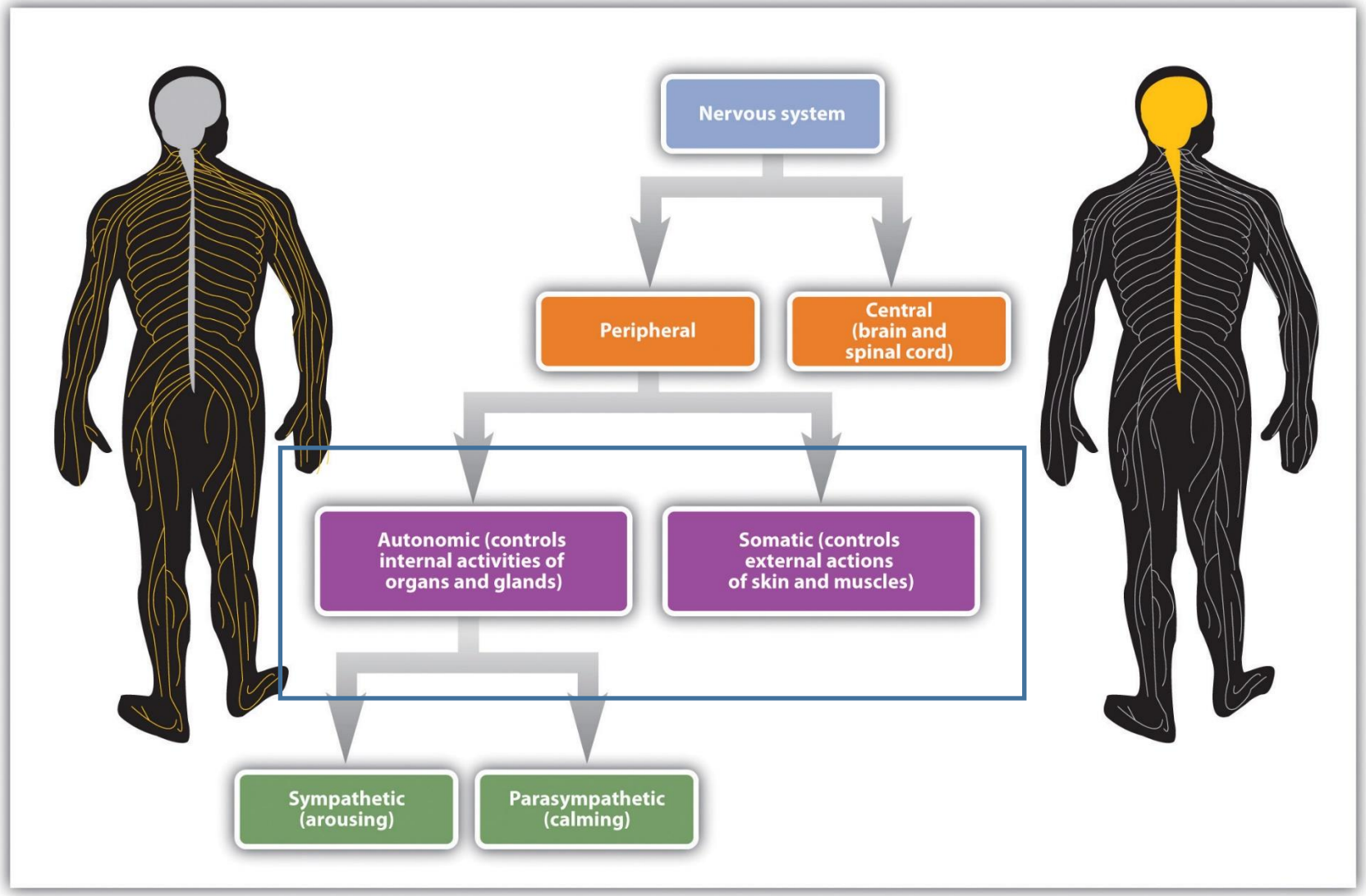


Peripheral Nervous System

- All nervous tissue not enclosed in bone
- Transmits information to and from CNS
- 12 pairs of cranial and 31 pairs of spinal nerves
- Consists of 2 main types of cells:
  - Afferent (sensory) neurons
  - Efferent (motor) neurons



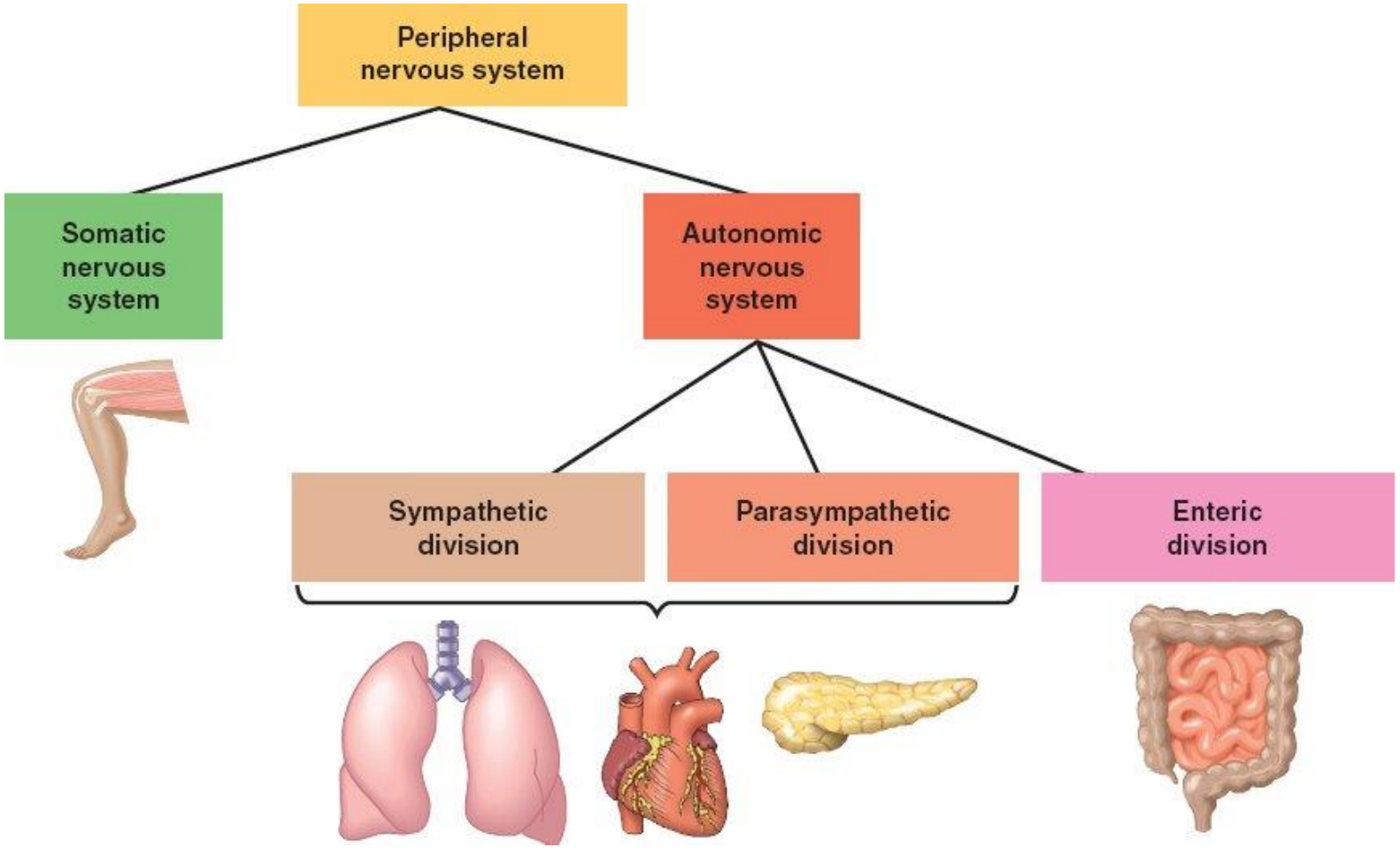
Divisions of the Nervous System



Somatic vs. Autonomic

Somatic = Associated with voluntary control of body movements

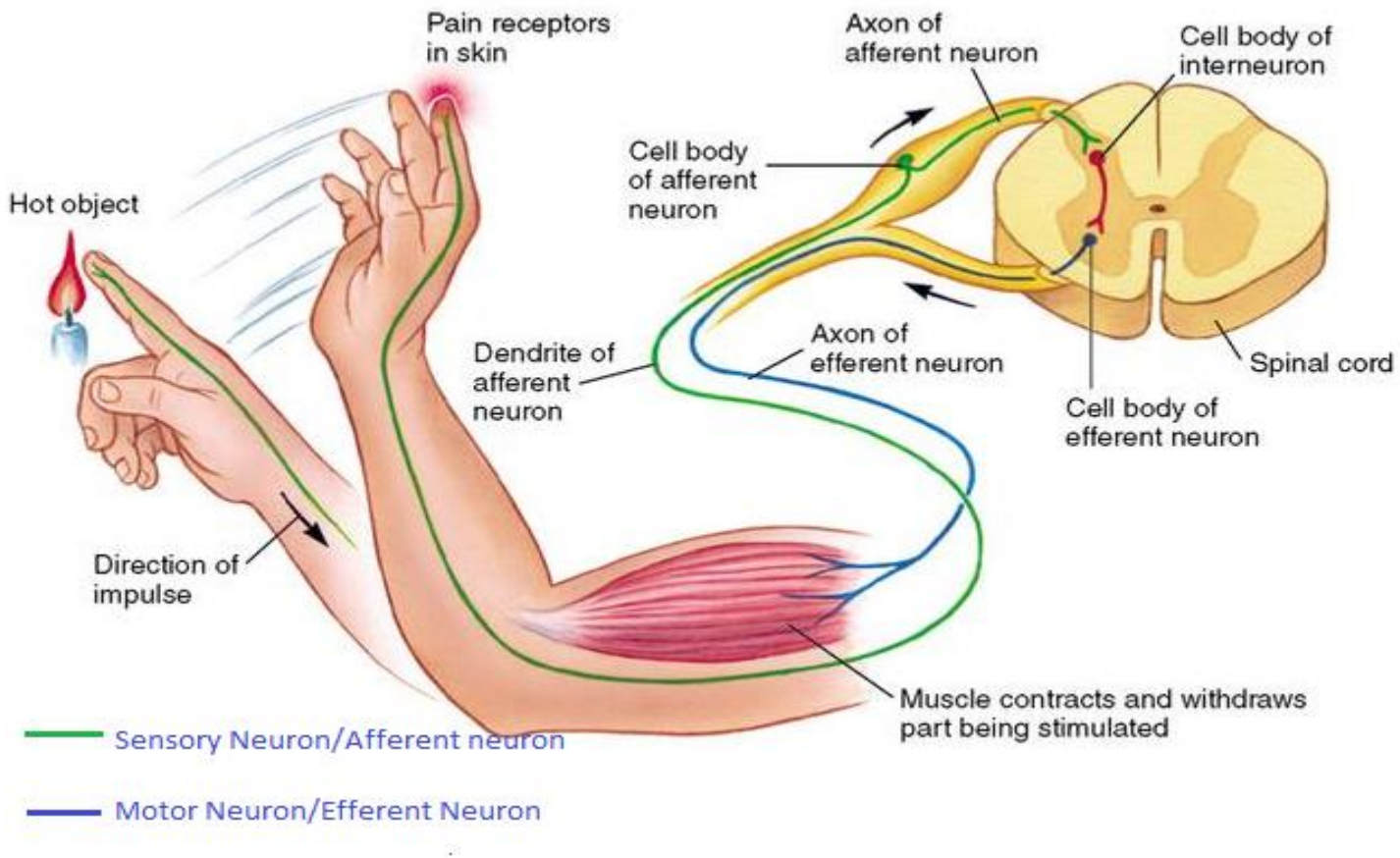
Autonomic = Associated with bodily functions that are not consciously directed (breathing, heartbeat)



Somatic Nervous System

Sensory neurons – conveys information from receptors for pain, temperature, and mechanical stimuli in the skin, muscles, and joints to the CNS

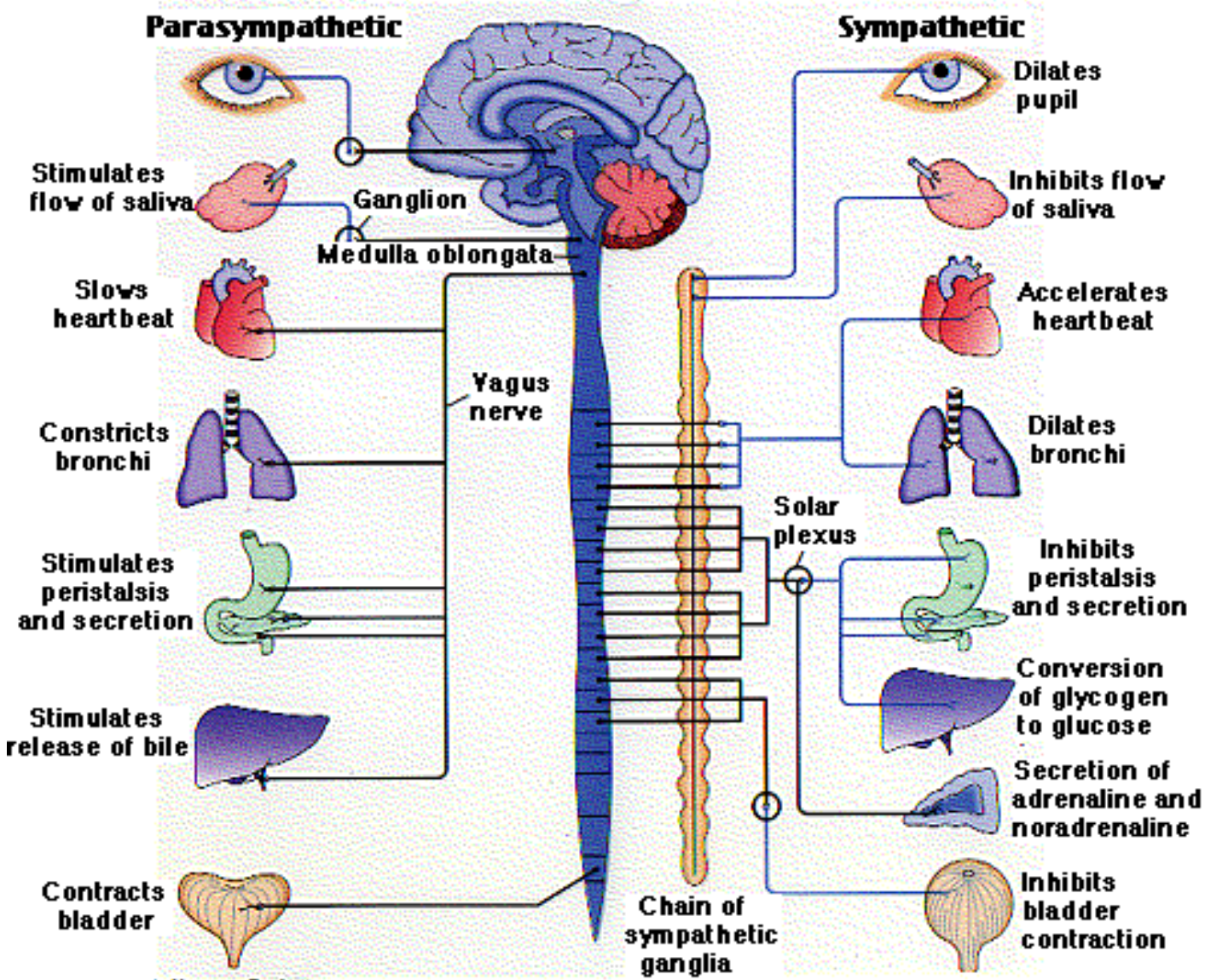
Motor neurons – return impulses from the CNS to these same body areas



Autonomic Nervous System

- Concerned with the involuntary regulation of smooth muscle, cardiac muscle, and glands

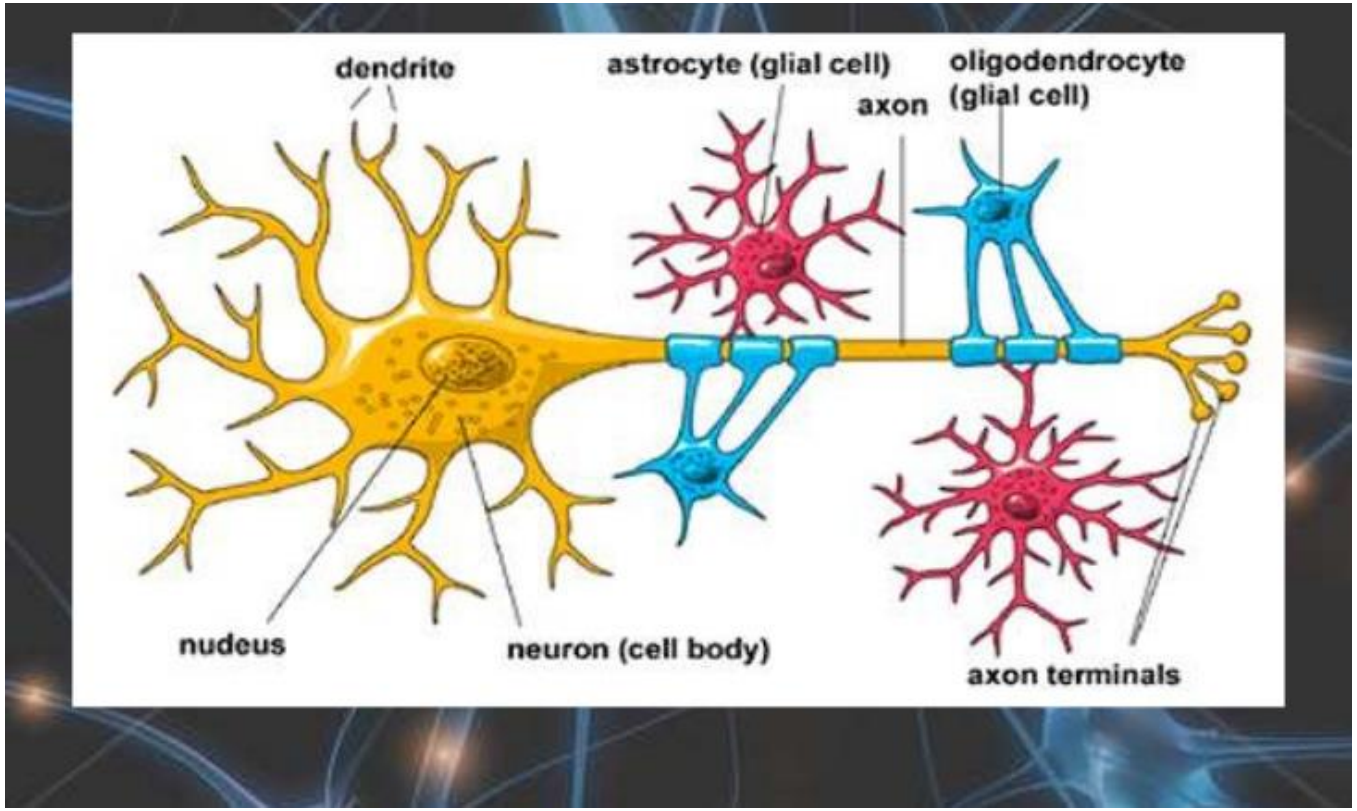
- Consists of the sympathetic & parasympathetic nervous system
  - Sympathetic (arousing) – constriction in skin & vessels, heart rate to increase, blood vessels to skeletal muscles to dilate (“Fight or Flight” reflex)
  - Parasympathetic (calming) – opposite of sympathetic, heart rate to decrease, returns body to normal state


Parasympathetic
Sympathetic
Stimulates flow of saliva
Ganglion
Medulla oblongata
Slows heartbeat
Vagus nerve
Constricts bronchi
Stimulates peristalsis and secretion
Stimulates release of bile
Contracts bladder
Chain of sympathetic ganglia
Dilates pupil
Inhibits flow of saliva
Accelerates heartbeat
Dilates bronchi
Solar plexus
Inhibits peristalsis and secretion
Conversion of glycogen to glucose
Secretion of adrenaline and noradrenaline
Inhibits bladder contraction

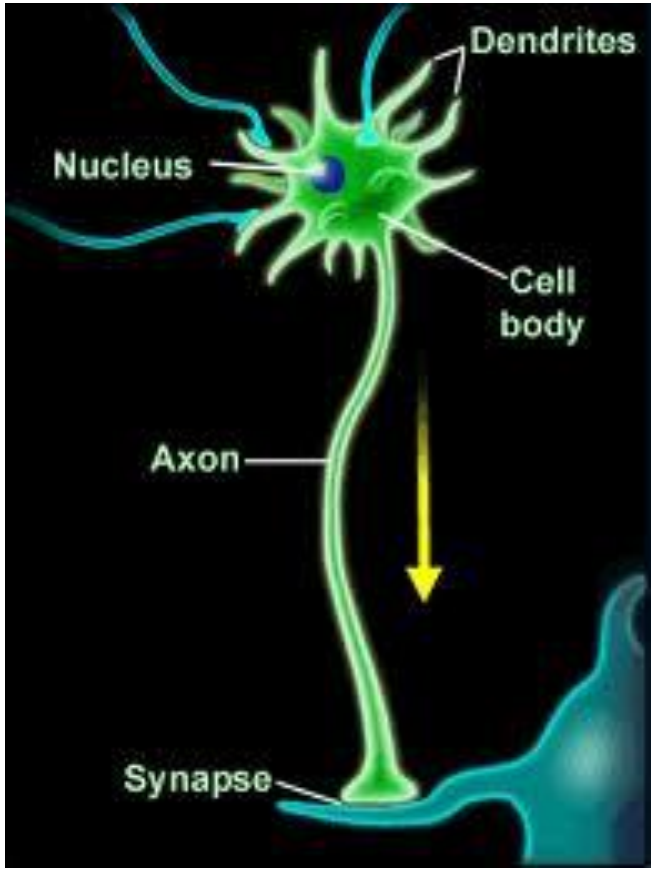
Cells of the Nervous System

- Neurons – conduct electrical signals

- Glial cells – make up different parts of the nervous system (support, structure, more?)



Neurons



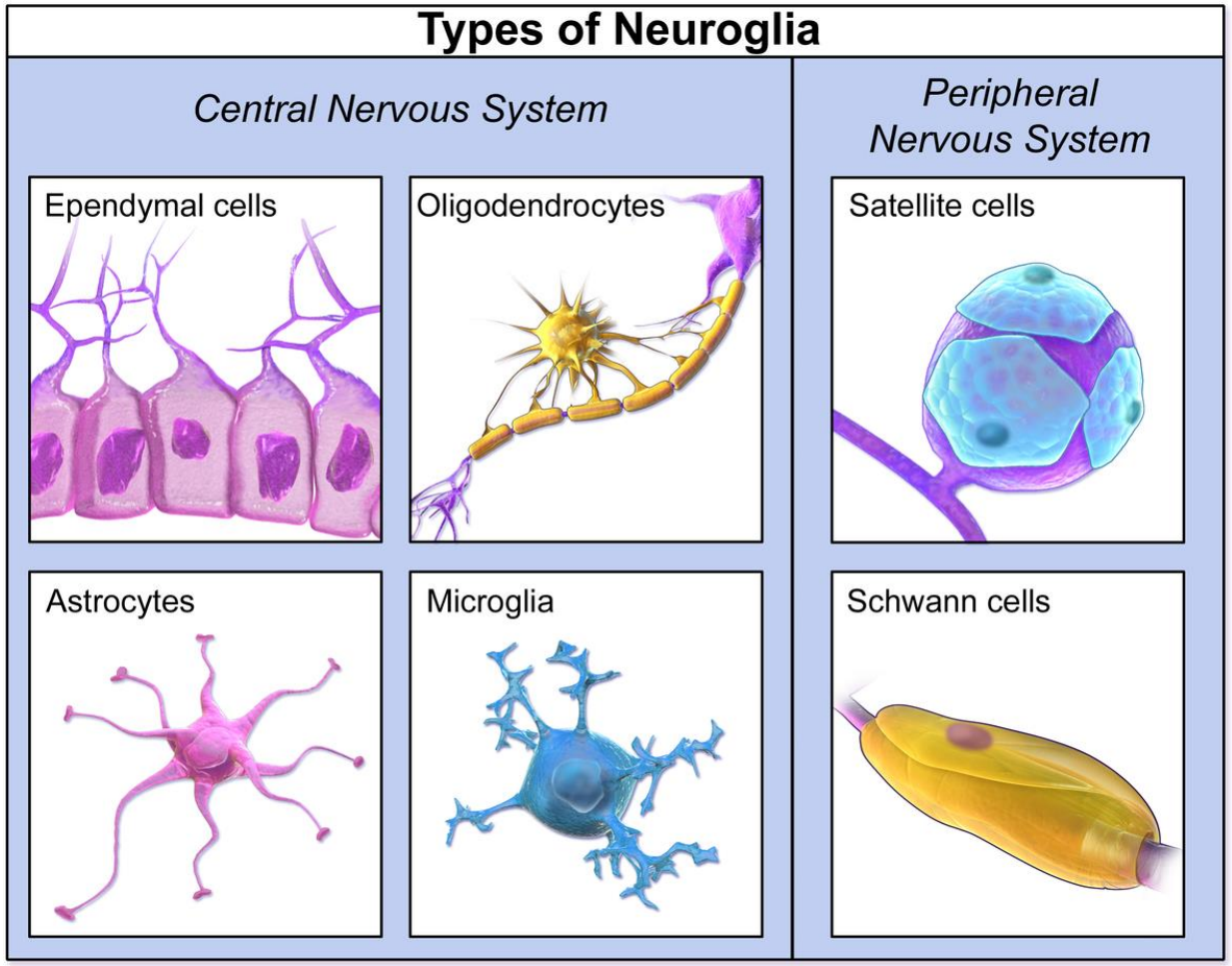
Dendrites – receive inputs from other neurons

Axons -

- Extend between a few millimeters (in the brain) to a meter (spinal cord to foot)
- Send signals to other neurons in brain or spinal cord, or to glands and muscles

Glial Cells

- Most abundant cells of the nervous system
- Long thought to be structural cells of the nervous system with little function
- Do not conduct electrical signals



Types of Glial Cells

- Oligodendrocytes and Schwann cells = form sheaths around neurons in the central & peripheral nervous system (myelination)
- Microglia = scavenge and remove dead cells
- Astrocytes and satellite cells = provide nutrients and support for neurons in the central & peripheral nervous system
- Radial glia = provide structure bridges for developing neurons
- Ependymal cells = line fluid-filled ventricles of the brain and central canal of the spinal cord and produce cerebrospinal fluid

Source: Boundless. “Glia.” *Boundless Biology*. Boundless, 26 May. 2016. Retrieved 25 Sep. 2016 from https://www.boundless.com/biology/textbooks/boundless-biology-textbook/the-nervous-system-35/neurons-and-glial-cells-199/glia-760-11993/

Neuron Communication

- Within cells (intracellular) or Neuroconduction

- Between cells (intercellular) or Neurotransmission

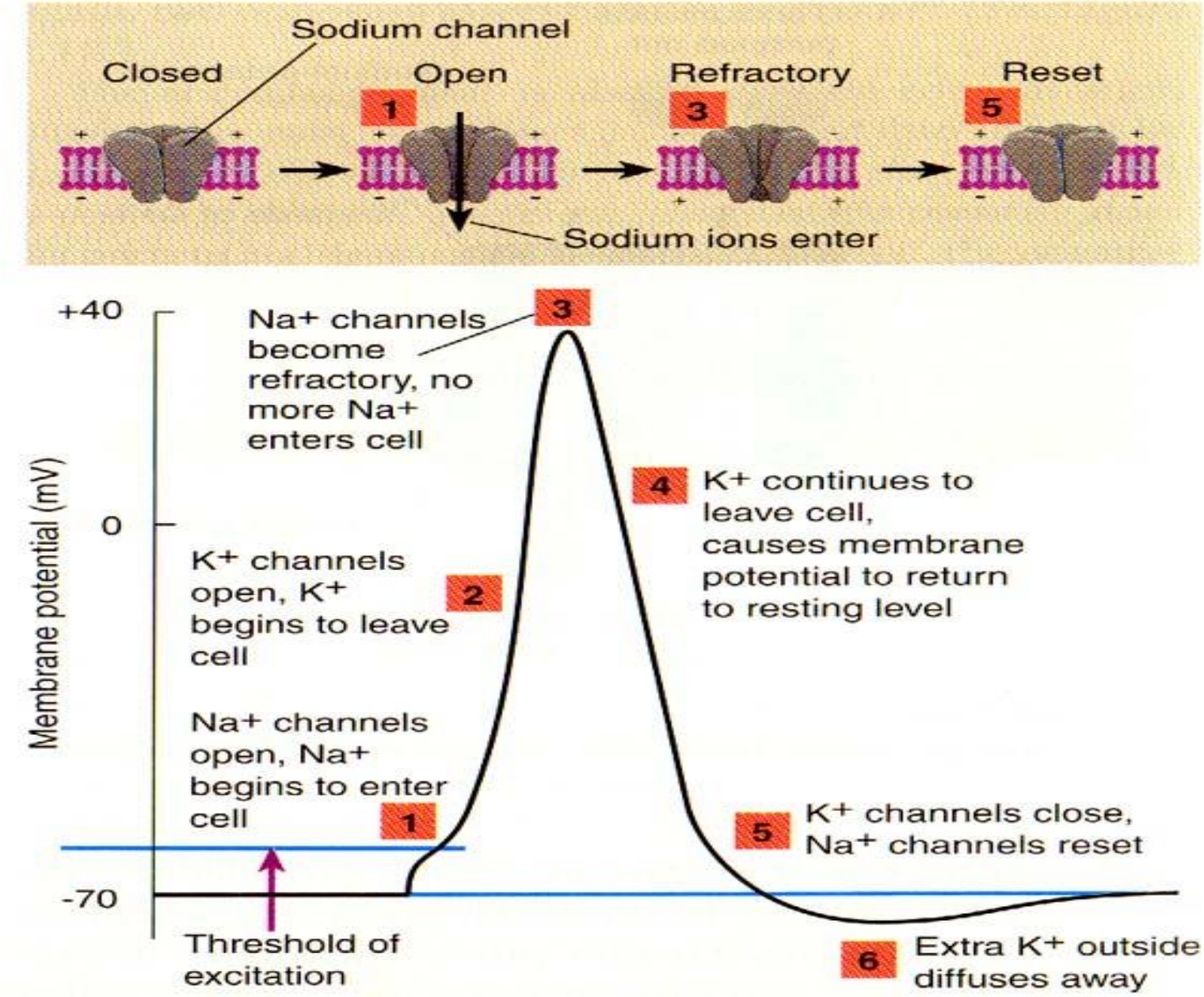
Neuroconduction

- Acts much like an electrical signal in a wire, but uses ions instead of electrons (K^+ and Na^+)
- Nerve cells (at rest) have a negative net charge inside compared to the outside of the cell = resting potential
- Nerve conduction begins with an Action Potential near the cell body
- When a signal is received, ion channels in the cell membrane open
- Charged particles flow through the membrane of the cell

Neuroconduction (continued)

- When the concentration of ions in the cell is high, the electrical charge of the cell changes (polarized to depolarized)
- When a certain threshold is reached, the cell sends an electrical signal
- Signal is propagated along the axon to the next cell
- Cell repolarizes to return to its resting state

Action Potential in terms of membrane voltage



Video of Action Potential

Action Potential Video

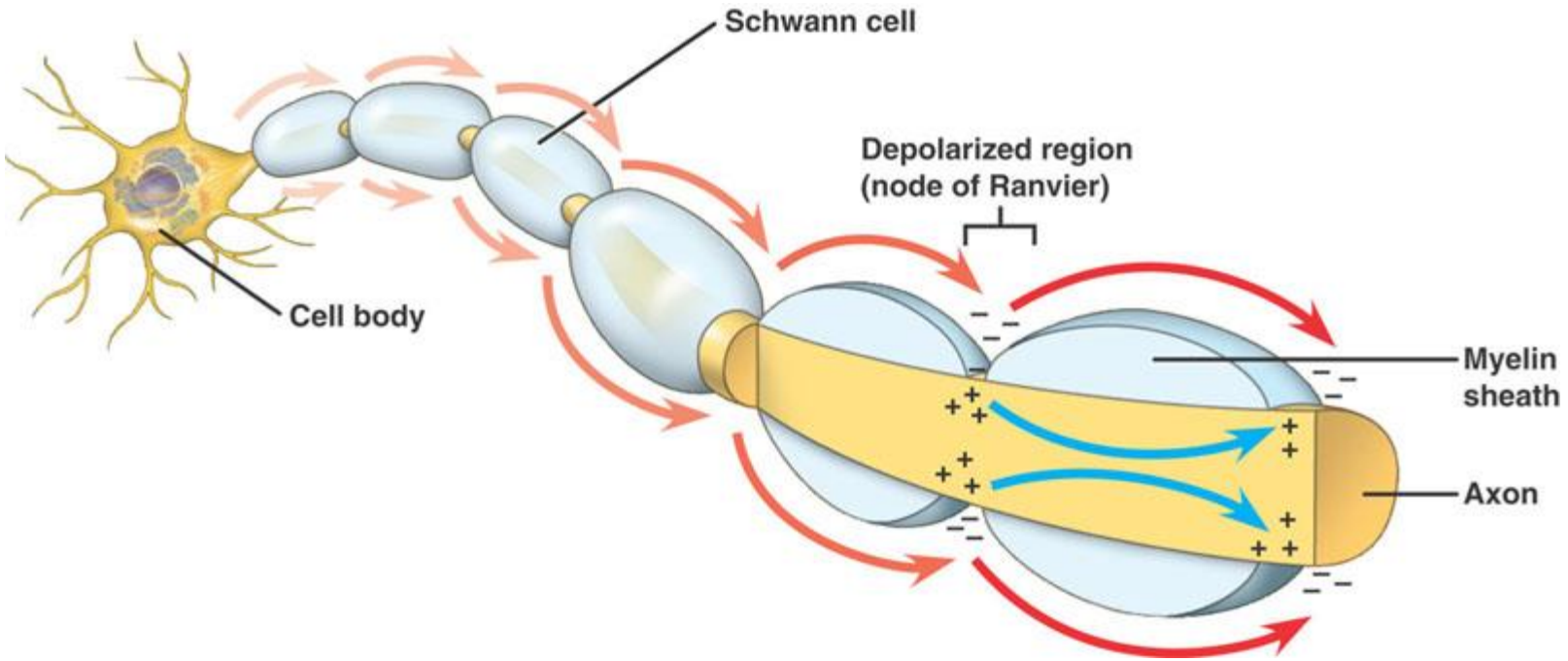
Speed of Nerve Conduction

- Action potential conduction velocity can vary from 0.25 m/s to 100m/s
- Generally increases with the square root of the fiber diameter (larger is faster)
- To increase conduction velocity, myelin is formed around the nerve cells
- Myelin is a fatty “insulation” material produced by glial cells
- Action potential “skips” the wrapped areas and jumps from open node to node along the axon

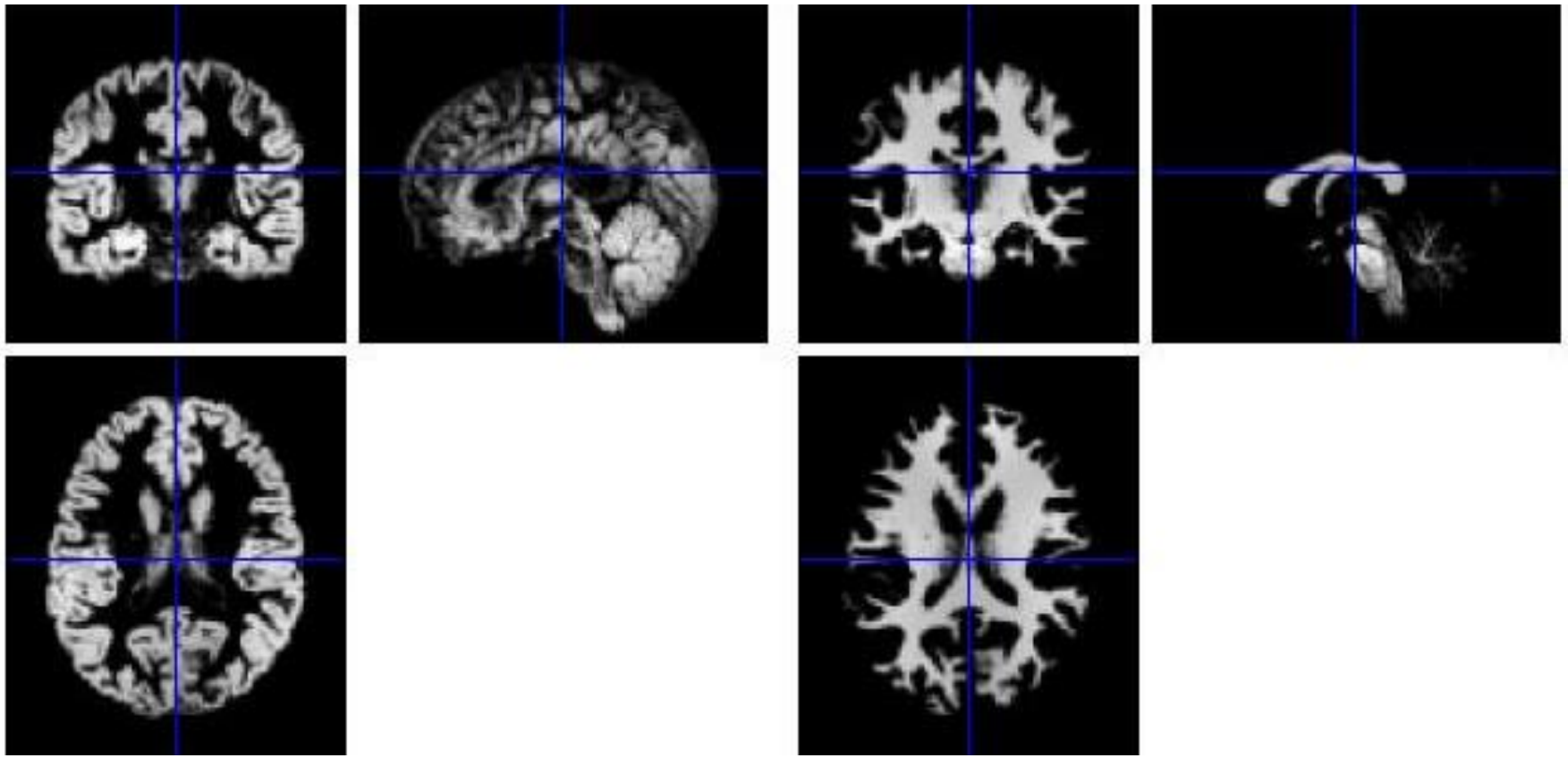
Myelination

- Electrically insulating and allows for faster conduction of nerve impulses

- Myelin is white and gives the “white matter” that is seen in the brain



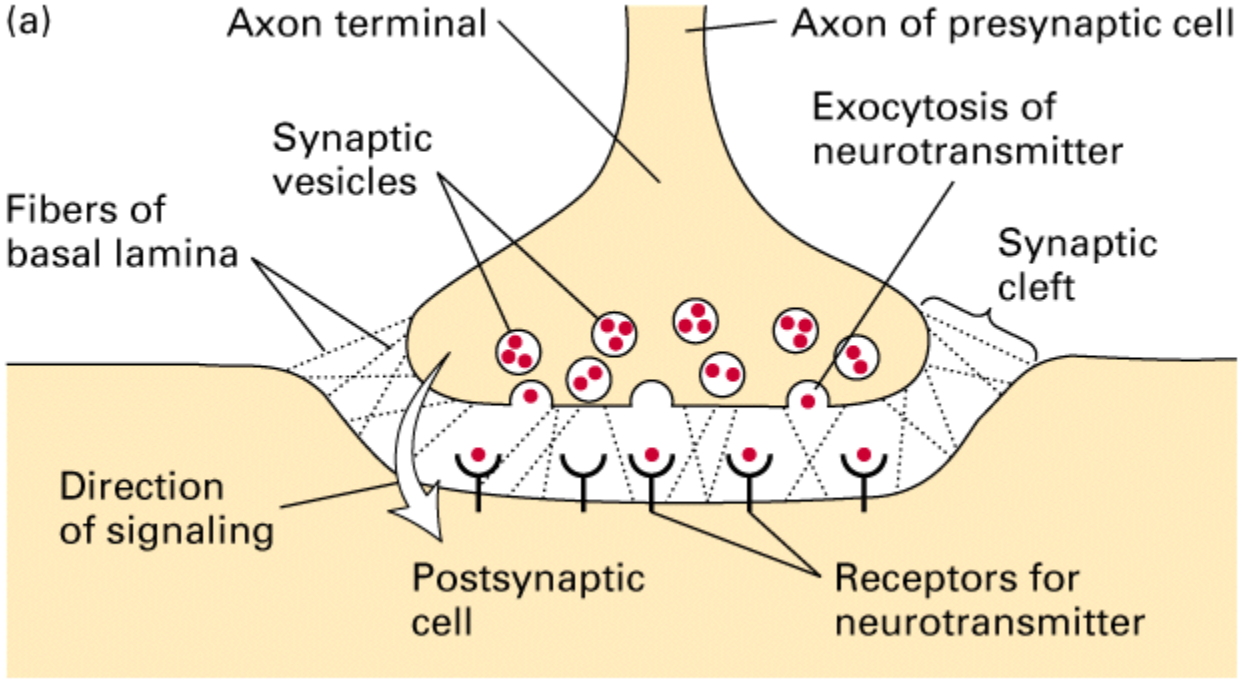
Gray Matter vs White Matter

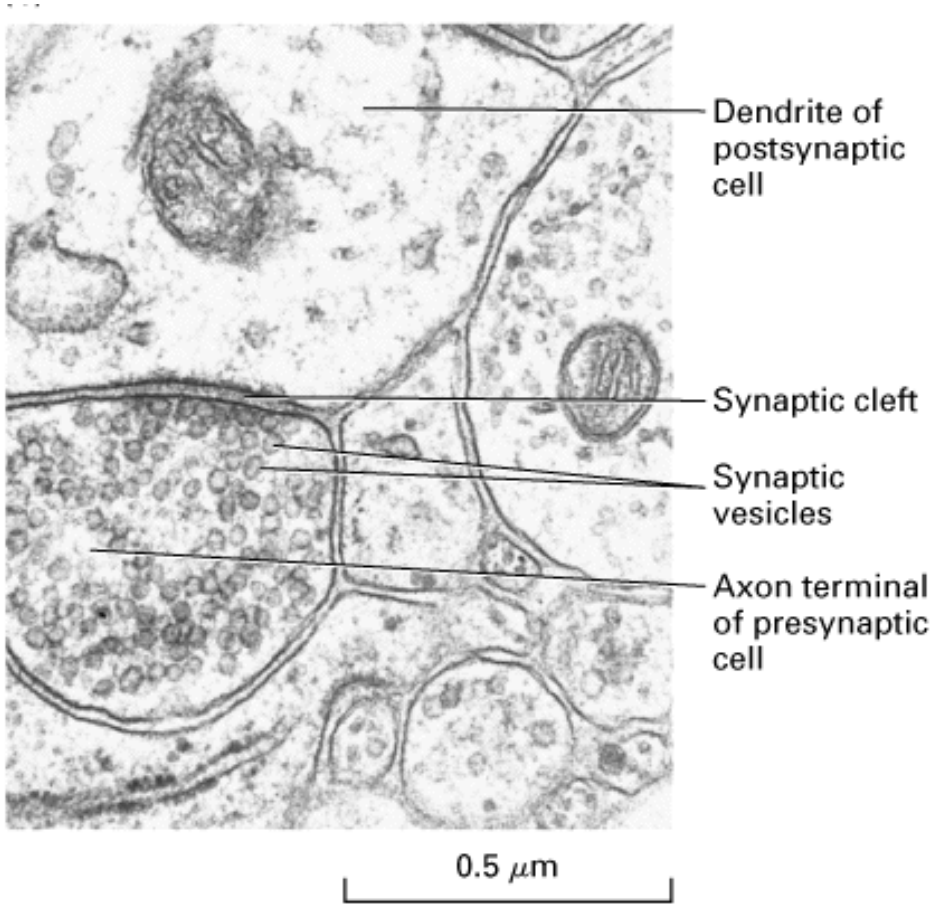


NeuroTransmission (Synapse)

- Communication between neurons
- At the end of axons are knob-like protrusions which hold synaptic vesicles that hold neurotransmitters
- When they receive a signal, **neurotransmitters** are released into the space between cells (synapse)
- Neurotransmitters diffuse across the synapse
- Dendrites have receptors on the other side of the synapse which detect the neurotransmitters, causing them to send a conduction signal back to the cell body (and propagate the signal)

Synapse





http://www.zoology.ubc.ca/~gardner/synapses-presynaptic.htm

Video of Synaptic Transmission

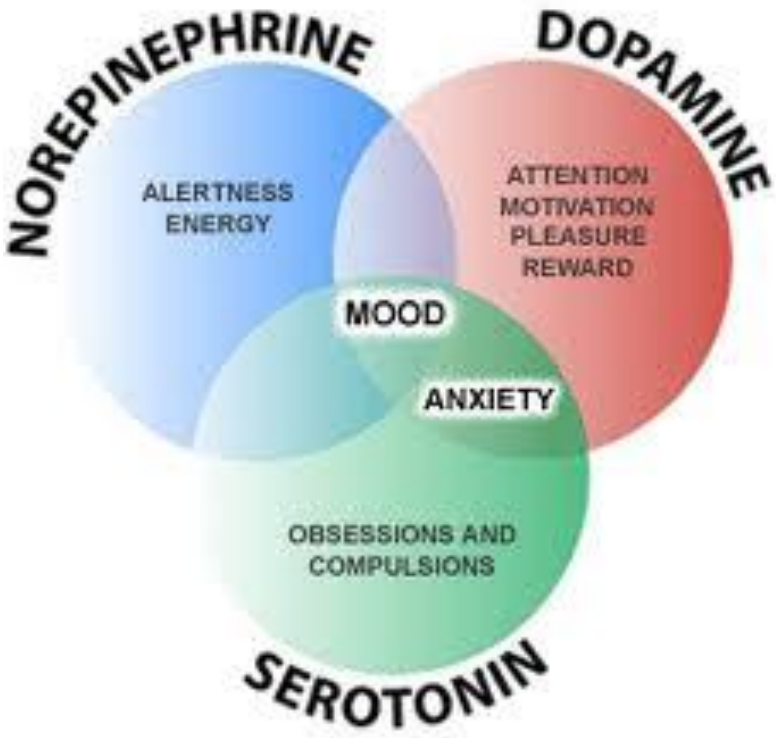
Synaptic Transmission Video

Neurotransmitters

- Endogenous chemicals which transmit signals from a neuron to a target cell across a synapse
- Packaged into synaptic vesicles clustered beneath the membrane on the presynaptic side of a synapse
- Released into the synaptic cleft, where they bind to receptors in the membrane on the postsynaptic side of the synapse
- Can excite (agonist) or inhibit (antagonist) a process
- After transmission, the neurotransmitter can be recycled, degraded, or diffuse away

Neurotransmitter Types

- Acetylcholine – excitatory, triggers muscle contraction, in CSN involved in wakefulness, attentiveness, anger, sex, among others
- Dopamine – Controlling movement and posture
- GABA – widely distributed in the brain, motor control, vision, anxiety
- Glutamate – excitatory, associated with learning and memory
- Norepinephrine – attentiveness, emotions, sleeping, learning
- Serotonin – body temperature regulation, sleep, mood, appetite



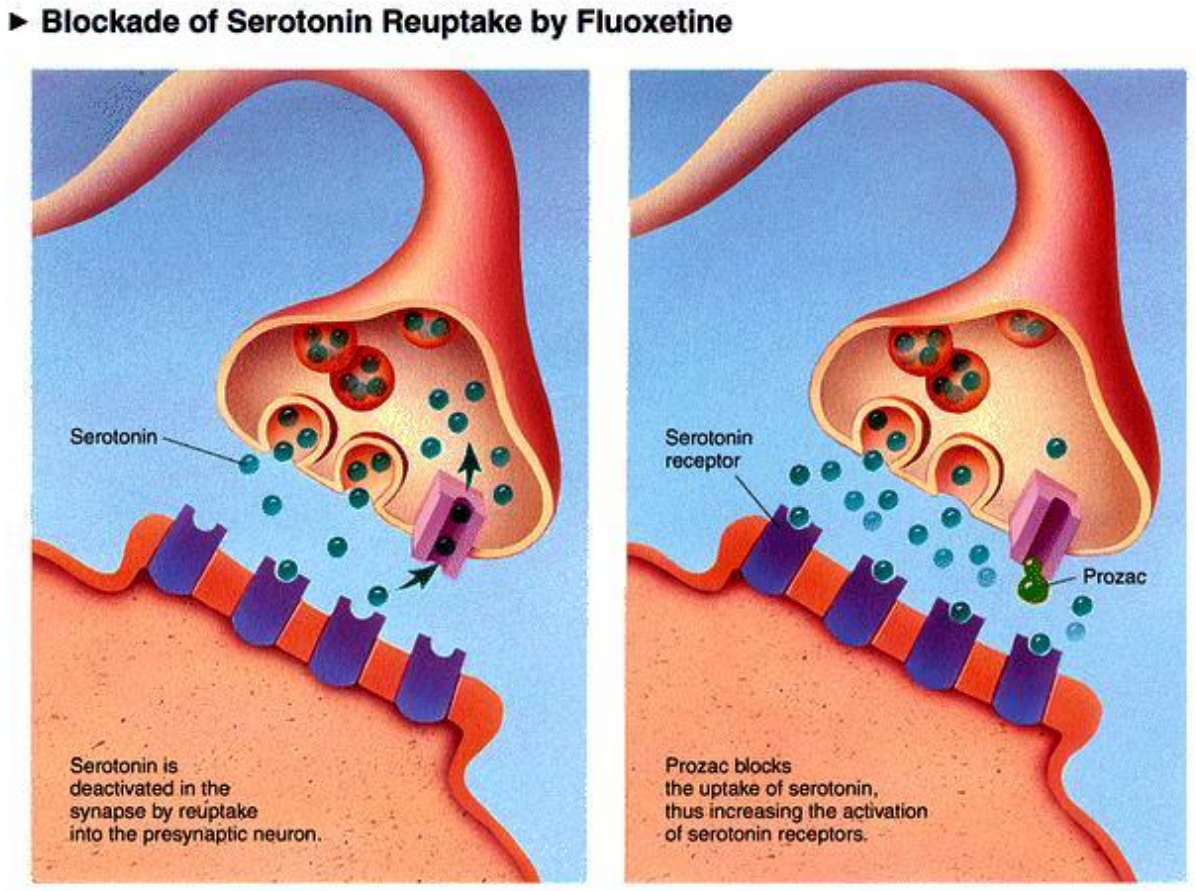
http://thebrain.mcgill.ca/flash/i/i_01/i_01_m/i_01_m_ana/i_01_m_ana.html

Disorders Involving Neurotransmitters

- Alzheimer's Disease (lack of Acetylcholine)
- Parkinson's Disease (loss of Dopamine)
- Mood Disorders (Norepinephrine)
- Depression, aggression, impulsive behavior (Serotonin)

Treatments involving Neurotransmitters

- Theory that low levels of Serotonin causes depression
- Treat with SSRIs (selective serotonin reuptake inhibitor, such as Prozac)
- By blocking the re-uptake of Serotonin, stays in the synaptic cleft longer and increases activation of the receptors



Summary

- Nervous system is a complex network of cells and connections
- Allows for communication throughout the body at a voluntary and involuntary level
- At the microscopic level, communication involves nerve conduction and nerve transmission
- Signals are electrically and chemically propagated