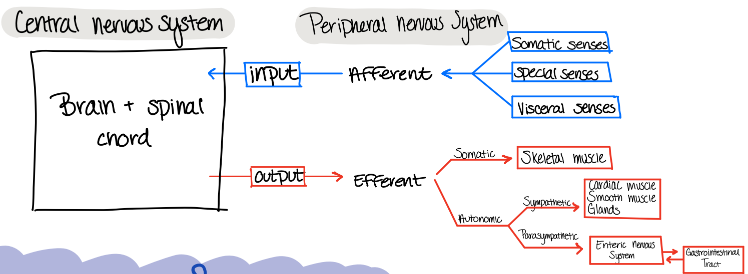
Nervous System

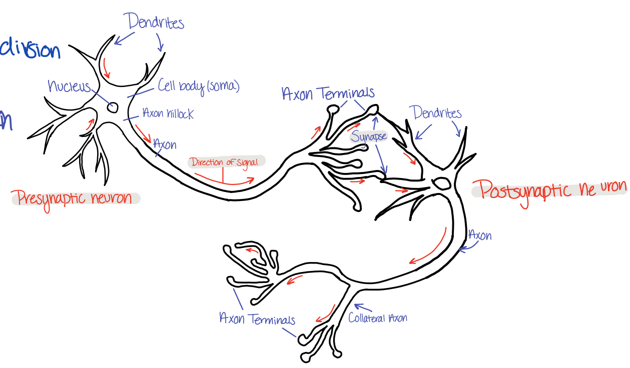
- Central nervous system: brain + spinal chord
- Peripheral nervous system: neurons for communication w/ cns througout the body
- Effector Organs: perform functions in response to neural commands that innervate the organ



Cells of the Nervous System

- Neurons

- cell body carries out most regular cell functions besides cell division
- Action Potentials: rapid transmission of information down axon
- Anterograde transport: moves products from the cell body to axon terminal (retrograde transport → opposite)



- Localization of Ion channels
  - leak channels: nongated, found in PM, always open → responsible for resting membrane potential
  - Ligand-gated channels: open/close in response to binding of a chemical (ligand) to receptors, located in dendrites + soma
  - Voltage-gated channels: open/close in response to changes in membrane potential, sodium + potassium channels are located throughout, but mostly in axon + axon hillock, necessary for acton potentials, calcium channels in axon terminals releases NT

- Structural Classification
  - classified by number of processes (axons + dendrites) that project from cell body
  - bipolar neurons: sensory neurons w/ two projections coming off the soma (olfactory + vision)
    - ↳ pseudo-unipolar: dendrite is a functional continuation of axon (peripheral axon)
  - multipolar neurons: most common, multiple projections from soma

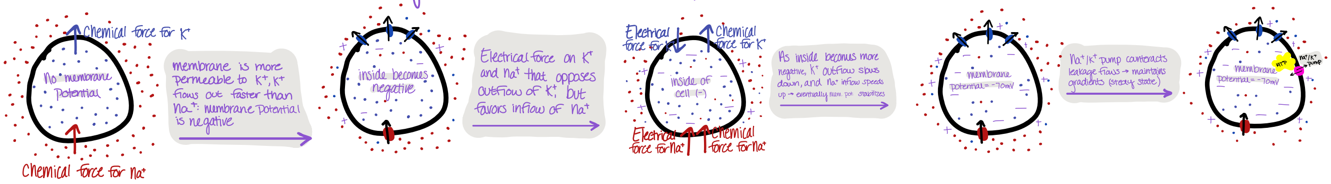
- Functional Classification
  - Efferent neurons: transmit info from cns to effector organs, axon leaves cns → becomes part of peripheral nervous system

- Afferent neurons: transmit info from sensory (outside environment) or visceral (conditions inside the body) receptors, most are pseudo-unipolar neurons (soma outside CNS in a ganglion → cluster of cell bodies outside CNS)
- Interneurons: 99% of neurons, all located in CNS, process info from afferent neurons + send commands to effectors; thought, memory, emotions

- **Glial Cells**: provide structural support for nervous system
  - Oligodendrocytes + Schwann cells form myelin around the axons of neurons → increases speed + efficency of action potentials
  - Other types: astrocytes, microglia

Resting Membrane Potential

- Resting membrane potential: inside −, outside + → approximately −70mV (inside is 70mV more negative than outside)
- Na^+/K^+ pump creates gradients by transporting 3 Na^+ out and 2 K^+ into the cell per ATP molecule hydrolyzed
- RP in neurons → # of open K^+ channels > # of Na^+ → membrane is 25x more permeable to K^+ than Na^+
  ↳ net outward movement of + charge → rise to a − membrane potential



- Na^+ electrochemical force inward > K^+ outward electrochemical force
- Ion currents: $I_{Na} = g_{Na}(V_m - E_{Na})$ $I_K = g_K(V_m - E_K)$ → I: current, E: equilibrium potentials, V_m: membrane potential

Electric Signaling → Changes in V_m

- **Graded potentials**: small changes in membrane potential due to ion channels open/closing in response to a stimuli
- Electronic conduction: spread of voltage by passive charge movement → decreases as it moves away from site of initial stimuli
- If a neurotransmitter causes sodium channels to open → depolarization (excitatory → bring membrane potential closer to threshold), if it causes potassium channels to open → hyperpolarization (inhibitory → further away from action potential)
  ↳ Graded potentials generate action potentials if they depolarize a neuron to the threshold

- Temporary summation: stimulus is repeatedly applied so first graded potential doesn't dissipate before next graded potential occurs → effects of the potentials sum, greater overlap in time → greater summation
- Spatial summation: effects of stimuli from different sources occuring at the same time (summation of a depolarizing GP and a hyperpolarizing GP cancel eachother out)

- Action Potentials

1) rapid depolarization: from -70mV to +30mV → caused by increased permeability to sodium → sodium floods the cell
2) repolarization: immediately after depolarization, potassium flows back in the cell, repolarizing the membrane potential to -70mV (rest)
3) After-hyperpolarization: membrane potential becomes more negative than resting value (-94mV)

- Voltage-gated ion channels
  - ↳ Activation gates: responsible for opening of sodium channels during depolarization
  - ↳ inactivation gates: responsible for closing of sodium channels during repolarization
- Closed but capable of opening: at rest, the inactivation gate is open, activation gate is closed → channel is closed but can be opened by depolarizing stimulus
- Open: occurs during depolarization
- Closed + incapable of opening: when inactivation gate closes, it won't open again in response to depolarization → only when repolarization occurs and activation gate closes, inactivation gate opens
- All-or-none principle: if stimulus doesn't meet the threshold, no action potential occurs
- Refractory Period: reduced excitability after an action potential
  - absolute refractory period: spans all depolarization + most of repolarization phase → a second action potential can't be generated until sodium channels return to resting state
  - relative refractory period: occurs immediately after absolute period → possible for second action potential to occur (but theres a higher threshold) due to increased permeability to potassium
- Propogation of Action Potentials
  - electrotonic conduction: mechanism that action potentials are propogated in unmyelinated axons → depolarization is restricted to one region of the axon (inside of the cell becomes +, outside -)

- diameter of axon $\propto$ speed that current spreads (b/c resistance decreases)

- Saltatory conduction: type of electrotonic conduction that propagates action potentials in axons sheathed in myelin
  - action potentials can't be produced where myelin is → action potentials 'jump' from node to node