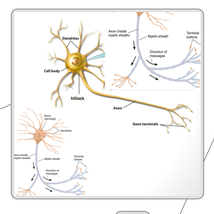
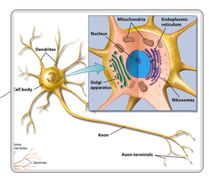
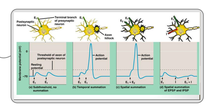
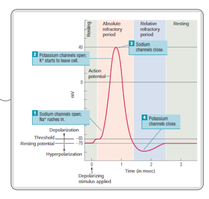
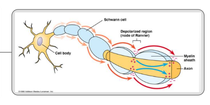
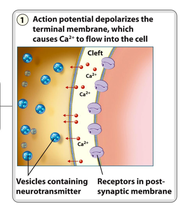
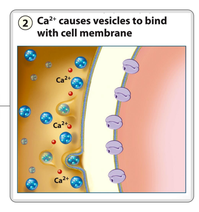
- nervous system
  - made of 2 classes of cells
    - neurons
      - made of
        - 2 cellular components unique to neurons
          - dendrites
            - branching extensions of the neuron
              - receive input from other neurons
            - many
            - input
            - dendritic spines
          - axon (inside myelin sheath)
            - one
            - output
            - axon hillock (junction with the soma)
            - axon terminal
          - 

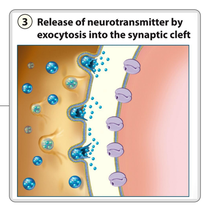
        - cell body (called soma for neurons)
          - contains the metabolic machinary that maintains the neuron
            - nucleus
            - endoplasmic reticulum
            - cytoskeleton
            - mitochondria
            - golgi apparatus
            - other common intercellular organelles
            - 

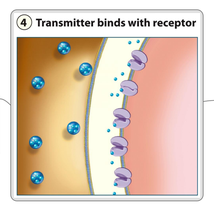
    - 2 types of transport
      - between neurons (received at synapses on dendrites, conducted within the neuron, transmitted down te axon, passed along at synapses on the axon terminals)
        - chemical (synaptic transmission)
          - transfer occurs at synapses
            - usually done by chemical signaling molecules (neurotransmitters)
            - sometimes by electrical signals
          - def: transfer of a signal from the axon terminal to the next cell
      - within a neuron (from one neuron to a non-neuronal cell)
        - electrical (membrane potential)
          - involves changes of in the electrical state of the neuron
            - resting potential
              - energy used to transmit information
                - process starts with excitatory postsynaptic potentials (EPSPs) at synapses on the neuron's dendrites cause ionic currents to flow in the volume of the cell body
                - if currents strong enough to reach the axon terminals -> the process on neuronal signaling can be completed
                - usually it is not the case, the distance is too big for the EPSP to have any effect
                - passive current conduction is called electronic conduction or decremental conduction (decremental because it diminishes with distance from its origin)
                - the maximum distance it can flow is 1mm
                - usually 1mm is too short to be effective for conducting electrical signals
            - action potentials
              - "all or none" phenomena: the amplitude of the action potential does not depend on the size of the triggering depolarization, as long as that depolarization reaches treshold for initiating the action potential
              - an action potential is a rapid depolarization and repolarization of a small region of the membrane caused by the opening and closing of ion channels
                - it can travel meters with no loss in signal strength because they continuously regenerate the signal
                - it is able to regenerate itself due to the presence of voltage-gated ion channels found at the spike-triggering zone in the axon hillock and along the axon
                - the passive currents generated after the EPSPs on multiple distant dendrites sum together at the axon hillock
                - this curent flows across the neuronal membrane in the spike-triggering zone, depolarizing the membrane
                - if the depolarization is strong enough (the membrane moves from its resting potential (-70mv) to a less negative value (-55mv) (treshold))
                - an action potential is triggered
                  - 1. voltage gated Na+ channels open and Na+ flows into the neuron
                    - influx of positive ions depolarizes the neuron
                  - 2. Even more Na+ channels open
                  - peak
                  - 3. the voltage gated K+ channels open and K+ flows out of the neuron down its concentration gradient
                    - outward flow of positive ions begins to go back to the resting potential
                      - outlasts the closing of Na+ channels
                        - second repolarizing phase
                  - 4. as result, the membrane is temporarily hyperpolarized (-80mv) (even further from the treshold required triggering an action potential
                    - causes to close the K+ channels
                    - Na+ channels are unable to open and other potential can't be generated
                      - absolute refractory period
                  - 5. the membrane goes back to its resting state
                    - relative refractory period: the neuron can generate new action potentials but with only larger than normal depolarizing currents (limit: 200 action potentials per sec) and the passive current can't reopen the ion-gated channels that generated it
                      - the action potential is propaged down the axon in one direction only - from the axon hiillock to the axon terminal
                        - self regenerating action potential could travel meters and meters
                  - 
                  - 

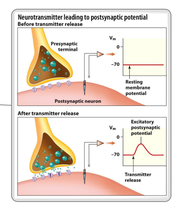
              - An action potential travels slowly but: the thick lipid sheath of myelin surrounding the membrane of myelinated axons makes the axon super-resistant to voltage loss
                - Myelin allows for the rapid transmission of action potential down an axon
                - action potentials in myelinated axons need occur only at the nodes of Ranvier, where myelination is interrupted
                  - Nodes of Ranvier are the spaces between sheats of myelin where voltage-gated Na+ and K+ channels are located and action potentials occur
                  - this creates the apparence that the action potential is jumping down the action at great speed from one node of Ranvier to the next called: Salvatory conduction
                  - 

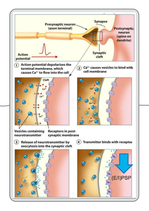
            - post-synaptic potentials
              - depolarization: excitatory postsynaptic potential EPSP
              - hyperpolarization: inhibitory postsynaptic potential IPSP
            - steps:
              - 1. Action potential depolarizes the terminal membrane, which causes Ca+2 to flow into the cell
                - 

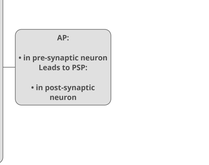
              - 2. Ca+2 causes vesicles to bind with cell membrane
                - 

              - 3. Release of neurostransmitter by exocytosis into the synaptic cleft
                - 

              - 4. Transmitter binds with receptor Receptor = Neurotransmitter-activated Ion-channel
                - 

                - 

                - E.g. Cl- = IPSP= E.g. Na+ = EPSP
              - 

                - AP:
                - • in pre-synaptic neuron Leads to PSP:
                - • in post-synaptic neuron
            - Resting potential
              - the voltage difference inside: -70 millivolts(mV)
                - means that the neuron has a kind of battery: stored energy can be used to do work
              - 2 forces act on all ions
                - concentration gradient (concentration force)
                - particles move down concentration gradient
                - force from high concentration to low (concentration force on Na+ is inward)
                - 

                - electrostatic pressure
                - particles move to opposite charge (+ -> -) (electrostatic pressure on Na+ is inward)
                -

                - the 2 forces are in opposite direction (with respect to k+) (not always)
                - eventually the force of the concentration gradient pushing K+ out through the K+ channels is equal to the force of the electrical gradient driving K+ in
                -

                - The difference in charge produced across the membrane is -70mV
              - energy needed for those signals
                - form of an electrical potential across the neuronal membrane
                - defined as the difference of voltage across the neuronal membrane (the voltage inside the neuron vs the voltage outside the neuron)
                - these 2 voltages depend on the concentrations of
                  - Potassium K+
                  - Calcium Ca+2
                  - Sodium Na+
                  - Chloride Cl-
                  - negatively charged proteins A-
                - resting state: when a neuron is not actively signaling
                  - the inside of the neuron is more negatively charged than the outside
            - with a pore in the center, allow certain ions to flow down their concentration gradients
            - Ions channels
              - the permeability:
                - permit one specific type of ion to cross the membrane through a given ion channel
                - selective permeability
                  - the neuronal membrane permeability to K+ is larger than Na+ because there are more K+ selective channels than any other type of ion channel
                - neurons are excitable
                  - they can change the permability of their membranes
                    - because ion channels are capable of changing their permeability for a particular ion
                      - gated ion channels:
                        - open or close based on changes in the transmembrane voltage or a response to chemical or physical stimuli
                        -

                      - nongated ion channels
                        - always allow the associated ions to pass through
              - its passageway is created by the 3D structure of the protein
            - Ions pumps (Na+,K+)
              - use energy to transport ions across the membrane against their concentration gradients (from low concentration to higher concentration)
              -

    - receive, evaluate and transmit information throughout the NS
      - this process is called the neuronal signaling
        - PSP vs AP

EPSPs/IPSPs	Action Potentials
• Dendrites/Soma	• Axon
• Decremental	• Nondecremental
• Fast	• Conducted more slowly than PSPs • But much faster when saltatory
• Passive (energy is not used)	• Passive and active (energy is used)
        - they are presynaptic:
          - when their axon makes a connection onto other neurons
            - almost each neuron is presynaptic and postsynaptic
        - they are postsynaptic:
          - when other neurons make a connection onto their dendrites
    - vary in their form location and interconnectivity related to their functions
    - the bulk of the neuronal membrane is a bilayer of fatty lipid molecules that separates the cytoplasm from the extracellular milieu
      - the lipid membrane maintains the separation of intracellular and extracellular ions and electrical charge that ultimately permits neuronal communication
      - the membrane is peppered with transmembrane proteins that serve as conduits for ions to move across the neuronal membrane
        - 2 types of proteins:
          - Ions channels
            - the permeability:
              - permit one specific type of ion to cross the membrane through a given ion channel
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                - the neuronal membrane permeability to K+ is larger than Na+ because there are more K+ selective channels than any other type of ion channel
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            - its passageway is created by the 3D structure of the protein
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            - use energy to transport ions across the membrane against their concentration gradients (from low concentration to higher concentration)
            -

    - glial cells (nonneural cells)
      - various functions
        - as providing structural support and electrical insulation to neurons and modulating neuronal activity
      - CNS:
        - Astrocytes
          - blood brain barrier
          - nutrition
          - waste management
          - signaling?
        - Oligodendrocytes
          - myelinisation
        - microglia
          - Brain's immune system
          - eat up pathogens
      - PNS
        - Schwann cells
          - myelinisation

K+ wants to leave the cell but is pumped in

Na+ want to enter the cell but is pumped out

- suspsended in cytosplasm
  - sits in a bath of salty extracellular fluid
    - made up of combinations of ions
      - potassium
      - sodium
      - chloride
      - calcium
      - other moleculs such as proteins