The Synapses

Conduction of a Depolarization
- In dendrites: ‘passive propagation’: There is attenuation of signal transmission
  - Further away they are, they lose signal & strength
- In axons: ‘active propagation’: The signal is regenerated. No attenuation.
  - From no matter where they are, there is no loss in signal or strength like in passive propagation
  - All or none conduction law for action potential (meaning that if the stimulus exceeds the threshold potential, the nerve will give either a complete response or no response at all).

Saltatory Conduction In An Axon (2.21)
- Saltatory Conduction = jumping conduction from node → node; this increases the conduction velocity of action potentials
- Regeneration of action potential at Nodes of Ranvier (gap in the myelin sheath of a nerve).
- Up to 260 miles/hour
- From soma → synapse

Rate Law (2.20)
- The greater the stimulus, the greater the # of action potentials (per second)
- Stronger stimulus on = more action potentials
- Spontaneous vs. Elicited
  - Elicited = done by stimulus
Source: http://animatlab.com/portals/0/Images/AnimatLab/NB_RateLaw.gif

**Sample Quiz**
- Sodium ions are more numerous outside the cell, and depolarize the neurons when they enter: True or False?
  - TRUE
- There are 5 times more neurons than glial cells: True or False?
  - FALSE; it is the opposite
- In a multipolar neuron information arrives at the _______, is summed at the _______, and sent out at the _______.
  - Dendrites, soma, axon

**The Synapses**
- Neurons are ‘simple’ computing devices
  - If you go in & kill a single one, it would not make a difference
  - Brain functions (including cognitive functions) rely on the activity of networks of interacting neurons; not just one single neuron
- These interactions = synapses
- Synaptic Morphology
  - Pre/post synaptic sites
  - Types of synapses
  - Synaptic vesicles
  - Neurotransmitter

**Axonal Transport**
- ‘Stuff’ moves along the axon microtubules (axoplasmic transport)
A Synapse: The Parts (2.23)

- Synaptic vesicles are filled with neurotransmitter molecules
- Synaptic cleft: gap

3 Kinds of Synapse Locations (2.22)

- **Axo-Dendritic**
  - Axon onto dendrite
- **Axo-Somatic**
  - Axon directly on soma
- **Axo-Axonic**
  - Axon connects to another axon
The Synapses

- **Synaptic Physiology**
  - Place where two neurons ‘talk’ to each other

**Neurotransmitter Release (2.24)**

- Synapse need action potential
- As soon as action potential arrives, vesicles fuse to membrane, open up and integrate membrane & release neurotransmitter
- Action potential → vesicle fusion → neurotransmitters released in cleft (this happens in microseconds)
- The action potential of A triggers fusion at synapse
- Neurotransmitters are released into synaptic cleft (area between two neurons at a synapse).

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**Ionotrophic Receptors (2.25)**

- Molecule in membrane waiting for neurotransmitters
- Transmitter binds → activates receptors → opens ion channels
- Very fast & local
- **Ligand**
  - Molecule of neurotransmitter attached to binding site

**Metabotropic Receptors (2.26)**

- Mediate the influence of hormones & drugs, state-dependent info processing
- Talk to other molecules
- Slow and diffuse action
- Second messengers: molecules that link receptors to ion channels
- Transmitter binds → activates receptors → activates ‘second messengers’ → open ion channels & intracellular effects

**IPSPs and EPSPs (2.27)**

- **EPSP** = Excitatory Post Synaptic Potential
- **IPSP** = Inhibitory Post Synaptic Potential
- **Inhibitory**: more negative & hyperpolarization (change in a cell’s membrane potential that makes it more negative; opp. of depolarization).
Calcium more outside than inside

**Excitatory**: more positive & depolarization (change in the difference between the electric charge on the inside/outside of the cell membrane; cell becomes more positively charged).

One given neuron releases the same neurotransmitter at all of its synapses

All synapse = excitatory

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**Regulation of Release: Re-Uptake**

- Recycling of molecules/extra neurotransmitters
- Helps w/ fast, efficient neurotransmission (low signal-to-noise)
- Re-uptake: clean up for next action potential
  - Transporter does this on pre-synaptic side

**Regulation of Release: Autoreceptors, Enzymatic Deactivation**

- Autoreceptors
  - On pre-synaptic membrane (AKA presynaptic receptors)
  - Tells all vesicles to slow down
  - Regulate synthesis & release of neurotransmitter (No ion flow)
  - Mostly metabotropic
  - If molecules linger, enzymes destroy them

- Enzymatic Deactivation
  - Acetylcholine (Ach): excitatory neurotransmitter
    - VS.
  - Acetylcholine esterase (AchE): destroys molecules (little Pacmen)

**Regulation of Release: Axo-Axonic Synapses**

- Presynaptic inhibition/facilitation
- The AB synapse helps (or interferes with) the BC synapse (Look at 2.30 in text book)
- The AB synapse exerts a presynaptic facilitation or inhibition of the BC synapse

**Fun Facts**

- Some neurotransmitters are released diffusely (leak out): Neuromodulators
- They have slow & diffuse actions (peptides). Influence many postsynaptic targets
- Involved in attention, emotions, pain sensitivity
- Most hormones are produced by endocrine glands in the body (adrenal glands, stomach, liver)
- Some neurons produce hormones rather than neurotransmitters
- Some neurons have hormone receptors (target cells)
  - Brain talks to body this way
- Communication between nervous system & body
  - Ex: sex hormones, aggression, stress

**Synaptic Physiology**
- Action potential $\rightarrow$ vesicle fusion $\rightarrow$ neurotransmitter release $\rightarrow$ receptor opening $\rightarrow$ ion flow $\rightarrow$ postsynaptic potentials

**Spatial Summation (Space)**
- Post synaptic potentials from different synapses sum up at the soma
- ATC cancels out

**Temporal Summation (Time)**
- Post synaptic potentials from the same synapse (but different action potentials) sum up
- Too fast = they add onto each other which shows the double humps