Overview of Neurons

Psychology 470

Introduction to Chemical Additions

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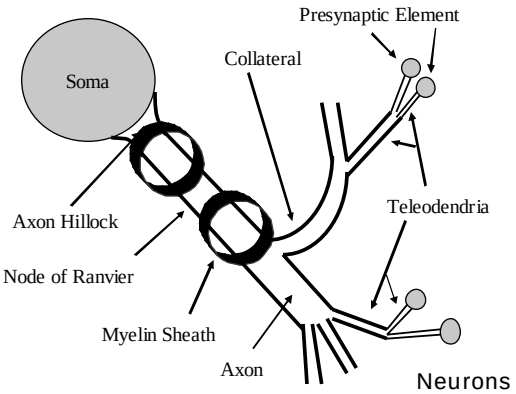


Neurons

Structures

Soma or cell body

- Is where cell metabolism takes place
- Has places where messages from other neurons can be received called a Post Synaptic Element)
- Contains many other structures related to metabolism
  - Mitochondria
  - Endoplasmic Reticulum
  - Golgi apparatus
  - Other structures
    - These structures are not important for this class.

Axons and Related Structures

- Axons are structures that send information to other neurons or muscle cells.
- Have many structures

Axon Hillock

- Is at the base of the axon
- Is the place where neurons decide to send a signal (called an action potential) to another neuron

Body of the Axon

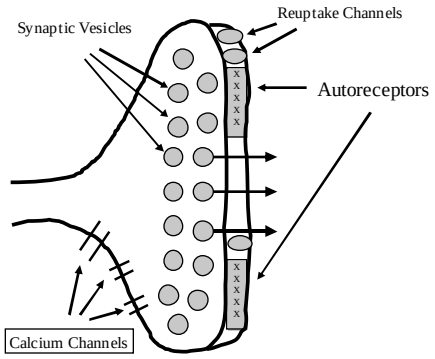
- This structure can branch (called a collateral)
- Branching continues into smaller and smaller branches called Teleodendria

Presynaptic Element

- Also called terminal buttons, terminal boutons, and other names)
- We will call it presynaptic element

Contains Several Structures

- Synaptic Vesicles (sacks)
  - Sacks contain chemicals called neurotransmitters
- Presynaptic Membrane
  - Autoreceptors
  - Reuptake channels
- Receptors from other neurons
- Calcium Channels



Presynaptic Element

Axons can be one of two types

- Myelinated
  - Myelin is a fatty covering over the axon
  - Helps to increase the speed of the action potential
  - The more myelin there is, the faster the speed of the action potential

Non-Myelinated axons

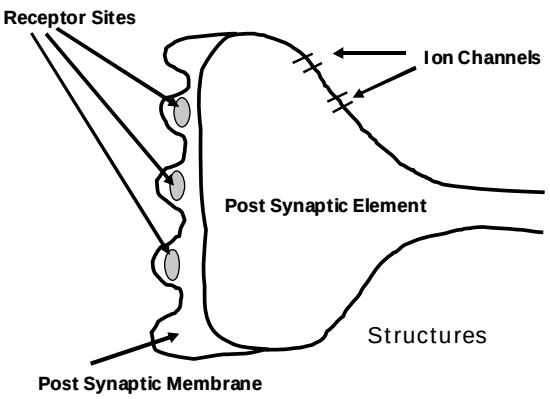
- Many axons do not have myelin
- Are slower than myelinated axons
- However, the fatter the axon is, the faster the action potential will go.

Dendrites

- Some neurons do not contain this structure.
  - only have soma's and axons
- Generally only receive information
- Contain a post synaptic element
  - Has a post synaptic membrane
  - Have receptor sites to receive neurotransmitters

Dendrites

- So, both Dendrites and Soma's can receive information. Both contain a post synaptic element.



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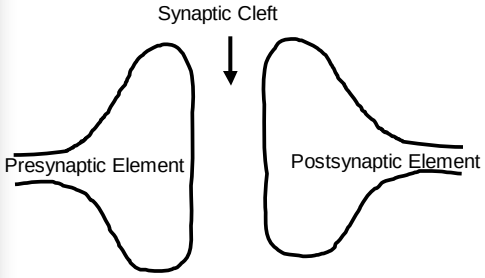


How Neurons Work

- Based on concentration gradients of four ions
- Sodium (Na), Potassium (K), Chloride (Cl), and Structures inside the axon called Anions (A)
- Sodium and Potassium are positively charged and are balanced out by chloride and anions

How Neurons Work Cont.

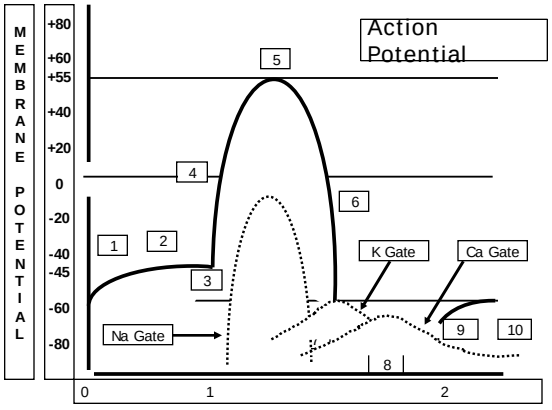
- Normally some sodium leaks into the axon.
- But cells don't like sodium, so they have pumps that remove sodium called sodium potassium pumps.
- The pumps remove sodium to the outside.

How Neurons Work Cont.

- The inside of axons have lots of potassium and anions and are negatively charged.
- The outside of axons have lots of sodium and chloride and are positively charged.
- So when an axon is at rest, the outside of the axon is positively charged and the inside is negatively charged.

Action Potential

- Occurs because voltage-gated channels open
  - (Different from Passive Channels)
- Results in rapid and large Na influx
- The inside of the neuron becomes more positive (depolarization) and then becomes more negative (hyperpolarizaton)



Process of an Action Potential

1. Stimulation Begins
2. K begins to leave by passive channels. Na enters by passive channels.
   - Get a change in concentration gradients
   - Amount that leaves depends on the strength of the stimulus, how often it occurs, etc.
   - Begins to become more positive (depolarization).
3. If depolarization is reaches 15mV, voltage-gated Na channels open.
   - Sodium enters the neuron (influx)
4. Sodium-Potassium Pumps (Na K ATPases) start
   - Removes Na and brings in K
   - K also leaves through passive channels.
   - K voltage gated channel begins to open about ½ millisecond after Na voltage gated channels open

Process of an Action Potential (cont.)

5. Na voltage-gated channel finally closes,
   - Action potential begins to fall
6. K gate finally closes
   - K is still leaving by passive channels
   - Na is leaving by Na K pump
   - Action potential continues to fall
   - Get a negative undershoot from resting state.
7. Ca voltage-gated channel begins to open
8. Still do not have enough K so Calcium continues to enter the neuron (influx)
9. Finally enough K has entered so the Calcium channel begins to close
10. Ca channel finally closes
11. Process Repeats

Review

- When a stimulus enters a receptor on a dendrite, it causes change in polarity.
- Causes a change in the chemical concentration gradients.
- Allows sodium to enter in small amounts and depolarizes (makes it more positive) the neuron.
- The depolarization travels to the axon hillock. If the charge depolarizes the hillock 15mv, get an action potential.
- If the charge is not strong enough, the signal stops.

Review cont.

- Causes sodium gates in the axon to open.
- Get Na Influx
- Result, the axon goes from negative on the inside to positive on the inside.
- This change goes down the axon like a wave.
- After the sodium enters, the sodium potassium pumps turn on and begin removing sodium.
- Also goes down like a wave

Review

- So we have two waves going down the axon,
  - The sodium entering the axon
  - The sodium being pumped out
- Ultimately the result is a negative undershoot

When the axon potential reaches the presynaptic element

1. It causes calcium (Ca) to enter the presynaptic element.
   - Calcium causes the synaptic vesicles to bind with the presynaptic membrane
   - The neurotransmitter is then released into the synaptic cleft.
   - The neurotransmitter crosses the cleft and binds on receptors in the post synaptic element on either the dendrite or soma.
2. Causes a small electrical charge and the process repeats itself.

How neurotransmitters (NT) are removed from receptors

- NT is removed two ways:
  1. It is degraded by enzymes made by glial cells or within the post synaptic membrane
  2. It is reabsorbed into the presynaptic element.

Impact of Drugs

- Impacts the neuron several ways
  - Entire neuron (Alcohol)
  - Presynaptic Element (Cocaine, Meth.)
  - Postsynaptic Element (Opiates)
  - Specific receptor sites (Barbiturates)
  - All of the above (Alcohol).

Entire Neuron

- Alters the lipid bilayer of the neuron
- Slows ion flow
- Ultimately reduces the height of the action potential
- Ultimately reduces Calcium influx
- Fewer NT is released
- Less stimulation on post synaptic element
- Less depolarization in the next neuron
  - Does not become as positive
- Result - Fewer action potentials in the next neuron

Presynaptic elements

- Drugs block the reabsorption of the NT
- Result, NT remains on post synaptic receptors longer
- Get more action potentials

Post Synaptic Elements

- Blocks the NT from binding on the receptor
- Less depolarization
- Fewer action potentials
- Depending on the brain area impacted (medulla) can cause death or temporary memory loss (hippocampus).

Conclusions

- Very important area
- Has had tremendous impacts in our understanding of drug effects (positive and negative)