Nervous System Communication

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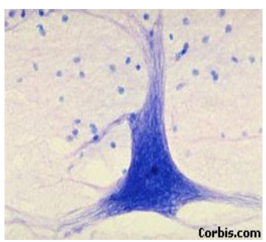
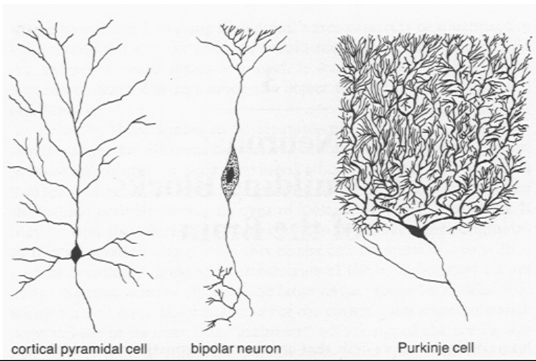
- Process information
- Transfer information to other neurons
- Generate behavior and experience



The First Nerve Cells

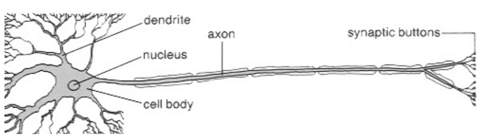
- Developed in primitive animals
  - Advantage over predecessors
- Neurons coordinate actions among groups of cells
- Neuron fixed in evolution

Types of Neurons



Neuron Features

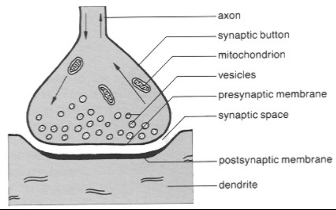
- Dendritic trees
  - Receives information
- Axon
  - Transmits signals from soma to other neurons
- Myelin sheath
  - Insulates, speeds signal transmission
- Terminal/synaptic buttons
  - Releases neurotransmitters
- Synapse



Synaptic Connections

- 10^{11} neurons = 10^{14} synaptic connections
  - 100,000,000,000,000 connections
- Synaptic connections make the brain a powerful tool
- Born with all the nerve cells we will ever have
- Synaptic connections can be formed throughout life

- Presynaptic terminal
  - Vesicles containing neurotransmitters
- Target neuron
  - Postsynaptic membrane
- Synaptic cleft/space
  - Most important part of neuron

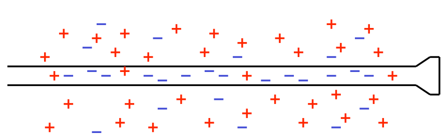


Nerve Cell Communication

- Action Potential
  - Transmits information within the cell
  - All or nothing
  - Same in all nerve cells
- Synaptic Transmission
  - Transmits information between cells
  - Graded
  - Release of chemical neurotransmitters

Action Potential

- Axon **Interior**
  - Many protein molecules, few sodium molecules
  - Negative charge
- Axon **Exterior**
  - Many sodium molecules, few protein molecules
  - Positive Charge
- Interior negative relative to exterior
  - Resting potential - 1/10V



Action Potential

- At rest neuron
  - Sodium channels closed
- Activated neuron
  - Nerve impulse causes sodium channels to open
- Action potential
  - Sodium ions rush into cell
  - Voltage shifts from - to +
  - Change in charge travels from axon top to bottom

Nerve Cell Activation

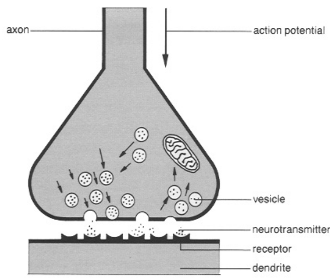
- Dendrites showered in chemicals
  - Causes changes in cell's electrical potential
- Sodium channels responsive to small changes in electrical potential
  - Open when potential becomes slightly more +
  - Typically only located on axon
- Nerve impulse develops at axon beginning and propagates downward

Refractory Period

- Cell can not fire until sodium is eliminated from interior of cell
- **Ion pump** pushes sodium ions out through cell membrane
- **Refractory period** is slower than nerve impulse
- Requires biological energy supplied by mitochondria

Synaptic Transmission

- Respond to action potential
  - Vesicles release chemical transmitter molecules
- Chemicals diffuse across synaptic space
- Chemicals attach to receptor molecules
- Synaptic action affects target neuron



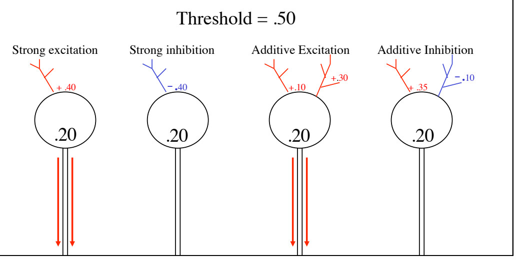
Excitation

- Increases neuronal activity
- Causes cell interior to become more positive than at rest
- Graded effect
  - No detectable action ⟶ Large action
- High cell excitation
  - Reach threshold
  - Action potential initiated

Inhibition

- Decreases neuronal activity
- Causes cell interior to become more negative than at rest
- Mechanism
  - Open chloride channels
  - Chloride enters cell
  - Chloride possesses a negative charge

- Each neuron bombarded by hundreds or thousands of synaptic actions
- Constantly fluctuating levels of excitation or inhibition



Neurotransmitters

- Specific neurons can only make one type of neurotransmitter
- Specific neurotransmitters work on specific synapses
  - Can only bind to specific receptor sites
  - "Lock & Key"
  - Binding triggers receptor molecule into action

Endorphins

- Opium
  - Extract of poppy plant
    - Relieves pain
    - Induces feelings of pleasure
  - Active ingredient - morphine
    - Simple molecule
    - Several atoms with a particular shape
    - Led to discovery of endorphins

Endorphins & Morphine

- Morphine is best understood of the drugs that act on the brain
- Morphine antagonists can be manufactured in lab
  - Naloxone
    - Binds to opioid receptors
    - Rapidly and completely reverses the effects of morphine

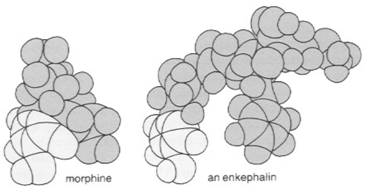
- Morphine related drugs and antagonists are chemically and structurally similar
- Suggests presence of opioid receptor system on brain neurons

Opiate Receptors in Brain

- Opiate receptors to which morphine binds discovered by Snyder & Pert in 1974
- Opiate receptors in brain suggests brain must produce its own opiates
- No natural biological substances in the body are chemically similar to morphine
  - Must be brain chemicals with an **architectural** similarity to morphine

Enkephalins

- Race to discover natural opiates
- Hughes & Kosterlitz (1975)
  - Pig brains
  - Same action as morphine - enkephalin
- Opiate receptors are actually enkephalin receptors



Natural Brain Opioids

- Several natural brain opioids discovered since enkephalin
  - Peptide compounds
  - Some more potent than morphine
  - Relieve pain and induce feelings of pleasure
  - Highly addictive

Purpose of Endorphins

- Counter pain and suffering induced by stress
- In emergencies, allow us to ignore minor injuries