The Nervous System - 2

Organization, Function & Communication

Agenda

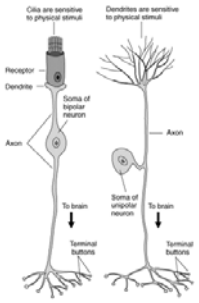
- Nervous Tissue
  - Classification of Neurons
  - Neuroglia
- Neuron Function
- Neural Communication
- Review

Nervous Tissue

- Structural Classification of Neurons
  - Classified based on processes off of soma
    - Many = multipolar
    - Two = bipolar
    - One = unipolar/pseudounipolar

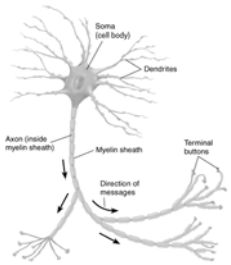
Nervous Tissue

- Functional Classification of Neurons
  - Sensory
    - 10 million neurons receive information from sensory receptors
    - Divided into
      - Somatic Sensory Receptors
        - » External receptors (exteroceptors)
        - » Proprioceptors
      - Visceral Sensory Receptors
        - » Internal receptors (interoceptors)



Nervous Tissue

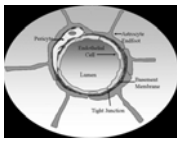
- Functional Classification of Neurons
  - Interneurons
    - 20 billion neurons involved in integrative brain function
    - May be commissural, associative or projection neurons
  - Motor
    - 500,000 motor neurons
    - Divided into somatic and visceral



Nervous Tissue

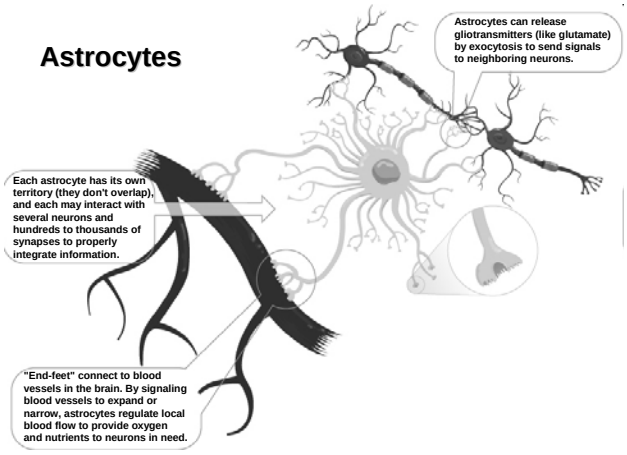
- Neuroglia
  - Cells that play an important supporting role in the nervous system
  - Grouped according to location
    - CNS
      - Astrocytes
      - Oligodendrocytes
      - Ependymal Cells
      - Microglia
    - PNS
      - Satellite Cells
      - Neurolemmocytes (Schwann Cells)

CNS Neuroglia



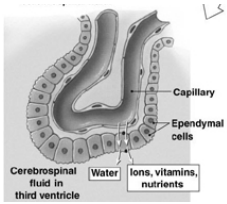
- Astrocytes
  - Local regulation of blood flow and support of the endothelial cells
    - aid in formation of blood brain barrier (BBB)
  - Regulate ion balance
  - Recycle neurotransmitters
  - Responsible for guiding and modulating synapse formation
  - Promote oligodendrocyte activity (myelination)
  - Phagocytosis of damaged neurons and formation of glial scars

Astrocytes



CNS Neuroglia

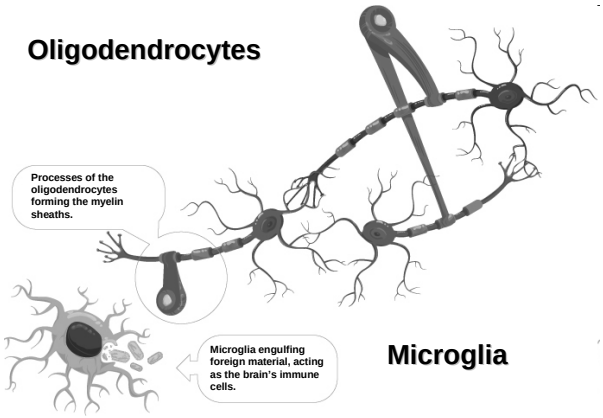
- Ependymal Cells
  - Line areas within the brain ventricles and are responsible for the production of cerebrospinal fluid (CSF)



CNS Neuroglia

- Oligodendrocytes
  - create the myelin sheath around axons in the CNS
  - processes, not the entire cell form the sheath
- Microglia
  - small phagocytic and migratory cells within the CNS
  - provide immune function

Oligodendrocytes

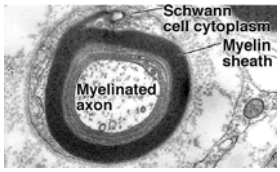


Microglia

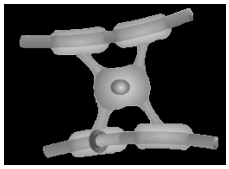
PNS Neuroglia

- Neurolemmocytes (aka Schwann cells)
  - Provide myelination within the PNS
  - Entire cell wraps the axon
  - Creates a "regeneration tube"
    - Allows regeneration of damaged axon
    - Responsible for return of sensation after peripheral nerve damage
- Satellite Cells
  - Provide support for neurons in the PNS
  - Located at ganglia

Neurolemmocyte



Neurolemmocyte vs. Oligodendrocyte



Neuron Function

Three things a neuron must do to function properly

1. receive input from sensory structure or another neuron
2. integrate information
3. create (or don't) an action potential

Neuron Function

Receive

- Synaptic input on the soma (dendrites & cell body)
- May be an
  - Excitatory post synaptic potential (EPSP)*
  - Inhibitory post synaptic potential (IPSP)*

**these are graded potentials and as such*

- ✓ *can be graded in the size of the electrical event*
- ✓ *will diminish over both space and time*
- ✓ *travel in all directions across the soma*

Neuron Function

Integrate Information

What information?

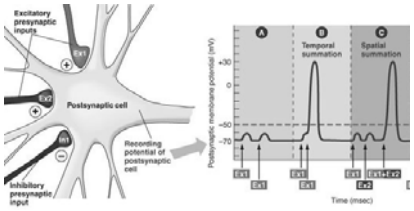
the EPSP's and IPSP's

How?

their summation either spatially or temporally to create a GPSP at the axon hillock which contains threshold voltage gated channels

Neuron Function

- Spatial and Temporal Summation



Neuron Function

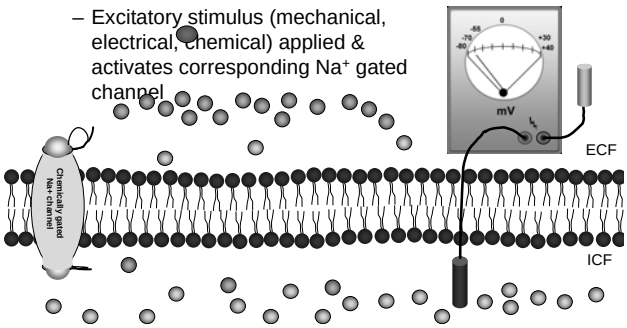
Action Potential creation

1. At axon hillock, if the GPSP is excitatory the voltage gated Na+ channels open, allowing rapid influx of Na+
2. Membrane is depolarized in the depolarizing phase (rising phase) of the action potential
   a. Charge goes from resting membrane potential of -70mV to max depolarized state (overshoot phase) of +30mV
3. Delayed voltage gated K+ channels open, allowing K+ to efflux from the cell during the repolarizing (falling phase) of the action potential
   a. Charge goes from +35mV to -80mv as the K+ rapidly leaves the cell, creating a brief hyperpolarizing event (undershoot phase)
   b. This is restored as the Na+/K+ ATPase (pump) works
4. Membrane potential is returned to resting value

Action Potential Animation

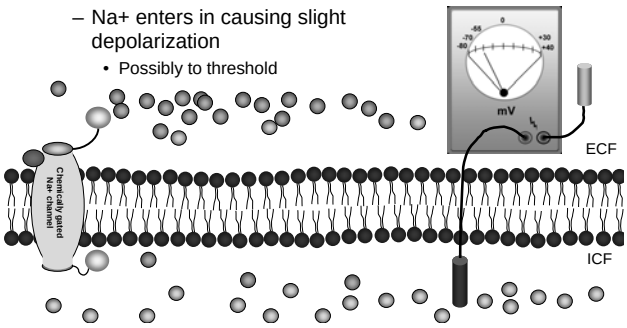
Potentials in Electrical Signaling

- Action Potentials – The process
  - Excitatory stimulus (mechanical, electrical, chemical) applied & activates corresponding Na^+ gated channel



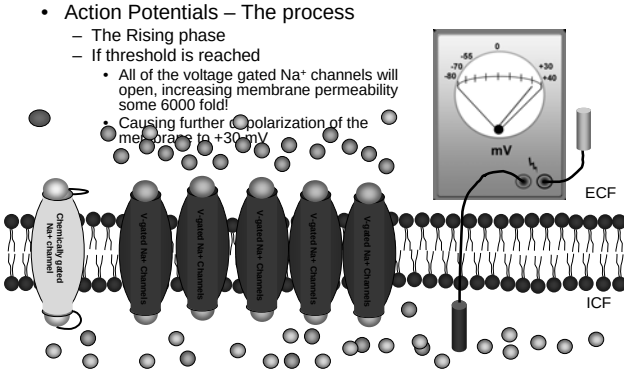
Potentials in Electrical Signaling

- Action Potentials – The process
  - Na+ enters in causing slight depolarization
    - Possibly to threshold



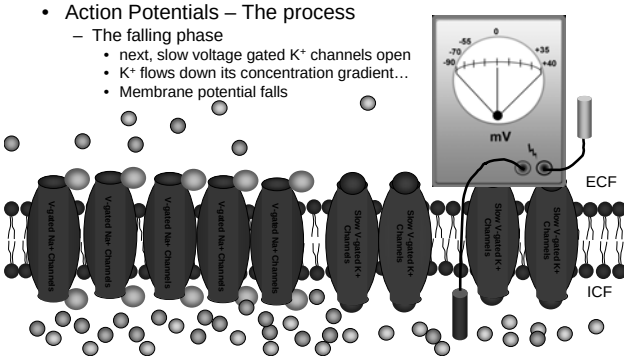
Potentials in Electrical Signaling

- Action Potentials – The process
  - The Rising phase
  - If threshold is reached
    - All of the voltage gated Na^+ channels will open, increasing membrane permeability some 6000 fold!
    - Causing further depolarization of the membranes to +30 mV



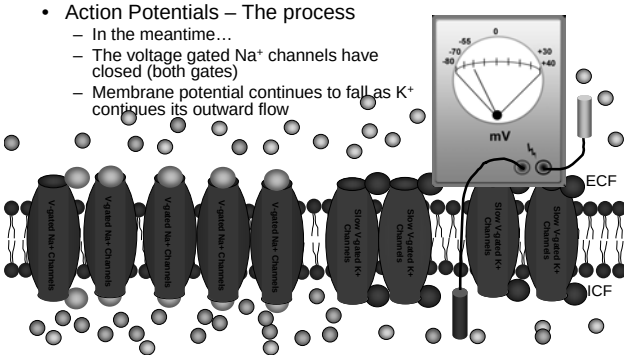
Potentials in Electrical Signaling

- Action Potentials – The process
  - The falling phase
    - next, slow voltage gated K^+ channels open
    - K^+ flows down its concentration gradient…
    - Membrane potential falls



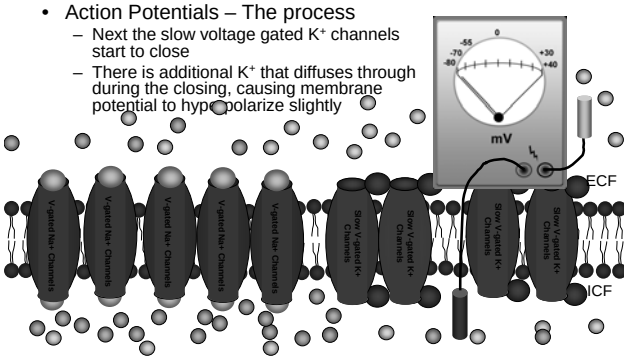
Potentials in Electrical Signaling

- Action Potentials – The process
  - In the meantime…
  - The voltage gated Na^+ channels have closed (both gates)
  - Membrane potential continues to fall as K^+ continues its outward flow



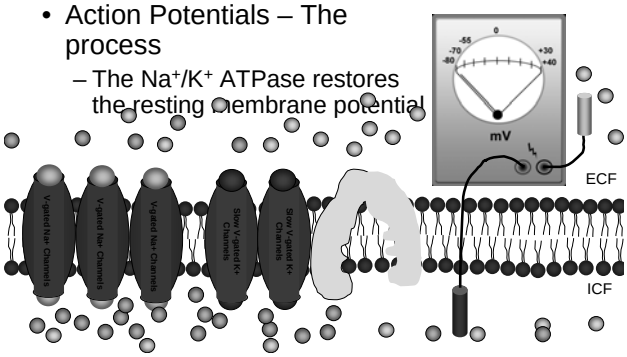
Potentials in Electrical Signaling

- Action Potentials – The process
  - Next the slow voltage gated K^+ channels start to close
  - There is additional K^+ that diffuses through during the closing, causing membrane potential to hyperpolarize slightly



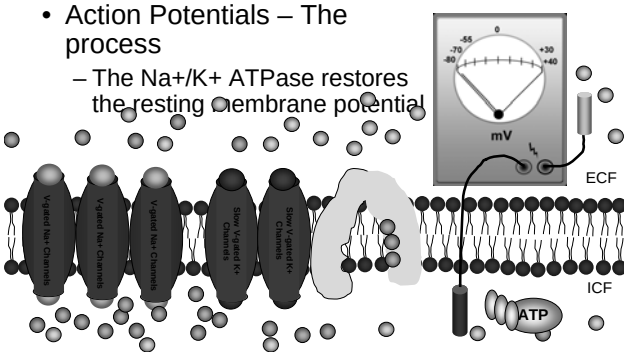
Potentials in Electrical Signaling

- Action Potentials – The process
  - The Na^+/K^+ ATPase restores the resting membrane potential



Potentials in Electrical Signaling

- Action Potentials – The process
  - The Na+/K+ ATPase restores the resting membrane potential



Potentials in Electrical Signaling

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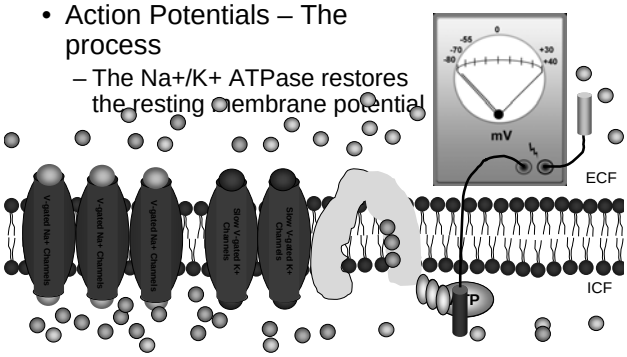

Potentials in Electrical Signaling

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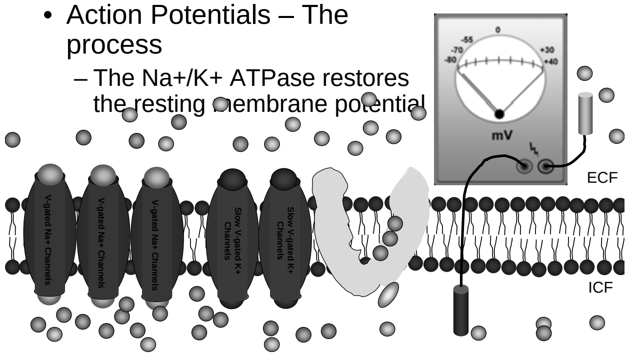

Potentials in Electrical Signaling

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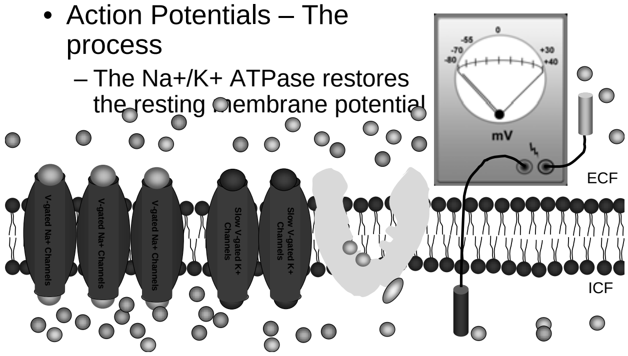

Potentials in Electrical Signaling

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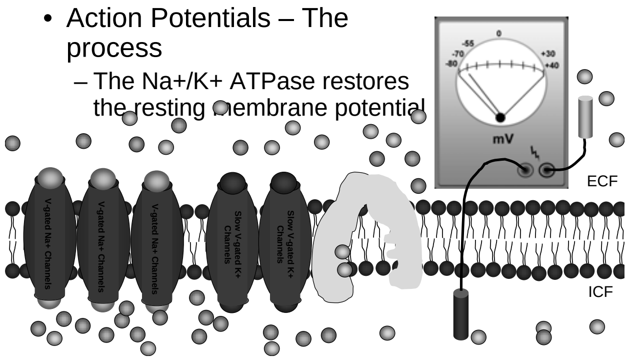
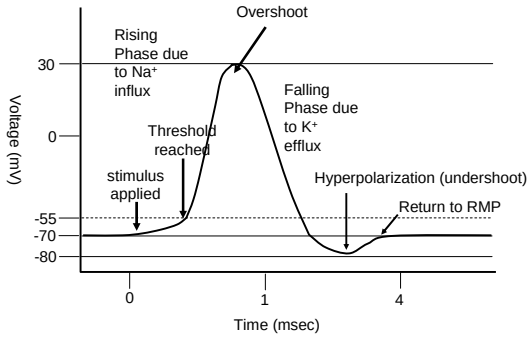
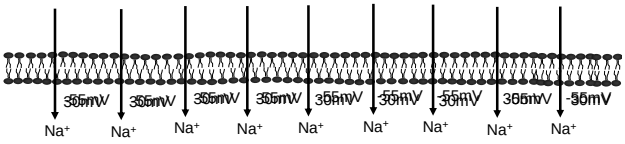


Neuron Function
Anatomy of an Action Potential



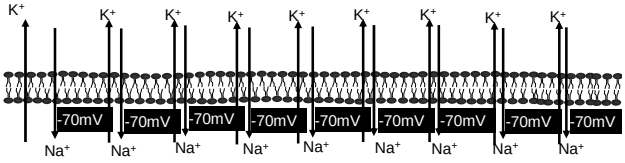
Neuron Function

- Action Potentials – The process
  - This process, will occur along the entire length of the excitable cell membrane
    - As long as it has…
  - The local influx of Na+ will cause the next adjacent voltage gated channels to open, cascading to the end of the membrane



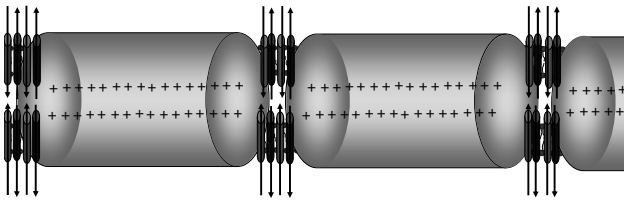
Neuron Function

- Action Potentials – The process
  - What happens when it gets to the end of the membrane?
  - The signal is transduced
    - And a chemical signal is generated
  - The prior sections of membrane are finishing up, getting back to resting membrane potential as K^+ effluxes



Neuron Function

- Saltatory Conduction



Neuron Function

- Characteristics of the action potential
  - all-or-none
  - non-decremental
  - unidirectional
  - magnitude is steady
    - No increase or decrease in a created action potentials depolarization

Neuron Communication

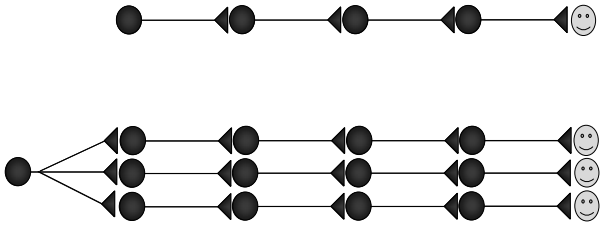
- So…. How does all of this action potential stuff allow for communication between excitable tissues?
  - It allows for the release of neurotransmitters from the terminal button (synaptic bulb)
    - No action potential, no release, no communication
- Excitable tissues have gated channels that respond to the neurotransmitter released by the terminal button
- Neurotransmitters may be excitatory and inhibitory
  - Depends on the receptor on the post-synaptic membrane
- Synapses may be
  - Excitatory
  - Inhibitory
  - Never both at the same time!

Neural Communication

- Neural pathways may be classified as
  - Sensory
  - Motor
  - Integrative
- Structurally they may be
  - Series
  - Parallel
  - Convergent
  - Divergent
  - Reverberating (oscillating)
  - Parallel after discharge

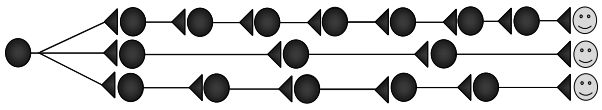
Neural Communication

- Serial & Parallel Circuits



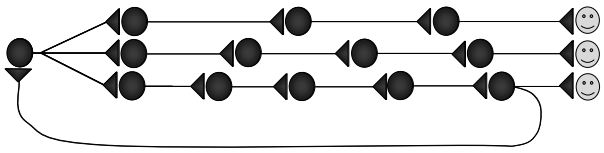
Neural Communication

- Parallel After Discharge Circuit



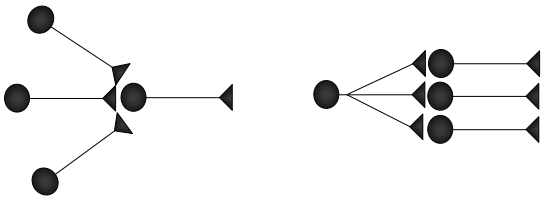
Neural Communication

- Reverberating (Oscillating) Circuits



Neural Communication

- Convergent & Divergent Circuits



The Big Picture

- It's this simple…
  (times 1 or 200 billion)