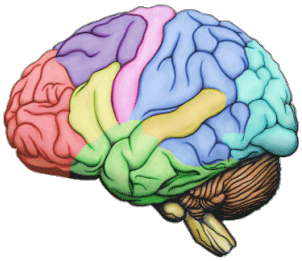
Overview of the Nervous System

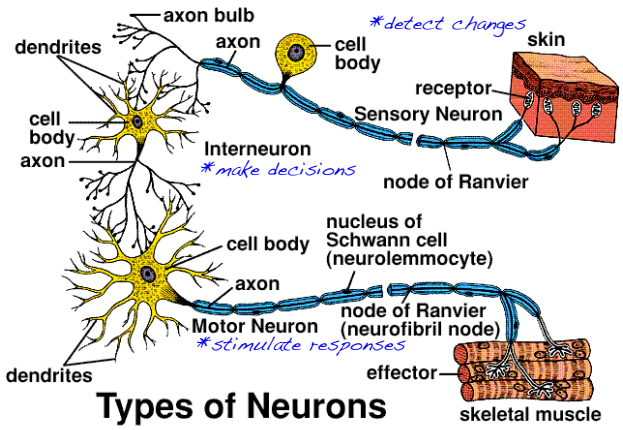


Click for NY Times video on Krista & Tatiana

Nervous System Functions

1. sensory input
   receptors monitor changes both inside and outside the body
2. integration
   interprets sensory data and decides what to do
3. motor output
   causes a response by stimulating effector organs (muscles and glands)

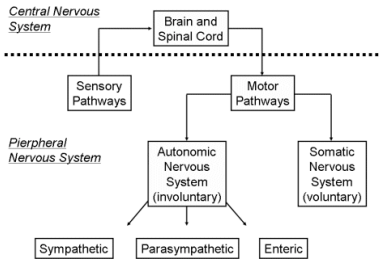
DETECT CHANGES, MAKE DECISIONS, & STIMULATE RESPONSES



Types of Neurons

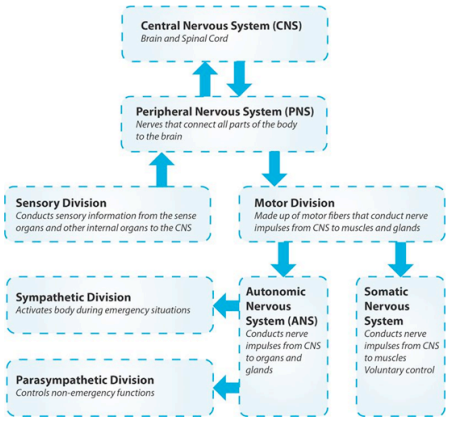
Divisions of Nervous System - CNS

- Central Nervous System (CNS)
  structures: brain and spinal cord
  function: integration based on reflexes, current conditions, or past experience



Divisions of Nervous System - PNS

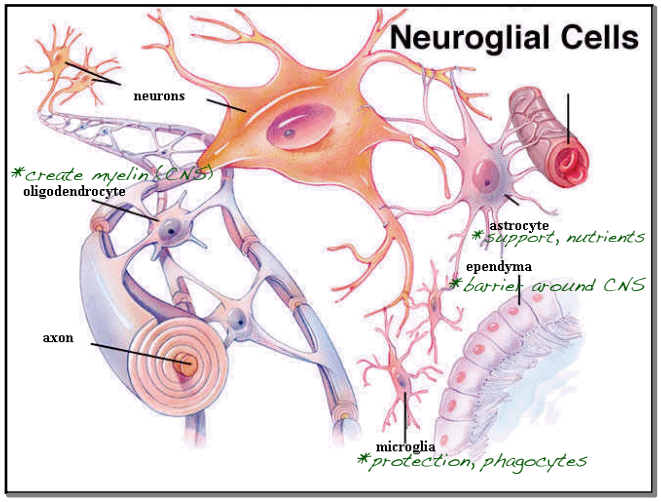
- Peripheral Nervous System (PNS)
  structures: nerves (spinal and cranial)
  afferent (sensory) division: carry info to the CNS
  efferent (motor) division: carry info away from CNS to effectors
  1. somatic nervous system - voluntary control of skeletal muscles
  2. autonomic nervous system (ANS) - involuntary control of smooth muscle, cardiac muscle, and glands
     a. sympathetic division
     b. parasympathetic division
     antagonistic pairs



Ch. 11 Neurons

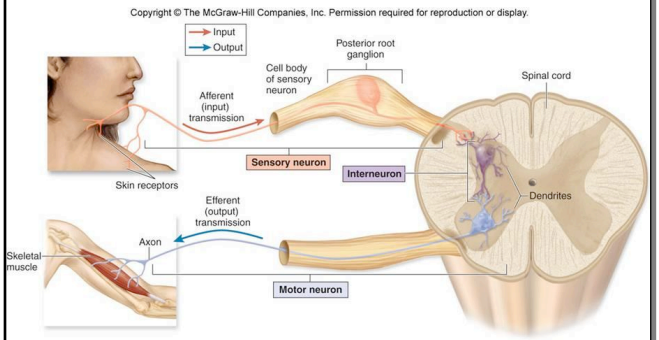
Neuroglia

- aka - glial cells
- provide physical support, insulation, and nutrients for neurons
- CNS (4)
  1. astrocytes ("star cells") - structural support, regulation of nutrients
  2. microglia - protection, phagocytize bacteria and cellular debris
  3. ependymal cells ("wrapping garment") - epithelial like cells that form a permeable barrier around CNS
  4. oligodendrocytes ("few branches") - create myelin sheath
- PNS (2)
  1. satellite cells - surround cell bodies; structural support, regulation of nutrients
  2. Schwann cells - create myelin sheath, important in regeneration of peripheral nerve fibers

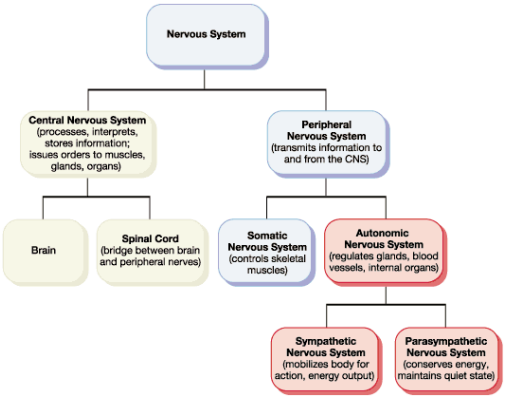


NOSE GOES

WINNER...USE THE PICTURE TO EXPLAIN THE 3 FUNCTIONS OF THE N.S.



NON-WINNER...HOW IS THE N.S. DIVIDED UP?



1 All of the following are functions of the nervous system EXCEPT

A motor output
B integration
C transport
D sensory input

2 **Afferent neurons carry information toward the brain, efferent carry information away from the brain, and both are part of the CNS.**

True

False

3 **MATA: What type of neuroglial cells create myelin?**

A **Schwann cells**

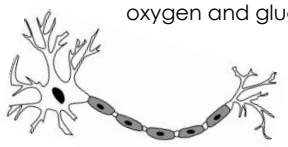
B **ependymal cells**

C **astrocytes**

D **oligodendrocytes**

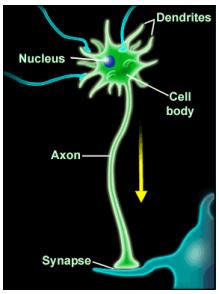
Neurons

- aka - nerve cells
- structural unit of the nervous system
- carry messages in the form of nerve impulses from one part of the body to another
- specialized characteristics
  - extreme longevity - over 100 years with good nutrition
  - amitotic - mature neuron do not divide
  - high metabolic rate - need abundant supplies of oxygen and glucose



Neuron Structure

- vary in size and shape
- 2 basic structural components
  1. cell body
  2. processes
     - dendrites - convey incoming messages toward the cell body
     - axon - convey outgoing messages away from cell body



4 **MATA: The structural unit of the nervous system**

A **is called a neuron**

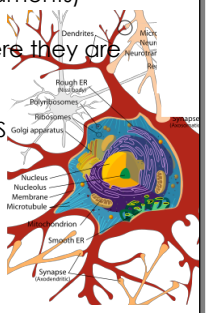
B **has dendrites, a cell body, and one or more axons**

C **divide readily**

D **can be called nerve cells**

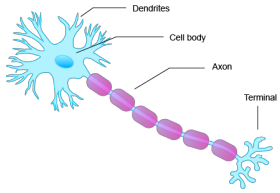
Cell Bodies

- nucleus and nucleolus centrally located
- free ribosomes, rough ER (called Nissl bodies or chromatophilic substance), and Golgi apparatus very active and best developed in body
- mitochondria, neurofibrils (protein filaments) scattered throughout
- most cell bodies located in CNS where they are protected by the skull and vertebra
  - nuclei - clusters of cell bodies in CNS
  - ganglia - clusters of cell bodies in PNS



Processes

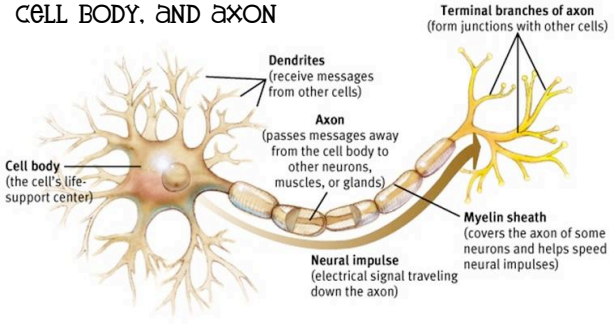
- dendrites - short and highly branched
- axon - nerve fiber
  - axon hillock ("little hill") - start of axon
  - terminal branches - branching ends of an axon
  - axon terminals, synaptic knobs, or boutons - knoblike ends of terminal branches
  - axolemma - plasma membrane; site of nerve impulse conduction
  - do not contain Nissl bodies or a Golgi apparatus



Feeling lucky?...choose ODD OR EVEN

WINNER...WHAT ARE THE 2 MAIN PARTS OF ALL NEURONS?

NON-WINNER...GIVE THE FUNCTION OF DENDRITES, CELL BODY, AND AXON



5 Dendrites bring info into a neuron and axons carry info away from the cell body.

True

False

6 Cell bodies work to integrate information and so are protected by the brain and spinal cord.

True

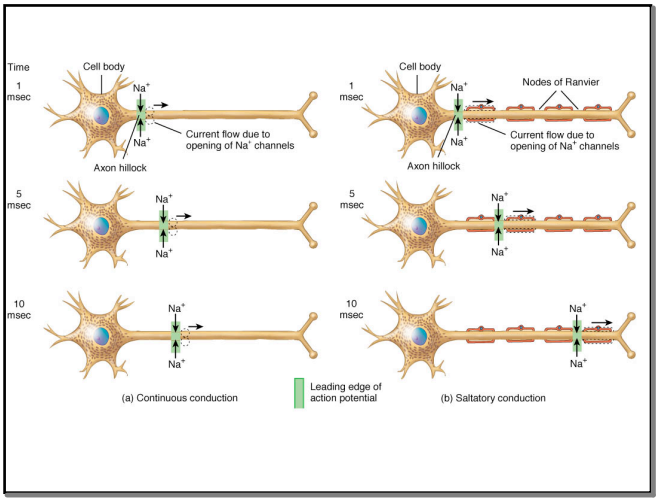
False

Myelin

Pull

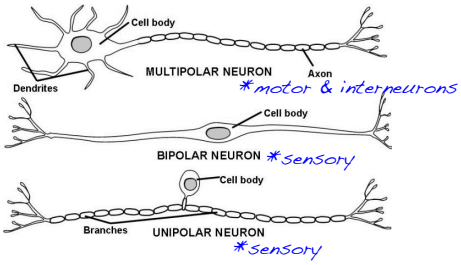
- whitish, fatty and segmented
- protects and electrically insulates fibers, and increases speed of nerve impulse transmission
- myelinated vs. unmyelinated
  - myelinated - fast transmission
  - unmyelinated - slow transmission
- Schwann cells - create myelin in PNS
- neurilemma - outer portion of Schwann cells
- nodes of Ranvier - narrow gaps between Schwann cells
- white matter - dense collections of myelinated fibers
- gray matter - nerve cell bodies and unmyelinated fibers

Ch. 11 Neurons



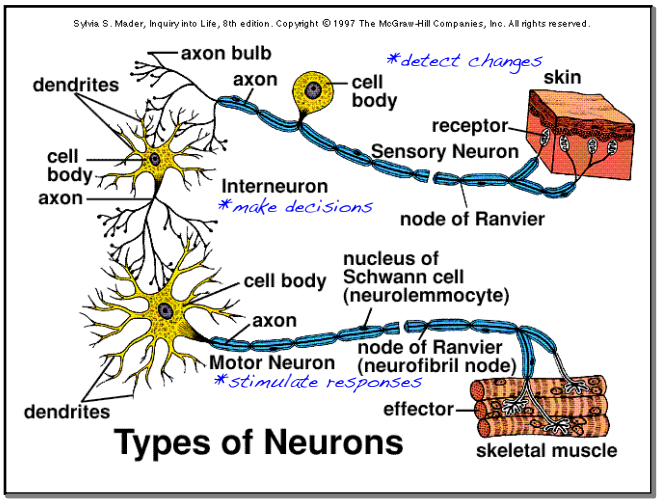
Structural Classification of Neurons

- multipolar - 3 or more processes (1 axon + many dendrites)
  most common type in humans (99%)
- bipolar - two processes (1 axon + 1 dendrite)
- unipolar - 1 process that divides into two branches

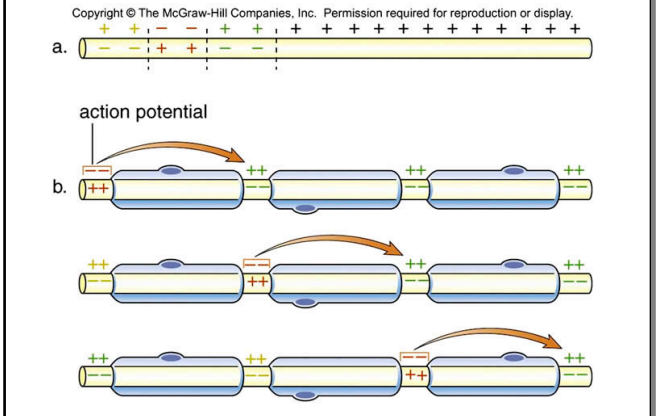


Functional Classifications of Neurons

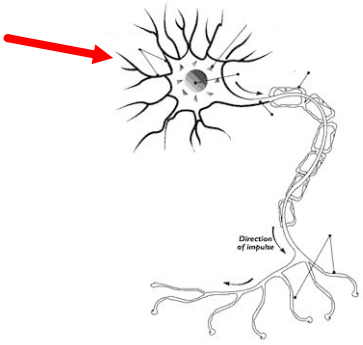
- sensory (afferent) neurons - carry nerve impulses from sensory receptors into brain or spinal cord
  most are unipolar, very few bipolar (retina)
- motor (efferent) neurons - carry nerve impulses out of brain or spinal cord to effectors
  multipolar
- interneurons (association neurons) - link sensory and motor neurons, shuttle signals through CNS pathways where integration occurs
  multipolar
  99% of neurons of the body
  confined within CNS



OLDER...WHAT'S THE PURPOSE OF MYELIN?

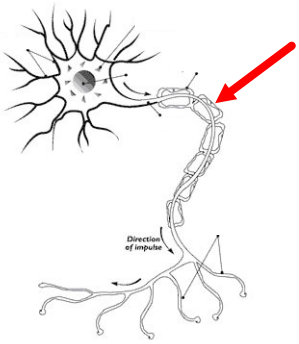


7 Name this part of a neuron.

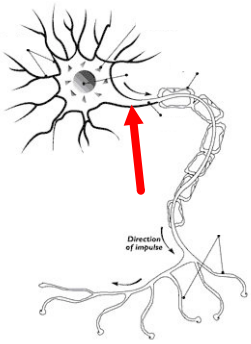


Ch. 11 Neurons

8 Name this part of a neuron.



9 Name this part of a neuron.



10 MATA: Neurons

A. can by unipolar, multipolar, or bipolar

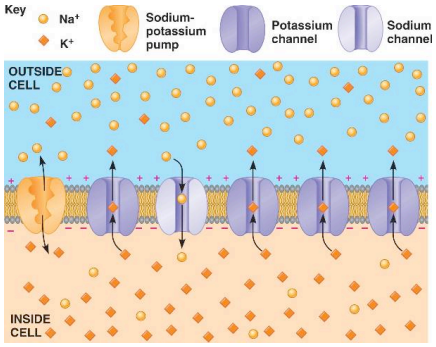
B. are the structural unit of the nervous system

C. carry info around the body

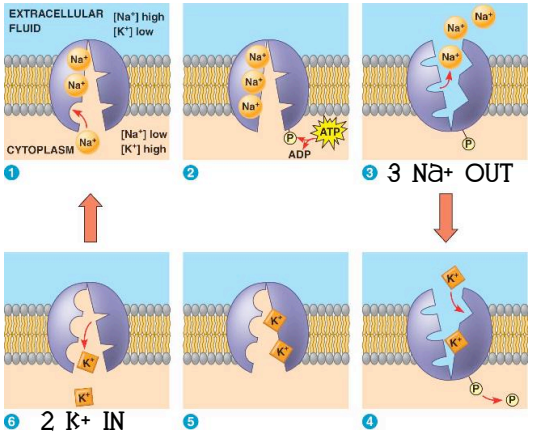
D. can be motor, sensory, or integration neurons

E. can be myelinated or unmyelinated

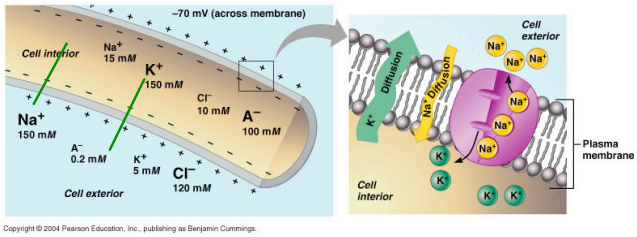
Membrane Potentials



Na+/K+ PUMP - CELL AT REST



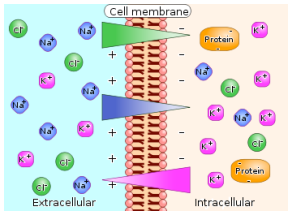
MAINTAINING RESTING POTENTIAL



*POTENTIAL MEANS A CHARGE DIFFERENCE ACROSS THE MEMBRANE
  *CELLS HAVE A NEGATIVE CHARGE INSIDE AND A POSITIVE CHARGE OUTSIDE
*RESTING REFERS TO A CELL NOT AT WORK
*WHAT KEEPS A CELL AT RESTING POTENTIAL?
  1. K+ LEAVES A CELL MORE EASILY THAN Na+ ENTERS.
  2. LARGE, NEGATIVELY CHARGED IONS TRAPPED INSIDE CELL
  3. Na+/K+ PUMP PUMPS OUT 3 + IONS FOR EVERY 2 THAT ENTER

Cell Membrane Potential

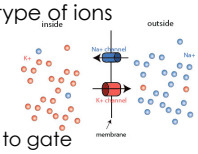
- polarized - unequal distribution of positive and negative ions across the cell membrane
- ions enter or leave the cell through pores or channels
- some ions pass more easily through the membrane
  - membrane slightly permeable to sodium (Na^+)
  - membrane 75x more permeable to potassium (K^+)
  - membrane impermeable to protein anions (neg.)

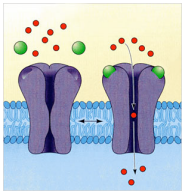


K^+ leaves the cell at a greater rate than Na^+ enters...slightly negative inside.

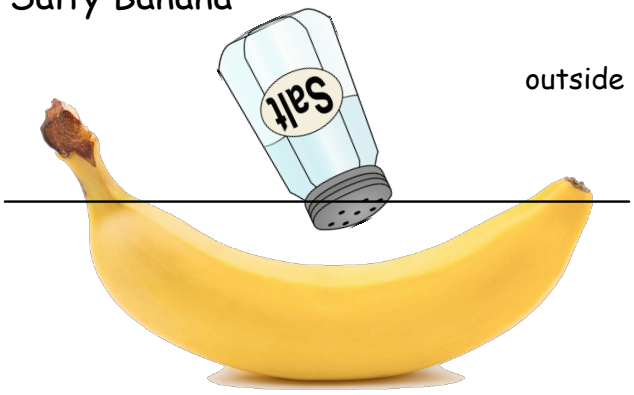
Role of Membrane Ion Channels

- ion channels are selective as to the type of ions they allow to pass
- leakage (non-gated) channels
  - always open
- chemically gated channels
  - open when the right chemical binds to gate
- voltage gated channels IMPORTANT TO NEURONS
  - open and close in response to changes in membrane potential (voltage)
- mechanically gated channels
  - open when physically deformed



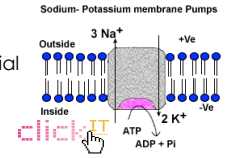


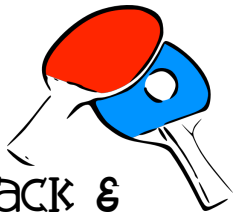
Salty Banana



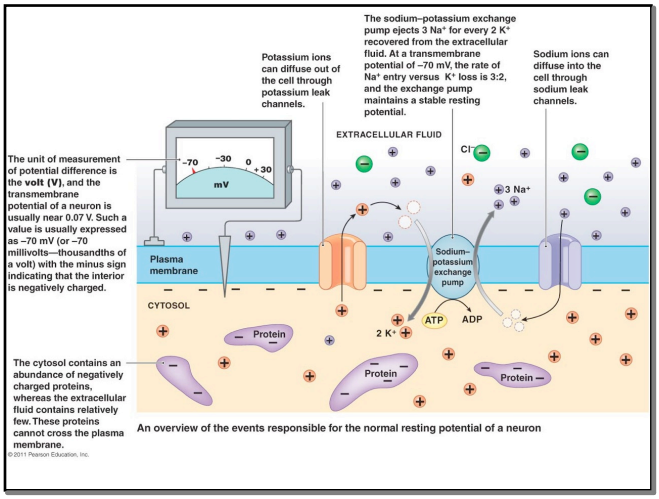
Resting Membrane Potential = -70mV

- lots of Na^+ outside cell; lots of K^+ inside the cell
- in a resting cell, more positive ions (K^+) leave than enter (Na^+) the cell (leakage channels)...this causes the outside to become slightly positive while the inside becomes slightly negative
- the potential difference between the inside and outside of the cell membrane is called the resting membrane potential (-70 mV)
- sodium-potassium pump - ejects 3 Na^+ out and transport 2 K^+ back into cell
  - ATP-driven
  - keeps resting membrane potential stable





PING PONG BACK & FORTH DESCRIBING WHAT YOU KNOW ABOUT A NEURON AT REST



An overview of the events responsible for the normal resting potential of a neuron

1 What term is used to describe the electrical state of a neuron at rest?

A specialized
B polarized
C differentiated
D voltage-gated

2 These channels allow ions to enter or leave the neuron at any time.

A leakage channels
B chemically-gated channels
C mechanically-gated channels
D voltage-gated channels

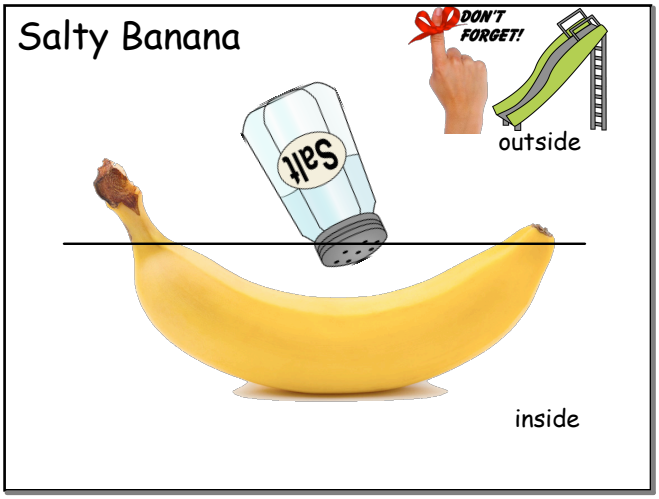
3 Resting membrane potential is -70mV. What does that mean?

A at rest, a neuron has 70mV of stored energy
B at rest, a neuron requires 70mV to "fire"
C inside slightly positive, oustide slightly negative
D inside slightly negative, outside slightly positive

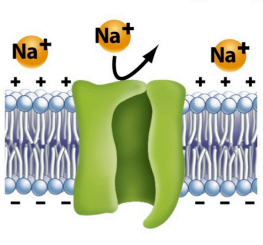
Changes in Membrane Potential

- causes
  1. anything that alters ion concentrations on the two sides of the membrane
  2. anything that changes membrane permeability to any ion
- produce 2 types of signals
  1. graded potentials - short distance signals
  2. action potentials - long distance signals
- terms associated with changes in mem. potential
  - depolarization - inside of membrane becomes less negative (moves closer to zero; -70 mV to -65 mV)
  - hyperpolarization - membrane becomes more negative than resting potential (-70 mV to -75 mV)

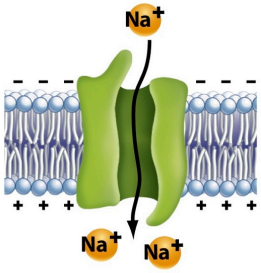
Salty Banana



How voltage-gated channels work



At the resting potential, voltage-gated Na^+ channels are closed.



When the membrane is depolarized, conformational changes open the voltage-gated channel.

Figure 45-8c Biological Science, 2/e
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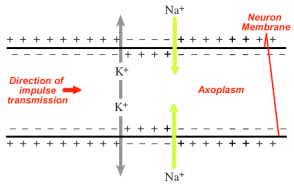
Action Potentials (AP)

- aka nerve impulse
- a brief reversal of membrane potential with a total amplitude change of 100 mV (-70mV to +30mV)
  - depolarization, repolarization, hyperpolarization
  - only takes a few milliseconds
- only occurs when a neuron is adequately stimulated
  - opens specific voltage-gated channels on axon
  - allows neuron to reach threshold potential
- at threshold, an AP can be generated



4 MATA: What can cause a change in membrane potential?

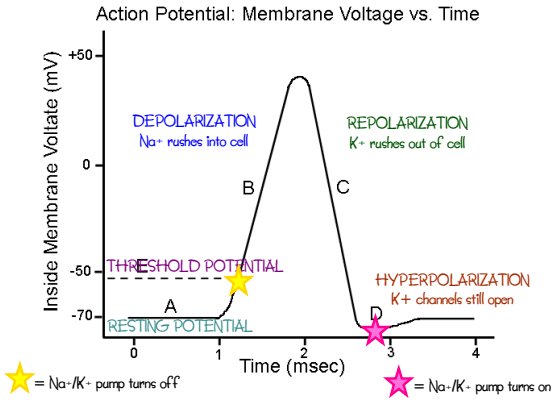
A **increased body temperature**

B **increased ion permeability**

C **increased voltage**

D **increased refraction**

E **increased ion concentration inside neuron**

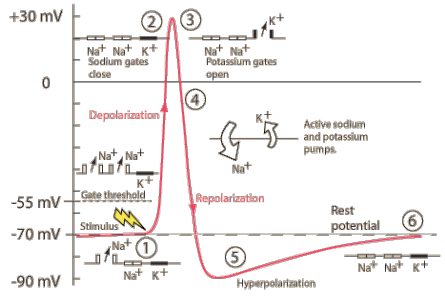


Events of a Nerve Impulse

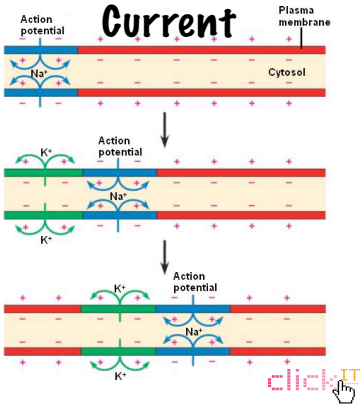
1. resting potential = -70mV
2. graded potentials allow neuron to reach threshold potential (-65 to -60mV)
3. Na^+/K^+ pump turned off at point of stimulus
4. Na^+ rushes into cell (depolarization = +30mV)
5. K^+ rushes out of cell (repolarization)
6. hyperpolarization
7. Na^+/K^+ pump turns on; returns neuron to resting potential
8. AP causes a bioelectric current that depolarizes the adjacent membrane
9. Wave of AP travels down the axon

SHORTER...DESCRIBE THE STEPS SHOWN IN THE AP GRAPH

TALLER...WHAT'S HAPPENING WITH Na+ AND K+ AT EACH STEP?



Bioelectric Current



5 When the sodium/potassium pump turns off, Na+ rushes into the cell.

True

False

6 What ion is responsible for hyperpolarization?

A K^+

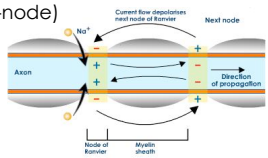
B Na^+

C Ca^{2+}

D Cl^-

AP Miscellaneous Info

- all-or-none phenomenon
  AP happen completely or not at all
- refractory period
  period of time when a neuron will not respond to another stimulus
- conduction velocity
  1. axon diameter - larger axons, faster conduction
  2. degree of myelination
     unmyelinated - continuous conduction (relatively slow)
     myelinated - saltatory conduction (30x faster; jumps from node-to-node)



7 Myelinated axons conduct impulses faster because AP only occur at the nodes of Ranvier.

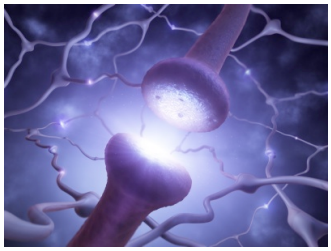
True

False

8 Put the steps of an AP in order. Enter as one continuous number.
Ex. 12345678

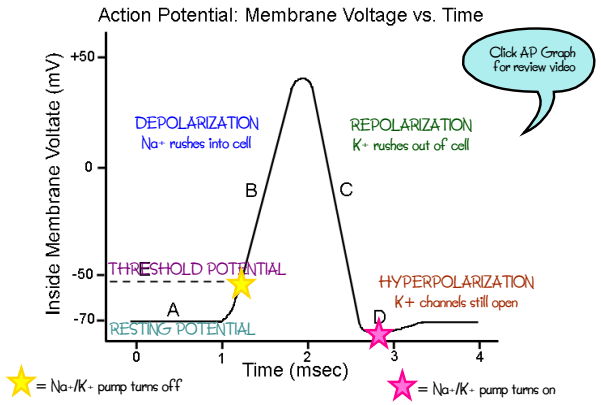
1 - hyperpolarization
2 - Na/K pump off
3 - repolarization (K)
4 - resting potential
5 - depolarization (Na) - results in a bioelectric current
6 - Na/K pump on
7 - threshold potential
8 - return to resting potential

The Synapse & Neurotransmitters



Ch. 11 Neurons

Action Potential

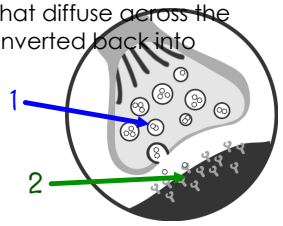


The Synapse

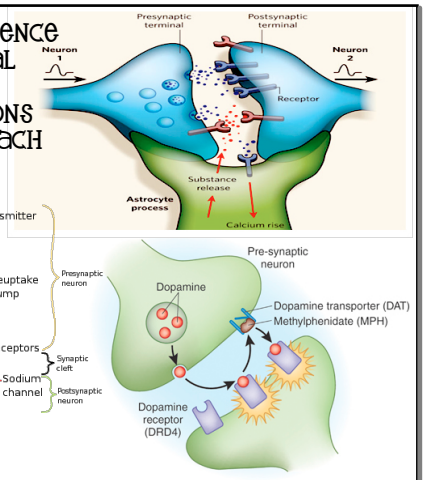
- a junction between 2 communicating neurons OR between a neuron and an effector cell (muscle or gland)
  - separated by a *synaptic cleft* (fluid-filled gap)
- information travels from the presynaptic neuron to the postsynaptic neuron
  - presynaptic - sender
  - postsynaptic receiver
- crossing the synapse is called *synaptic transmission*

Chemical Synapses

- specialized for the release and reception of neurotransmitters
- 2 parts
  1. axon terminals containing synaptic vesicles full of neurotransmitters (presynaptic)
  2. neurotransmitter receptors (postsynaptic)
- electrical signals (AP) converted to chemical signals (neurotransmitters) that diffuse across the synapse where they are converted back into electrical signals (AP)



Together...difference between chemical and electrical signals in neurons AND where do each occur



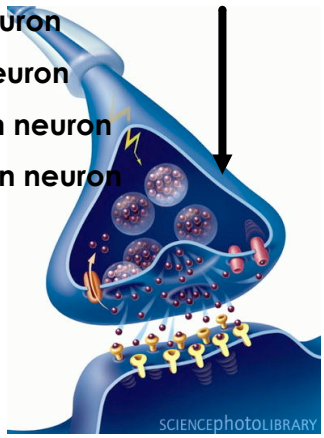
1 What structure is this?

A presynaptic neuron

B postsynaptic neuron

C pretransmission neuron

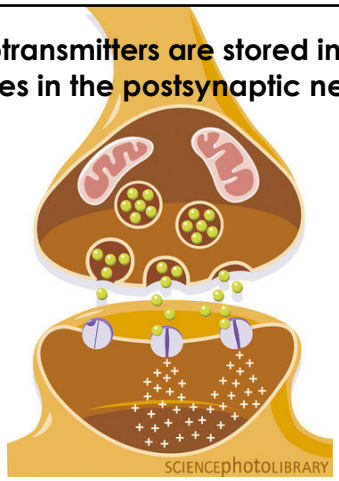
D posttransmission neuron



2 Neurotransmitters are stored in synaptic vesicles in the postsynaptic neuron.

True

False



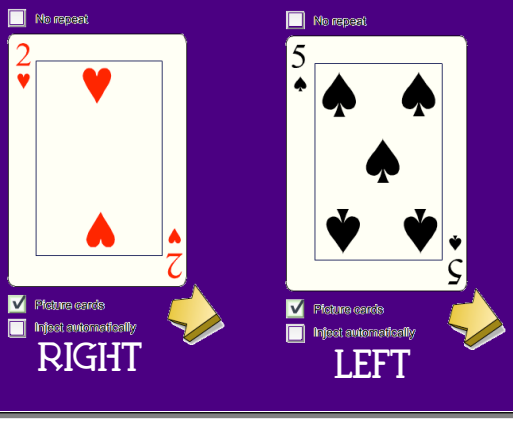
Release of Neurotransmitter

1. AP arrives at axon terminal
2. Voltage-gated Ca^{2+} channels open
3. Ca^{2+} rushes into axon terminal
4. Synaptic vesicles fuse with axon terminal membrane (exocytosis)
5. Neurotransmitters are released into synapse
6. Neurotransmitters diffuse across the synapse and bind to specific receptors on the postsynaptic membrane.
7. Binding of neurotransmitters opens ion channels, resulting in graded potentials
8. Neurotransmitter effects are terminated
   - re-uptake - stored or destroyed by enzymes
   - degradation - broken down
   - diffusion away from synapse

Calcium mediates the exocytosis of neurotransmitter

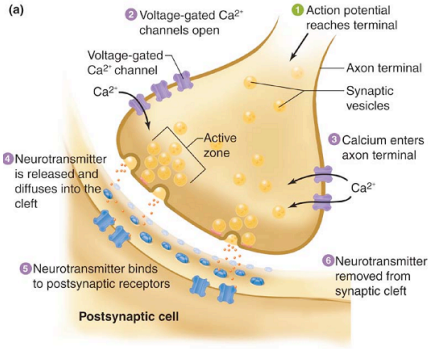
Click for synaptic transmission animation

HIGH CARD WINS...BEST 2 OUT OF 3



WINNER...AP TO RELEASE

NON-WINNER...WHAT HAPPENS TO THE NEUROTRANSMITTER ONCE ITS RELEASED?



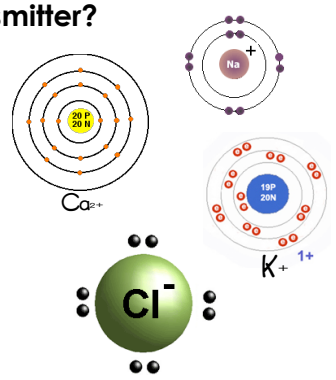
3 What ion is responsible for the release of neurotransmitter?

A K^+

B Na^+

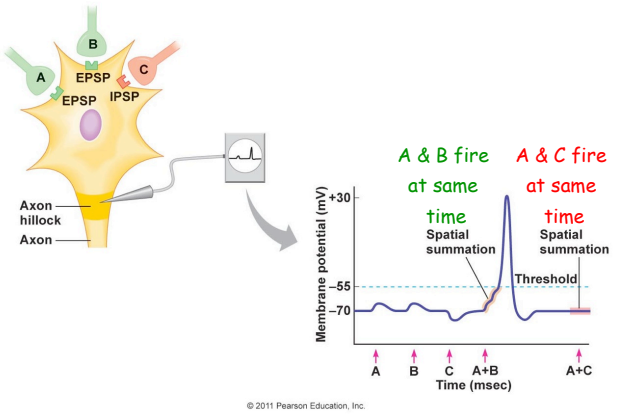
C Ca^{2+}

D Cl^-



Excitatory vs. Inhibitory Synapses

- postsynaptic membranes do NOT generate AP
- excitatory synapses
  - depolarization occurs at postsynaptic membrane
  - depolarization generates an excitatory postsynaptic potential (EPSP) which helps trigger an AP at the axon hillock
- inhibitory synapses
  - hyperpolarization occurs due to an efflux of K^+ or an influx of Cl^-
  - inhibitory postsynaptic potentials (IPSPs) reduce the postsynaptic neuron's ability to generate AP



Neurotransmitters

- "language" of the nervous system (about 50)
- chemical classifications
  - acetylcholine, biogenic amines, amino acids, peptides, purines, gases and lipids
- functional classifications
  - excitatory - cause depolarization
  - inhibitory - cause hyperpolarization
  - direct - bind to and open ion channels (rapid responses)
  - indirect - act like hormones (broader, longer-lasting effects)
- Table 11.3 (p. 416-418)

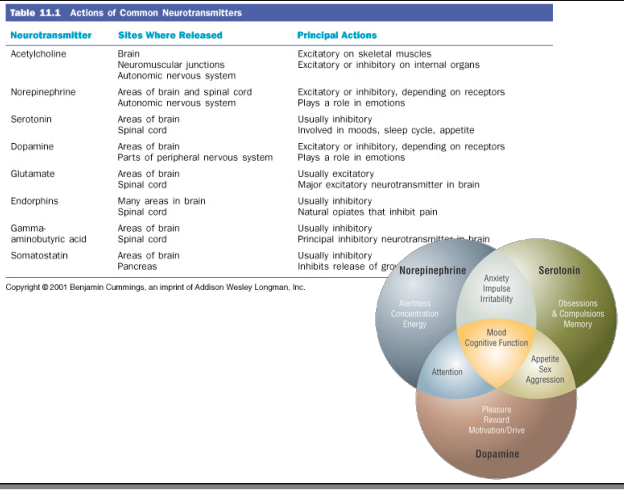


Table 11.1 Actions of Common Neurotransmitters

Neurotransmitter	Sites Where Released	Principal Actions
Acetylcholine	Brain Neuromuscular junctions Autonomic nervous system	Excitatory on skeletal muscles Excitatory or inhibitory on internal organs
Norepinephrine	Areas of brain and spinal cord Autonomic nervous system	Excitatory or inhibitory, depending on receptors Plays a role in emotions
Serotonin	Areas of brain Spinal cord	Usually inhibitory Involved in moods, sleep cycle, appetite
Dopamine	Areas of brain Parts of peripheral nervous system	Excitatory or inhibitory, depending on receptors Plays a role in emotions
Glutamate	Areas of brain Spinal cord	Usually excitatory Major excitatory neurotransmitter in brain
Endorphins	Many areas in brain Spinal cord	Usually inhibitory Natural opiates that inhibit pain
Gamma-aminobutyric acid	Areas of brain Spinal cord	Usually inhibitory Principal inhibitory neurotransmitter in brain
Somatostatin	Areas of brain Pancreas	Usually inhibitory Inhibits release of gro

4 MATA: EPSPs...

A **are neurotransmitters.**

B **depolarize postsynaptic neurons.**

C **hyperpolarize postsynaptic neurons.**

D **are likely to generate APs.**

E **are excitatory.**

5 The Nervous System uses _____ to communicate with other neurons and effector cells.

A **neurotransmitters ONLY**

B **electrical signals ONLY**

C **neurotransmitters AND electrical signals**

D **neurotransmitters OR electrical signals**

E **NEITHER**