Nervous System

Function

1. **Gather Information**

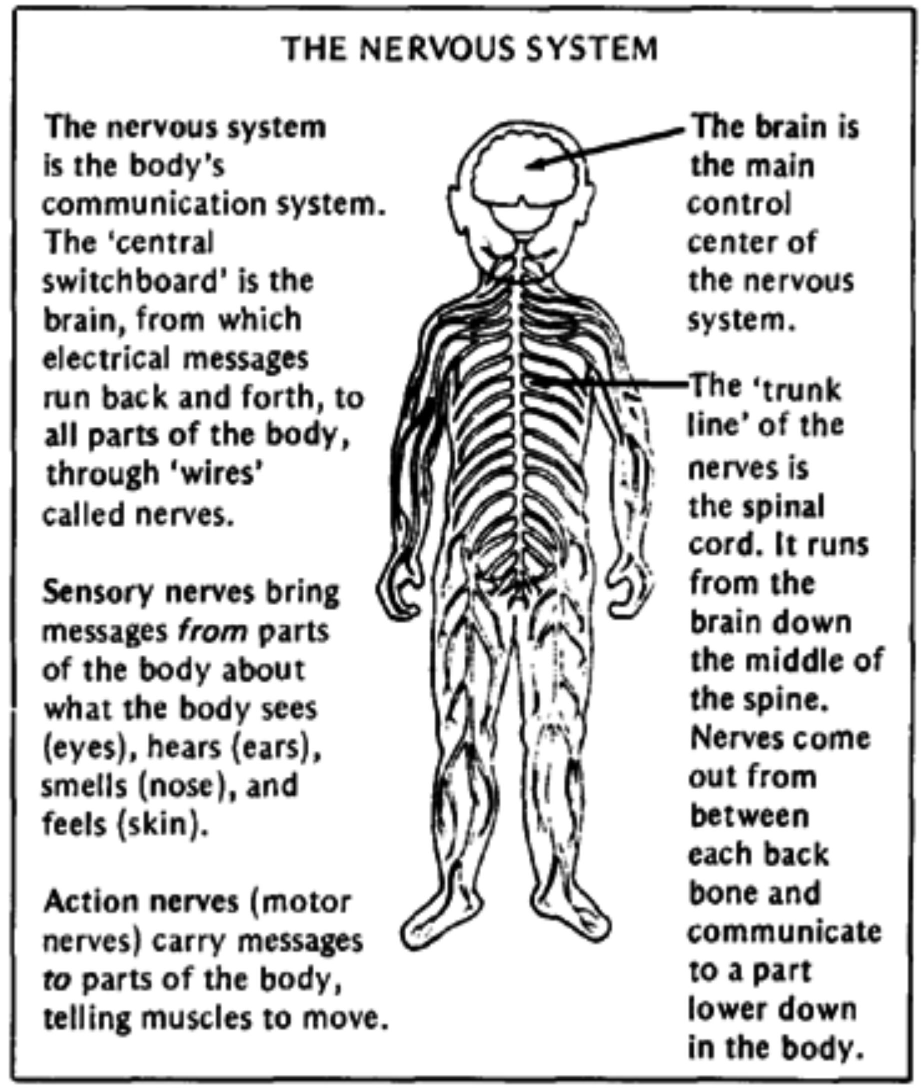
   Detect Changes in the environment (stimuli)

2. **Process information**

   Interpret/evaluate those stimuli

3. **Respond**

   (trigger muscle contractions or glandular response)



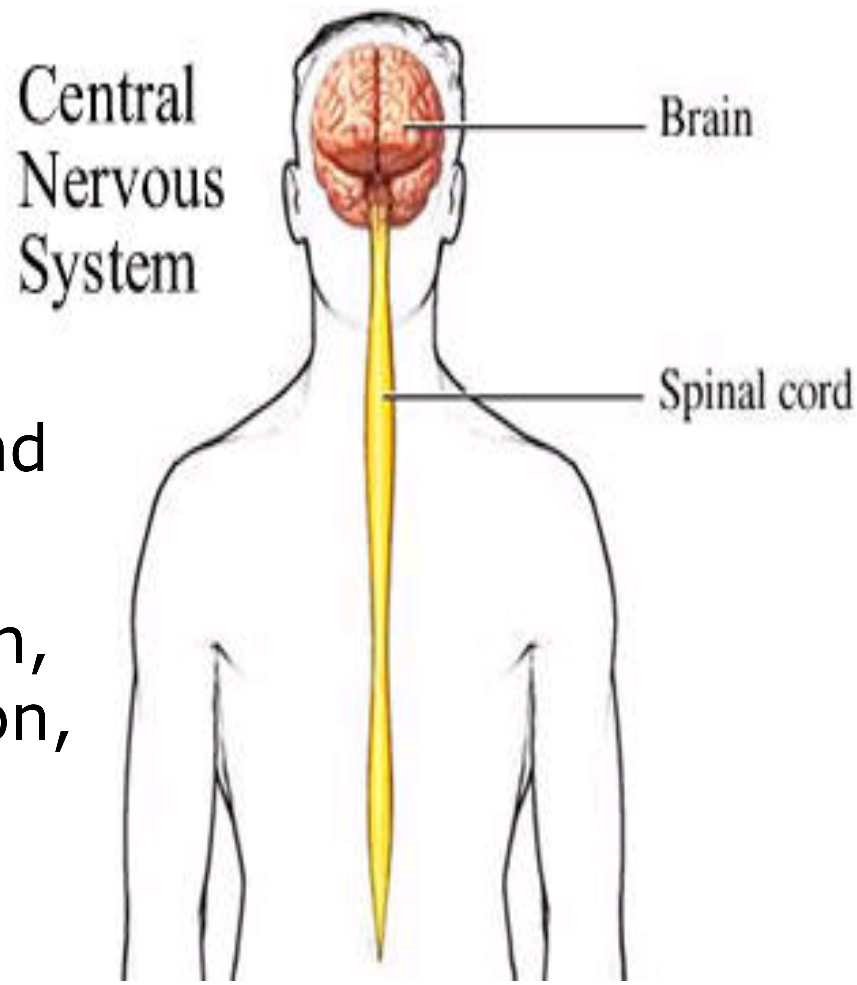
•**<u>Nervous System (NS) Organization</u>**: can be organized by location/ structure or by function

A. Structural Organization

1. Central N.S. (CNS)

-Consists of brain and spinal cord

-receives information, processes information, Sends response



Peripheral N.S. (PNS)

all the nerves outside CNS

-Receives information from the environment

-Receives the response from the CNS

-Nerve cells are responsible for long distance communication in the body. The specialized cells never touch. They send chemical messages.

Functional Organization:

1. By direction of info flow
   a. <u>Afferent:</u> made of nerve cells that take in info (sensory)
   b. <u>Efferent</u>: made of nerve cells that take info out to muscles/glands

   <u>Types of neurons:</u>

   Sensory: INPUT senses stimuli (heat, pressure, light etc)

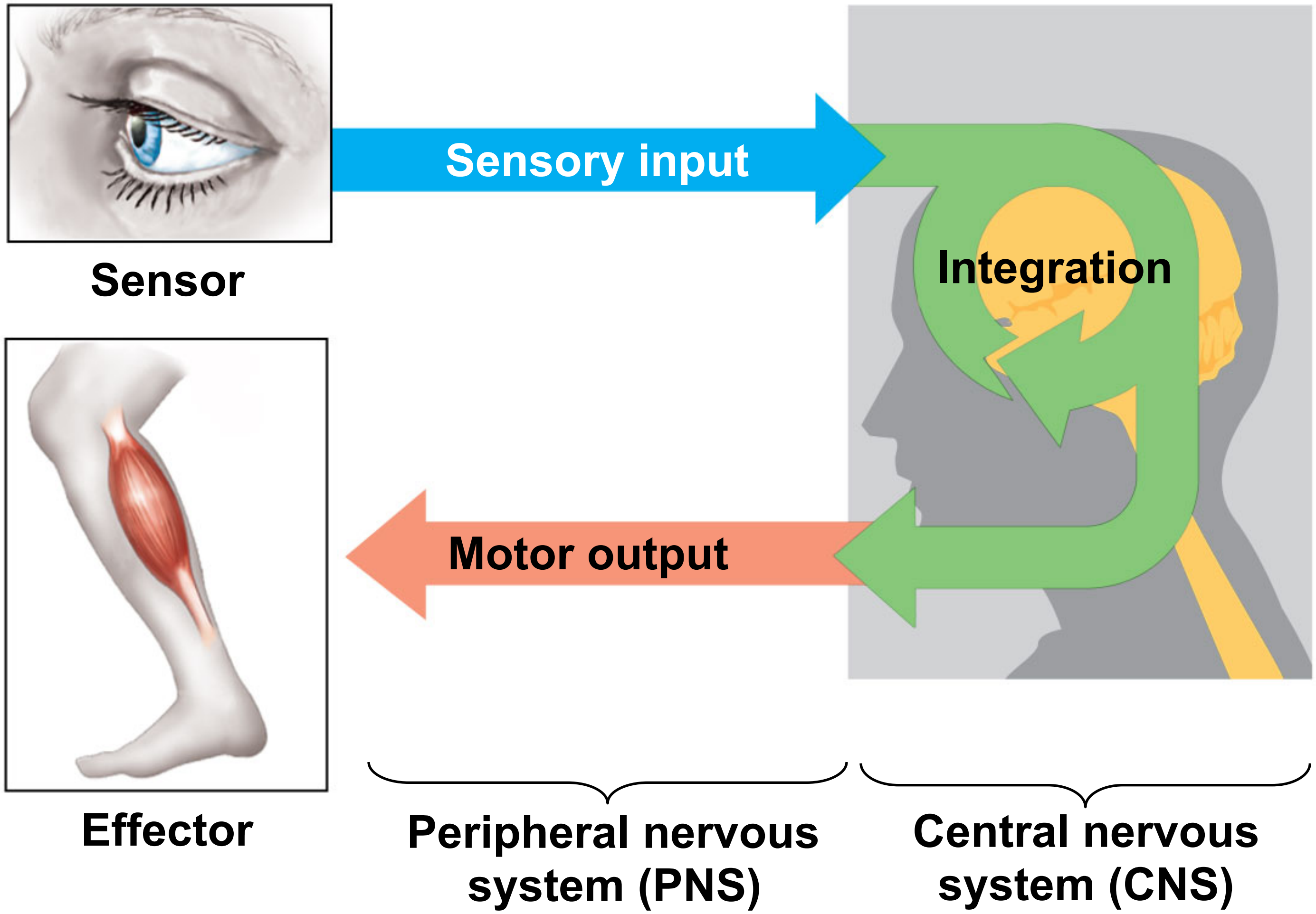
   Interneuron: Integration processes response in CNS

   Motor Neuron: Response Sends response to correct place

By type of effectors they regulate or control

- **Somatic N.S**. - this controls skeletal muscles
  - Under voluntary control
  - Includes sensory and motor neurons
- **Autonomic N.S.** - controls smooth muscles, cardiac muscles, and glands = involuntary
  - (a) Sympathetic Division - gets ready for action = “fight or flight”
  - (b) Parasympathetic Division - “rest and repair”

Figure 48.3


Sensory input
Sensor
Integration
Motor output
Effector
Peripheral nervous system (PNS)
Central nervous system (CNS)

III. Cells of the nervous system

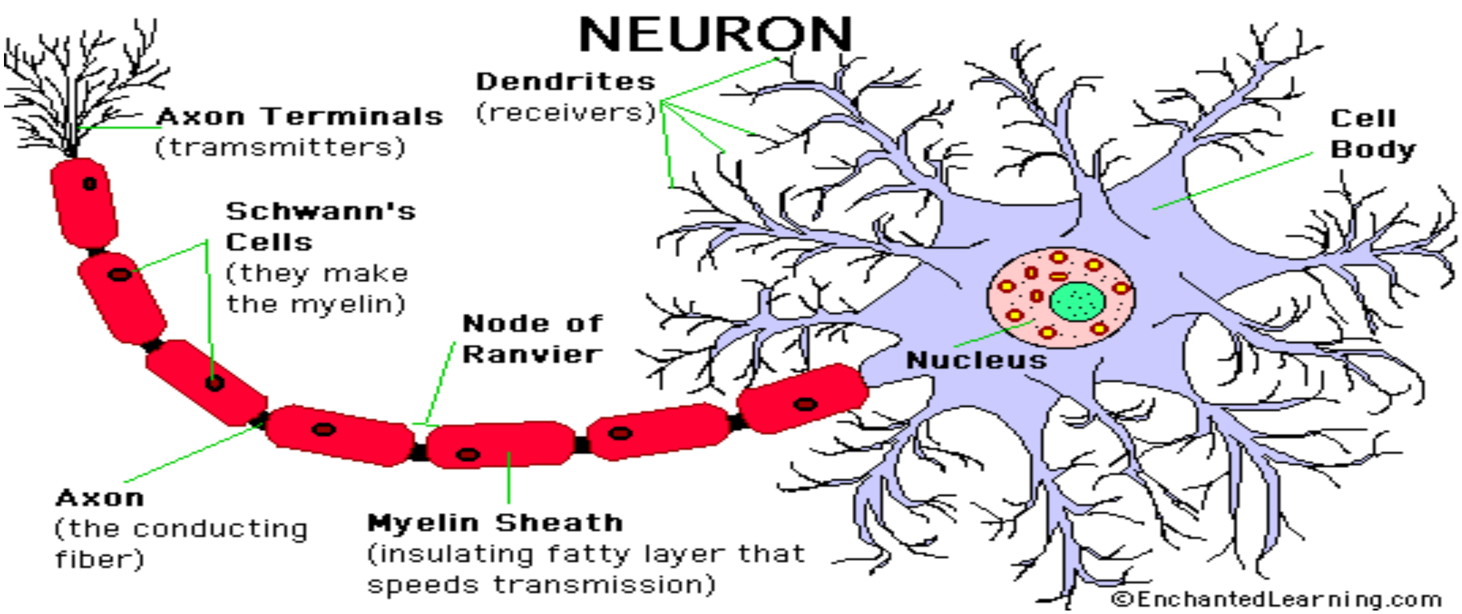
A. 2 cell types

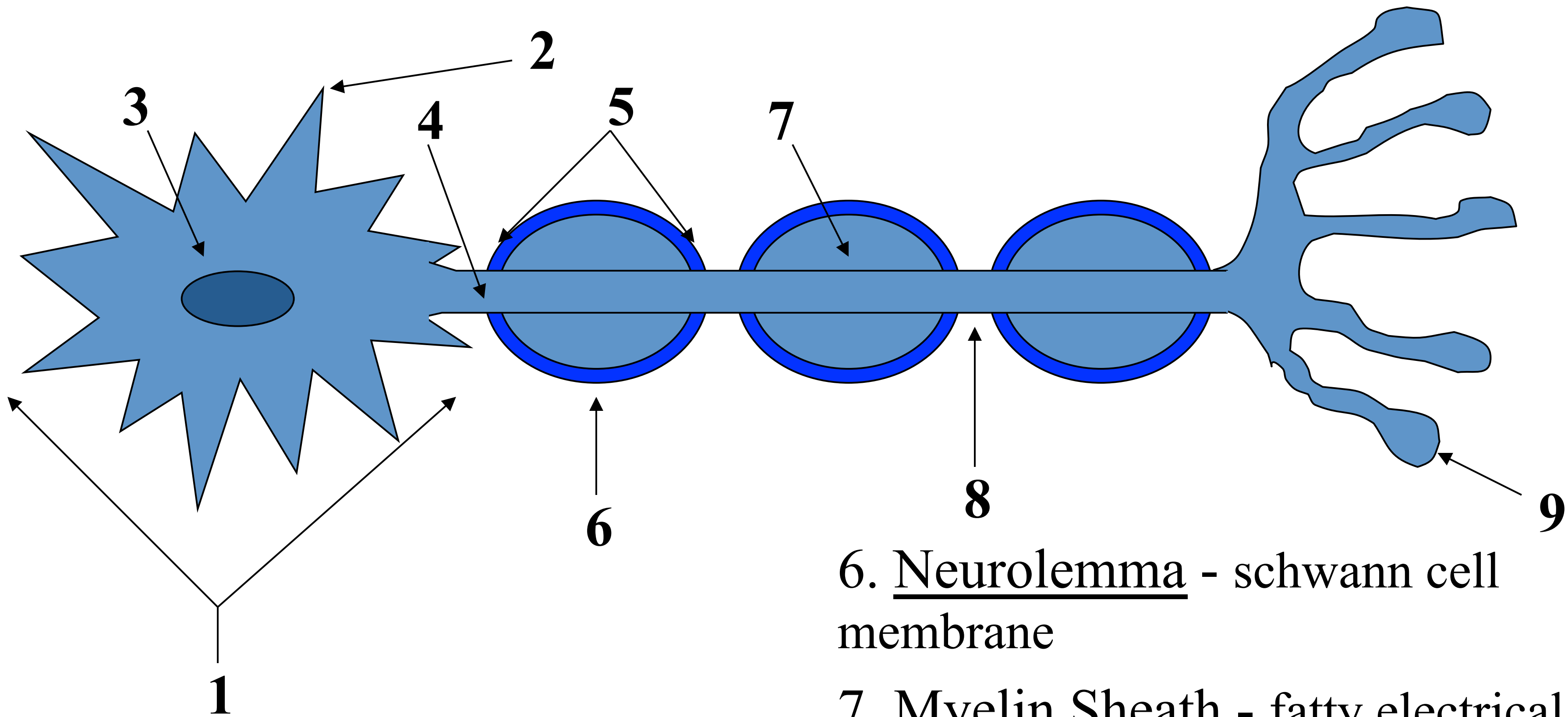
1. Neurons - cells that can send signals

2. Glia - helper cells that support neurons

a. some (oligodendrites, schwann cells) form myelin sheath around neurons

b. some feed (astrocytes) and protect the neurons (microglial)





1. Cell Body - main part of cell

2. Dendrites - nerve fibers that take **IN** signals

3. Nucleus

4. Axon - nerve fibers that send signals **OUT**

5. Schwann Cell - glial cell that wraps around axon to form myelin sheath

6. Neurolemma - schwann cell membrane

7. Myelin Sheath - fatty electrical insulation that helps speed up nerve signals (A.P.)

8. Node of Ranvier - gaps between schwann cells that A.P. jump along

9. Synaptic end bulb(terminal) - forms a connection to other neurons/glands/muscles.

The Nerve impulse

- When a nerve is at rest there are more sodium ions (Na^+) on the outside and more potassium ions (K^+) on the inside. This causes the cell to become **polarized** this is known as the **resting potential**

Na+ Na+ Na+ Na+ Na+ Na+ Na+ Na+ Na+ Na+

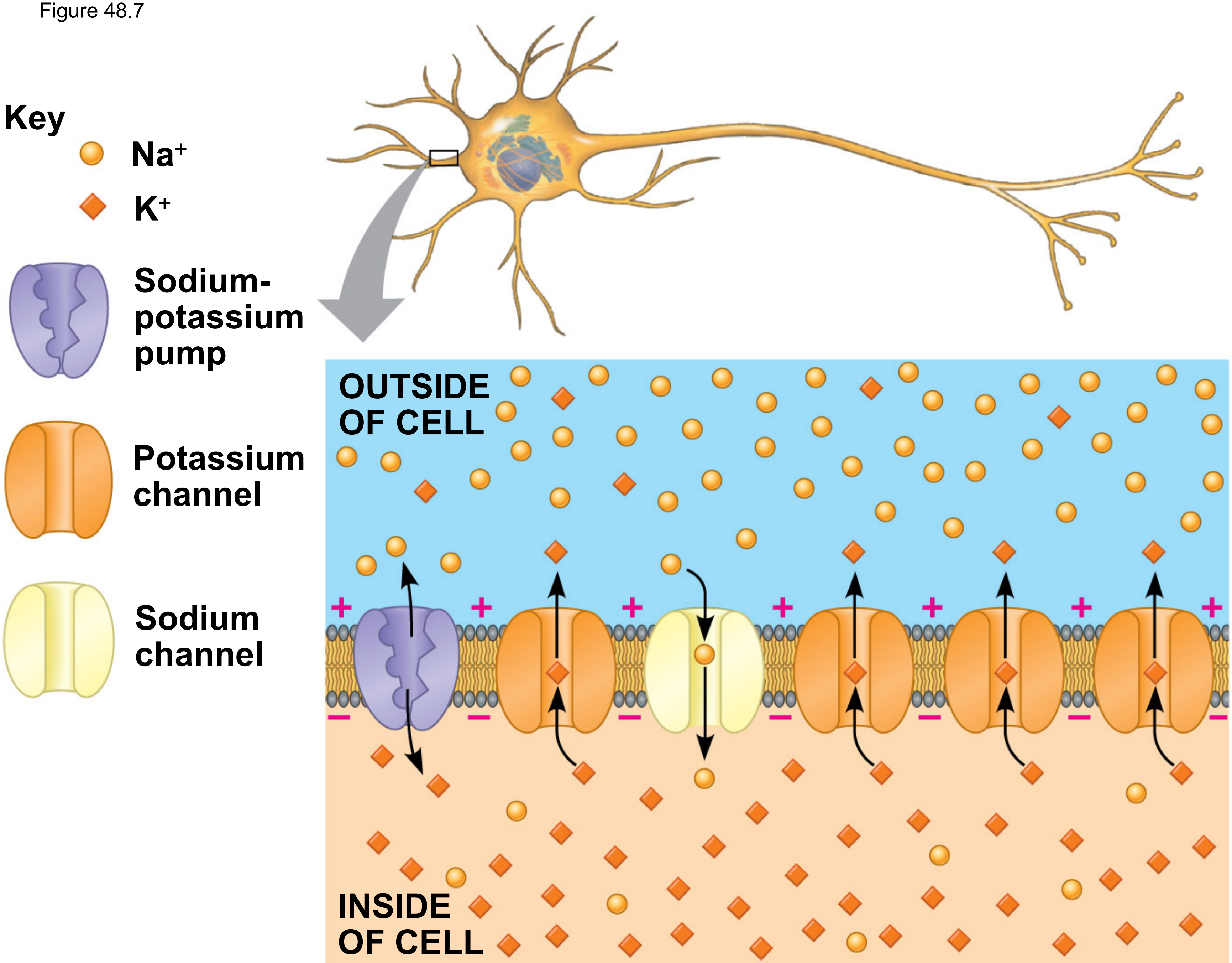
\- -

K+ K+ K+ K+ K+ K+ K+ K+ K+ K+ K+ K+ K+ K+

-- -

Na+ Na+ Na+ Na+ Na+ Na+ Na+ Na+ Na+ Na+

Figure 48.7



Key
Na+
K+
Sodium-potassium pump
Potassium channel
Sodium channel
OUTSIDE OF CELL
INSIDE OF CELL

Nerve Impulse cont'

- When a stimulus activates the nerve the channels open and Na^{+} ions rush into the cell (remember diffusion) causing the charge of the membrane to change This is called **Action Potential** this causes the cell to become **depolarized** and this happens along the length of the neuron until it reaches the axon terminals.
- This only happens if we reach the threshold

Steps of the nerve impulse

- Normally the inside of a nerve cell has a negative charge (-), the outside is positive (+).
- When the stimulus is sensed, the Receptor Proteins in the Dendrites receive the signal.
- In response, the Channel Proteins on the Axon open and positive ions rush in. (Sodium - Na)

  *This is the nerve impulse **(action potential)**
- When the action potential reaches the Axon Terminals, Neurotransmitters (chemical signals) are released and targeted to the muscle, gland or other nerves that are needed to react.

Figure 48.12-3

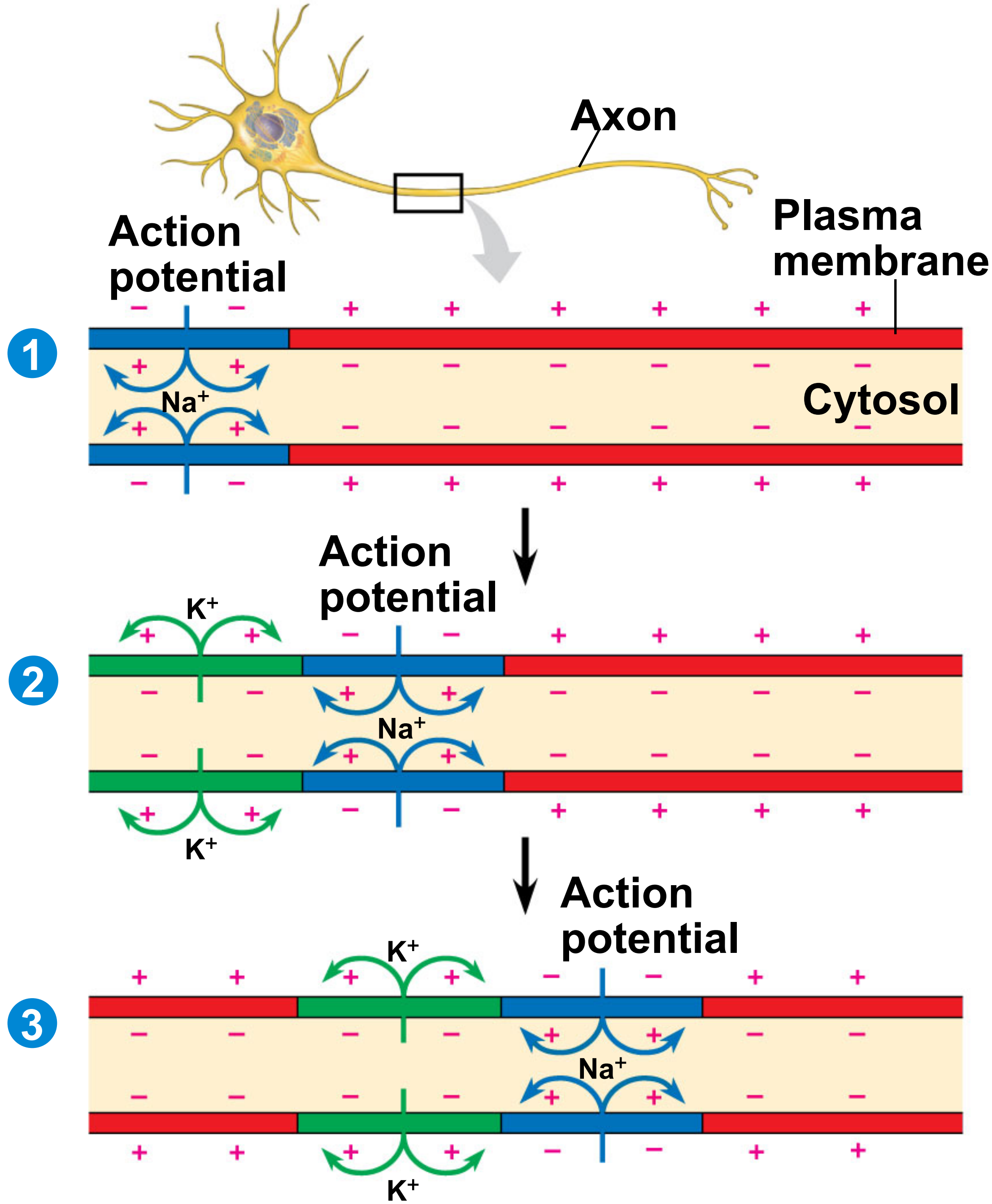
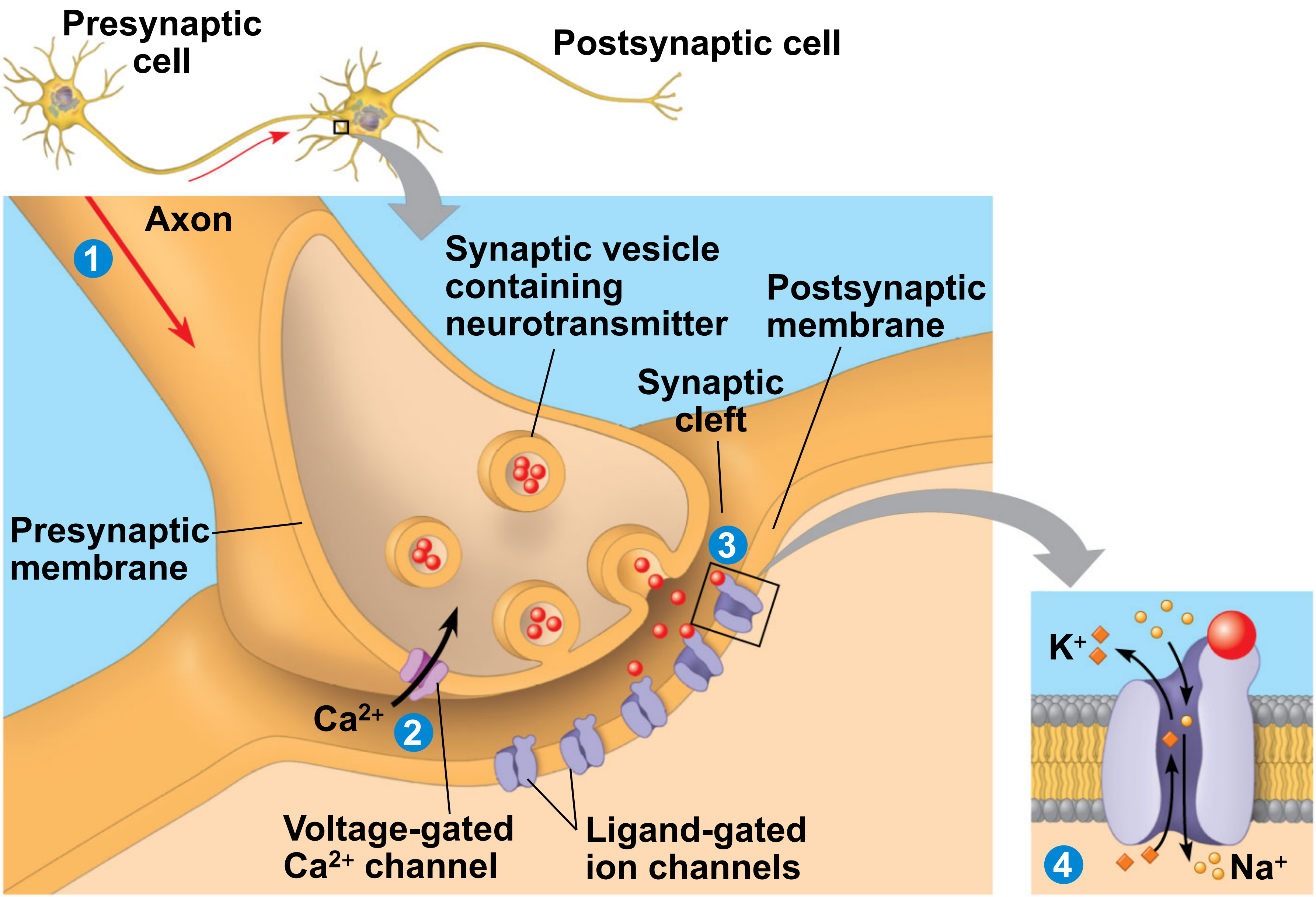
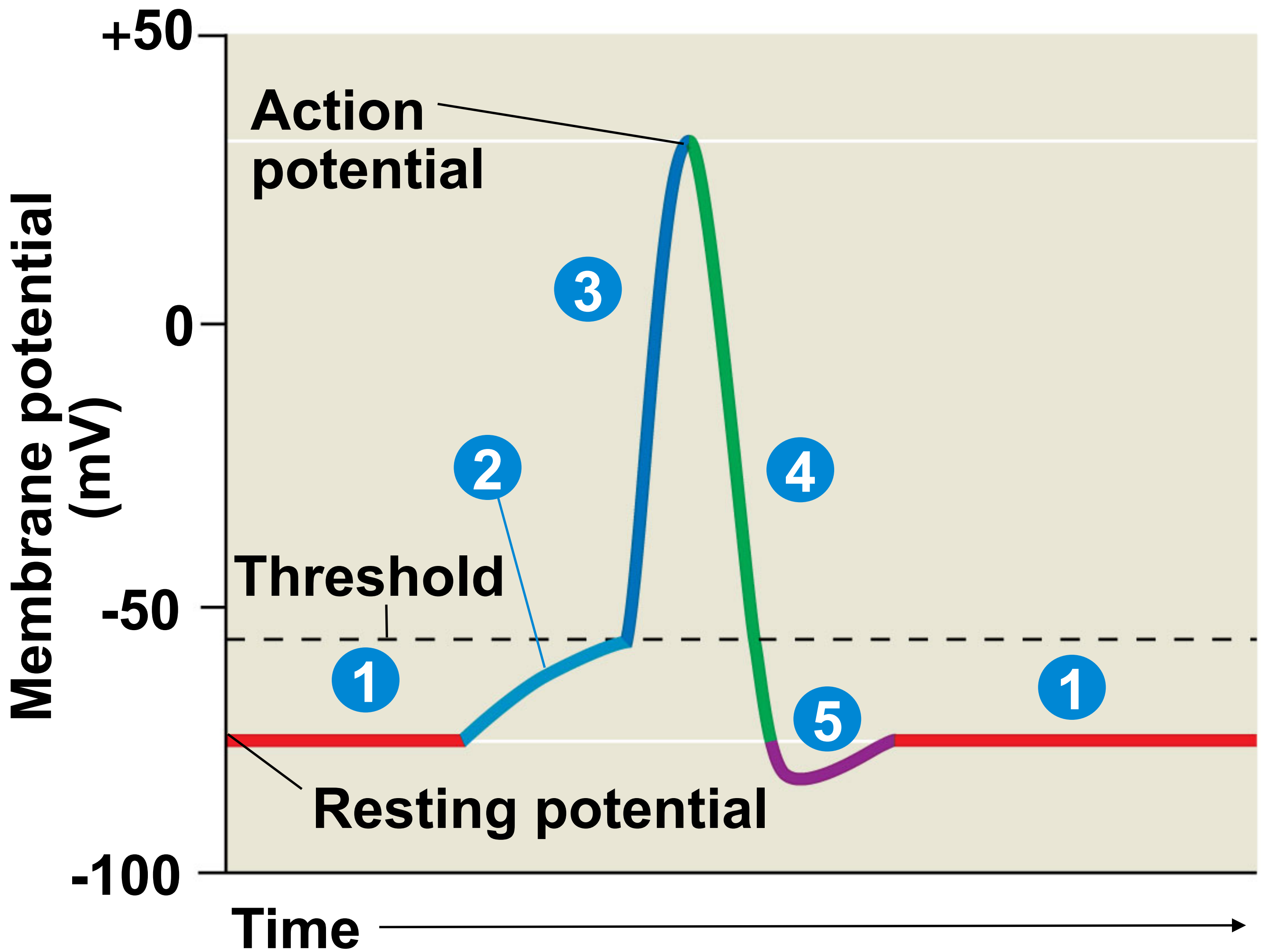


Figure 48.15



Presynaptic cell
Postsynaptic cell
Axon
1
Synaptic vesicle containing neurotransmitter
Postsynaptic membrane
Synaptic cleft
Presynaptic membrane
3
Ca^{2+}
2
Voltage-gated Ca^{2+} channel
Ligand-gated ion channels
K^+
Na^+
4

Figure 48.11a

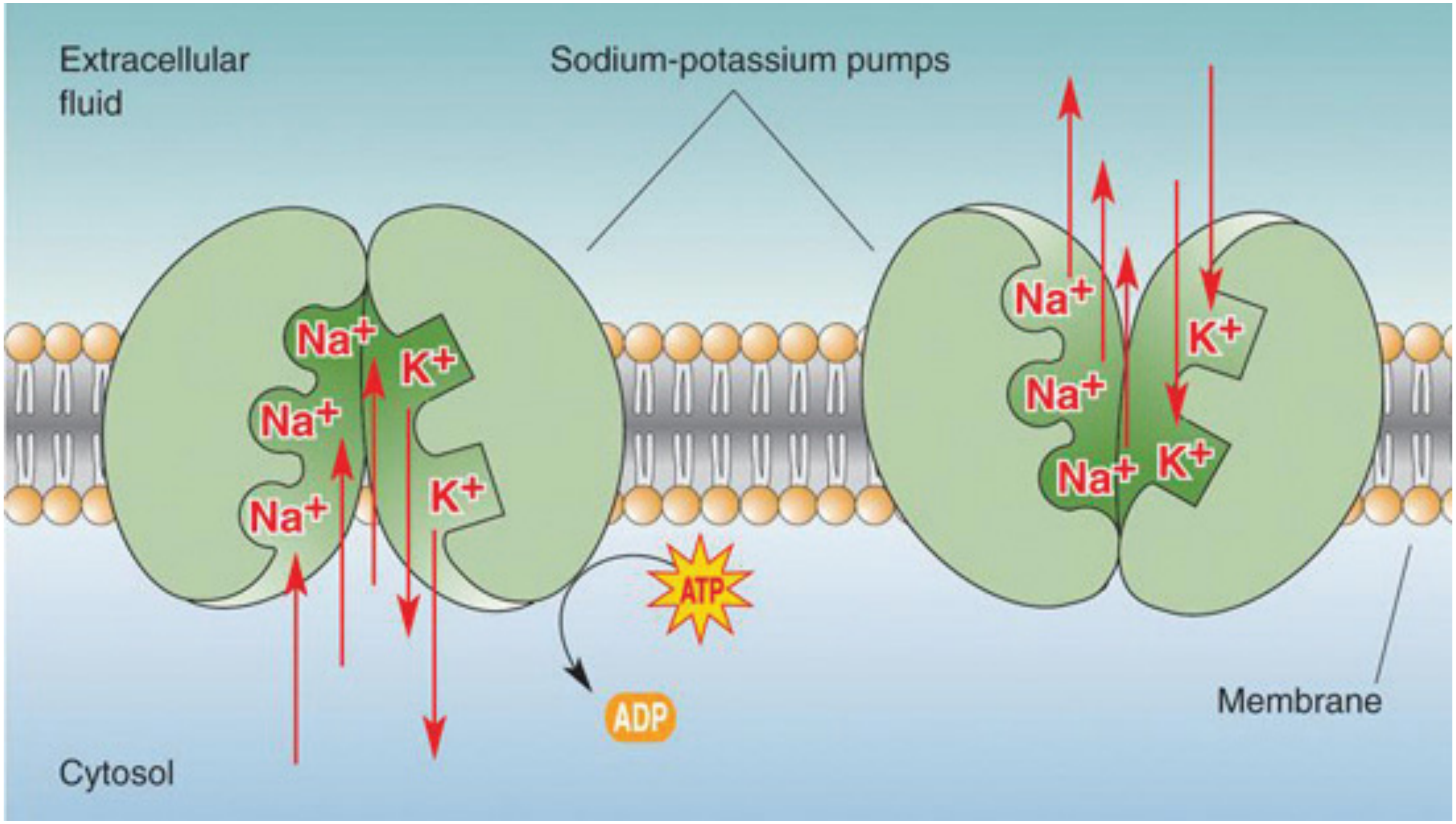


Nerve impulse cont'

- <u>**Myelin acts like insulation**</u> and allows the impulse to jump from node to node causing it to move faster

- <u>**Sodium-potassium pump**</u>: once a nerve is activated it can not be activated again until it is restored to normal – this requires active transport – sodium and potassium are pumped against the concentration gradient (low to high)

Sodium Potassium pump



*notice this step requires ENERGY!

Generation of Postsynaptic Potentials

- transmission involves binding of neurotransmitters to **ligand-gated ion channels** in the next cell
- Neurotransmitter binding causes ion channels to open, generating a postsynaptic potential
- There are more than 100 neurotransmitters, belonging to five groups: acetylcholine, biogenic amines, amino acids, neuropeptides, and gases
- A single neurotransmitter may have more than a dozen different receptors

Senses and the nervous system

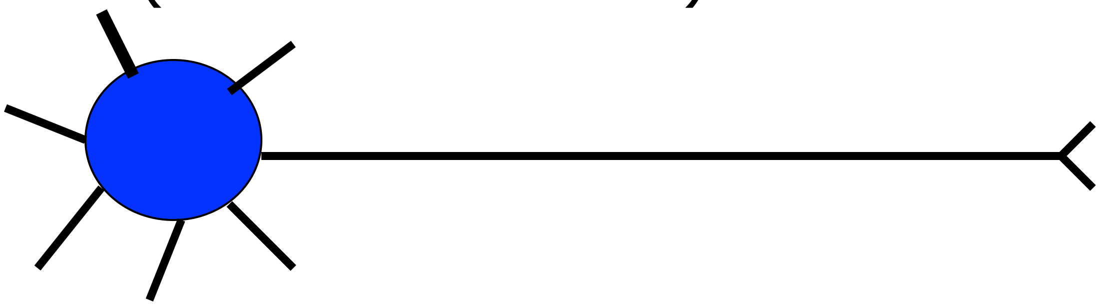
The nervous system has 5 types of sensory receptors that respond to a variety of stimuli

- **Pain receptors:** located throughout the body except in the brain respond to chemicals released by damaged cells
- **Thermoreceptors:** located in the skin, body core, and hypothalamus. Thermoreceptors detect variations in temperature.
- **Mechanoreceptors:** found in the skin, skeletal muscles, and inner ears. They are sensitive to touch, pressure, stretching of muscles, sound, and motion.
- **Chemoreceptors:** located in the nose and taste buds, are sensitive to chemicals in the external environment.
- **Photoreceptors:** found in the eyes, are sensitive to light.

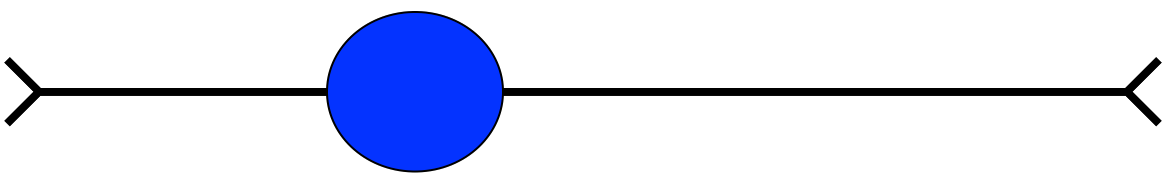
C. Types of Neurons

1. Classified by structure

a. Multipolar - many dendrites and one axon, (common in CNS)

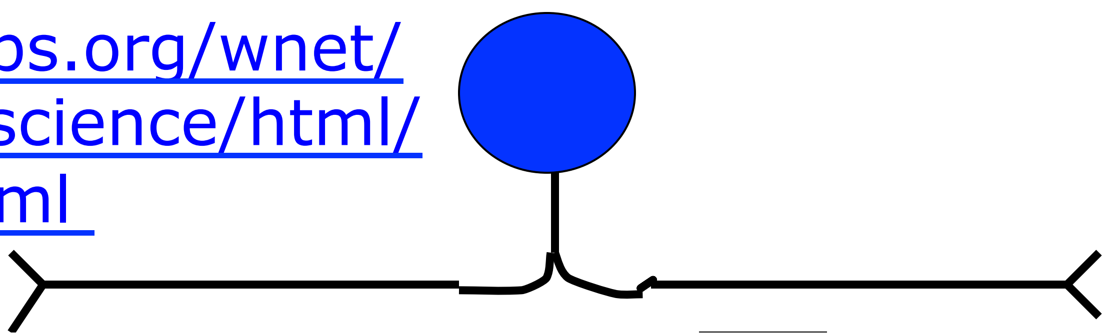


b. Bipolar - one dendrite, one axon (retina, inner ear, olfactory bulb)



c. Unipolar - one central fiber that branches into a dendrite and axon (sensory)

http://www.pbs.org/wnet/closetohome/science/html/animations.html



IV. Reflex Arcs

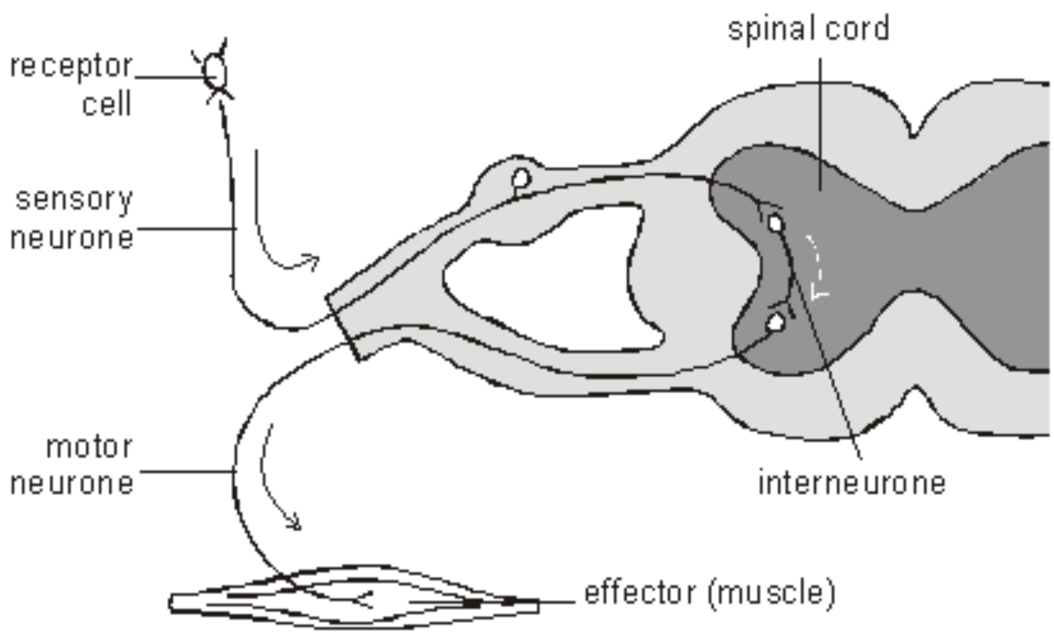
A. Signal conduction pathway to and from CNS

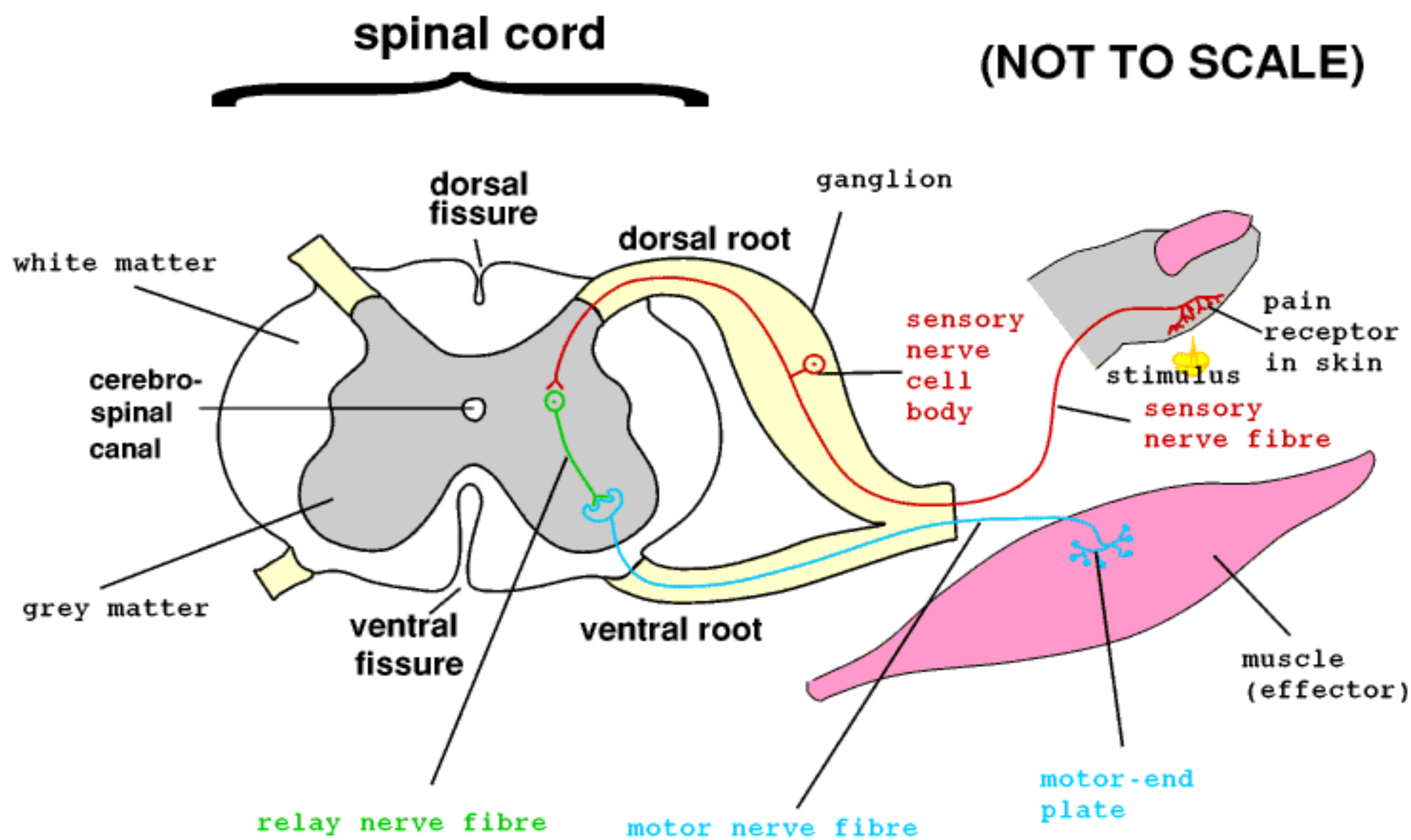
B. Reflexes are responsible for survival and homeostasis

1. Allows fast response w/out need to make decisions

2. Ex-pain response, knee jerk, blood pressure

C. Most Common sort is 3 neuron arc - signal goes from sensory to interneuron to motor neuron





D. Can have ipsilateral reflex arc - sensory receptor and effector are on the same side of spinal cord

E. Contralateral reflex arc - sensory receptor and effector are on opposite sides

F. Can have more complex arcs that go up and down spinal cord, affecting many effectors, stimulating some, inhibiting others.

G. Instinct - series of reflex arcs that produce complex, overall organism behaviors.

1. They have trigger stimulus = Releaser
2. Parts of the brain that recognize releaser and coordinate response = Innate Releasing Mechanism
3. Fixed Action Patterns = reflexes

H. Can also develop patterns of behavior similar to instincts but more complex and adaptable

1. Caused by patterns of behavior/circuits of neurons called engrams
2. These are built/ reinforced over time w/more signals sent through them

I. Engrams are ex of learning - change in behavior brought about by experience

1. <u>Habituation</u>
    a. Learning NOT to respond to a stimulus by repeated exposure without any effects
    b. ex: public speaking
2. <u>Classical Conditioning</u>
    a. associating an unrelated stimulus to a stimulus that normally causes a response, the unrelated stimulus now causes the response
    b. ex: Pavlov's Dogs

3. Operant Conditioning

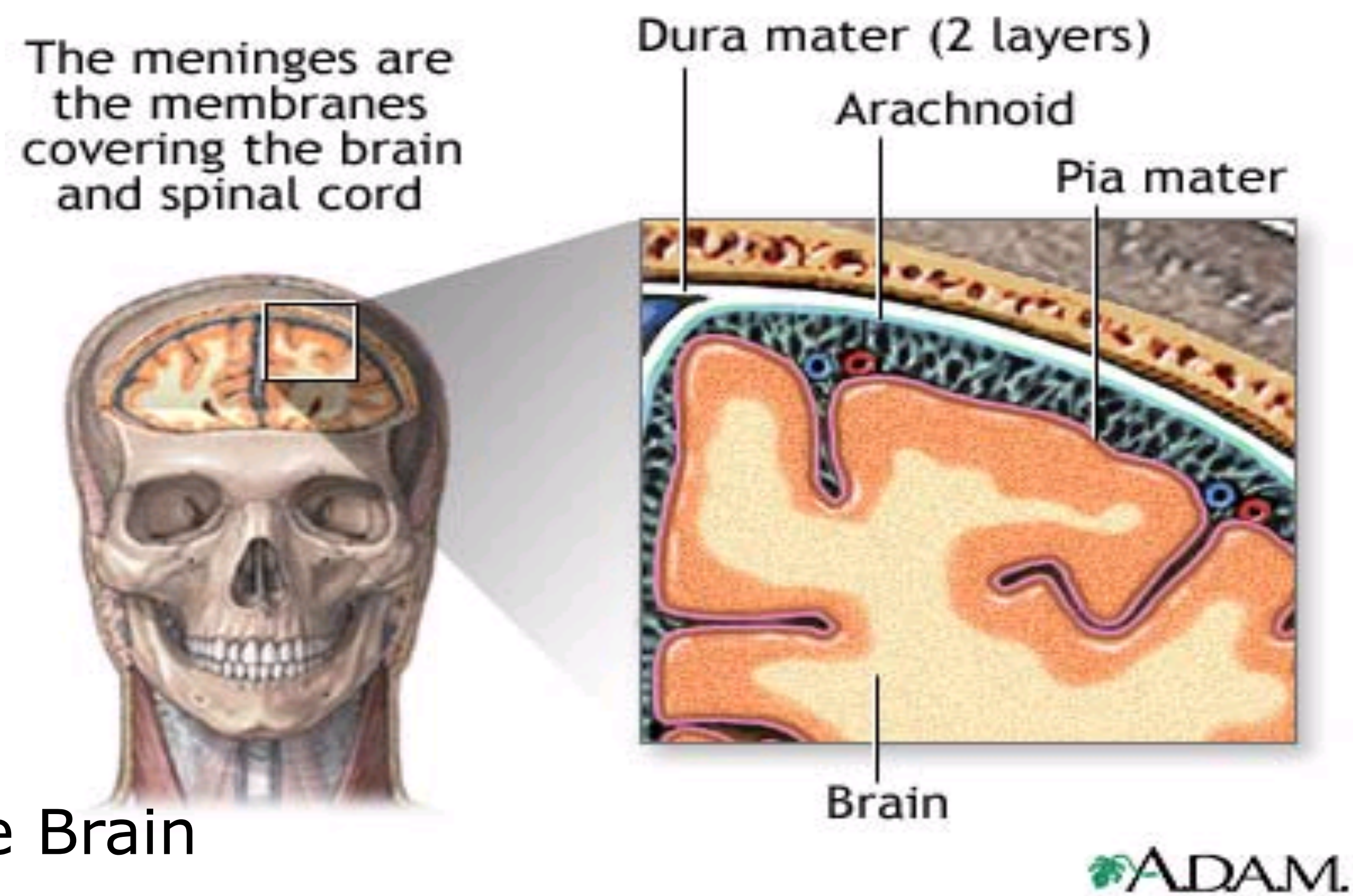
a. Using a reward to encourage a specific response

b. ex: if you gave a treat to a dog everytime it happened to sit, it would soon learn to sit.

4. Imprinting

a. learning a specific response/ behavior that takes place in a specific, relatively brief period of time.

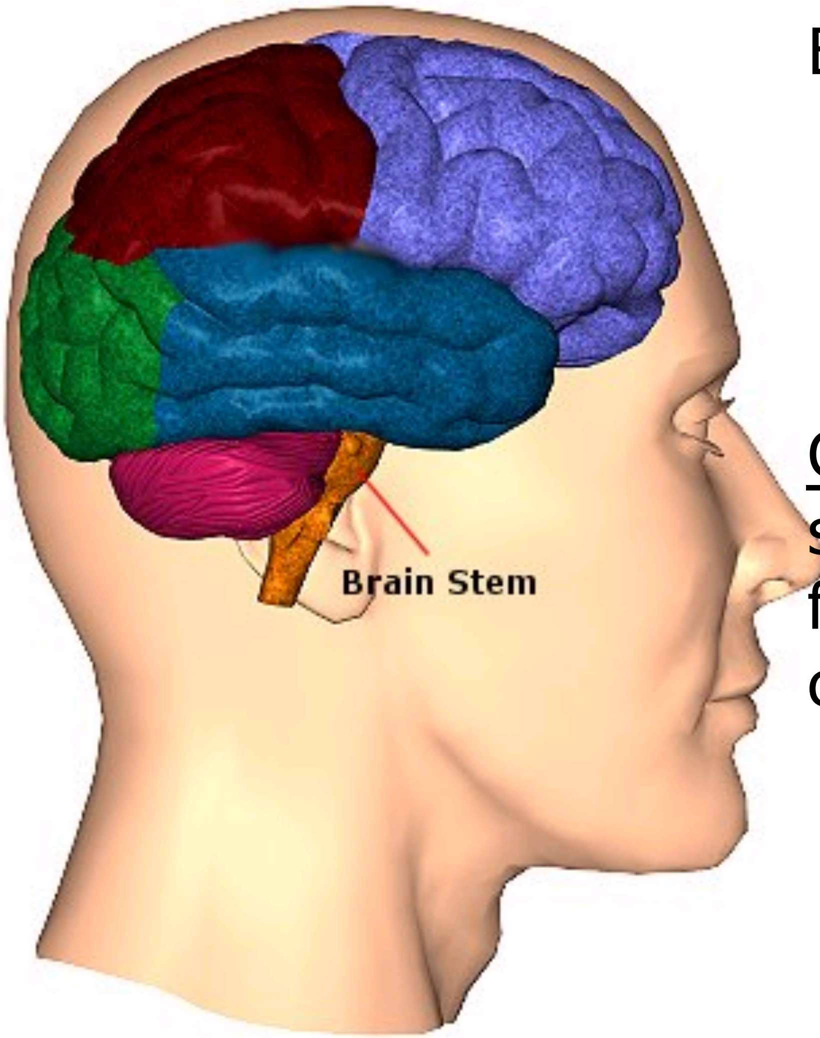
b. ex: learning language/ learning what your species is/ birds recognizing their parent.



V. The Brain

A. Has 3 coverings called <u>meninges</u> that extend down the spinal cord

1. <u>Dura Mater</u> - tough outer layer
2. <u>Arachnoid membrane</u> - thin middle layer
3. <u>Pia Mater</u> - thin transparent layer on the surface, contains blood vessels

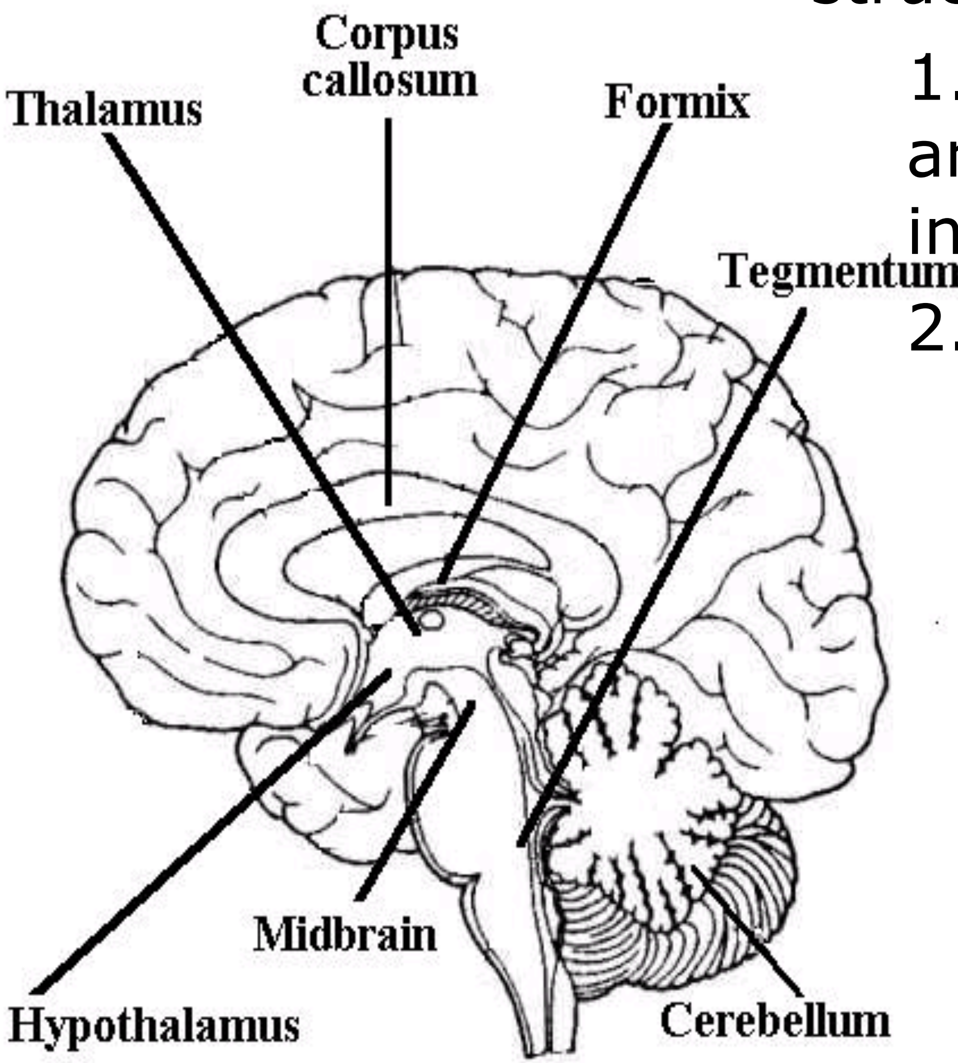


B. Brain is made of 4 parts:

1. Brainstem
2. Cerebellum
3. Diencephalon
4. Cerebrum

C. Brainstem - deals with basic survival, contains reticular formation: maintains consciousness

1. Medulla oblongata - has control centers (nuclei) for cardiac, respiratory, and vasomotor (opening and closing of blood vessels) control.
2. Pons - site of many cranial reflexes, helps regulate breathing
3. Midbrain - site of many visual reflexes



D. Cerebellum - similar in structure to cerebrum

1. Connected to motor area of cerebrum; 2 influence each other

2. Functions:

a. Coordinates muscle action to produce skilled movement

b. Controls skeletal muscles to maintain balance

c. Helps posture, make movement smooth

E. <u>Diencephalon</u> ("between brain") - several structures including thalamus, hypothalamus, and pineal body

1. <u>Thalamus</u>

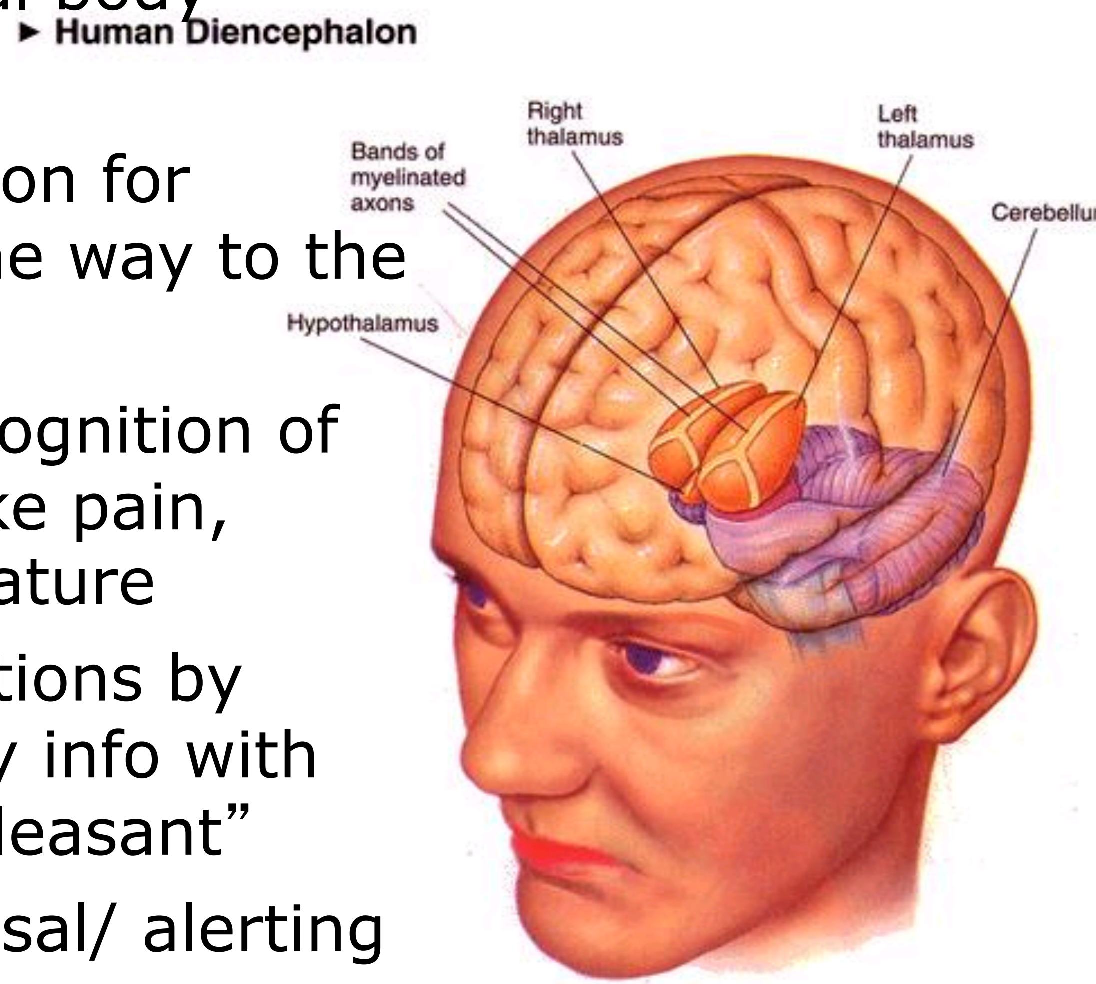
a. Major relay station for sensory info. On the way to the cerebrum

b. Makes initial recognition of basic sensations like pain, touch, and temperature

c. Involved in emotions by associating sensory info with "pleasant" or "unpleasant"

d. Involved in arousal/ alerting mechanisms

e. Involved in complex reflex movements



2. Hypothalamus (under the thalamus)

a. Nervous system link to endocrine (hormone) system via pituitary gland (posterior=N.S. anterior=endocrine)

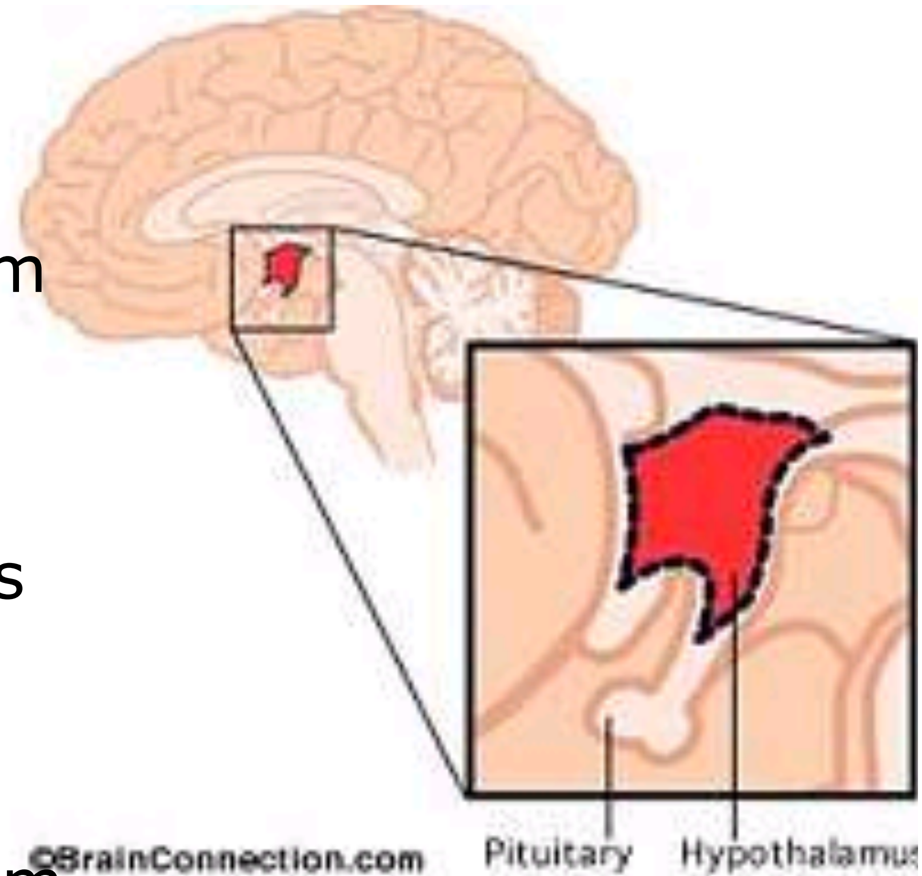
b.Regulates and coordinates many autonomic activities

c. Connects the cerebral cortex to autonomic (involuntary) nervous system so conscious thought can influence body

d. Functions in arousal/ alerting mechanisms

e. Regulates hunger

f. Maintainance of body temperature

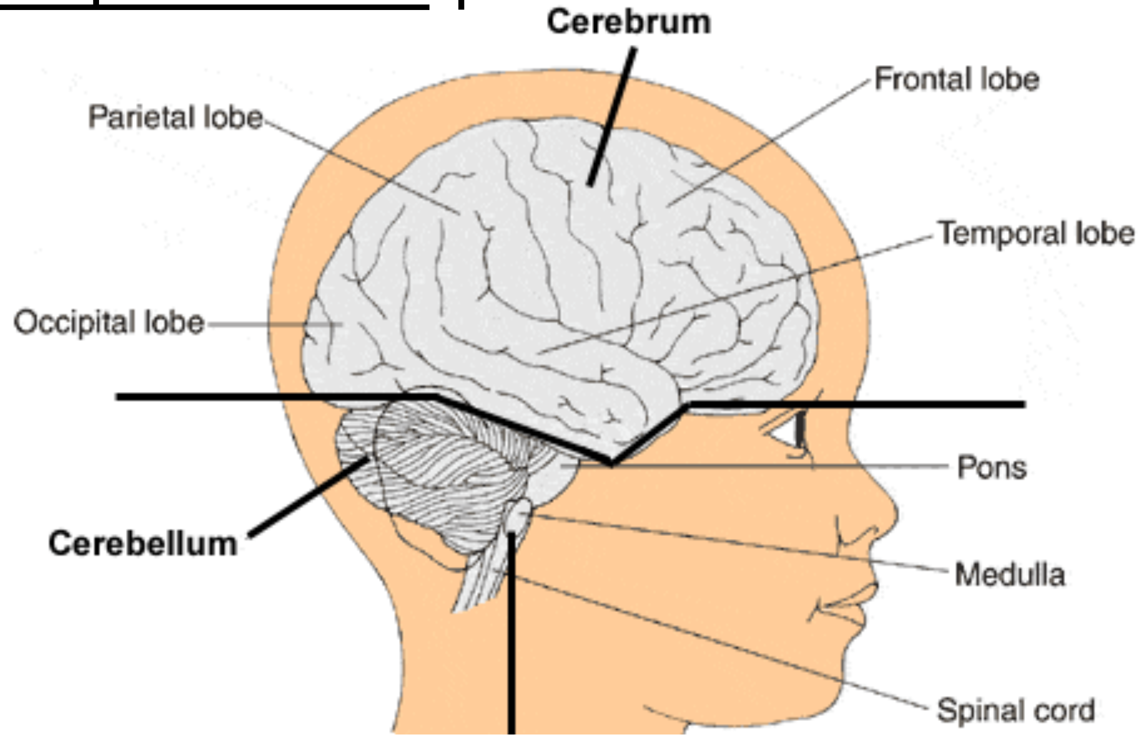


3. Pineal Body (gland)

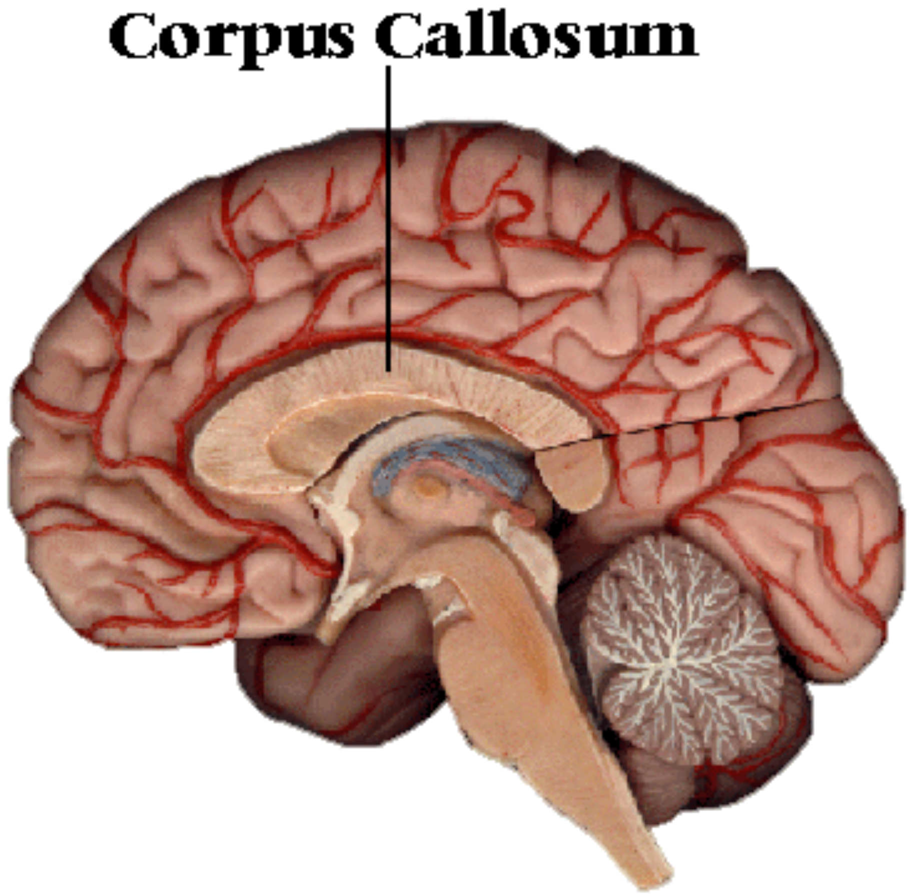
a. Involved in biology cycles (circadian rhythm)

b. Release melatonin- hormone that helps synchronized body fxns, causes sleepiness.

- <u>F. Cerebrum</u>
  - 1. Divided into several parts called lobes
  - 2. 4 major lobes:
    - a. <u>Frontal Lobe:</u> generally controls muscles and complex conscious thought and personality
    - b. <u>Parietal Lobe:</u> takes in sensory
    - c. <u>Temporal Lobe:</u> takes in auditory and smell info
    - d. <u>Occipital Lobe:</u> processes visual info



•<u>3. Corpus Callosom</u> - mass of white matter fibers that connect the two hemispheres of cerebrum so they can communicate



4. Specific functional areas

a. Primary somatic motor areas

1. Located on prefrontal gyrus
2. Has specific neurons controlling specific muscles
3. More area is devoted to muscles needing fine control (i.e. fingers more than thighs)

b. Primary somatic sensory area

1. On postcentral gyrus
2. Similar to "a" above, but instead takes in sensory info (touch)
3. Has somatic sensory association area posterior to it, interprets touch info

c. Primary taste area is on the same as "b" - takes in info from tongue about taste

d. Primary auditory area

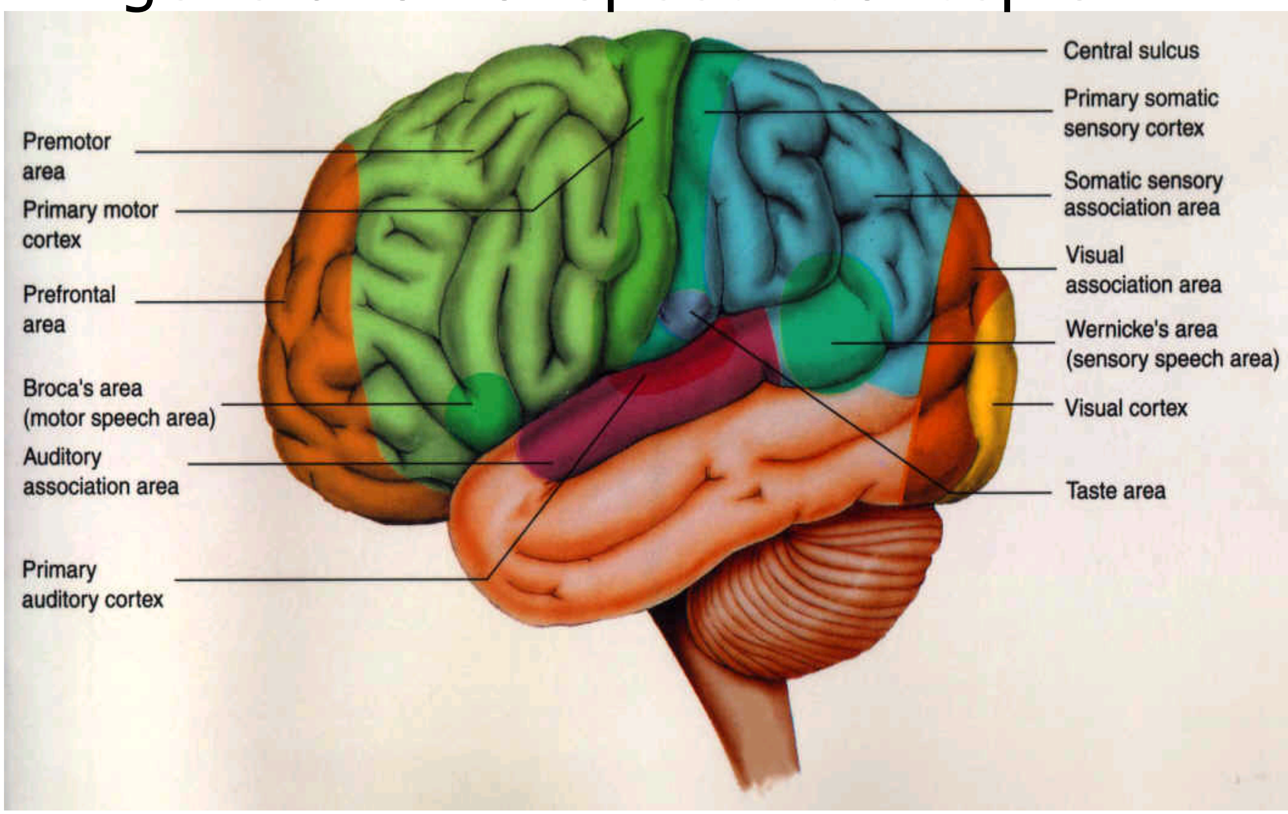
1. Takes in info from ear (sound)
2. Surrounding area is association area

e. Primary olfactory area

1. On front of temporal lobe
2. Takes in smell info from chemoreceptors in the nose

f. Wernike's area

1. Left hemisphere's pareital lobe in most people, near temporal lobe
2. Responsible for interpretations of speech and generation of speech concepts



G. Brocha's area

1. Frontal lobe, left hemisphere
2. Responsible for taking concepts from Wernike and converting into specific muscle actions to produce speech

VI. Action Potential

A. Resting potential(Campbell:Nerve Impulses-Action Potential 1&2)

1. When a neuron is not sending signals, membrane pumps pump out NA^+ and K^+ in.

2. Result is high $[Na^+]$ outside and high $[K^+]$ inside.

3. Also, because of many negatively charged proteins (anions) inside the cell, the inside of the membrane becomes more negative than the outside. Resting potential = -70 mV.

B. Steps of Action Potential

(Campbell:Nerve Impulses - Action Potential 3)

1. Stimulus triggers stimulus-gated Na^+ channels (tunnels through the membrane that open due to a stimulus) to open, allowing some Na^+ to move in, making inside less negative. This process = depolarization

2. If enough Na^+ ions move in and depolarize membrane to -60mV (the threshold potential), voltage-gated Na^+ channels open. These remain open for about 1 millisecond, allowing more Na^+ to rush in, depolarizing the membrane even more.

3. Voltage-gated Na^+ channels close, voltage-gated K^+ channels open at +30 millivolts.

4. K^+ ions rush out by diffusion, repolarizing (returning to -) the membrane. Typically an excess of K^+ moves out, making it more negative than -70mV (hyperpolarization)

5. Na^+/ K^+ pump works to return K^+ and Na^+ to original levels (Na^+ high and K^+ low outside)

6. When inside of the membrane starts to become + (in step 3), that triggers voltage gated Na^+ channels in neighboring sections to open causing action potential to spread.