Nervous System

Control center & communication network of the body

Nervous System

- Doctor: Neurologist
- Fxn: **Communication** – through an **electrochemical impulse/nerve** impulse that works **fast** to maintain **short-term homeostasis**

Sensory → PNS → Integrative/Decision → PNS → Motor

CNS → Brain
CNS → Spinal Cord

3 Functions

1. **Sensory** – perceives or senses changes as they occur

2. **Integrative** – processing/integrating the sensory information to arrive at a desired response

3. **Motor** – ability to initiate a response that has a desired effect

Organs: brain, spinal cord, nerves, sensory organs

Specialist: Neurologist

Divisions of the Nervous System

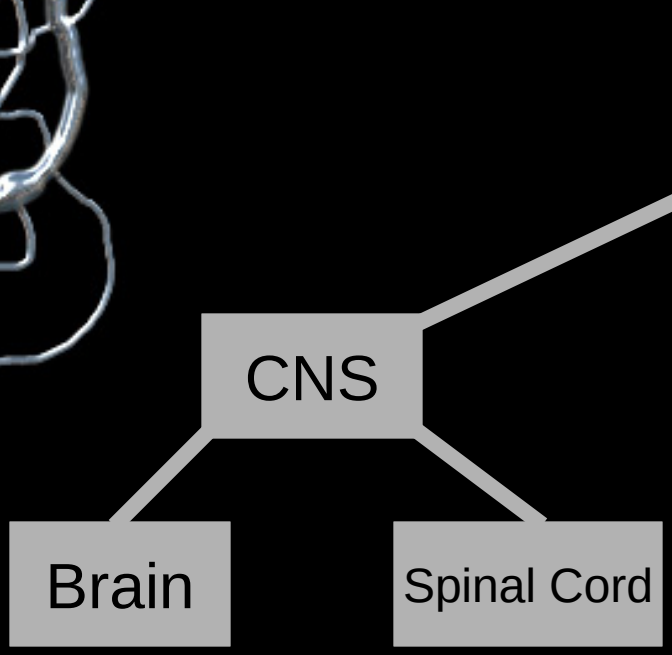


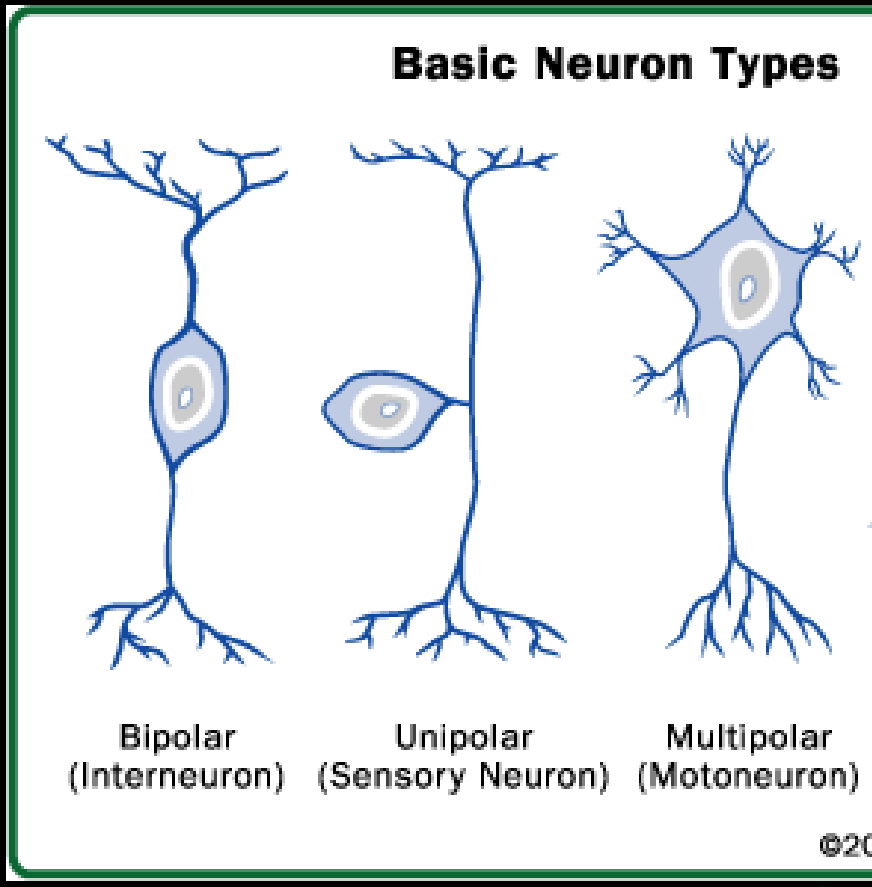
Figure 9-1

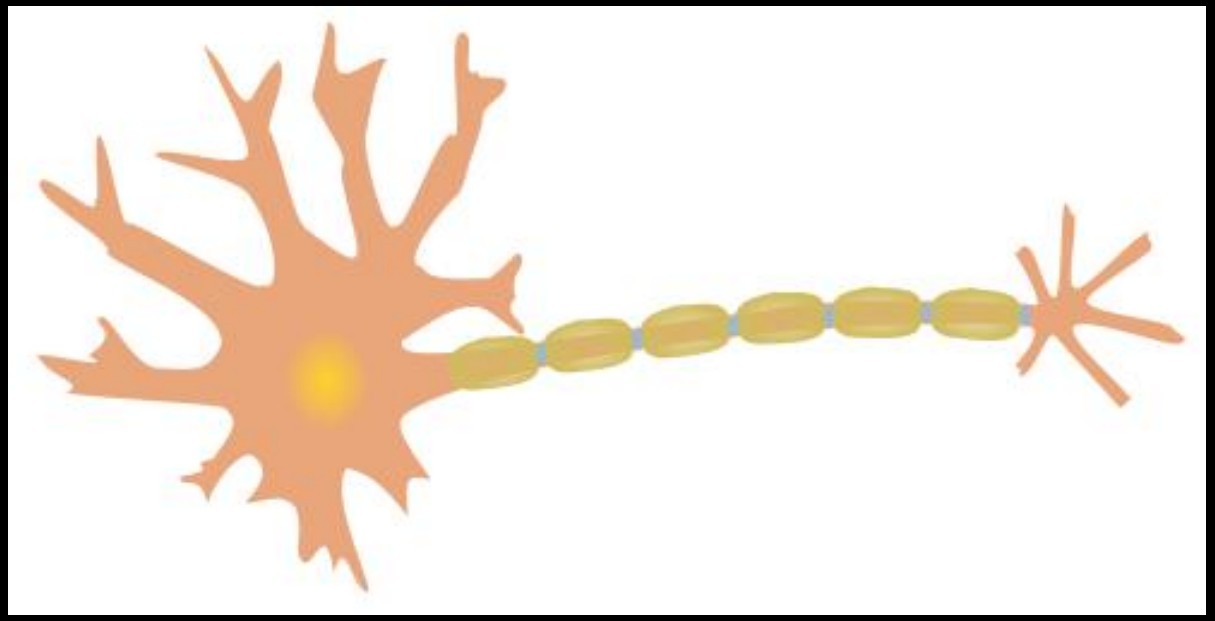
Page 240

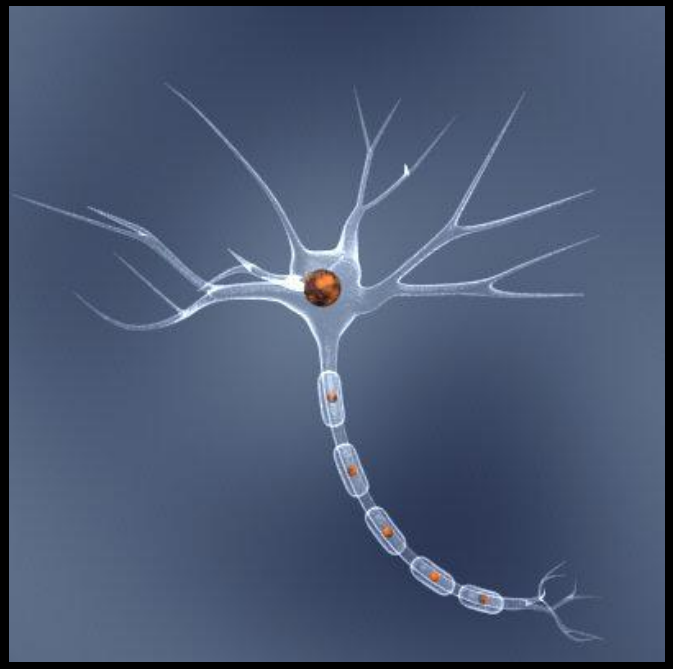
Tissue Level of Organization

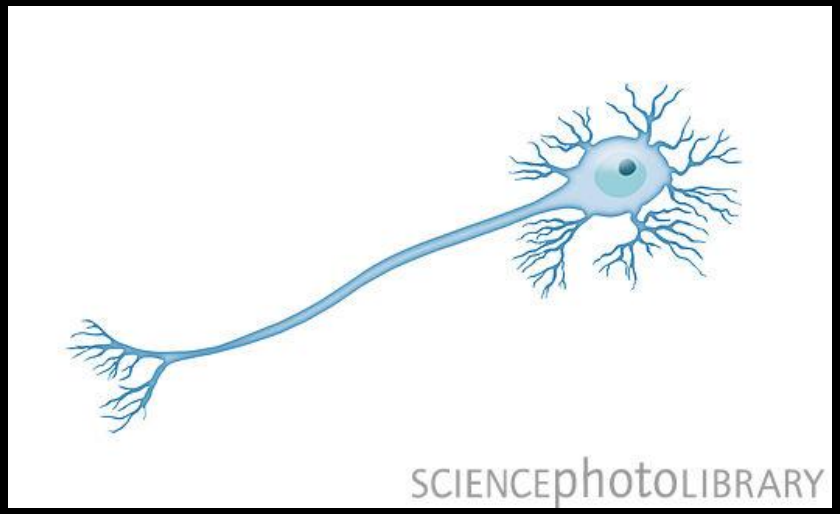
Nerve Tissue

Consists of nerve cells and interstitial tissue. It has the properties of excitability and conductivity, and functions to control and coordinate the activities of the body.








SCIENCEphotoLIBRARY

Nerve Tissue

- One of the four types of tissues in the body
- Highly specialized to respond to changes in environment and to conduct impulses
- 2 types of cells: **neurons**, **supporting cells**

- **Neurons →**
  - AKA nerve cells (responsive cells)
  - Excitable nerve cells that transmit electrical signals

- **Supporting cells →**
  - AKA **neuroglia** or **glial cells**
  - Smaller cells that surround, support, protect neurons
  - **4 types in CNS ; 2 types in PNS**

** Did you know? → supporting cells of CNS:

- account for ½ of brain mass
- outnumber neurons in CNS ~ 10:1

Supporting cells of **CNS**:

- **Astrocytes**
  - Most abundant type
  - Anchor neurons and capillaries
- **Microglia**
  - Contain long processes
  - Can transform into phagocytic cells when neurons injured
- **Ependymal cells**
  - Ciliated
  - Found in lining of cavities of brain and spinal cord
  - Helps circulate CSF
- **Oligodendrocytes**
  - Tightly wrapped around neuron, form myelin sheath

Supporting cells of **PNS**:

- **Satellite cells**
  - Wrap around neuron cell body
- **Schwann cells**
  - Wrap around larger, longer nerve fibers
  - Form myelin sheath

Figure 9-2
page 241

Neurons…Nerve Cells

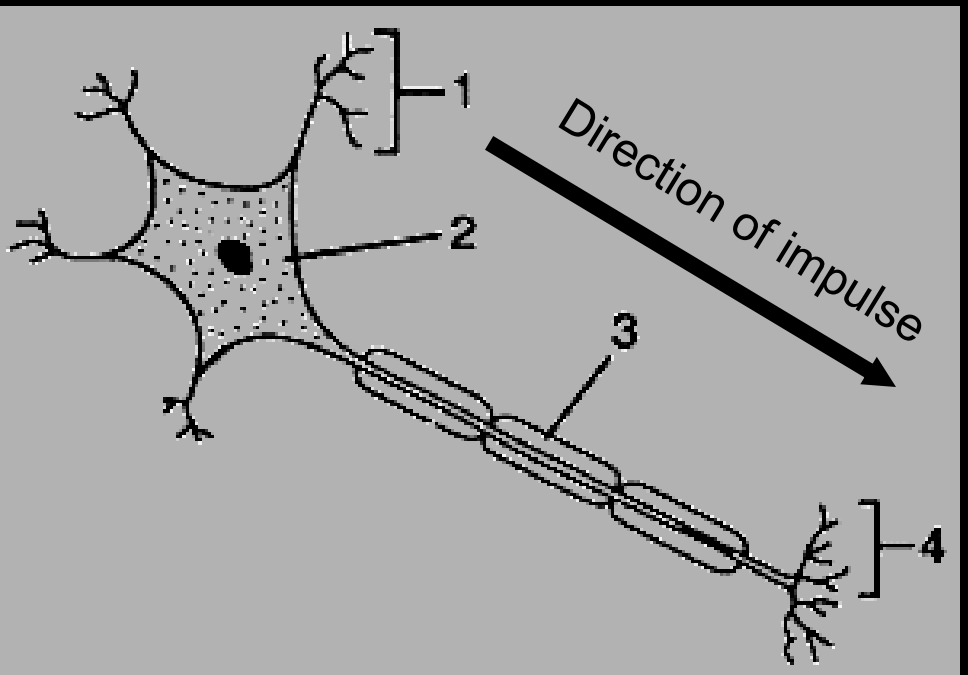
- The facts:
  - Cells: conduct electrical impulses
  - Generally are amitotic (no mitosis)
  - Extreme longevity
    - 70-80, sometimes 100 years
  - High metabolic rate
    - Don't live very long w/o oxygen
    - Require large amounts of glucose and oxygen
  - Contain several major regions
    - Cell body (Central portion) and various cellular processes……. → next slide!

Parts of a Neuron:

- 1. **Dendrite** = short, thin, branching extensions originating from cell body
  - Receive impulses from adjacent neurons or receptors
  - *Conduct info TO cell body*
- 2. **Cell Body** = part of neuron that contains cell membrane, nucleus, cytoplasm, and many organelles
  - New organelles: Nissl bodies w/ribosomes (sim 2 rER), neurofibrils, NO mitotic spindles

Parts of a Neuron (continued):

- 3. **Axon** = highly specialized area
  - AKA nerve fiber
  - One axon per neuron
  - Axons range in size: very short to lengthy
  - *conducts impulses AWAY from cell body*
  - *TO adjacent neuron, muscle, organ, gland, etc.*



Parts of a Neuron (continued):

3. **Axon** = (continued)
   - side branches: collaterals
   - Of PNS: very long, enclosed with Schwann cells
     - Wound tightly around axon
     - Form multiple layers of plasma membrane
     - Rich in fat, provides a high insulation and nutrition value for axon
       - White fatty insulation barrier: myelin sheath
       - Outer layer of myelin sheath: neurilemma
       - Axon gaps: nodes of Ranvier

Parts of a Neuron (continued):

- 3. **Axon** =

Myelinated = fast (130m/s-300mph), longer in length
white matter

Unmyelinated = slow (<10m/s), shorter in length
gray matter

*groups of fibers

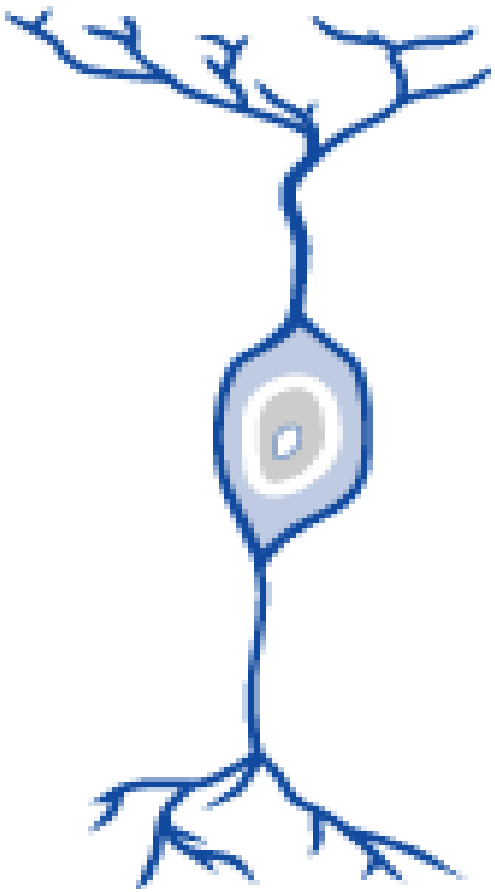
Draw:

- Figure 9-4 in notes
- Label the following structures:
  - Cell body
  - Dendrites
  - Axon
  - Nucleus
  - Schwann cells
  - myelin sheath
  - nodes of ranvier
  - collateral branch
  - Then, draw arrow showing dxn impulse travels

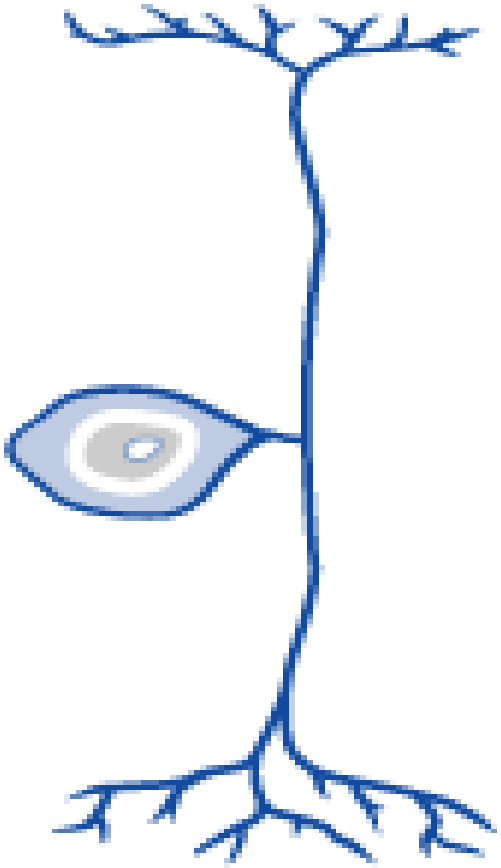
Neurons come in many shapes and sizes…

- Structural differences: (3) types
  - **Multipolar neuron**
  - **Bipolar neuron**
  - **Unipolar neuron**
- Functional differences: (3) types
  - **Sensory neurons (afferent)** *uni
  - **Association neurons (interneurons)** *multi
  - **Motor neurons (efferent)** *multi

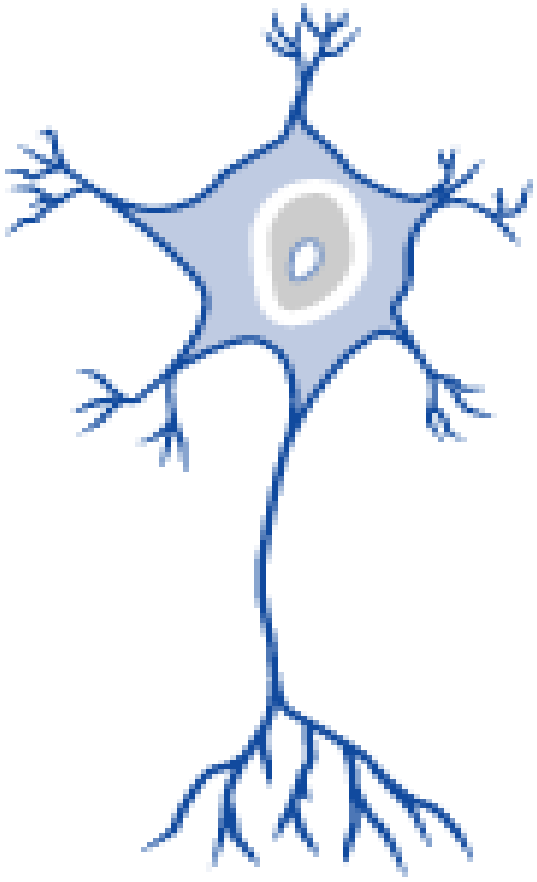
Basic Neuron Types



Bipolar
(Interneuron)

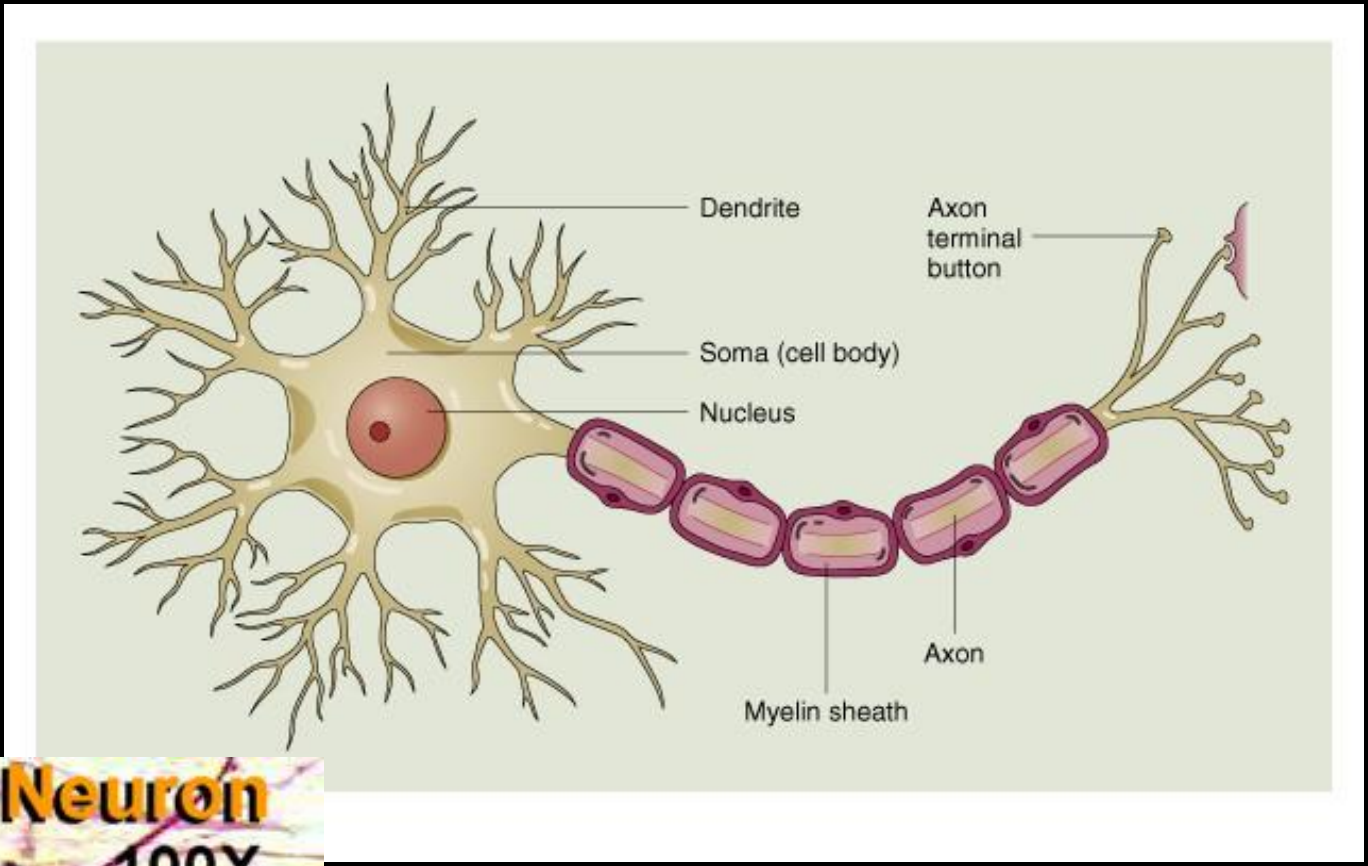


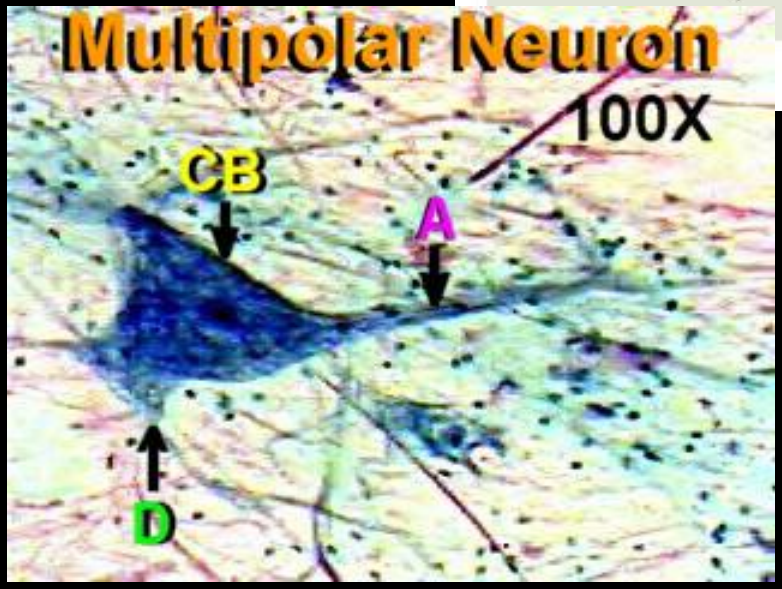
Unipolar
(Sensory Neuron)



Multipolar
(Motoneuron)

Py


Dendrite
Axon terminal button
Soma (cell body)
Nucleus
Axon
Myelin sheath


Multipolar Neuron
100X
CB
A
D

Read:

- Internet article
- Neuron regeneration article

Neuron Regeneration:

- A neuron that is destroyed is permanently lost
- A damaged neuron can be repaired, restoring at least partial function
  - Nissl bodies regenerate cytoplasmic material
  - Schwann cells nourish/protect axon

Nerve Injuries:

- Sensory nerves signal pain, pressure, temperature
- Individual axon (nerve fiber) carries either motor OR sensory
- Nerves are made up of sensory and motor nerve fibers
- Nerve can be damaged by pressure, stretching, cutting
- Nerve can be damaged with or w/o disrupting insulating cover
- When nerve fiber broken, end of fiber farthest from brain dies

Nerve Injuries:

- If insulation not cut, nerve fibers can grow back to reach muscle or sensory receptor
- Neuroma= nerve scar, results from nerve and insulations being cut yet growing nerve fibers grow into a ball
- To fix a cut nerve: insulation is sewn together so nerve fibers can grow down empty tube
- Nerve fibers begin to grow after 3-4 weeks
- Grow at a rate of 1”/month

Chapter 9 (p.245-252

RMP & ACTION POTENTIAL

Resting Potential

Not contracting

Not sending impulse

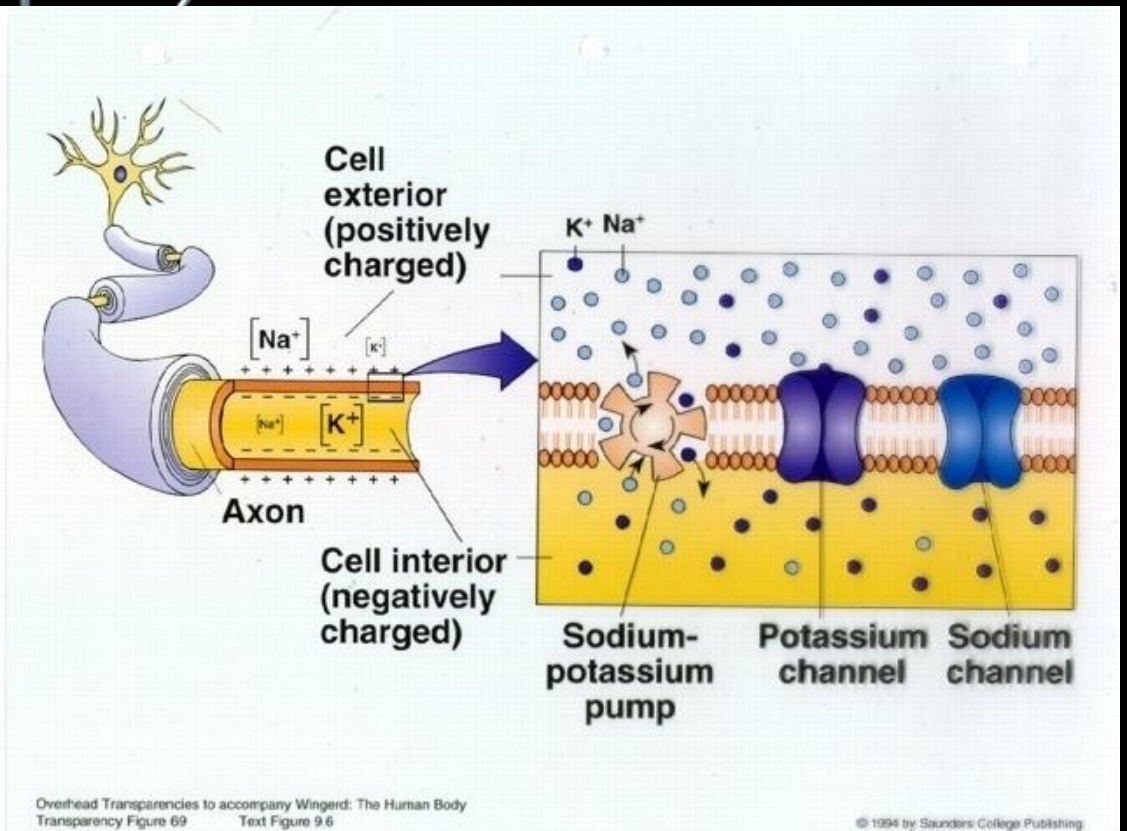
Muscle cells or neurons

Many cells exhibit resting membrane potentials but only muscle & nerve cells are capable of action

Action Potential

Contracting

Sending an impulse

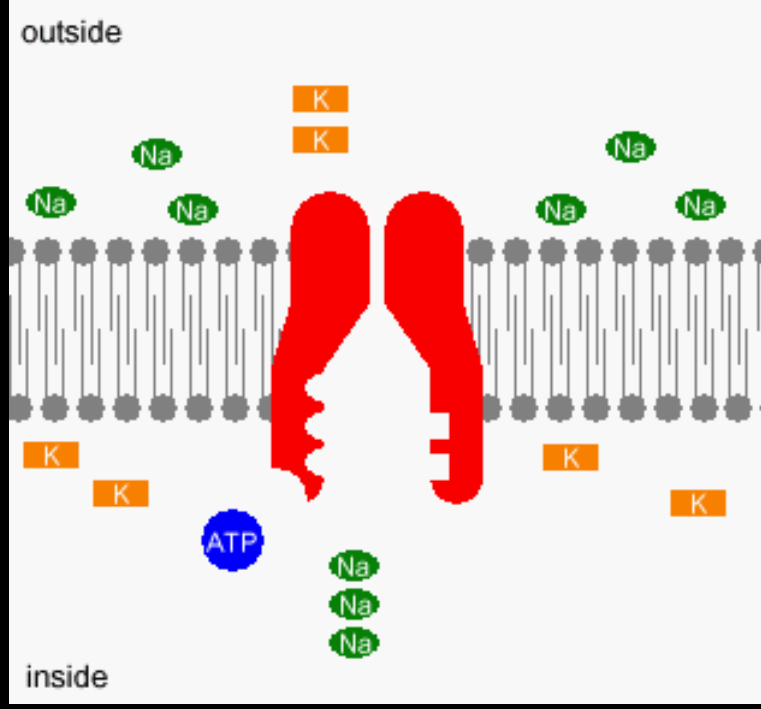


Overhead Transparencies to accompany Wingerd: The Human Body
Transparency Figure 69 Text Figure 9.6

Potential (uneven distribution of ions) – separation of charges between 2 pts measured in volts

ACTION POTENTIAL / NERVE IMPULSE

If conditions were ideal: equal distribution of ions across mem. BUT: they aren't → due to…



Cause of Resting Potential:

1. ***Sodium-potassium pump*** – uses energy to unevenly transport ions (**3 net Na^+ out and 2 K^+ into**) the cell

2. Membrane is more permeable to K^+, therefore K^+ leaks back out faster than Na^+ leaks in

All results in the outside of the membrane having a positive charge and the inside having a negative charge

Resting membrane potential

Na^+ Na^+ Na^+ Na^+ Na^+

\+ + + + + + + + + + + + + + +

- proteins - - - K^+ - - - K^+ - - - - K^+ - Cl^-

Polarized *state*

**uneven distribution of ions* *= resting membrane potential*

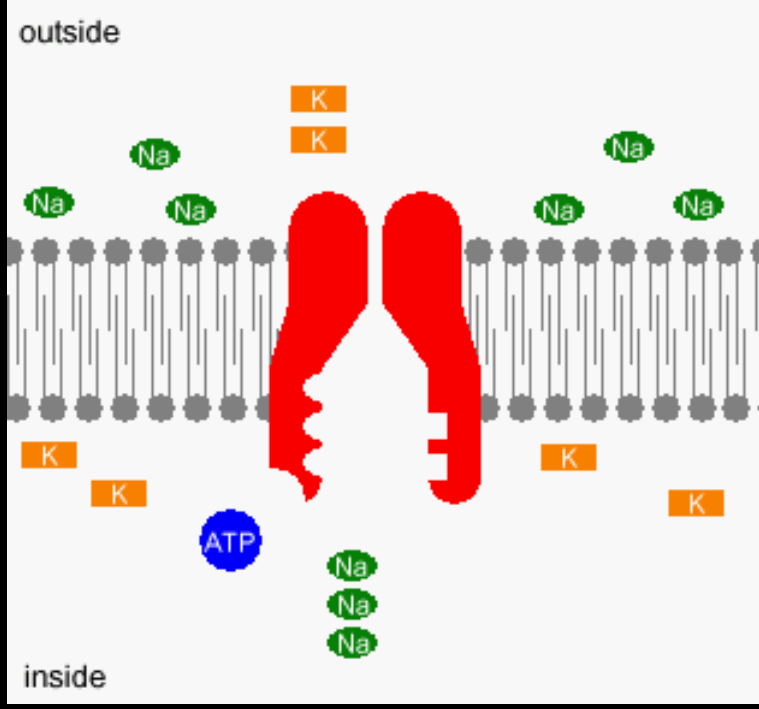
Allowing cells to respond to changes in the environment = ***excitability***

Na^+ Na^+ Na^+

- - - - - - - - - - - - - - - - - - - -

+ + + + + + + + + + + +

Depolarized state



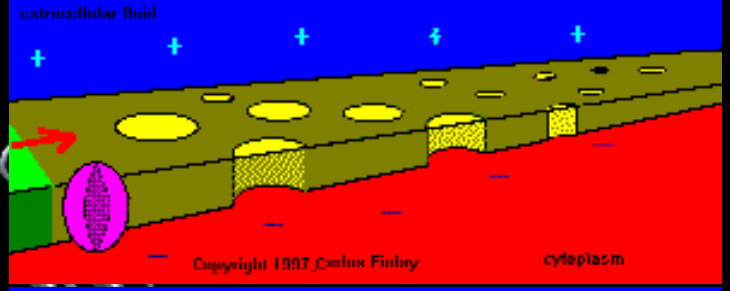
Stimulus reaches threshold and the cell membrane becomes permeable to Na^+. Then, Na^+ rush into the cell from high to low concentration via diffusion.

Na^+ Na^+ Na^+ Na^+ Na^+

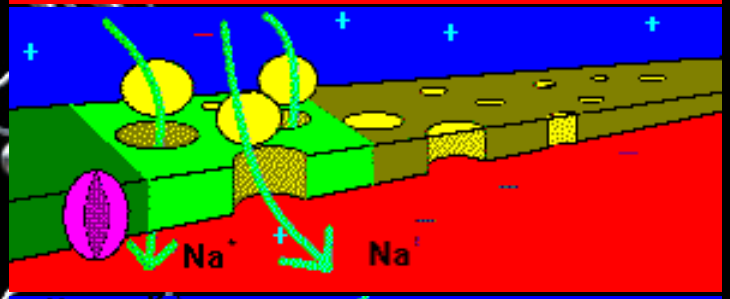
+ + + + + + + + + + + + + + +

- - - K^+ - - - K^+ - - - - K^+ -

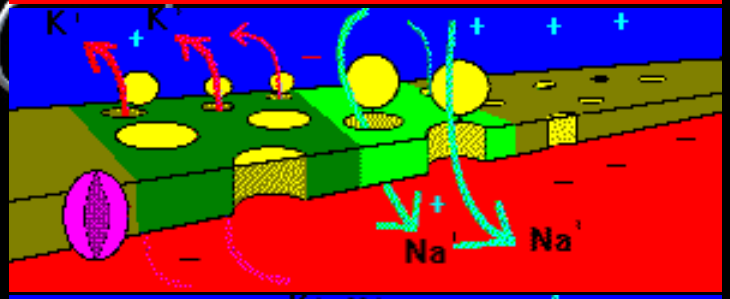
Polarized state



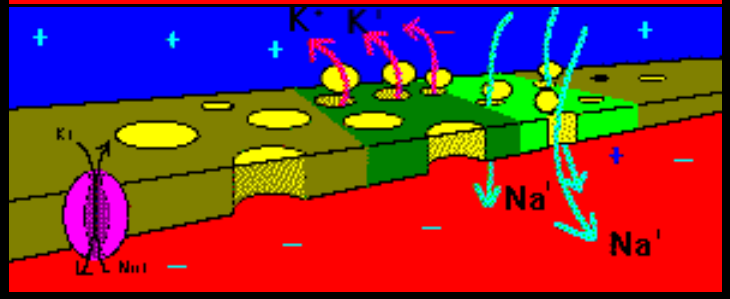
At rest, the inside of the neuron is slightly negative due to a higher concentration of positively charged sodium ions outside the neuron.



When stimulated past threshold, sodium channels open and sodium rushes into the axon, causing a region of positive charge within the axon.

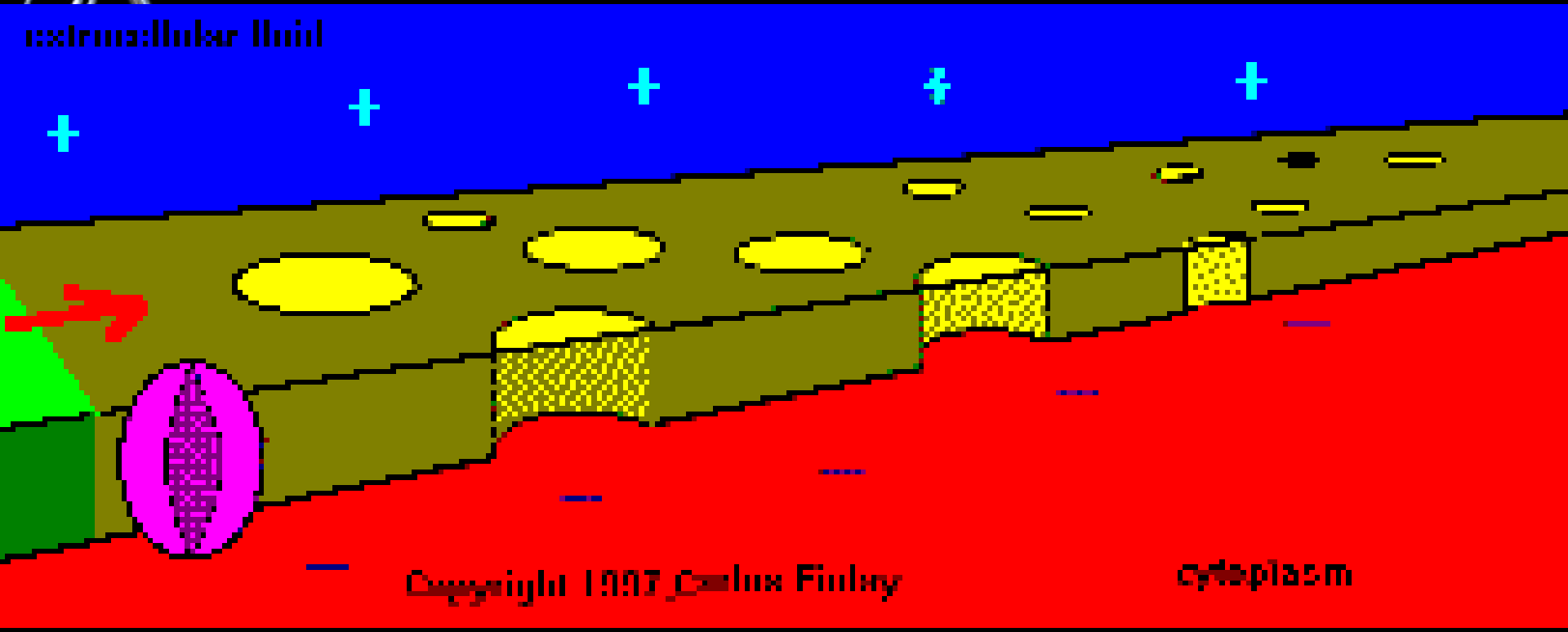


The region of positive charge causes nearby sodium channels to open. Just after the sodium channels close, the potassium channels open wide, and potassium exits the axon.



This process continues as a chain-reaction along the axon. The influx of sodium depolarizes the axon, and the outflow of potassium repolarizes the axon.

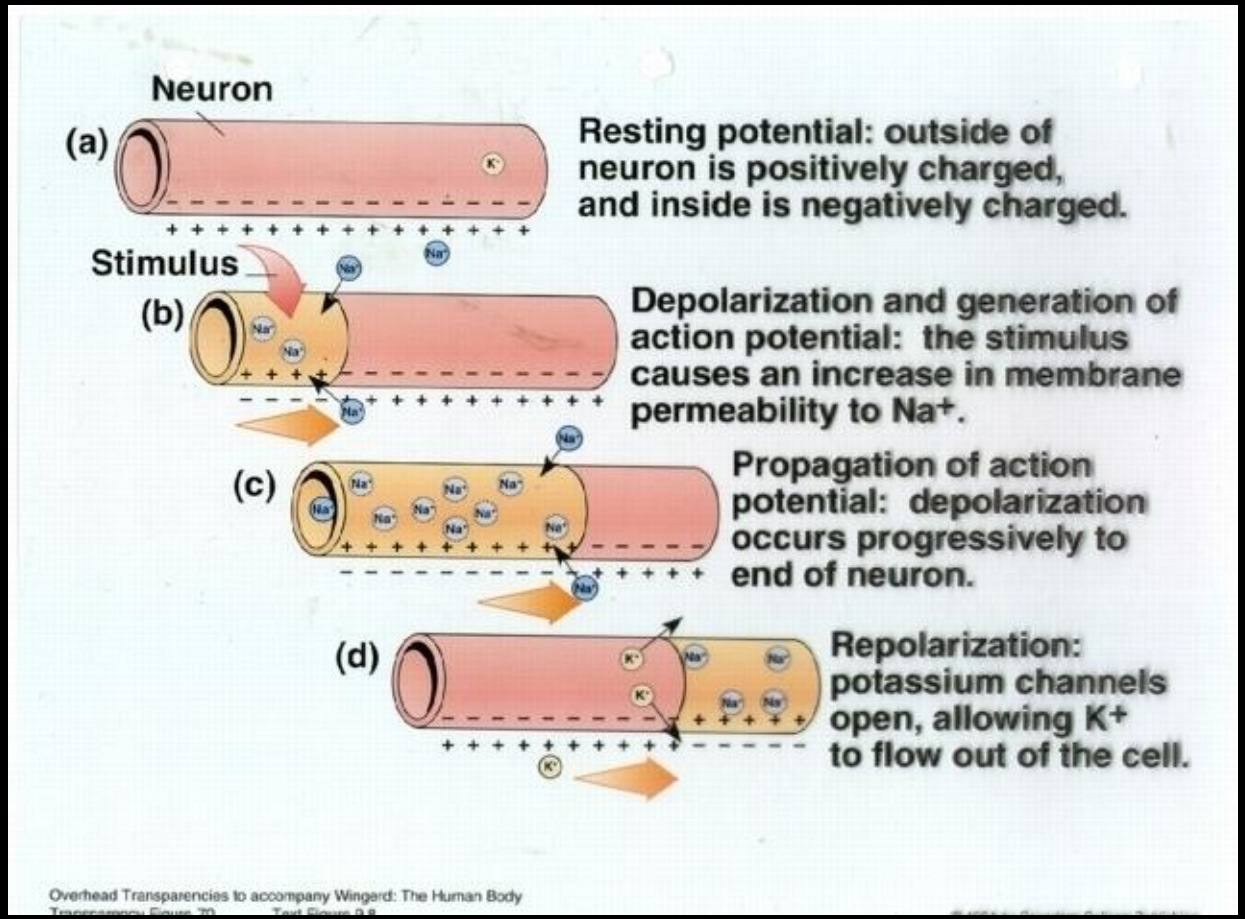
The sodium/potassium pump restores the resting concentrations of sodium and potassium ions



http://www.youtube.com/watch?feature=player_detailpage&v=U0NpTdge3aw

Action potential by MediMationz

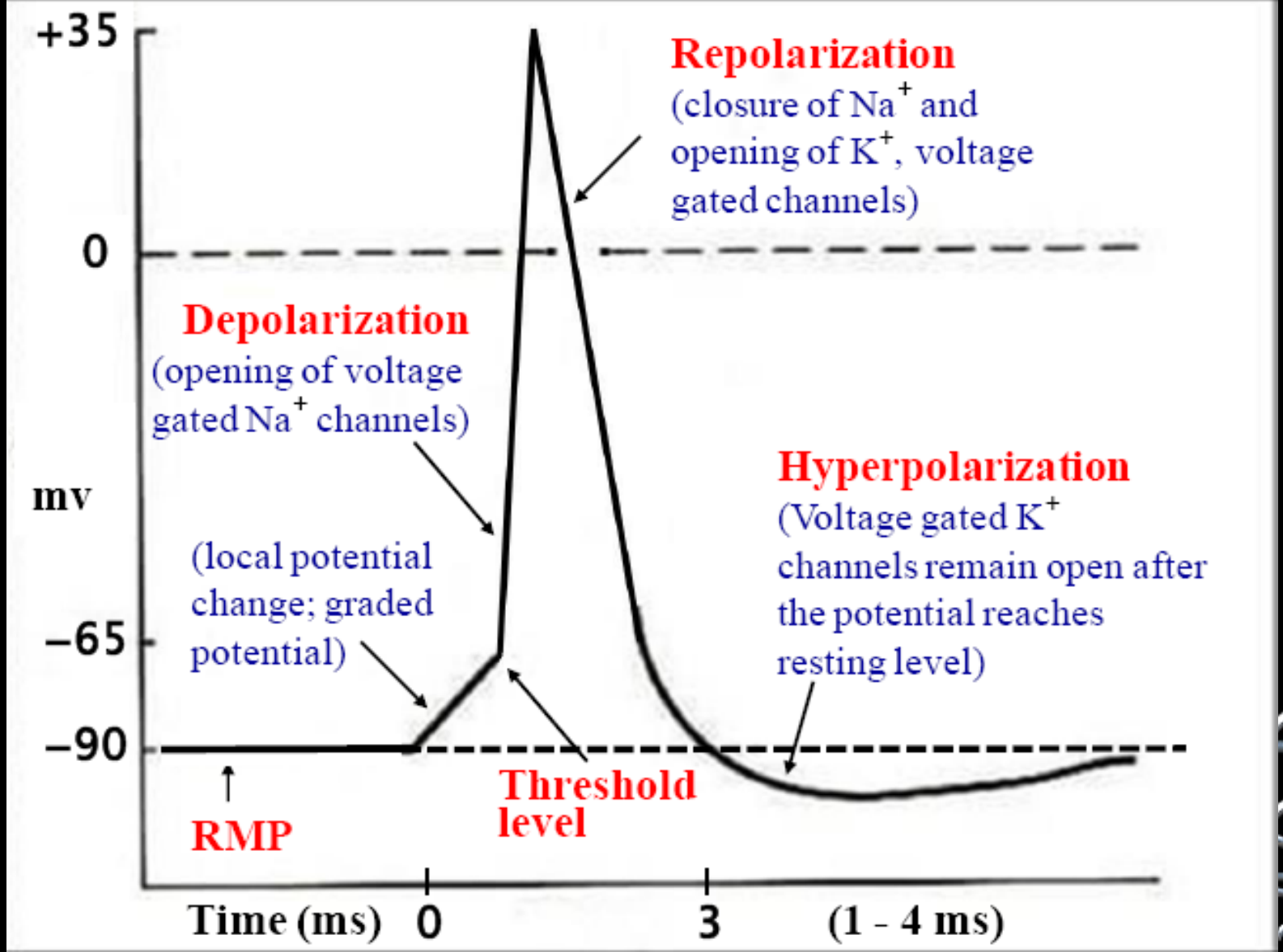
Homework: nerve signals worksheet w/questions



http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter14/animation__the_nerve_impulse.html

http://mcat-review.org/specialized-eukaryotic-cells-tissues.php

Action potential



STIMULUS

Ions changed

Resting Membrane Potential

- no contraction
- no impulse being sent

Action Potential

- contraction
- impulse

Na+ + + + +

+ K^+ - - + - - -

+ + + + + + +

Polarized

Na+ - - - - - -

- + + + + + - - - - - -

Depolarized

Repolarized

– back to resting

Na^+ / K^+ pump

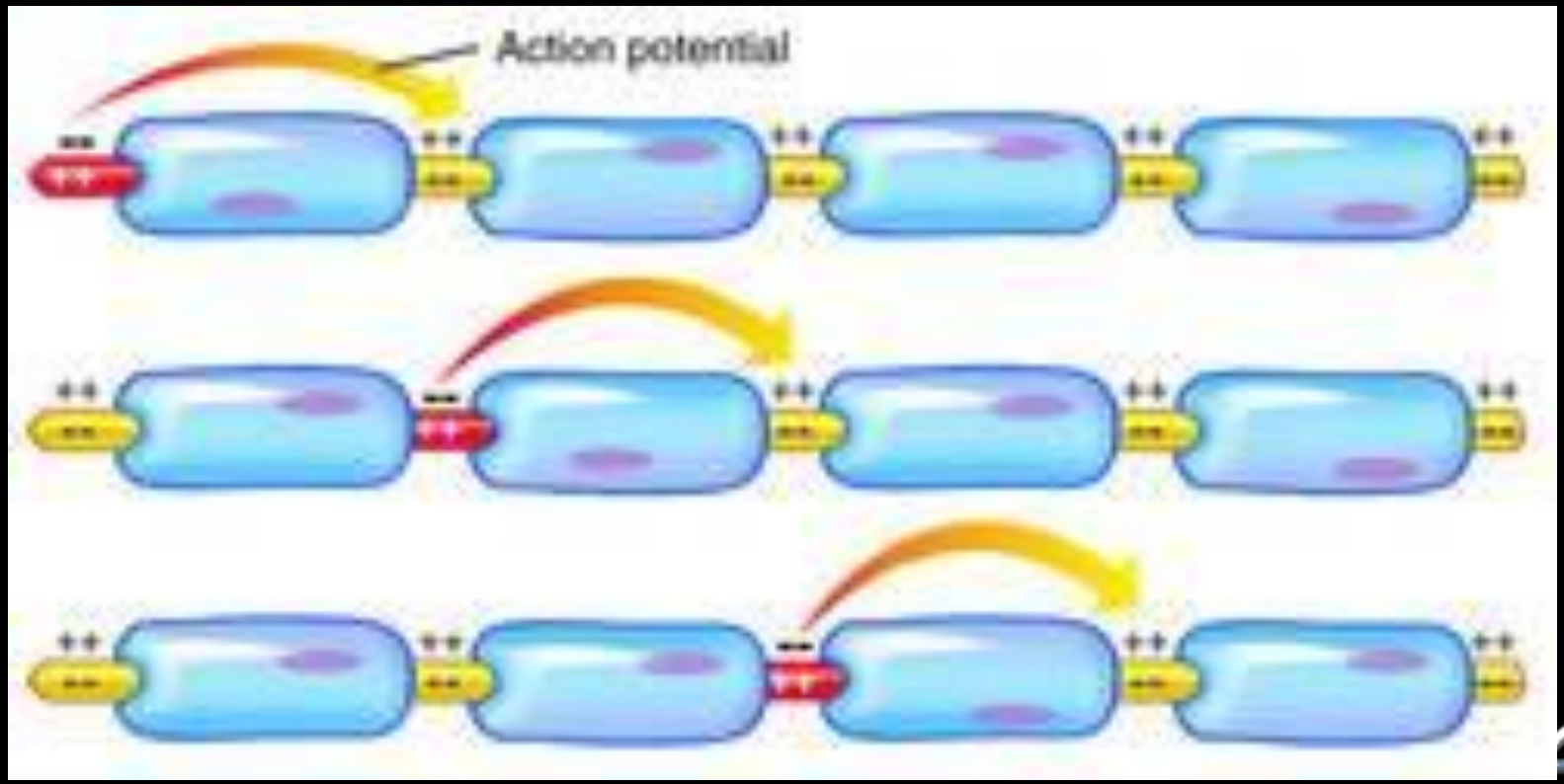
Membrane is more permeable to K^+ than Na^+

Cl- inside cell, (-) proteins inside

Speed of Nerve Impulses

- Rapid, yet varies on presence/ absence of myelin sheath
- Myelin sheath blocks continuous flow of ions
  - Saltatory conduction
- Jumps great distances → 2-3mm
- Great speed of conduction → 130m/s vs. 10m/s

Saltatory conduction – the jumping of the impulse from one node of Ranvier to another



All-or-None Response

- Nerve impulses occur in all-or-none fashion
- If stimulus strong enough → impulse conducted along entire length of neuron @ max strength
  - Minimum strength of stimulus required to cause AP = **threshold stimulus**
  - Increasing strength beyond level→ no effect!
  - Stimulus weaker than level needed = **subthreshold** → no effect (no impulse)!
  - Series of subthreshold stimuli→ cumulative effect leading to AP= **summation**

Impulse Transmission – cell to cell

- Junction btwn adjacent neurons = synapse
- Impulses travel over synapses to travel neuron to neuron

- Nerve impulse arrives @ presynaptic neuron (axon terminal)
  - Contains synaptic vesicles
  - Contains neurotransmitters (NT): chemicals to relay impulses across synapse
- Calcium ion channel opens (allows vesicles 2 diffuse, NT release)

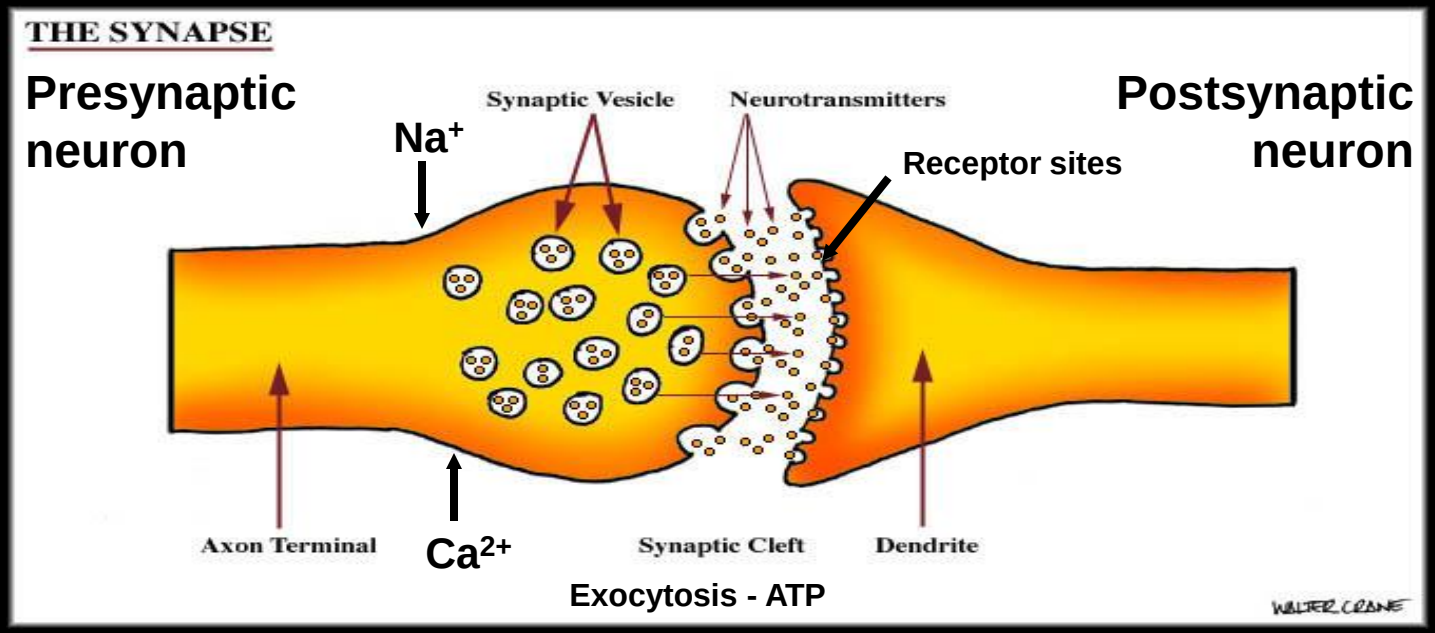
Impulse Transmission – cell to cell

- NT released (exocytosis) in synaptic cleft -- diffuse from neuron to neuron
- NT bind to receptors on postsynaptic neuron → impulse received
- postsynaptic channels open – AP continues

- ***RESULT***: **excitation** OR **inhibition**
  - Brief effect/response

Impulse transmission from cell to cell

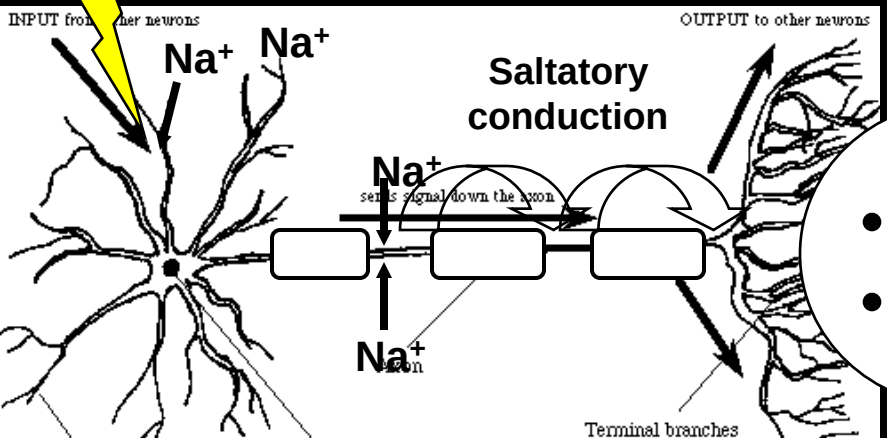
http://highered.mcgraw-hill.com/sites/0072495855/student_view0/chapter14/animation__chemical_synapse__quiz_1_.html

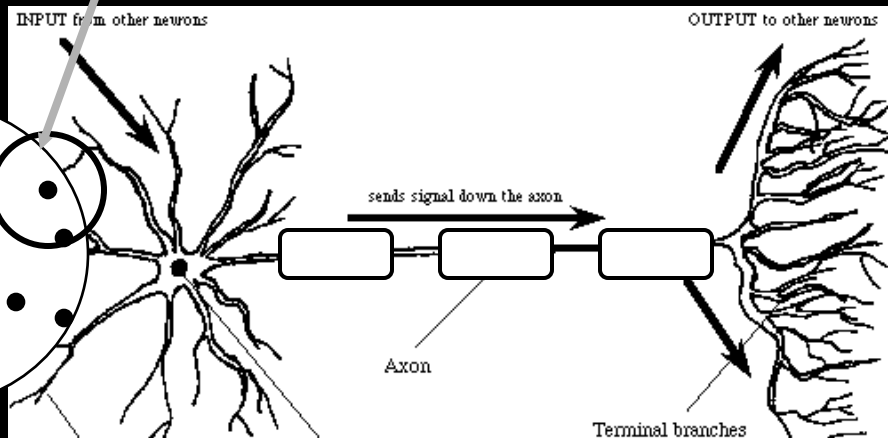


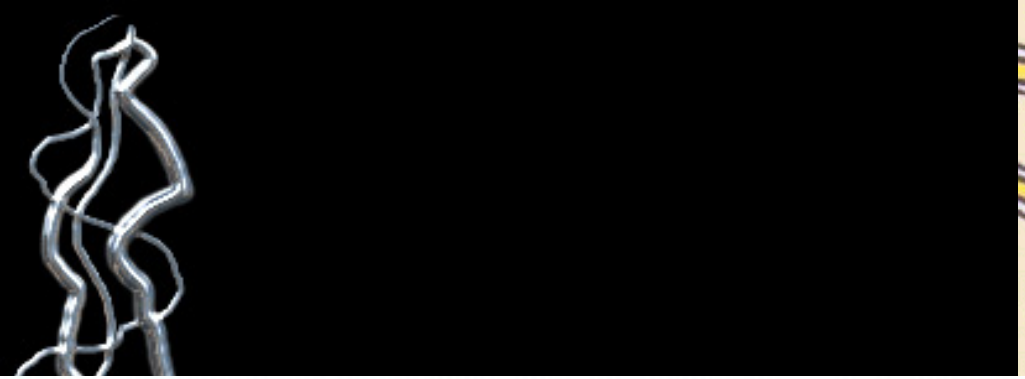
STIMULUS

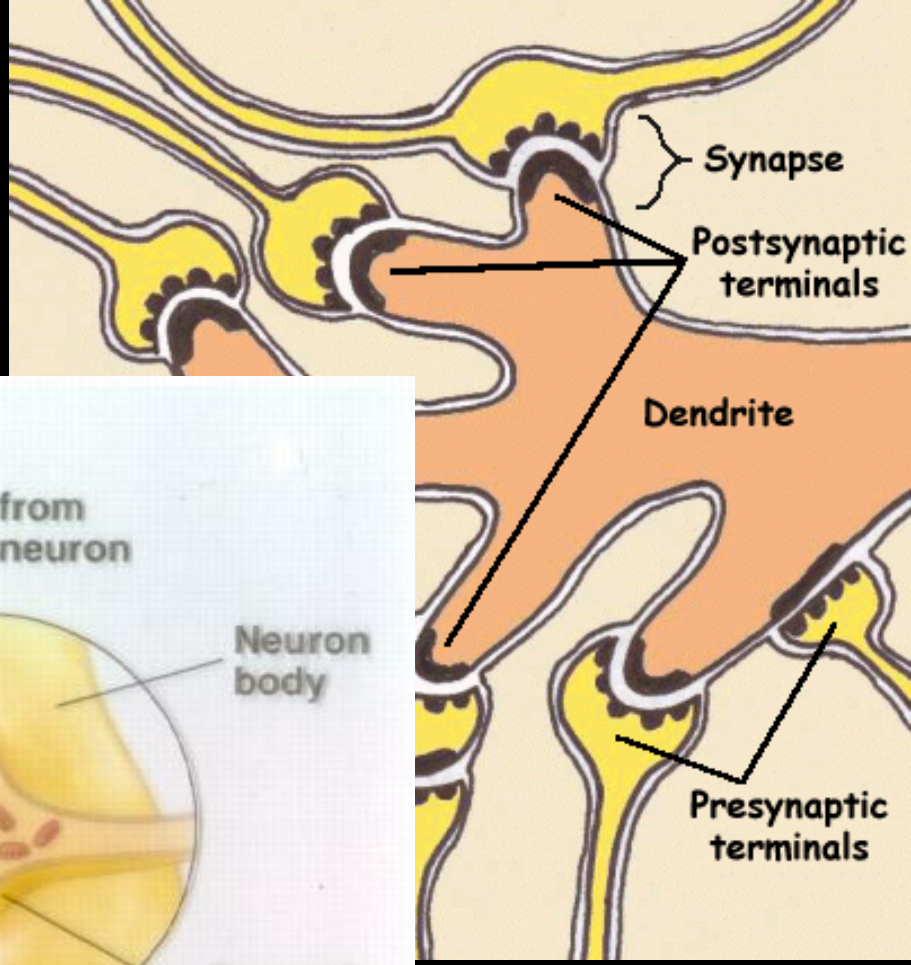
Synapse - gap

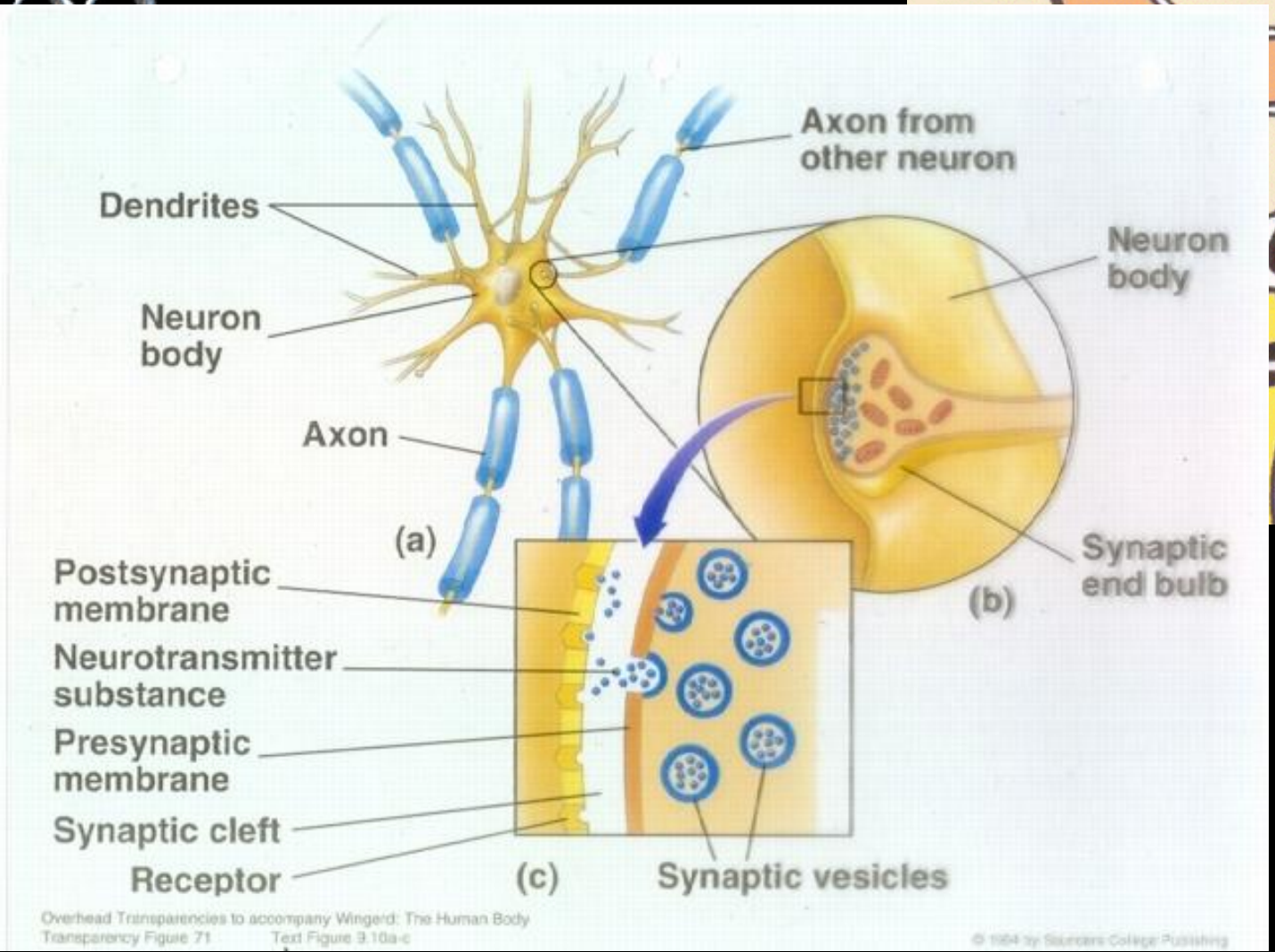
Receptor site: think lock-n-key

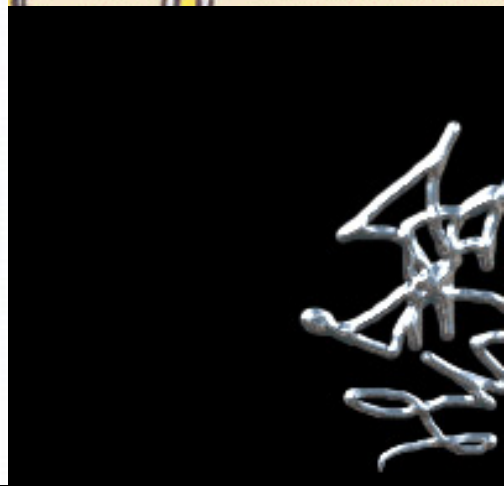






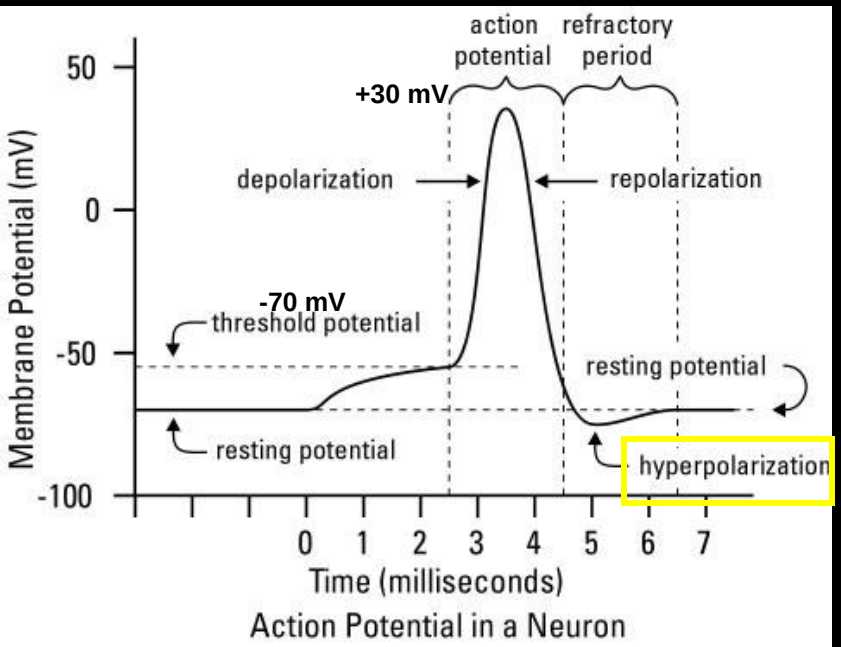

Synapse
Postsynaptic terminals
Dendrite
Presynaptic terminals


Axon from other neuron
Dendrites
Neuron body
Axon
(a)
Neuron body
Synaptic end bulb
(b)
Postsynaptic membrane
Neurotransmitter substance
Presynaptic membrane
Synaptic cleft
Receptor
(c)
Synaptic vesicles
Overhead Transparencies to accompany Wingerd: The Human Body
Transparency Figure 71
Text Figure 9.10a-c



Neurotransmitters

- **Excitatory** – continues impulse / message
  - Na^+ channels open
  - Na^+ flows in
- Examples…
  - dopamine, seratonin, AcH, etc…
    - Antidepressants work on keeping these in the synapse longer

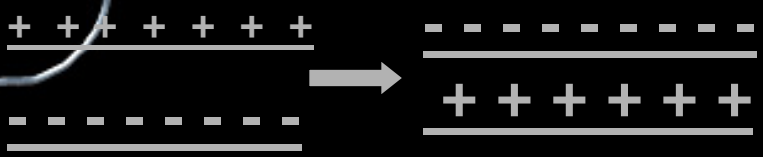


Action Potential in a Neuron

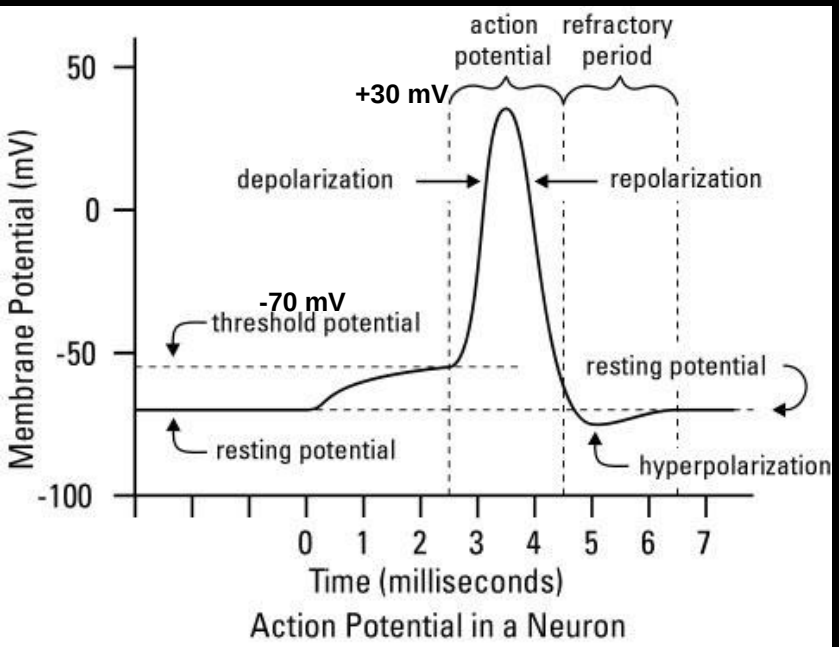
- **Inhibitory** – prevents impulse / message
  - K^+ channels open
  - Na^+ remain closed
  - Cl^- open inside
- Examples…
  - GABA, endorphins, enkephalins
    - Our bodies natural painkillers
- Hyperpolarizes (below this level)
  - K^+ channels open more
  - Na^+ remain closed
  - Cl^- open even more inside

Neurotransmitters (proteins – a.a.)

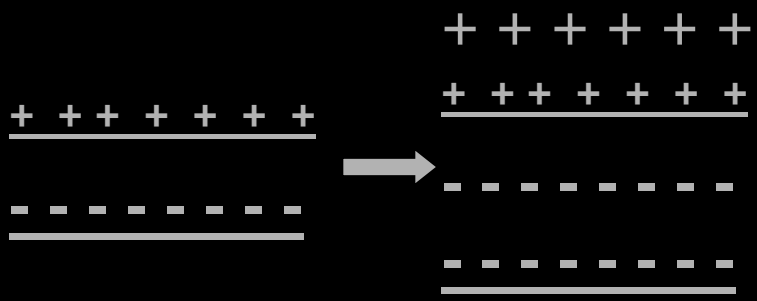
- **Excitatory** – continues impulse / message
  - Na^+ channels open
- Polarized ➡ Depolarized
- Resting ➡ Action



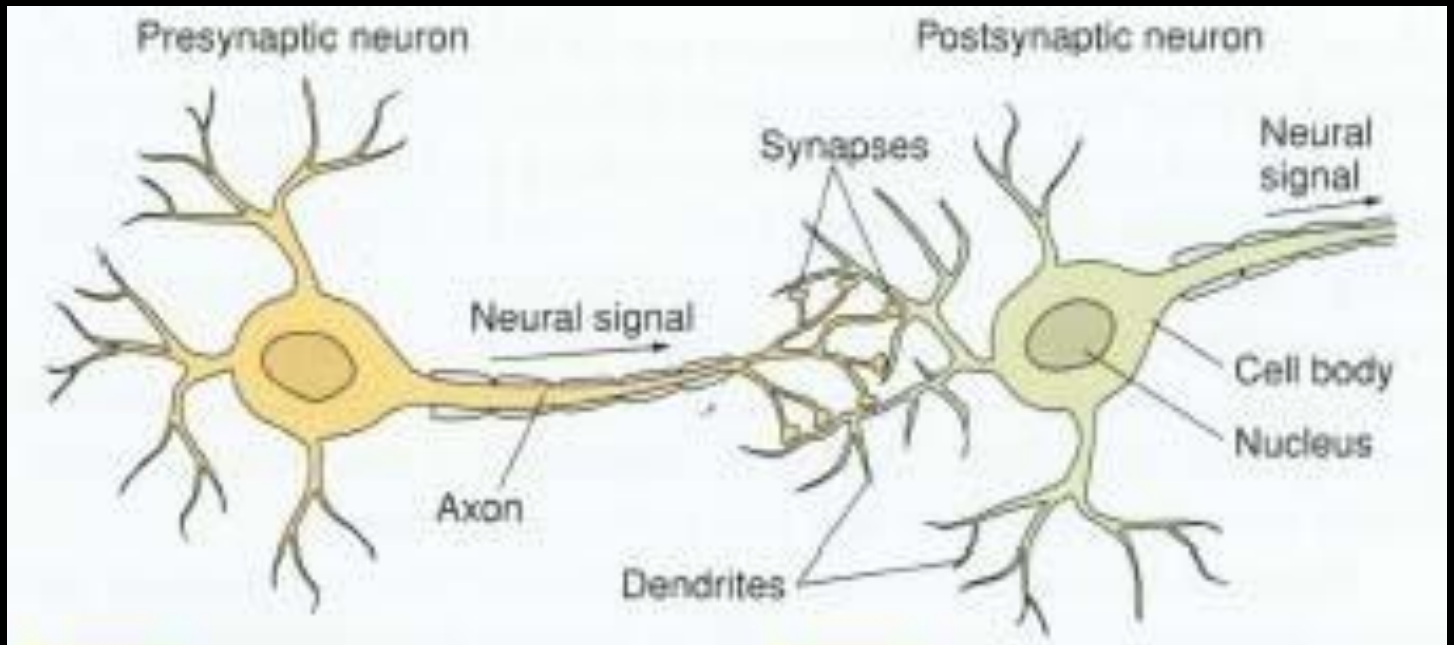
- **Inhibitory** – prevents impulse / message
  - K^+ channels open
  - Na^+ remain closed
  - Cl^- open inside
- Hyperpolarizes (below this level)
  - K^+ channels open more
  - Na^+ remain closed
  - Cl^- open even more inside
- Polarized ➡ Hyperpolarized
- Resting ➡ Resting

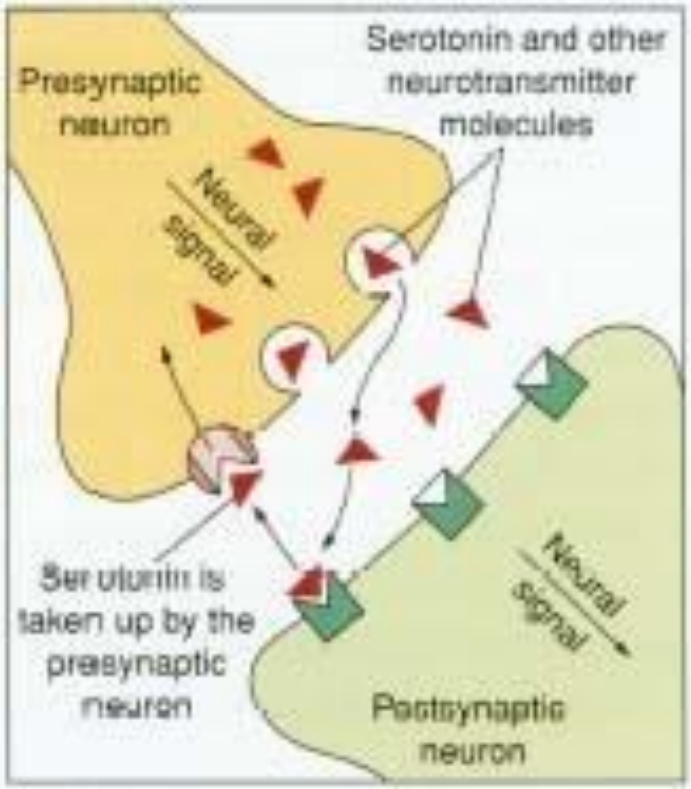


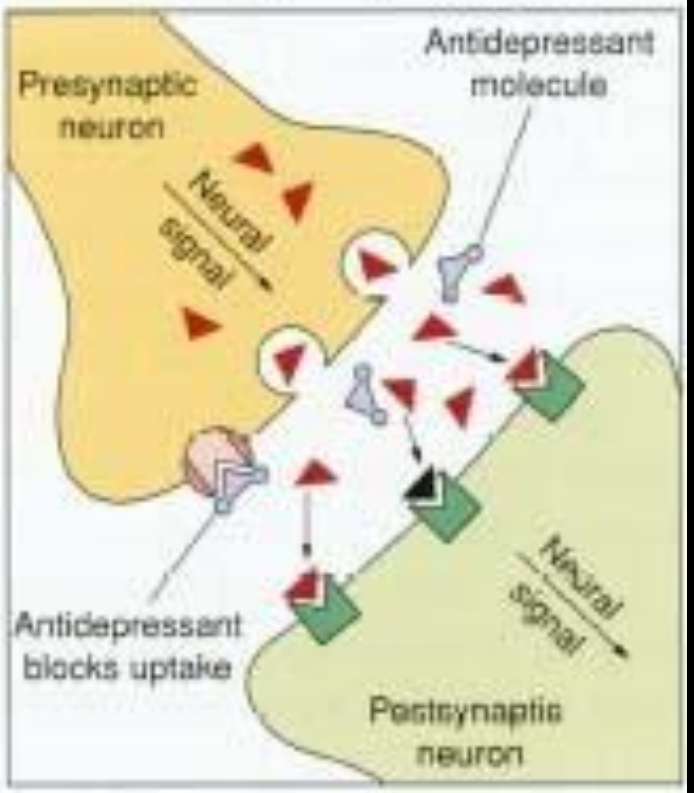
Action Potential in a Neuron



EXCITATORY



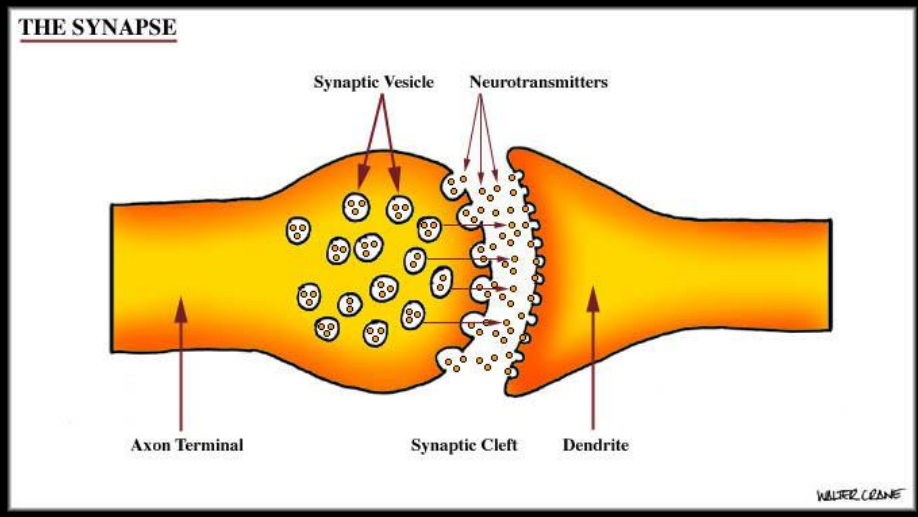




INHIBATORY

Video clip:
synaptic transmission
cell to cell

3 Ways Neurotransmitters are removed from the synapse

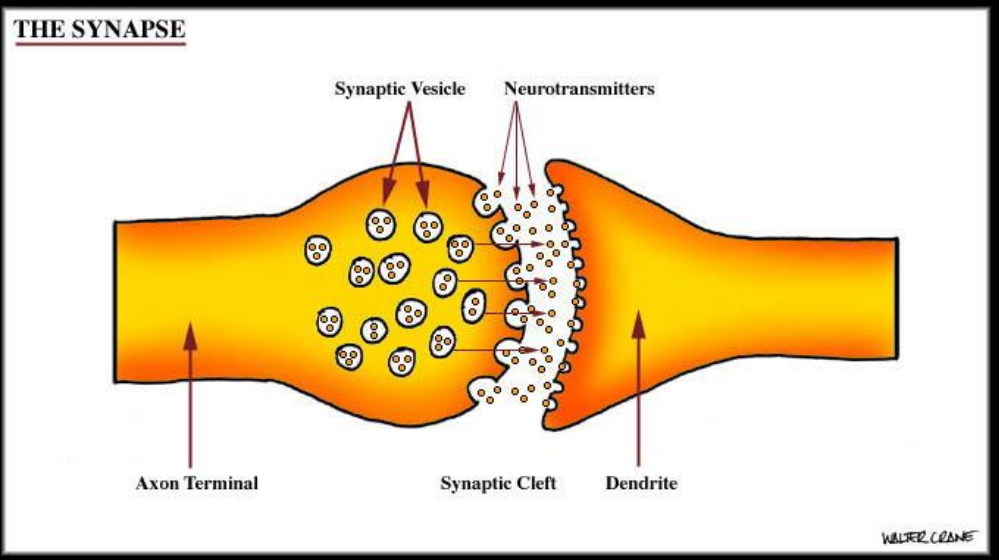


1. Diffusion
2. Enzymes
   - Proteins – a.a. provide specificity (lock-n-key)
     - EX. A → T
     - EX. Lactose → lactase
     - Acetylcholine - Acetylcholinasterase
3. Neurotransmitter Transporters – “The Bus”
   - Reabsorbed by the sending neuron or broken down chemically in synaptic cleft

Ways to Chemically Modify Synaptic Transmission

1. Increase/Decrease (Inc/Dec) synthesis of neurotransmitters
2. Inc/Dec release of neurotransmitters
3. Inc/Dec removal of neurotransmitters (enzyme… bus)
4. Inc/Dec activation of receptor site

**Excitatory or Inhibitory neurotransmitters



EX. Cocaine use
- chemically similar to dopamine –
  - (excitatory neurotransmitter in the brain)
- "bus" affected

Agonist – an agent that enhances synaptic transmission or mimics the effect of natural neurotransmitters

Antagonist – an agent that blocks the action of a neurotransmitter

Chemicals & their Influence the Nervous System

- Neurotransmitters:
  - synthesized in cytoplasm of neurons
  - OR introduced into body
- Used to alter normal fxn or correct deficiency
- Types of chemicals: stimulants, depressants, antidepressants, psychedelics, analgesics, antianxiety

Chemicals & their Influence the Nervous System

- Stimulants → increase synaptic transmission
- Produce: increased energy, elevate mood, decrease appetite, increase irritability/anxiety
- Example: caffeine, cocaine, nicotine, amphetamines

Chemicals & their Influence the Nervous System

- Depression→ inhibition, block NT receptors (norepinephrine, acetylcholine)
- Produce: risk of extreme depression
- Example: sleeping pills, tranquilizers, ethyl alcohol (whiskey, beer, wine), opiates (herion, morphine, codeine)

Chemicals & their Influence the Nervous System

- Analgesics→ interfere with transmission of pain impulses
- Produce: relief of pain
- Example: asprin, acetominophen (tylenol), ibuprofen (advil)

Chemicals & their Influence the Nervous System

- Antidepressants→ increase level of norepinephrine
- Produce: reversal of psychological depression

- Psychedelic drugs→ affects role of NT serotonin
- Produce: altered perception/mood, hallucinations
- Ex: marijuana, LSD

Project: How does “It” affect communication?

What neurotransmitter? Excitatory or Inhibitory?

Affects synapse by:

1. Synthesis of neurotransmitters
2. Release of neurotransmitters
3. Reuptake
4. Activation of receptor site

--What is supposed to occur? How does “It” alter communication?
--Where in the body is the communication taking place? Provide visual.
--Does your explanation make sense to explain the feeling achieved, symptoms of disease, etc?
--If it’s a drug, picture before drug, picture after drug.
--If it’s a disease, picture without disease and one with the disease.
Go through you’re A&P terms for this unit, and what terms could be correctly used?