Ch. 2, part 2: Cells & Their Environment

This PowerPoint has been updated 5/29/23

OBJECTIVES:

1. Understand cell membrane permeability
2. To recognize different types of cellular transport (passive vs active)
3. To understand membrane potential and action potentials

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1. Types of Cell Membranes

- **Freely Permeable Membrane** = allows gasses through with ease.
  (eg. For gases like O2, CO2)

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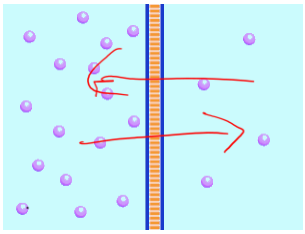
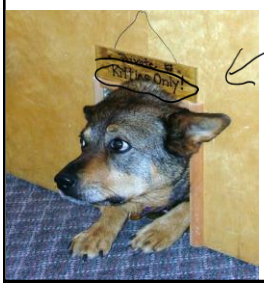


- **Selectively Permeable Membrane** = that allows small particles through, but not large ones.



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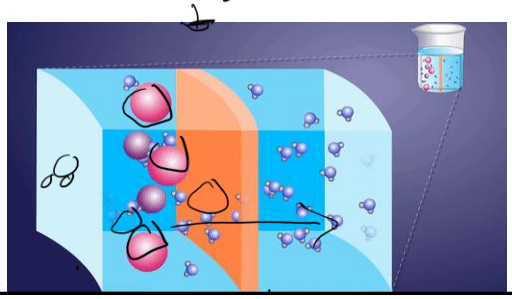

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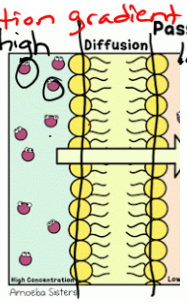
2. Types of Cellular Transport (how substances get across cell membrane)

1. **Passive transport =** movement of substances without need of ATP. Substances move from high to low concentration with their concentration gradient



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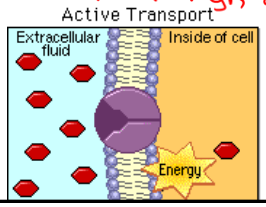
2. **Active transport =** movement of substances using ~~ATP~~ ATP

Substances move from low to high concentration, against the concentration gradient.



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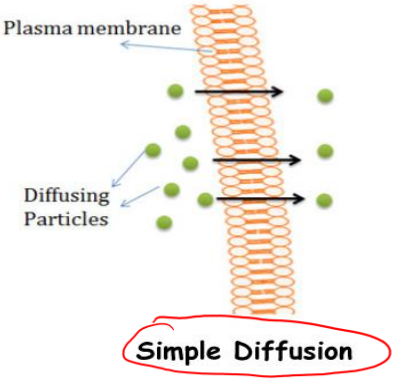
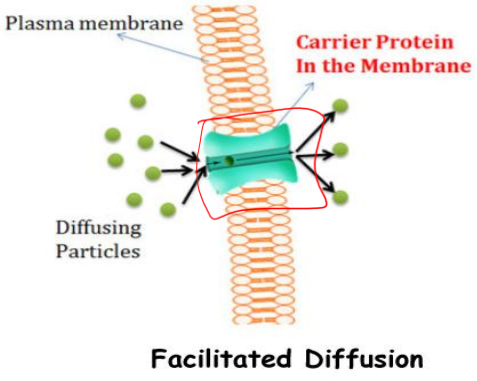
4 types of Passive Transport (Pg 16 Wiki Text)

1) Simple Diffusion (no protein carrier on cell)
2) Facilitated Diffusion (has protein carrier on cell)





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4 types of Passive Transport (Pg 16 Wiki Text)

1) Simple Diffusion

= movement of particles across membrane with no channels, no protein carriers, no receptors.

Click HERE for online GIF

ex.
gasses
O_2
CO_2

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Passive Transport (4 types):

1) Simple Diffusion

= movement of particles freely across membrane high to low concentration (with concentration gra
Ex. O2, CO2

2) Facilitated Diffusion (2 types!)

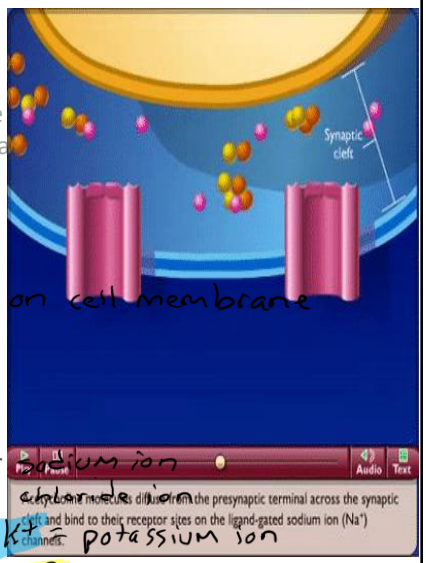
= 2a. facilitated diffusion with ion channels

(=

Ex: charged ions (Na+, Cl-, K+, Ca+2)

Na^+ = sodium ion
Cl^- = chloride ion
K^+ = potassium ion
Ca^{+2} = calcium ion.

Often involve a **neurotransmitter** binding to open the ion channel!



on cell membrane

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Facilitated Diffusion w/ion channels

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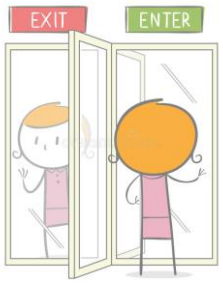
Passive Transport (4 types):

1) Simple Diffusion

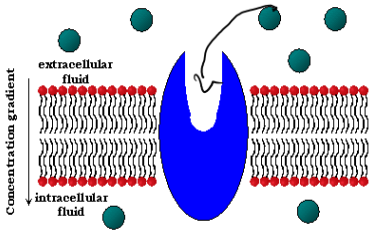
= movement of particles freely across membrane from high to low concentration (with concentration gradient)
Ex. O2, CO2



2) Facilitated Diffusion (2 types!)

2a. facilitated diffusion with ion channels

Facilitated Diffusion



2b) Facilitated Diffusion with Carriers

= particles bind to protein channel on cell to enter cell.

Facilitated Diffusion

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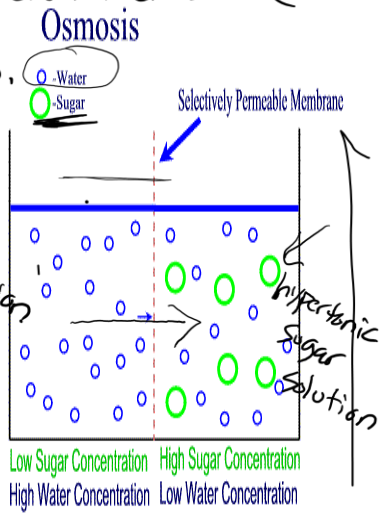
H_2

3) Osmosis = water moves across membrane from where water is in high to low concentration.

Water moves to side of membrane having higher solute (sugar, salt) concentration.



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Osmosis depends on "Tonicity"

Normal (isotonic) saline

high concentration

Hypertonic solution = solution having higher concentration of solutes than inside of a cell. Cell will lose water, & shrink.

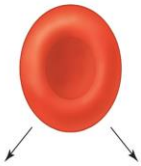
low concentration.

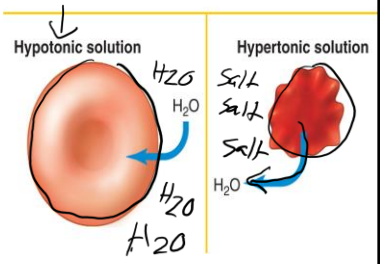
Hypotonic solution = solution having lower concentration of solutes than inside cell. Cell gains water, & swells & can lyse.

Isotonic solution = solution around a cell has same concentration of solutes as inside cell. cell stays same shape/size.

(ex. Normal or physiologic saline)

Isotonic solution





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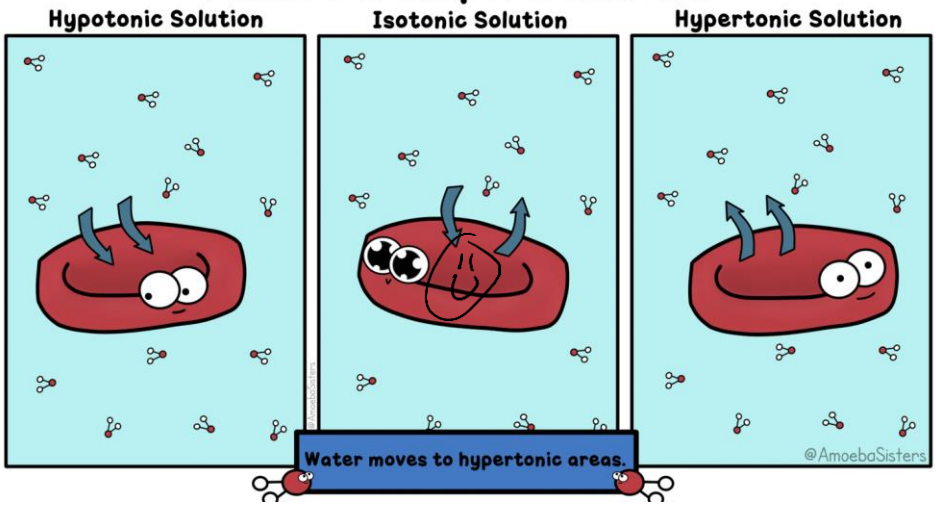
Passive Transport: Osmosis



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4) Filtration (or "dialysis")

= movement of fluid & particles across membrane with fluid pressure. (ex. arterial blood pressure)

Ex. **Filtration** of solutes through glomerulus of kidney nephron based on arterial blood pressure entering nephron.

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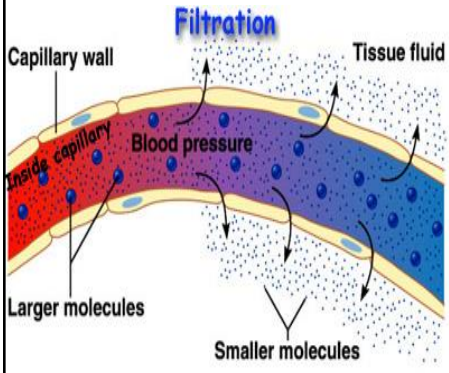

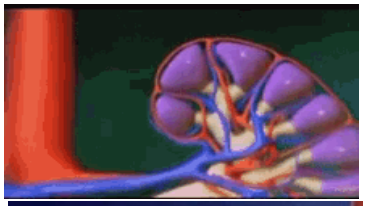

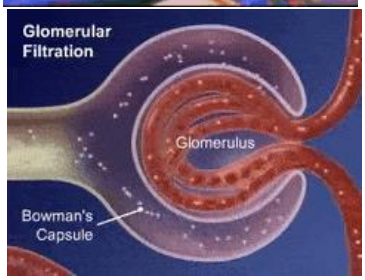

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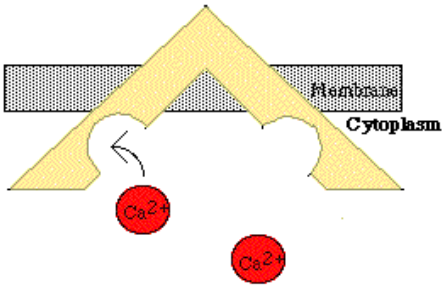
2. Active Transport Pg 17 Wiki text

a) Primary Active Transport = movement of ions with a pump fueled by ATP.

i) Calcium (Ca+2) Pump from low to high concentration
Ex. important in muscles (skeletal, smooth, cardiac)



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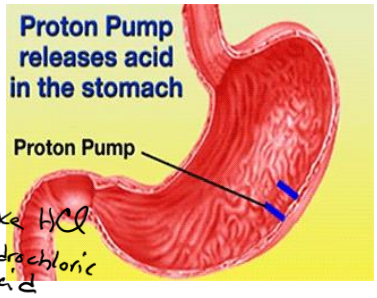

ii) Hydrogen (H+) Pump

important ex. H^+ pumps in stomach → to make HCl hydrochloric acid

Ex. Parietal cells of stomach have H+ pumps. *Nexium®* targets these cells for those with GERD.

gastroesophageal reflux disease – acid from stomach backs up into esophagus.

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2. Active Transport Pg 17 Wiki text

a) **Primary Active Transport =** movement of ions with a pump fueled by ATP.

i) Calcium (Ca+2) Pump

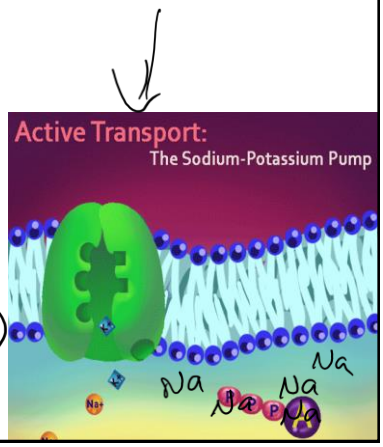
ii) Hydrogen (H+) Pump

Ex. Parietal cells of stomach have H+ pumps. *Nexium®* targets these cells for those with GERD.

iii) Sodium – Potassium (Na+/K+) Pump

To help a cell rest, this pump pumps 3 Na^+ out of cell and pumps 2 K^+ into cell (restores cell resting membrane potential)

Click HERE for online GIF. Click **HERE** for video showing the Na+/K+ pump.



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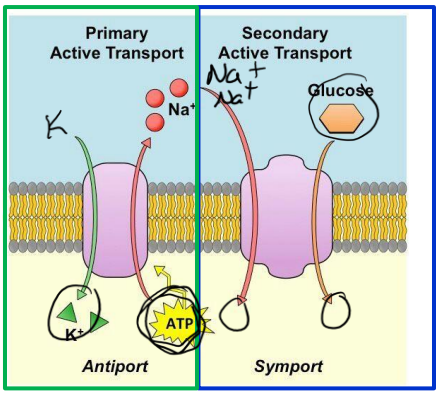
b) Secondary Active Transport: Coupled transport

i) Co-transport ("symport") = Energy gained from passive transport of one ion fuels the active transport of another ion ***in the same direction***.

Ex. Passive transport of Na+ with its concentration gradient helps fuel the active transport of glucose against its concentration gradient.



ii) Counter-transport ("antiport") = Energy gained from passive transport of one ion fuels the active transport of another ion ***in the opposite direction***.

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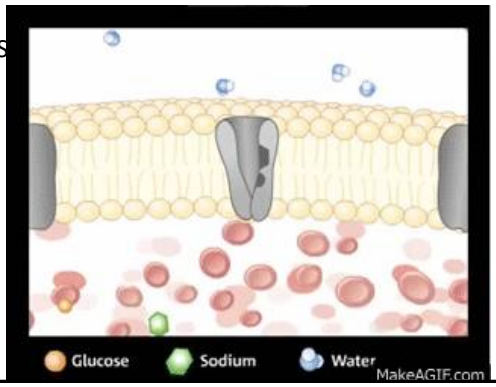
The importance of co-transport of Na+ and glucose in Oral Rehydration Therapy (ORT):

https://people.fmarion.edu/tbarbeau/236%20clinical%20applications.htm

Chronic diarrhea (from acute gastroenteritis, cholera, etc…) limits ability of intestines to reabsorb salt & water, leading to risk of dehydration (life-threatening in children).

BUT diarrhea doesn't interfere with co-transport of Na+ & glucose in intestines. **Water follows Na+ and glucose, by osmosis, across intestinal bloodstream**. Patient gets hydrated.



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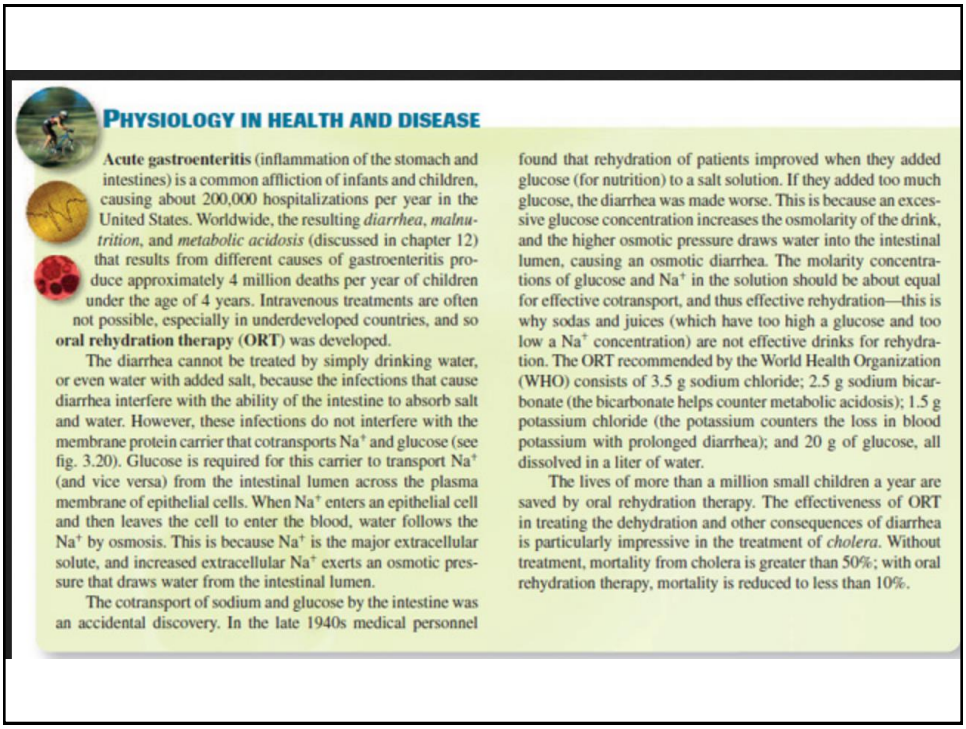

PHYSIOLOGY IN HEALTH AND DISEASE

Acute gastroenteritis (inflammation of the stomach and intestines) is a common affliction of infants and children, causing about 200,000 hospitalizations per year in the United States. Worldwide, the resulting *diarrhea*, *malnutrition*, and *metabolic acidosis* (discussed in chapter 12) that results from different causes of gastroenteritis produce approximately 4 million deaths per year of children under the age of 4 years. Intravenous treatments are often not possible, especially in underdeveloped countries, and so **oral rehydration therapy (ORT)** was developed.

The diarrhea cannot be treated by simply drinking water, or even water with added salt, because the infections that cause diarrhea interfere with the ability of the intestine to absorb salt and water. However, these infections do not interfere with the membrane protein carrier that cotransports Na^+ and glucose (see fig. 3.20). Glucose is required for this carrier to transport Na^+ (and vice versa) from the intestinal lumen across the plasma membrane of epithelial cells. When Na^+ enters an epithelial cell and then leaves the cell to enter the blood, water follows the Na^+ by osmosis. This is because Na^+ is the major extracellular solute, and increased extracellular Na^+ exerts an osmotic pressure that draws water from the intestinal lumen.

The cotransport of sodium and glucose by the intestine was an accidental discovery. In the late 1940s medical personnel found that rehydration of patients improved when they added glucose (for nutrition) to a salt solution. If they added too much glucose, the diarrhea was made worse. This is because an excessive glucose concentration increases the osmolarity of the drink, and the higher osmotic pressure draws water into the intestinal lumen, causing an osmotic diarrhea. The molarity concentrations of glucose and Na^+ in the solution should be about equal for effective cotransport, and thus effective rehydration—this is why sodas and juices (which have too high a glucose and too low a Na^+ concentration) are not effective drinks for rehydration. The ORT recommended by the World Health Organization (WHO) consists of 3.5 g sodium chloride; 2.5 g sodium bicarbonate (the bicarbonate helps counter metabolic acidosis); 1.5 g potassium chloride (the potassium counters the loss in blood potassium with prolonged diarrhea); and 20 g of glucose, all dissolved in a liter of water.

The lives of more than a million small children a year are saved by oral rehydration therapy. The effectiveness of ORT in treating the dehydration and other consequences of diarrhea is particularly impressive in the treatment of *cholera*. Without treatment, mortality from cholera is greater than 50%; with oral rehydration therapy, mortality is reduced to less than 10%.

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BulkTransport = form of active transport to move large substances across membrane.

A) Endocytosis = movement into cell

i) phagocytosis = bulk movement of particles into cell.

ii) Pinocytosis = bulk movement of fluid into cell.

iii) Receptor-mediated endocytosis = needing receptor to move particles into cell.

Exit

B) Exocytosis = movement out of cell.

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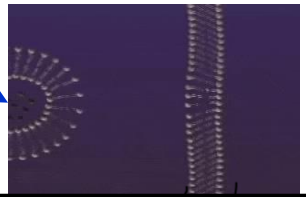

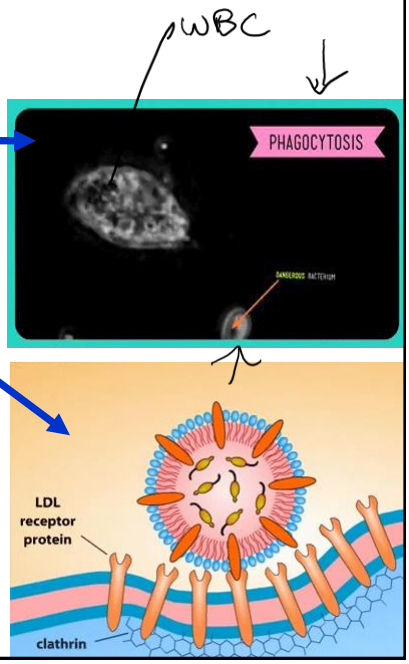

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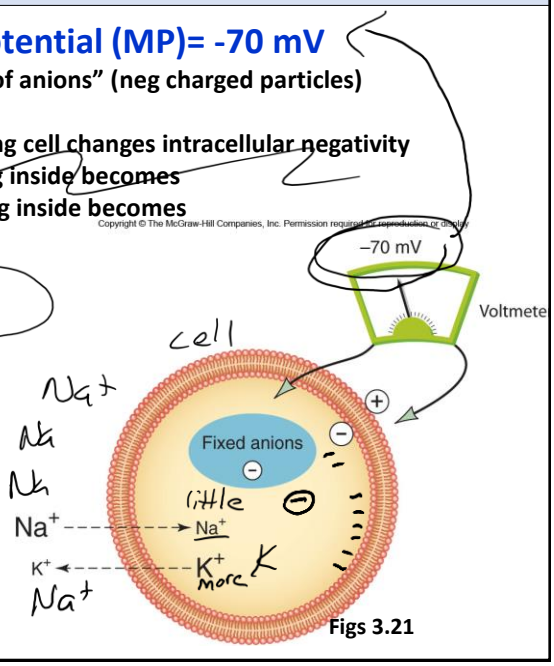
4. Membrane Potential

Resting cell membrane potential (MP)= -70 mV

- inside of cell has "fixed number of anions" (neg charged particles)

> number of K+ ions entering / leaving cell changes intracellular negativity
- The more K+ exits, the more neg inside becomes
- The more K+ enters, the less neg inside becomes

- MP maintained by Na+/K+ pump



Figs 3.21

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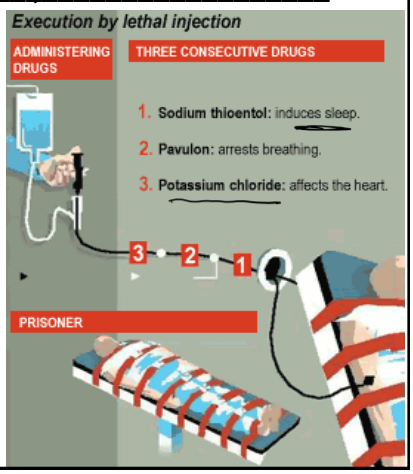
Click HERE on the PDF of this powerpoint to see Clinical App reading on hyperkalemia & Lethal Injections

Lethal injection is potassium chloride.

Hyperkalemia = high blood K+ potassium



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Action Potential - Changes In Membrane Potential

4 AP steps:

1. - Stimulus above MP thresh hold opens intital Na+ channels.

2. Opens more Na+ voltage gated channels (Na+ floods inward)
   - drives MP from -70 to +30 mV = "depolarization"
   - Na+ channels close

3. - K+ voltage gated channels open, K+ exits cell.
   - drives MP back toward -70 mV = "repolarization"
   - may overshoot MP & go to -80 mV ("hyperpolarization")

4. Na+/K+ pump restores normal Resting MP (-70mV) by pumping Na+ out and K+ back in.

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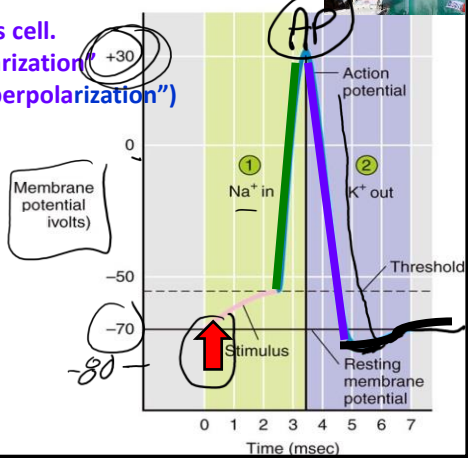

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Cell Transport - Review

"Permeability" of membranes

Passive transport = no energy, with concentration gradient ("downhill")
- Simple diffusion
- Facilitated diffusion
- Osmosis
- Filtration

Active transport = ATP required, against concentration gradient ("uphill")
- Primary active transport (calcium, hydrogen, & Na+/K+ pumps)
- Coupled transport (co-transport & counter-transport)
- Bulk transport

Cell membrane potential (MP)
- Resting potential
- Action potential

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