Ch. 3: Cells & Their Environment

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
4. To understand different types of cellular signaling

See Supplements Page! > Cell Physiology

3. Types of Cellular Transport

- **Permeable Membrane** = allows substances to move freely across cell membrane.

- **Selectively Permeable Membrane** = is selective in what it lets across membrane. Small particles, gases, uncharged ions go easily, but large particles, charged ions, glucose are regulated.
2. Types of Cellular Transport

1. **Passive transport** = when substances diffuse across a membrane from high to low concentration (with gradient), it requires no energy (ATP)

2. **Active transport** = When substances moving across membrane from low to high concentration (against gradient) it requires energy.

3. **Bulk transport** = for movement of very large particles across membrane, which requires energy. (A form of active transport.)

1) **Passive Transport (5 types):**

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

b) **Simple Diffusion with Channels**
   = movement of particles freely across membrane from high to low concentration, by moving through channels that open & close. Ex charged ions (Na+, Cl-, K+)

c) **Facilitated Diffusion with Carriers**
   = movement of particles across membrane from high to low through use of revolving membrane carriers. Ex. Glucose, amino acids.
Osmosis = movement of water from high to low concentration.

Another way of thinking about it is:

Water wants to move to the side of the membrane that has a higher solute concentration (to dilute it).

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**Osmosis depends on “Tonicity”**

**Isotonic solution** = Concentration of solute is the same on either side of the membrane. Water doesn’t move across membrane.

(ex. Normal or physiologic saline)

**Hypotonic solution** = solute concentration is lower outside the side than inside, and water enters the cell, causing swelling (possible bursting and cell death).

**Hypertonic solution** = solute concentration is higher outside the cell than inside, and water leaves the cells, causing shrinking (crentation) and cell death.
**e) Filtration**

= when substances move across a membrane due to fluid pressure being higher on one side of the membrane than the other.

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

![Filtration Diagram]

**Rate of diffusion depends on:**

> Concentration gradient of solutes

> Membrane permeability
(see ex of diffusion through a dialysis membrane, Pg 66)
- an artificial membrane with fixed pore sizes
- small molecules can pass but not large ones. “Semipermeable”
- we will exam diffusion & osmosis through a dialysis membrane in lab!

> Surface area of membrane
- more surface area the more diffusion occurs.

> Temperature of solution
- warmer temperature speeds diffusion.
2. Active Transport

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

i) Calcium (Ca+2) Pump
keeps Ca+2 concentrations low inside cells.

ii) Hydrogen (H+) Pump
used to increase acidity.
Ex. Parietal cells of stomach have H+ pumps. Nexium® targets these cells for those with GERD.

iii) Sodium – Potassium (Na+/K+) Pump
3 Na+ exit for every 2 K+ that enter cell. Helps maintain cell membrane resting potential.

Fig 6.19

Sodium-Potassium Exchange Pump

This conformation has a low affinity for potassium ions, so the two bound potassium ions dissociate from the protein and diffuse into the interior of the cell.

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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 in kidney tubules.*

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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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**Read “Physiology in Health & Disease” – Pg 80**

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

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+ by osmosis into cells, and into bloodstream. Patient gets hydrated.

So, ORT with salt AND glucose is vital!
3. Bulk Transport = form of active transport to move large substances across membrane.

A) Endocytosis = bulk movement of molecules into a cell.
   - i) phagocytosis = endocytosis of large particles
   - ii) Pinocytosis = endocytosis of fluid
   - iii) Receptor-mediated endocytosis = A receptor on cell is bound by hormone or other molecule causing it to allow substance to move into cell.

B) Exocytosis = bulk movement of molecules out of a cell.

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
Clinical Application—Hyperkalemia & Lethal Injections

Lethal injection is potassium chloride.

Hyperkalemia = too much K+ in blood.

Action Potential - Changes In Membrane Potential

4 AP steps:

1. Stimulus above MP threshold opens initial 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.
Cell Transport - Review

“Permeability” of membranes

Passive transport = no energy, with concentration gradient (“downhill”)
- Simple diffusion
- Simple diffusion w/ channels
- 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
- Endocytosis
- Exocytosis

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