Cell Membrane and transport

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Cell Biology, 1st Semester/W5

Outline

- Phospholipid Bilayer
- Fluid Mosaic Model
- Membrane Proteins
- Diffusion
- Facilitated Diffusion
- Osmosis
- Active Transport

Functions of Plasma Membrane

✓Protective barrier

✓ Regulate transport in & out of cell (selectively permeable)

✓ Allow cell recognition

✓ Provide anchoring sites for filaments of cytoskeleton

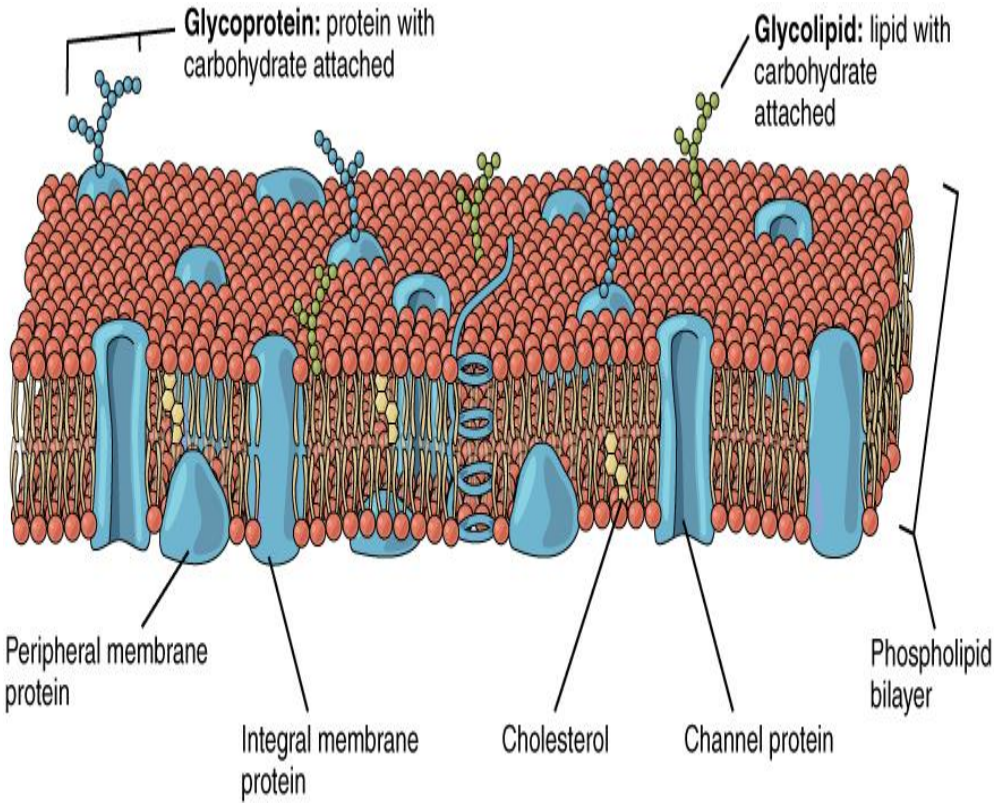
✓Provide a binding site for enzymes

✓ Interlocking surfaces bind cells together (junctions)

✓Contains the cytoplasm (fluid in cell)

Cell Membrane

- The cell membrane of the cell is a phospholipid bilayer containing many different molecular components, including proteins and cholesterol, some with carbohydrate groups attached.
- Cholesterol contributes to the fluidity of the membrane, and there are various proteins embedded within the membrane that have a variety of functions.

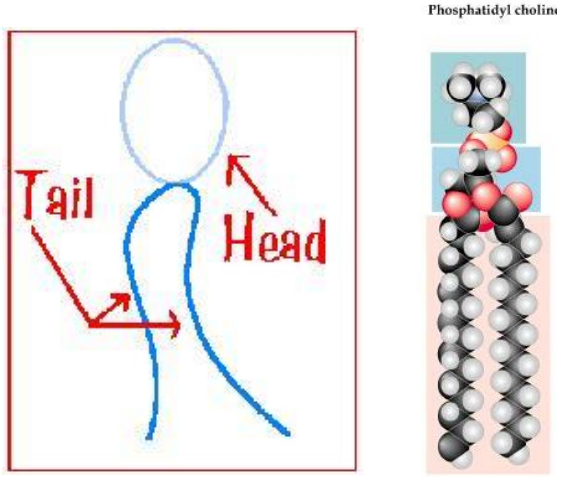


About Cell Membranes (continued)

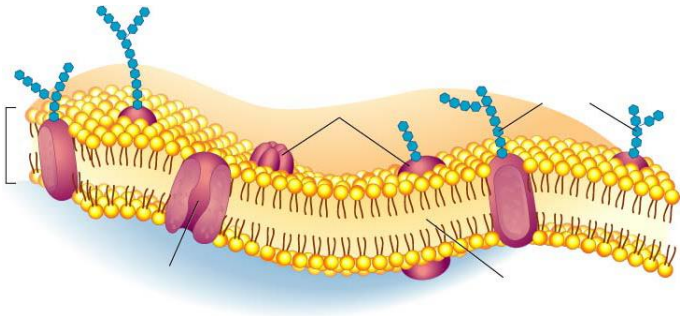
Structure of cell membrane

Lipid Bilayer -2 layers of phospholipids

a. Phosphate head is *polar* (water loving)
b. Fatty acid tails *non-polar* (water fearing)
c. Proteins embedded in membrane



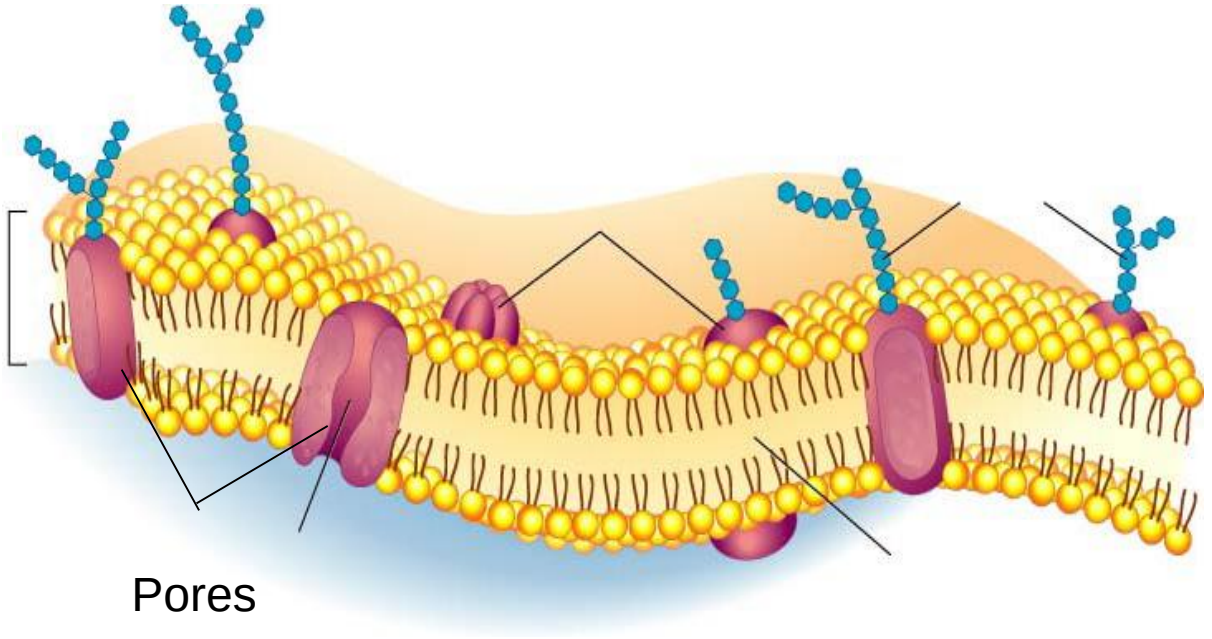
Phospholipid



Lipid Bilayer

About Cell Membranes (continued)

- Cell membranes have pores (holes) in it
  - a. **Selectively permeable**: Allows some molecules in and keeps other molecules out
  - b. The structure helps it be selective!



Membrane Proteins

- Two different types of proteins that are commonly associated with the cell membrane are the **integral proteins** and **peripheral proteins**.
- an **integral protein** is a protein that is embedded in the membrane.
- A **channel protein** is an example of an integral protein that selectively allows particular materials, such as certain ions, to pass into or out of the cell.
- A **receptor** is a type of recognition protein **(glycoproteins)** that can selectively bind a specific molecule outside the cell, and this binding induces a chemical reaction within the cell. Also, **serve to mark a cell's identity** so that it can be recognized by other cells.

- **Peripheral proteins** are typically found on the inner or outer surface of the lipid bilayer but can also be attached to the internal or external surface of an integral protein.
- These proteins typically perform a specific function for the cell. Some peripheral proteins on the surface of intestinal cells, for example, act as digestive enzymes to break down nutrients to sizes that can pass through the cells and into the bloodstream.

Principles of membrane transport

- The rate of diffusion depend on the size of the molecule but mostly on its relative solubility in oil.
- Gases and hydrophobic molecules in the oil they are more rapidly across the bilayer (such as 02, CO2 and benzene).
- Small uncharged polar molecules such as water or urea, also diffuse across a bilayer but much more slowly.
- Also some polar molecules such as sugars, amino acids, nucleotides and many cell metabolites can across the membrane but only very slowly. (because of molecular size)
- By contrast, due to highly impermeable to charged molecules (ions) of lipid bilayers, they cannot across. (Na, K, CI, H)

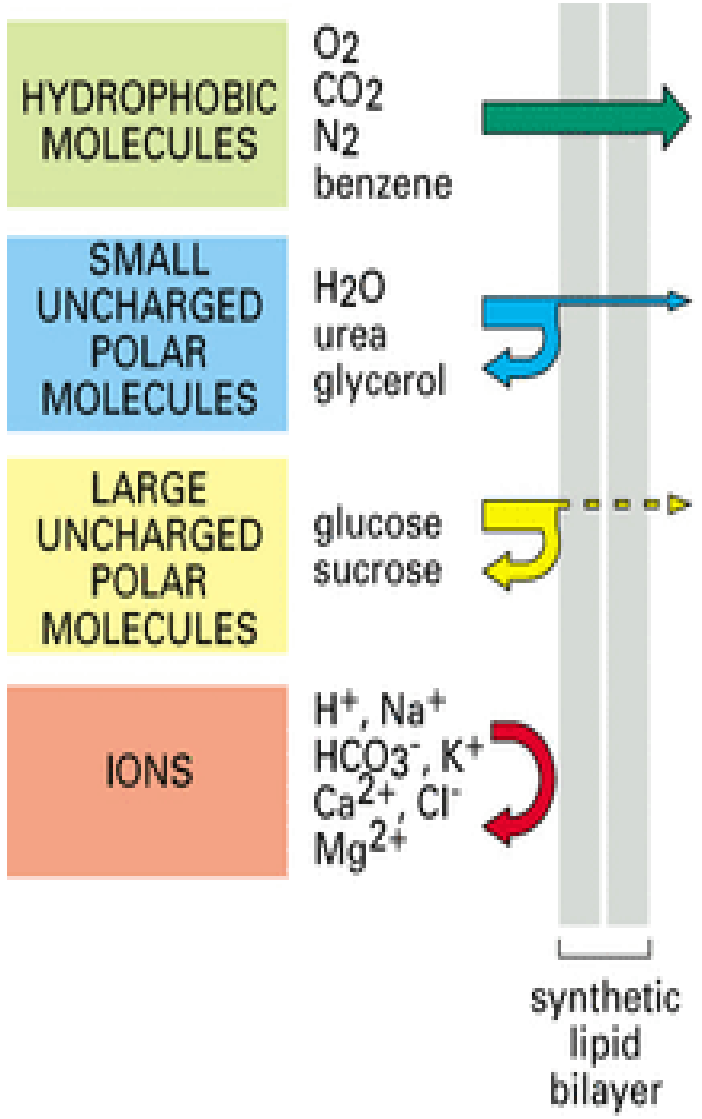


Figure 11–1. Molecular Biology of the Cell, 4th Edition.

Types of Cellular Transport

- **Passive Transport**

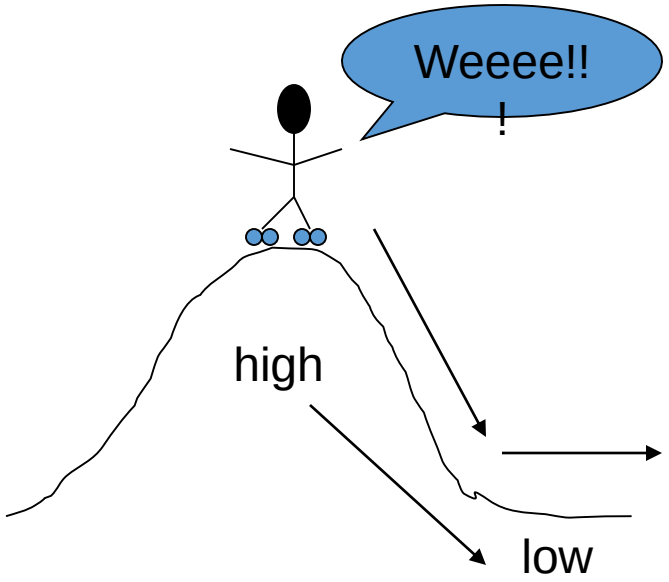
  cell doesn't use energy

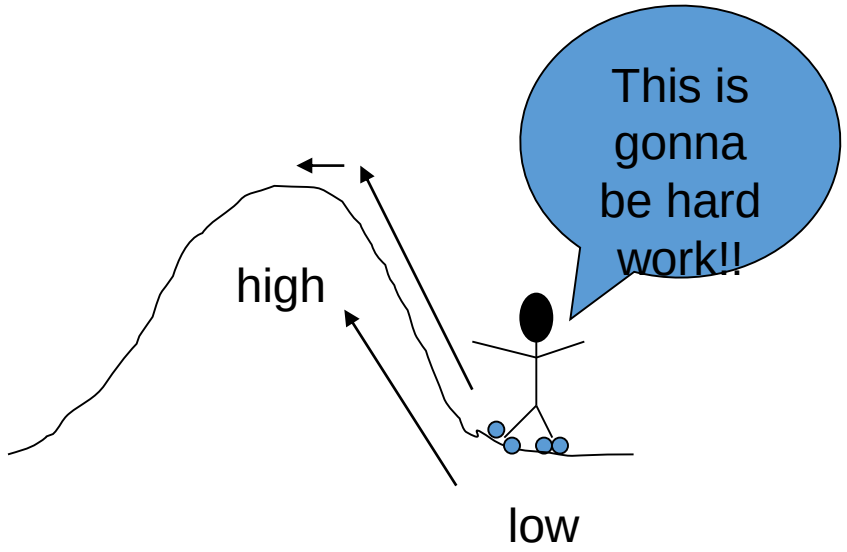
  1. Diffusion
  2. Facilitated Diffusion
  3. Osmosis

- **Active Transport**

  cell does use energy

  1. Protein Pumps (Na/K Pump)
  2. Endocytosis;
     - ✓ Phagocytosis
     - ✓ Pinocytosis
     - ✓ Receptor-mediated endocytosis
  3. Exocytosis





Passive Transport

- cell **uses no energy**
- molecules move randomly
- Molecules spread out **from an area of high concentration to an area of low concentration**.
- (High→Low)

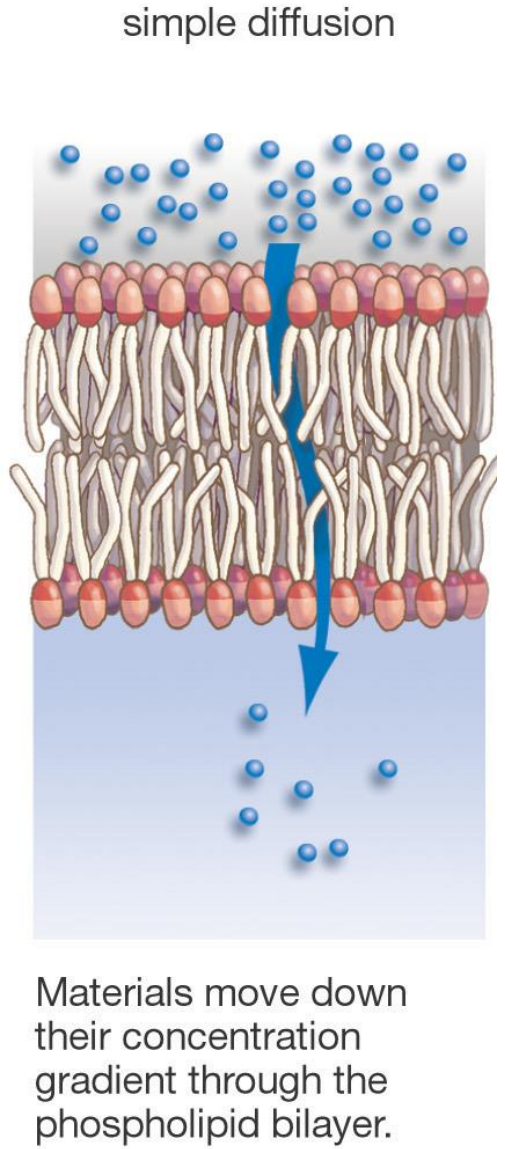
Three types:

1. **Diffusion**
2. **Facilitative Diffusion** – diffusion with the help of transport proteins
3. **Osmosis** – diffusion of water

Passive Transport:
1. Diffusion

1. **Diffusion**: random movement of particles **from an area of high concentration to an area of low concentration**.

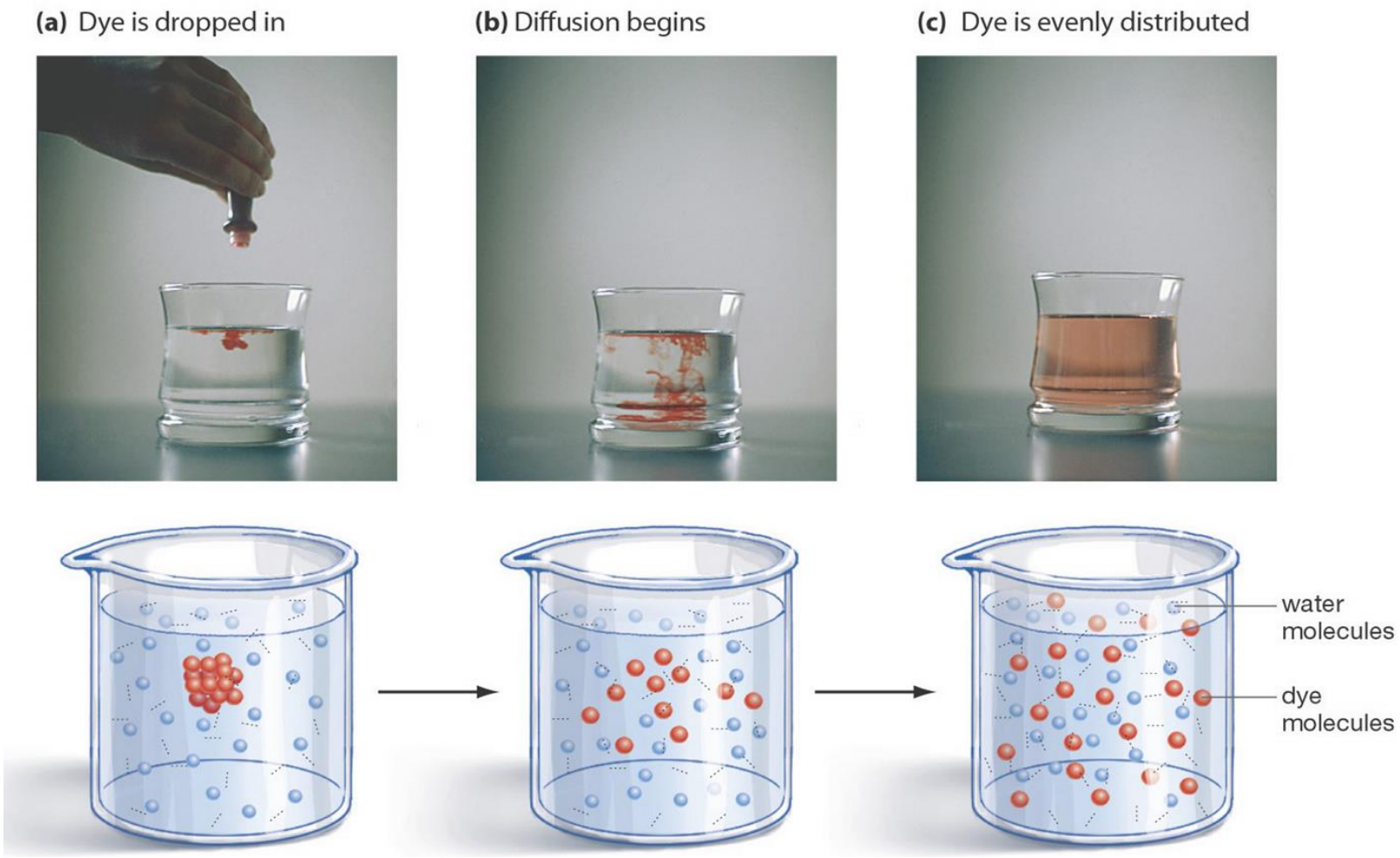
- Does not require energy
- Diffusion continues until equal. (**equilibrium** is reached)-***Note:*** molecules will still move around but stay spread out.
- Example: Oxygen or water diffusing into a cell and carbon dioxide diffusing out.



Materials move down their concentration gradient through the phospholipid bilayer.

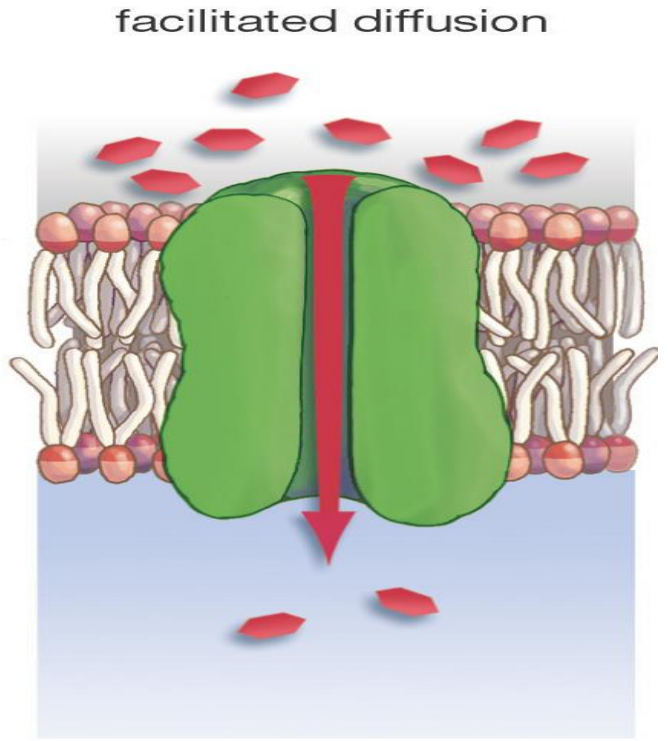
http://bio.winona.edu/berg/Free.htm

Diffusion of Liquids



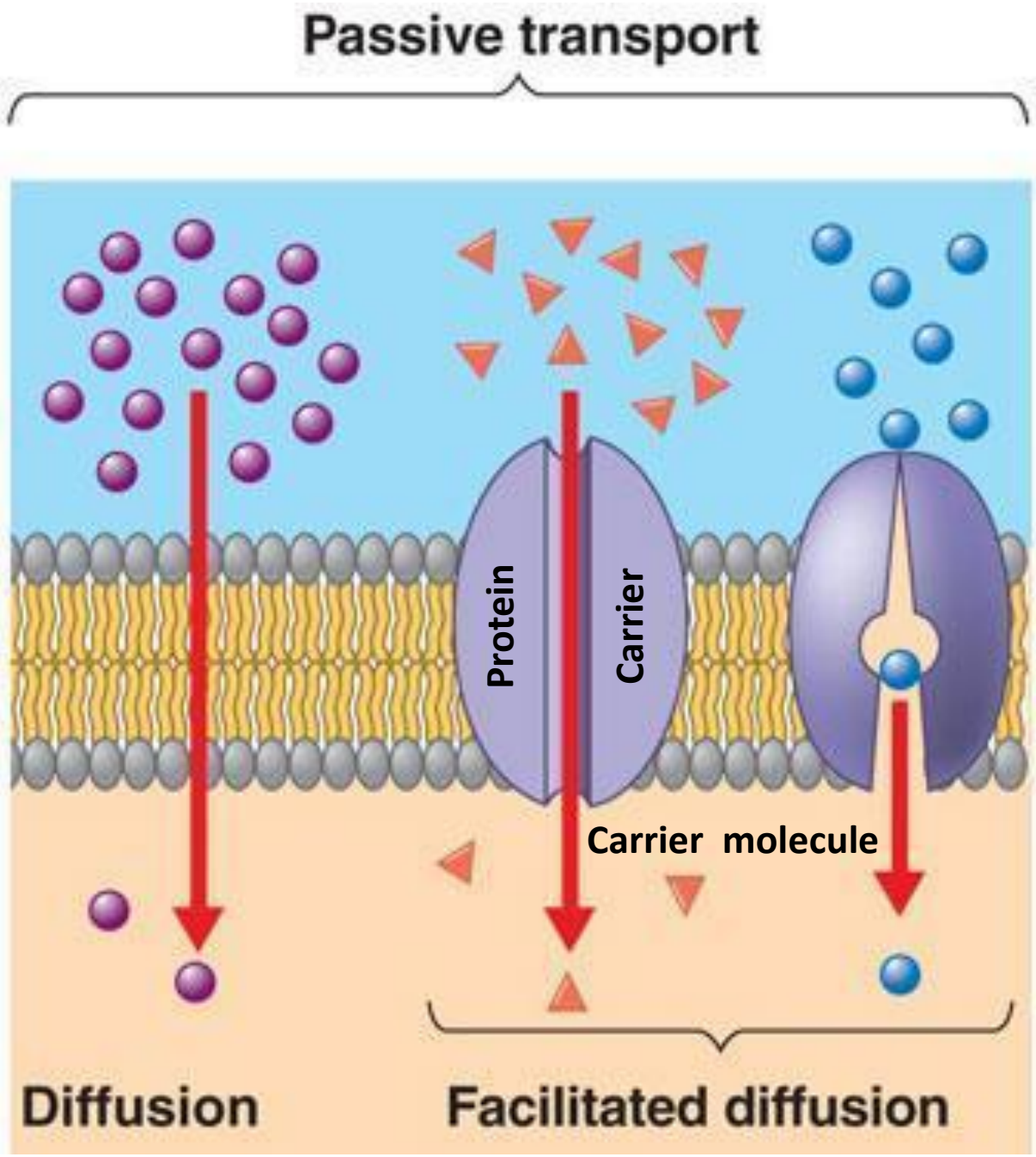
Passive Transport:
2. Facilitated Diffusion

- **2. Facilitated diffusion**: is the movement of **larger molecules** like glucose through the cell membrane – larger molecules must be "helped"
- Proteins in the cell membrane form **channels** for **large molecules** to pass through
- Proteins that form channels (pores) are called **protein channels**
- Examples: Glucose or amino acids moving from blood into a cell.



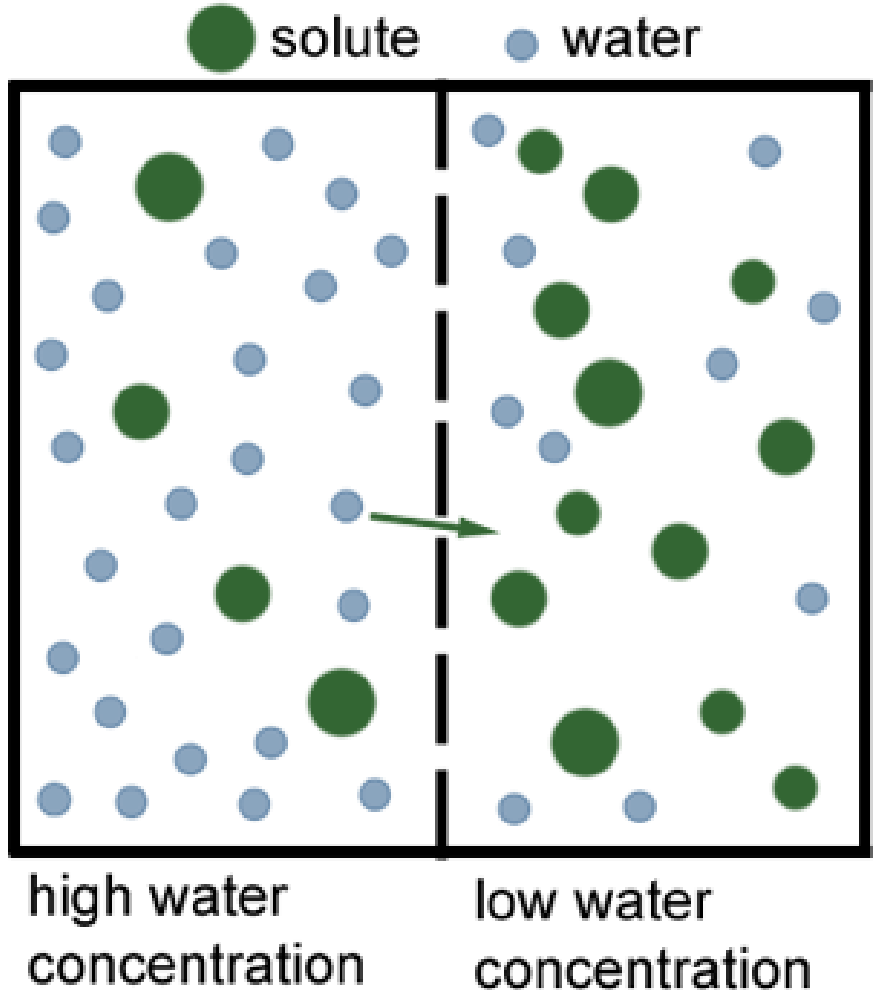
The passage of materials is aided both by a concentration gradient and by a transport protein.

- http://bio.winona.edu/berg/Free.htm


Passive transport
Protein
Carrier
Carrier molecule
Diffusion
Facilitated diffusion

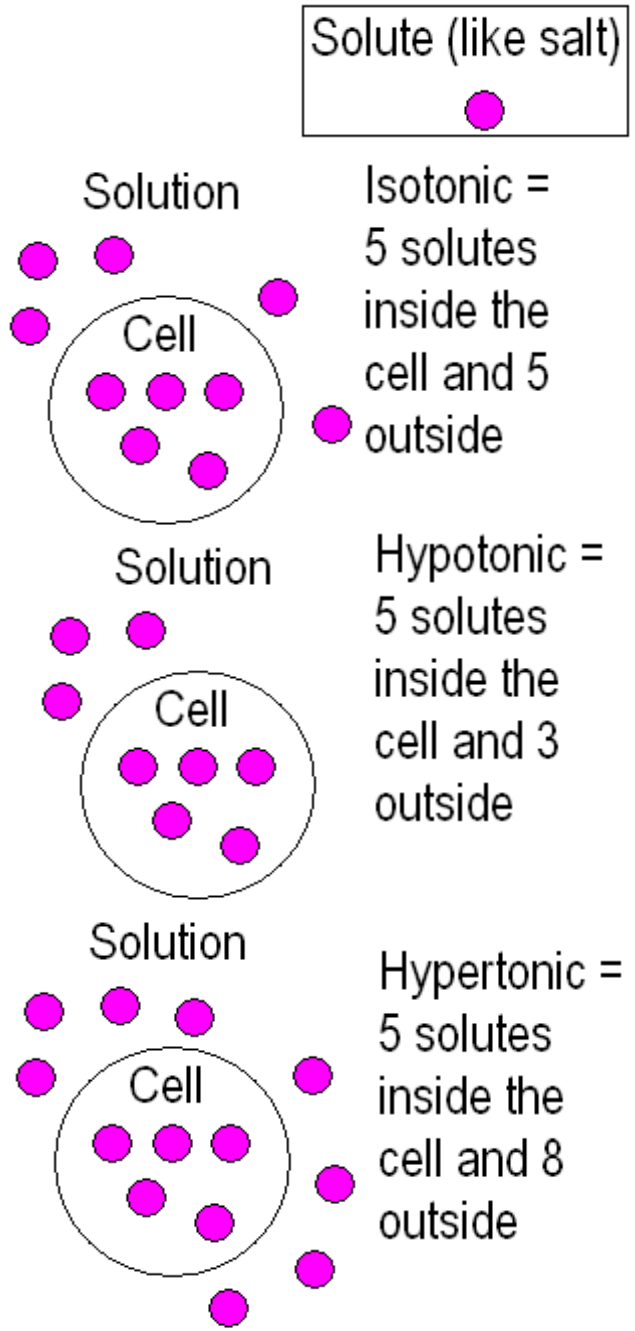
Passive Transport:
3. Osmosis

- Diffusion of water across a selectively permeable membrane
  - Moves from HIGH water concentration to LOW water concentration
    - Water is attracted to solutes (like salt) so it will also travel to areas of low solute concentration to high solute concentration.



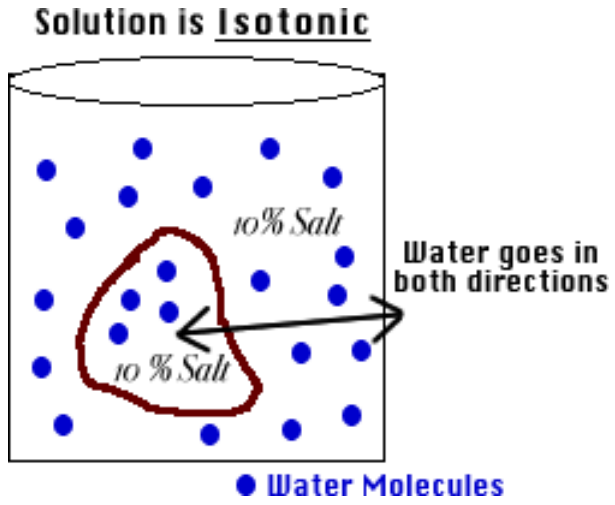
Cells in Solutions

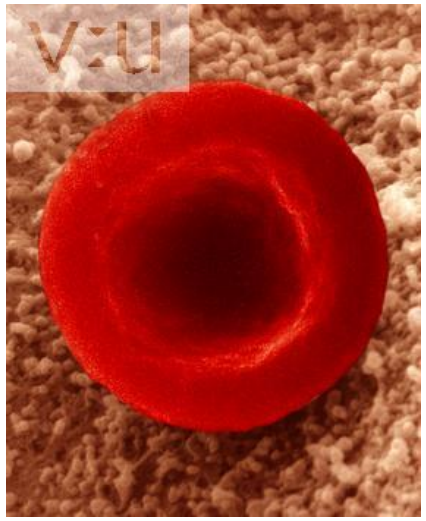
- Isotonic
  - A solution whose solute concentration is the same as the solute concentration inside the cell.
- Hypotonic
  - A solution whose solute concentration is lower than the solute concentration inside a cell
- Hypertonic
  - A solution whose solute concentration is higher than the solute concentration inside a cell.



Isotonic Solution

Isotonic: The concentration of solutes in the solution is equal to the concentration of solutes inside the cell.

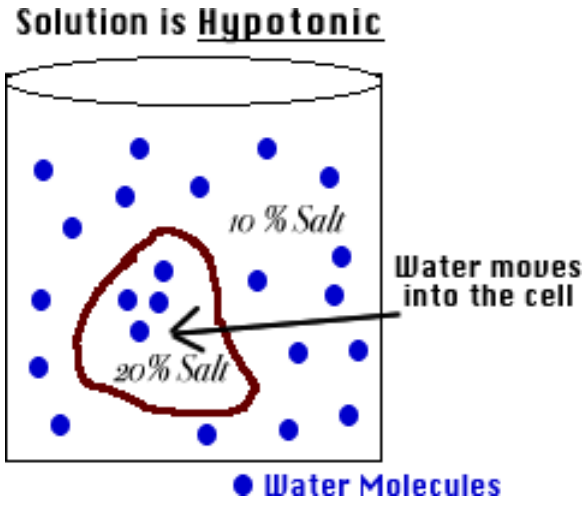


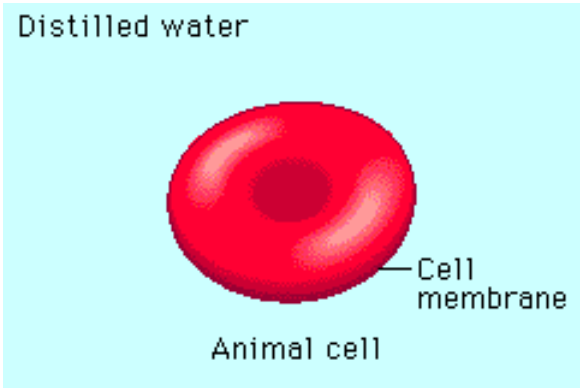


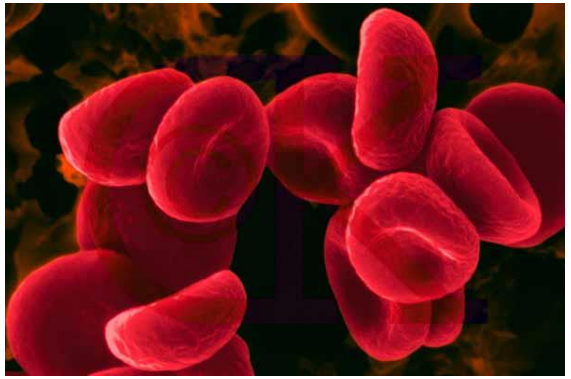
Result: Water moves equally in both directions and the cell remains same size! (Dynamic Equilibrium)

Hypotonic Solution

Hypotonic: The solution has a lower concentration of solutes and a higher concentration of water than inside the cell. **(Low solute; High water)**



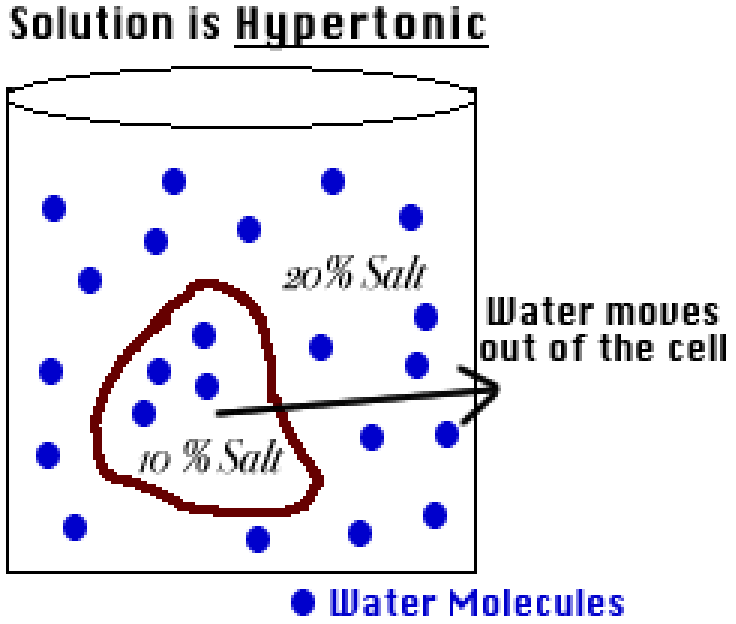


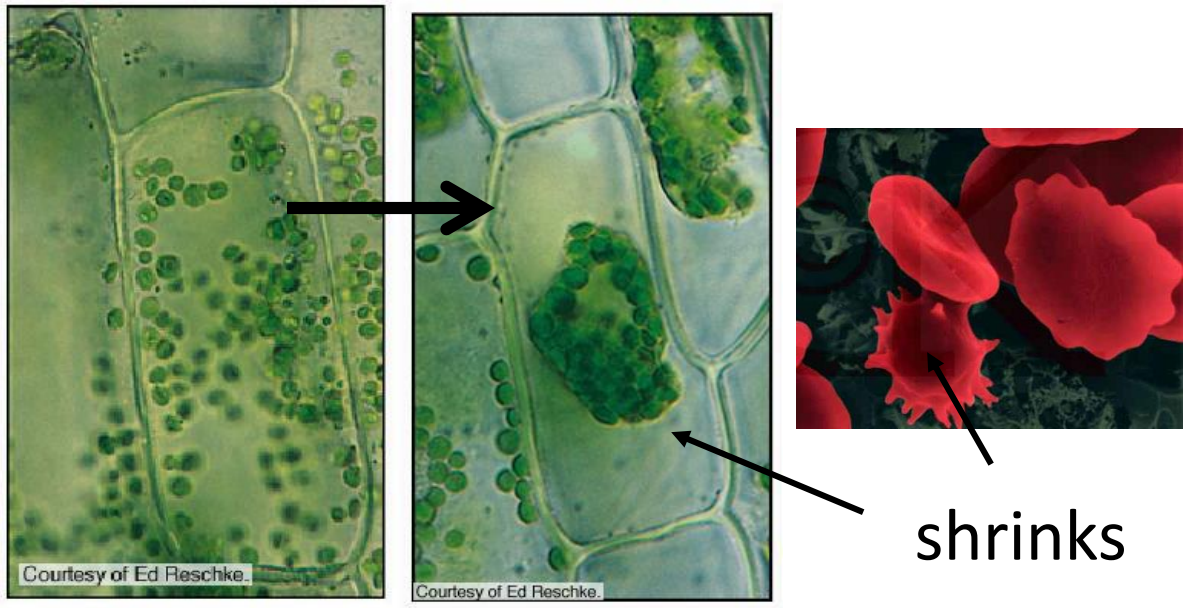


Result: Water moves from the solution to inside the cell): Cell Swells and bursts open (*cytolysis*)!

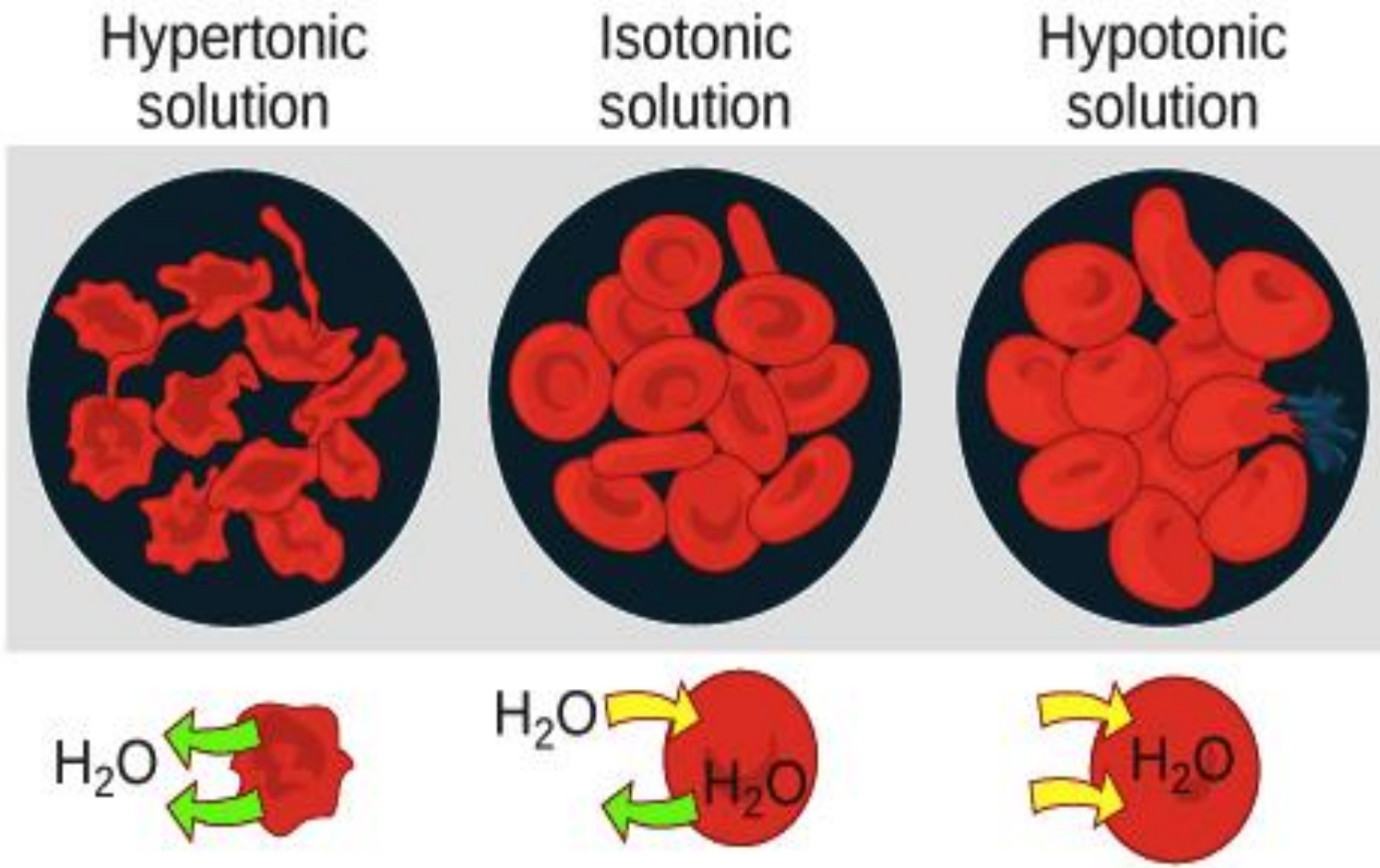
Hypertonic Solution

Hypertonic: The solution has a higher concentration of solutes and a lower concentration of water than inside the cell. **(High solute; Low water)**





Result: Water moves from inside the cell into the solution: Cell shrinks (*Plasmolysis*)!


Hypertonic solution
Isotonic solution
Hypotonic solution
H_2O
H_2O
H_2O
H_2O

Active Transport
1) Ion Channels

- The **sodium-potassium pumps** are particularly abundant in nerve cells, which are constantly pumping out sodium ions and pulling in potassium ions to maintain an electrical gradient across their cell membranes.
- An **electrical gradient** is a difference in electrical charge across a space.
- In the case of nerve cells, for example, the electrical gradient exists between the inside and outside of the cell, with the inside being negatively-charged relative to the outside.
- The negative electrical gradient is maintained because each Na^+/K^+ pump moves three Na^+ ions out of the cell and two K^+ ions into the cell for each ATP molecule that is used.
- This process is so important for nerve cells that it accounts for the majority of their ATP usage.

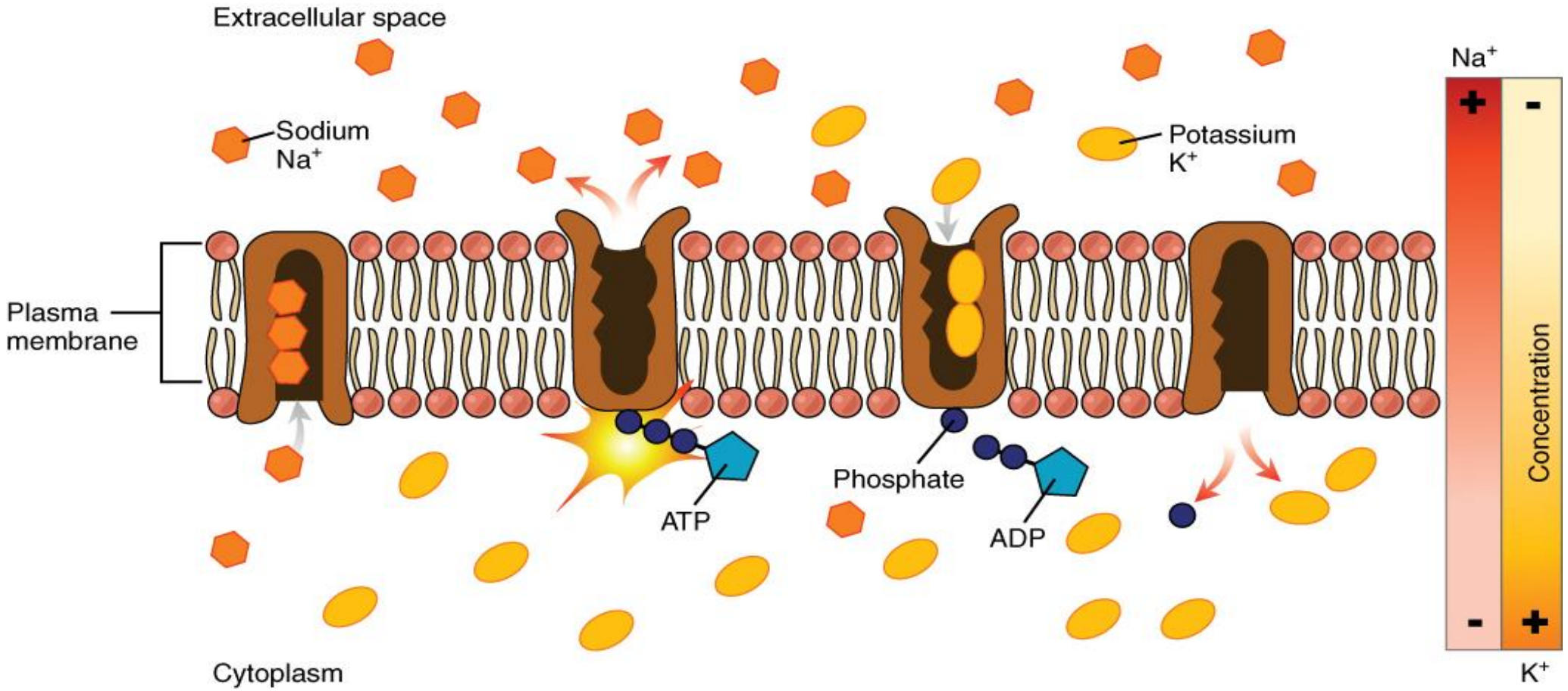
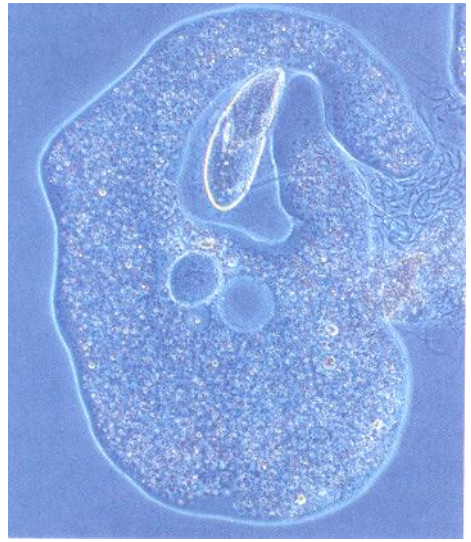


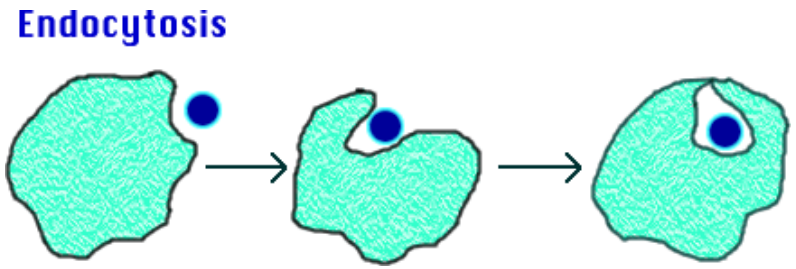
Figure: Sodium-Potassium Pump. The sodium-potassium pump is found in many cell (plasma) membranes. Powered by ATP, the pump moves sodium and potassium ions in opposite directions, each against its concentration gradient. In a single cycle of the pump, three sodium ions are extruded from and two potassium ions are imported into the cell.

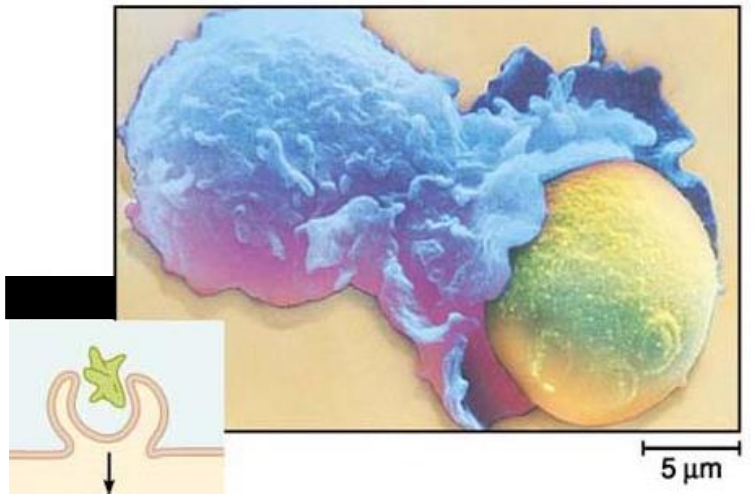
Types of Active Transport

2. Endocytosis: Other forms of active transport do not involve membrane carriers.

- **Endocytosis** (bringing "into the cell") is the process of a cell ingesting material by enveloping it in a portion of its cell membrane, and then pinching off that portion of membrane.
- This becames an independent, intracellular **vesicle**.







- Endocytosis often brings materials into the cell that must to be broken down or digested.
- There is three forms of endocytosis:
- **2.1. Phagocytosis** (“cell eating”) is the endocytosis of large particles. Many immune cells engage in phagocytosis of invading pathogens.
- For example, when microorganisms invade the human body, a type of white blood cell called a neutrophil removes the invader through this process, surrounding and engulfing the microorganism, which is then destroyed by the neutrophil.
-

- **2.2. pinocytosis** (“cell drinking”) brings fluid containing dissolved substances into a cell through membrane vesicles.
- Cells in the kidney can use pinocytosis to separate nutrients and fluids from the urine that will be expelled from the body.
- In addition, human egg cells also use it to absorb nutrients prior to being fertilized.

- Cells regulate the endocytosis of specific substances via receptor-mediated endocytosis.
- **2.3. Receptor-mediated endocytosis;** is endocytosis by a portion of the cell membrane that contains many receptors that are specific for a certain substance.
- Once the surface receptors have bound sufficient amounts of the specific substance (the receptor's ligand), the cell will endocytose the part of the cell membrane containing the receptor-ligand complexes.
- Some human diseases are caused by a failure of receptor-mediated endocytosis.
- For example, the form of cholesterol termed low-density lipoprotein or LDL (also referred to as "bad" cholesterol) is removed from the blood by receptor-mediated endocytosis. Because their cells cannot clear the chemical from their blood.

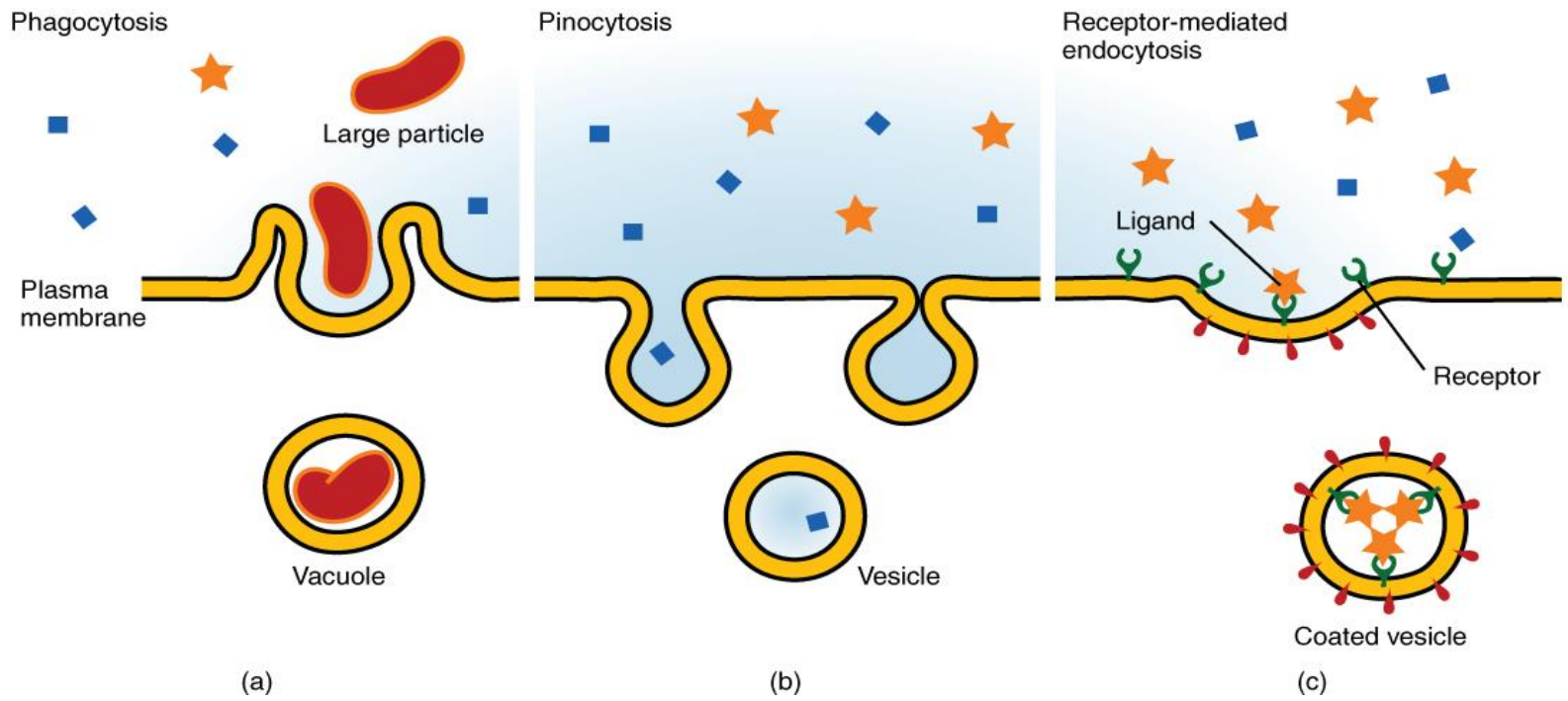


Figure: Three Forms of Endocytosis. Endocytosis is a form of active transport in which a cell envelopes extracellular materials using its cell membrane. **(a)** In phagocytosis, which is relatively nonselective, the cell takes in a large particle. **(b)** In pinocytosis, the cell takes in small particles in fluid. **(c)** In contrast, receptor-mediated endocytosis is quite selective. When external receptors bind a specific ligand, the cell responds by endocytosing the ligand.

3. Exocytosis: (taking “out of the cell”) is the process of a cell exporting material using vesicular transport.

- Many cells manufacture substances that must be secreted, like a factory manufacturing a product for export. These substances are typically packaged into membrane-bound vesicles within the cell.
- When the vesicle membrane fuses with the cell membrane, the vesicle releases it contents to the out of the cell. The vesicle membrane then becomes part of the cell membrane.
- **Example:** Cells of the stomach and pancreas produce and secrete digestive enzymes through exocytosis.
- Endocrine cells produce and secrete hormones that are sent throughout the body, and certain immune cells produce and secrete large amounts of histamine, a chemical important for immune responses.
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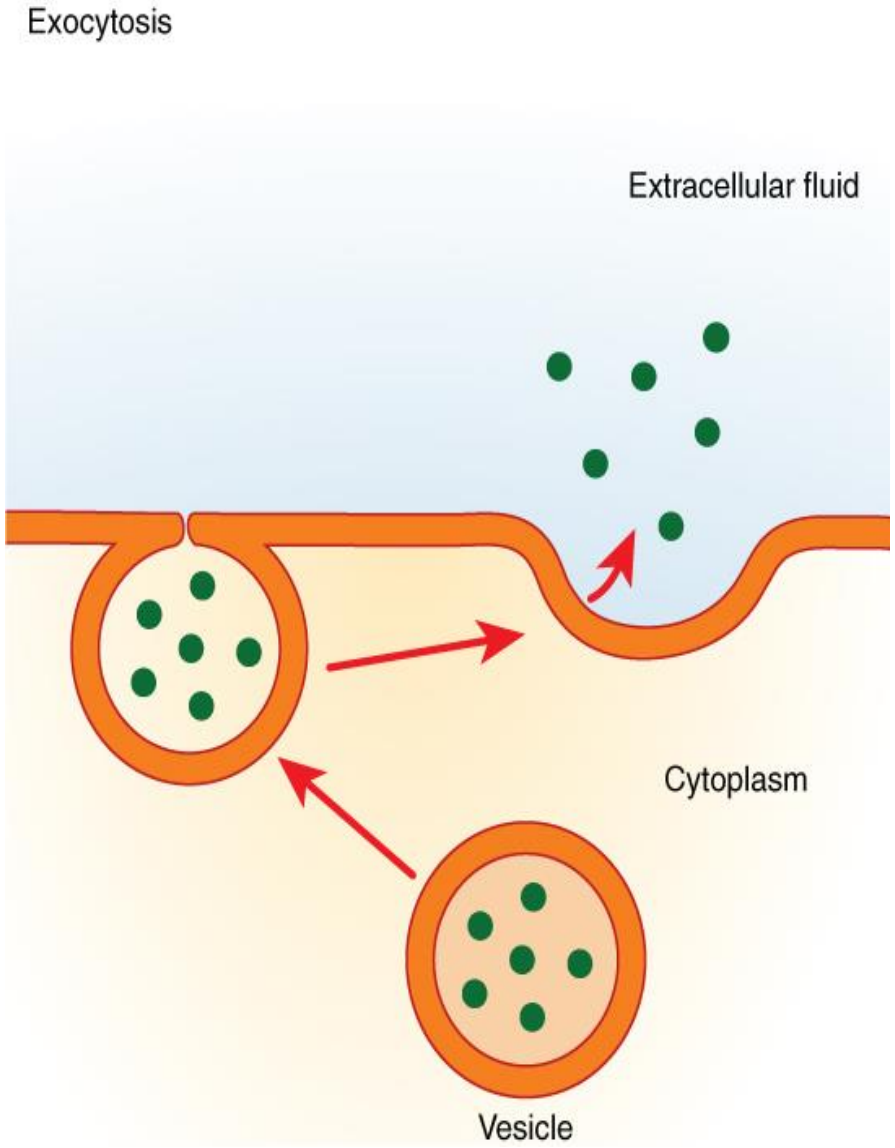

Figure: Exocytosis is much like endocytosis in reverse. Material destined for export is packaged into a vesicle inside the cell. The membrane of the vesicle fuses with the cell membrane, and the contents are released into the extracellular space.