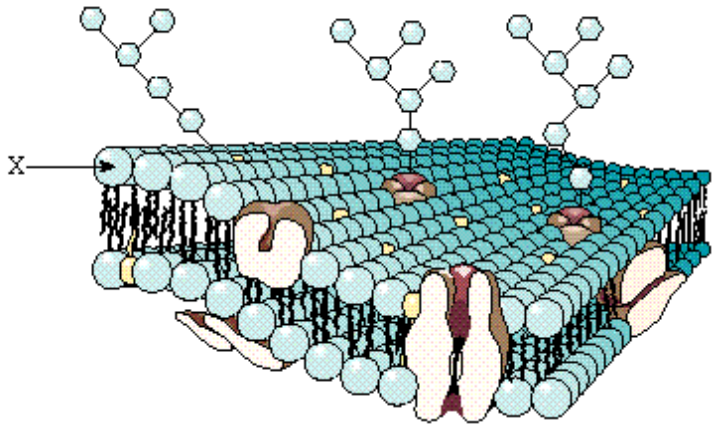
BIOLOGY 12 - Cell Membrane and Cell Wall Function: Chapter Notes

- *The cell membrane is the **gateway into the cell**, and must allow needed things such as **nutrients** into the cell without letting them escape. In the same way, it must allow **wastes** to leave the cell. A **wide variety** of molecules and substances must pass through the cell membrane -- large, small, **hydrophobic**, **hydrophilic**. Molecules of the **same size** must sorted out, and the cell must also be able to get **large amounts** of molecules in and out when necessary. How can the cell membrane accomplish this?*

- The answer lies in its structure. We already know about the FLUID MOSAIC MODEL of membrane structure. Why is it given that name?

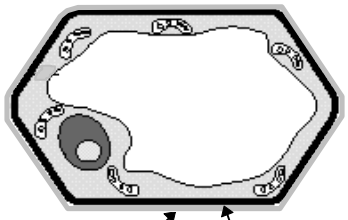
Review of FLUID MOSAIC MODEL:



Please Label the Parts of the Cell Membrane

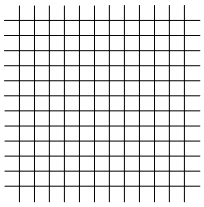
- double layer of phospholipid molecules ("X" on diagram)
- consistency of light machine oil (~*fluid*)
- proteins wholly or partly embedded in phospholipid bilayer ➔ forms *mosaic* pattern
- carbohydrates strung together in chains are attached to proteins ("glycoproteins") or lipids ("glycolipids") of membrane. Function as identification markers for cell recognition (helps immune system identify which cells belong to body and which are invaders).
- is SELECTIVELY PERMEABLE: some molecules enter the cell, while other molecules (which can be the same size) are not allowed to enter. The cell membrane can discriminate between different molecules that are the same size!
- all living cells, whether plant, animal, fungal, protozoan, or bacterial, are surrounded by cell membranes

Plant Cell Wall



Primary Cell Wall Secondary Cell Wall

- plants have cell walls in addition to cell membranes. The cell wall lies outside the cell membrane.
- *(bacteria have cell walls too, but bacterial cell walls are NOT the same in composition as plant cell walls).*
- thickness of cell wall varies with cell function
- primary cell wall is outermost layer, composed of threadlike cellulose microfibrils.
- sticky substance called middle lamella binds cells together



Cellulose Microfibrils

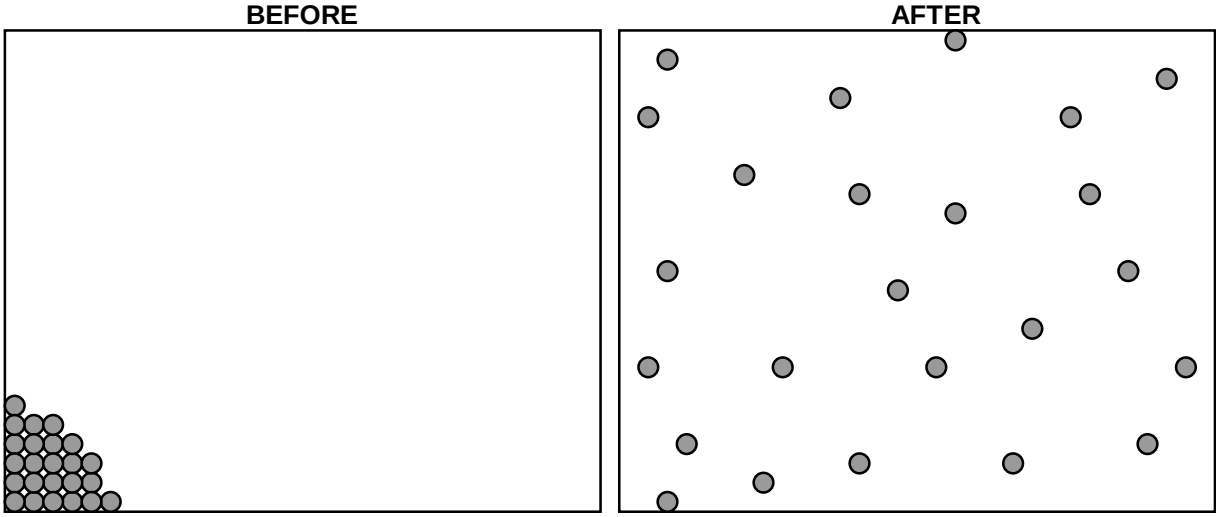
- woody plants also have a secondary cell wall which forms inside the primary wall. Composed of alternating layers of cellulose microfibrils reinforced with lignin (which adds strength). Function is support of large plants. Wood is made largely of secondary cell wall material.
- Cellulose of plant cell walls used by humans: cotton, rayon, flax, hemp, paper, wood, paper (paper has lignin removed to prevent yellowing). Lignin used in manufacture of rubber, plastics, pigments, adhesives.
- plant cell wall is FREELY PERMEABLE (anything small enough to fit through openings in cellulose microfibrils will get through).
- plant cell therefore relies instead on its cell membrane to regulate what gets in and out.

THERE ARE THREE GENERAL MEANS BY WHICH SUBSTANCE CAN ENTER AND EXIT CELLS:

Name	Examples
1. DIFFUSION	lipid-soluble molecules, water, gases

2. TRANSPORT BY CARRIERS (i.e. active and facilitated transport)	sugars and amino acids sugars, amino acids., ions
3. ENDOCYTOSIS AND EXOCYTOSIS (e.g. pinocytosis and phagocytosis)	macromolecules (e.g. proteins), cells or subcellular material

Diffusion



- diffusion is a **physical process** that can be observed with **any type of particle**. A UNIVERSAL PHENOMENON.
- Law of Diffusion: particles MOVE FROM THE AREA OF GREATER CONCENTRATION TO THE AREA OF LESSER CONCENTRATION UNTIL EQUALLY DISTRIBUTED.
- for instance: *opening a perfume bottle* in corner of a room. The smell of perfume soon permeates the room because the molecules that make up the perfume have drifted to all parts of the room. e.g. dropping dye into water.
- movement by diffusion **requires no energy** to be added (although adding energy (i.e. heat) will speed it up).
- diffusion is a slow process. The rate of diffusion is affected by the concentration gradient (the **difference in concentration** of the diffusing molecules between the two regions), the size & shape of the molecules, and the temperature. Diffusion in liquid is slower than in gas. However, distribution of molecules in cytoplasm is **speeded up** by an ever-constant flow of the cytoplasm that is called **cytoplasmic streaming**.

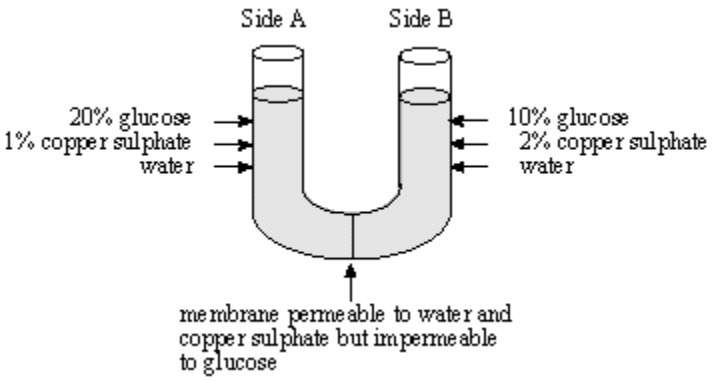
Three Ways of increasing the rate of diffusion:

1. **increase the temperature**
2. **increase the concentration gradient**
3. **decrease the size of the diffusing molecules**

- The properties of the cell membrane allow **few types** of molecules to pass by diffusion: **Lipid-soluble** molecules like steroids and alcohols can diffuse directly across because the membrane itself is made of lipids.
- water diffuses readily across membrane, probably through charged, protein-lined pores in the membrane (remember, water is not lipid-soluble) that will not allow anything else but water through.

Osmosis

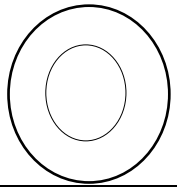
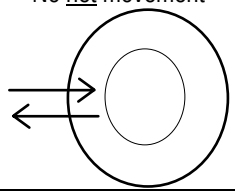
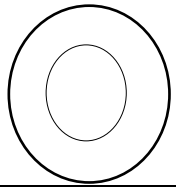
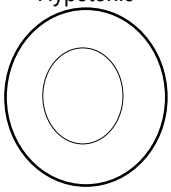
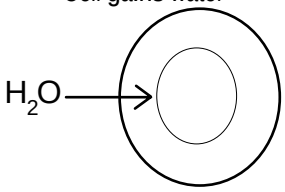
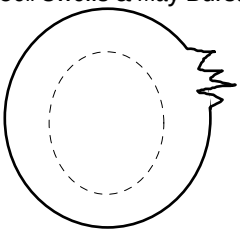
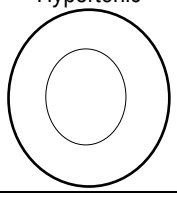
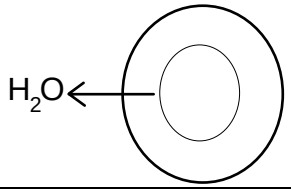
- the movement of water across a selectively permeable membrane is a special case of diffusion called OSMOSIS.
- Definitions:
  Osmosis: *the net movement of water molecules from the area of greater concentration to the area of lesser concentration across a selectively-permeable membrane*.
  Solute: particles which are dissolved in water
  Solvent: liquid which dissolves the solute. This is water when we are talking about osmosis.
  Solution: combination of solute and solvent.
  Osmotic Pressure: the pressure due to the flow of water from the area of greater concentration to the area of lesser concentration.
  The **greater the concentration difference** across the membrane, the **greater the osmotic pressure**.



Explain what would happen to the concentrations of water, glucose, and copper sulphate on side A of this experiment.

- In cellular systems, **water can move easily across membranes**, but other molecules can't. Therefore, it is often **only water** that can move and follow the law of diffusion. According to the law of diffusion, water will move from where it is more concentrated (i.e. solution that has **less** solute in it) to where it is less concentrated (i.e. solution that has **more** solute in it). This has important consequences on living systems.
- **Cells may be placed in solutions** that contain the same number of solute molecules per volume as the cell (= **isotonic solution**), a greater number of solute molecules per volume (= **hypertonic solution**), or a lesser number of solute molecules per volume than the cell (= **hypotonic solution**).

Summary of what happens to ANIMAL CELLS placed in different tonicities of solution:

Tonicity of Solution Cell is Put Into	Net Movement of Water	Effect on Cell
Isotonic 	No net movement 	Remains the same 
Hypotonic 	Cell **gains** water 	Cell **Swells & May Burst**  "**lysis**"
Hypertonic 	Cell **loses** water 	Cell Shrinks  "**crenation**"

Isotonic ("same" "strength") solution:

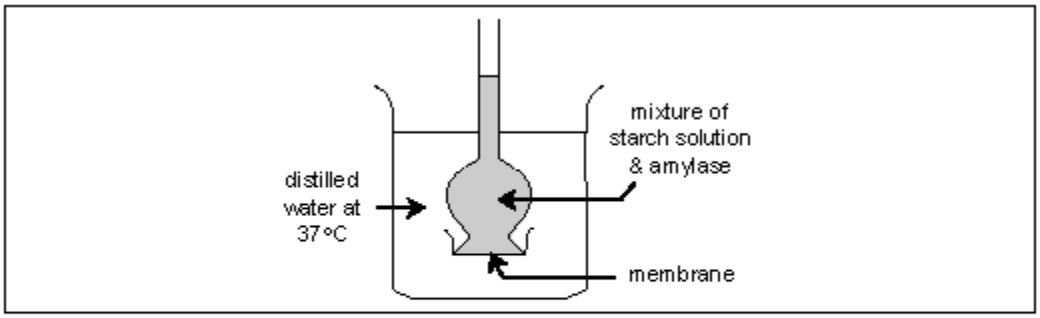
- **no net movement** of water across membrane.
- **Same number** of solute molecules per unit volume
- Cells placed in such a solution **neither** gain or lose water
- a 0.9 **percent solution of NaCl is isotonic to red blood cells** (RBC). *How can you tell this is so*?

Hypertonic Solutions ("greater" "strength")

- greater concentration (symbol for concentration ="[ ]") of solute than the cell (and therefore a lesser [ ] of water
- if a cell is placed in hypertonic solution, water will leave the cell and the cell will **shrivel** up. This is called CRENATION in animal cells. e.g. a 10% solution of NaCl is hypertonic to RBC -- they'll shrink

Hypotonic Solutions ("hypo" means "less than")

- these solutions have **lower concentration** of **solute** than the cell contents.
- if cell placed in hypotonic solution, **water will enter cell**, it will <u>swell</u> <u>and</u> <u>possibly</u> <u>burst</u>.
- e.g. a salt solution with a concentration greater than 0.9% is hypotonic to RBC.

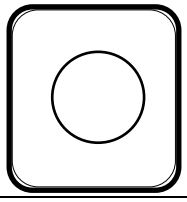
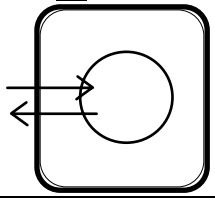
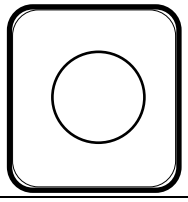
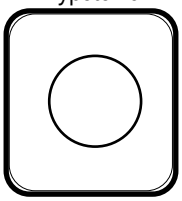
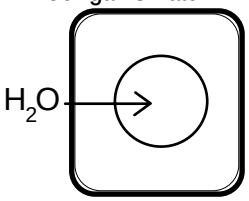
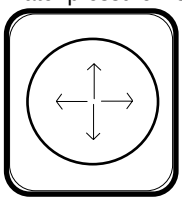
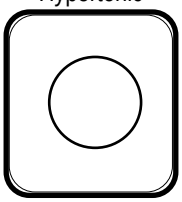
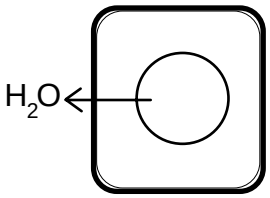
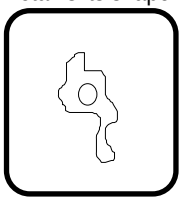


1. A student set up the experiment illustrated above and kept it at 37°C. After five minutes, the distilled water in the beaker was tested and found to contain a sugar but no starch.

   a) What had occurred inside the tube? **(1 mark)**

Significance of Tonicity to <u>PLANT</u> <u>CELLS</u>

Summary of what happens to <u>PLANT</u> <u>CELLS</u> placed in different tonicities of solution:

Tonicity of Solution Cell is Put Into	Net Movement of Water	Effect on Cell
Isotonic 	No <u>net</u> movement 	Remains the same 
Hypotonic 	Cell **gains** water 	Greater water pressure inside cell  "**turgor pressure**"
Hypertonic 	Cell **loses** water 	Cell Contents Shrink, but cell wall retains its shape  "**plasmolysis**"

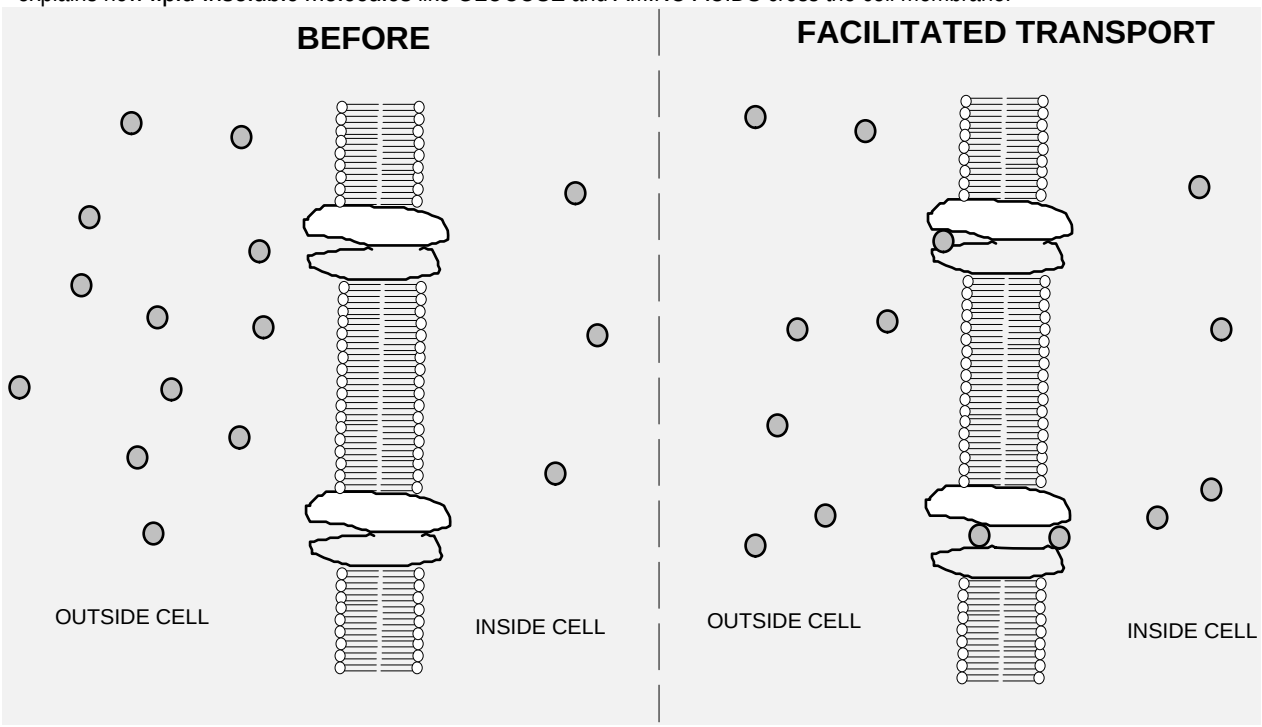
- **Hypertonic solutions** cause <u>PLASMOLYSIS</u> (shrinking of cell due to osmosis).
- **central vacuole loses water**, cell membrane shrinks and pulls away from cell wall.
- **Hypotonic solutions** causes <u>TURGOR</u> <u>PRESSURE</u>, against rigid cell wall (turgor pressure occurs when plant cells, placed in hypotonic solution, admit water. As water enters, **pressure builds up inside the cell** (*<u>hydrostatic</u>* *<u>pressure</u>*). When hydrostatic pressure = osmotic pressure, the plant is said to have developed turgor pressure).
  - cell wall keeps cell from bursting
  - <u>osmosis</u> <u>continues</u> <u>until</u> <u>turgor</u> <u>pressure</u> <u>=</u> <u>osmotic</u> <u>pressure</u>

- turgor pressure important for plant cells to retain erect positions. Now you should be able to explain why plants wilt when you don't water them!

TRANSPORT BY CARRIERS

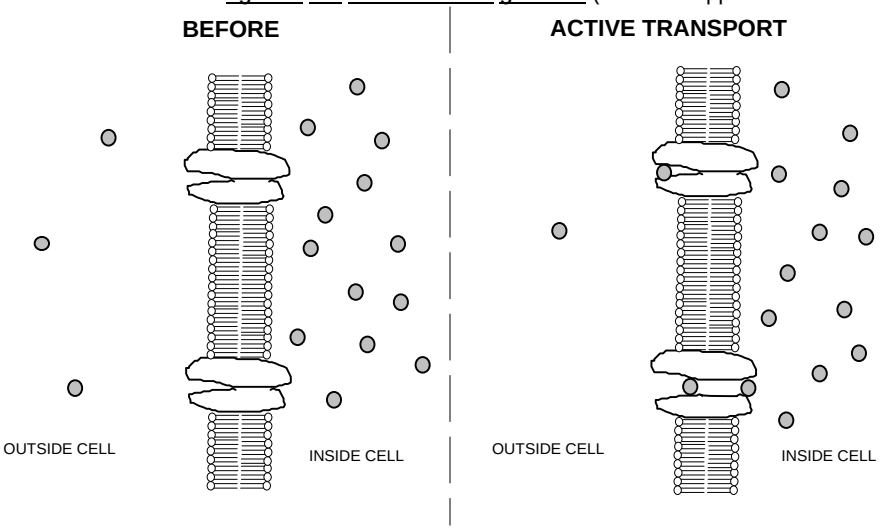
FACILITATED TRANSPORT

- utilizes PROTEIN CARRIERS in cell membrane to control passage of molecules in and out of cell.
- are highly specific - each carrier passes only one type molecule
- molecules only pass along concentration gradient.
- REQUIRES NO ENERGY - is like diffusion in this sense
- explains how **lipid-insoluble molecules** like GLUCOSE and AMINO ACIDS cross the cell membrane.



ACTIVE TRANSPORT

- also performed by **protein carriers**
- REQUIRES ENERGY (ATP)
- moves molecules against the concentration gradient (i.e. in the opposite direction of diffusion).



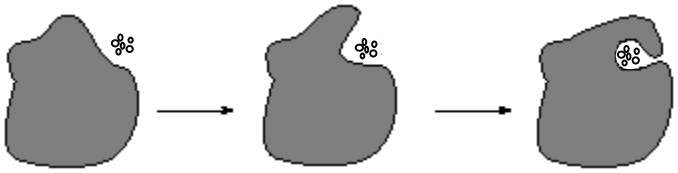
- molecules move from area of lower concentration to area of higher concentration.
- Active Transport **vitally important** to organisms:
  e.g. **Iodine & Thyroid Gland**. [I^+] is low in blood, high in Thyroid Gland. Active Transport moves I^+ from blood to thyroid.
  e.g. Na^+ actively transported out of urine by kidney tubule cells
  e.g. **sodium/potassium pump** in nerve/muscle cells (see text). Moves Na^+ from inside to outside of cell, and K^+ from outside to inside.
  e.g. Na^+ Cl^- and cystic fibrosis - a **genetic disease**, usually **fatal**, caused

by **blockage of Cl^- transport**.

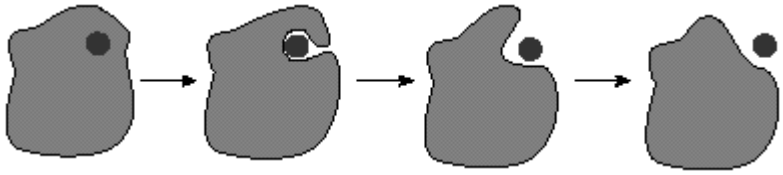
ENDOCYTOSIS AND EXOCYTOSIS

- another way to get molecules, **especially large particles**, in and out of cell.
- ENDOCYTOSIS: cell membrane forms a **vesicle** around the substance to be taken in.
  - Phagocytosis: what you call endocytosis if particles taken in really large (like other cells - e.g. human macrophages). Can be see with **light** microscope.

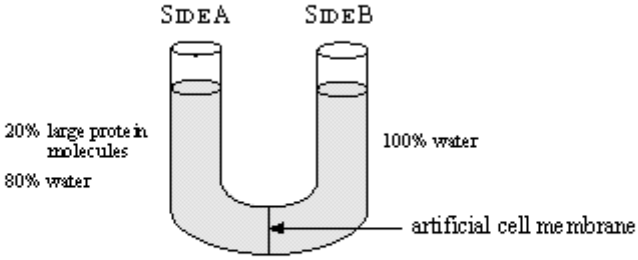
  - Pinocytosis: (= cell drinking) - same idea as phagocytosis, except smaller particles taken in (requires electron microscope to see).



- EXOCYTOSIS: Reverse of endocytosis. Vacuole within cell fuses with cell membrane and the vacuole contents are deposited on the outside. Important in secretion and excretion in cells.



What will happen to the protein solution in Side **A** of the apparatus in the diagram below?



A. It will become less concentrated since water passes from **B** to **A**.
B. It will become more concentrated since water passes from **B** to **A**.
C. It will become more concentrated since water passes from **A** to **B**.
D. It will become less concentrated since protein will move from **A** to **B**.