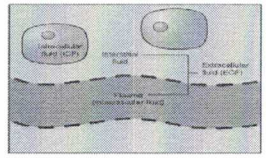
Cellular Membranes

All cells have a membrane and many organelles also have their own membranes.

Functions of the cell membrane:

a. Controls what enters and exits the cell to maintain an internal balance called homeostasis
b. Separates intracellular fluid (ICF) from extracellular fluid (ECF)
c. Provides protection and support for the cell

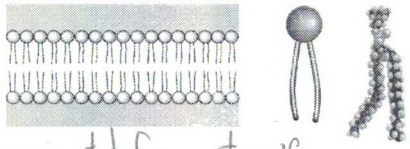


Structure of the cell membrane:

The lipid bilayer

- 2 layers of phospholipids:
  - Phosphate head is *polar* and hydrophilic and the fatty acid tails *non-polar* and hydrophobic
- Proteins, carbohydrates and other lipids embedded in membrane

1. **PHOSPHOLIPID MOLECULES**:
   a. Phosphate Group Head - hydrophilic & polar
   b. Fatty Acid Tail - hydrophobic & non-polar
   c. Arranged as a **bilayer.** Explain why:



Allows the area in between to be separated from water. If the tails were exposed, they would repel the water & such, they are covered in the bilayer.

Explain why the model of the cell membrane is called the Fluid-Mosaic Model:

The cell membrane is not static (hence fluid) & made of many difference components (hence mosaic).

2. **CHOLESTEROL**
   - Cholesterol is amphiphilic
     a. It contains a hydrophilic *and* a hydrophobic portion.
     b. Cholesterol's hydroxyl group aligns with the phosphate heads of the phospholipids.
     c. The remaining portion of it tucks into the fatty acid portion of the membrane.
     d. This helps slightly immobilize the outer surface of the membrane and make it less soluble to very small water-soluble molecules that could otherwise pass through more easily.

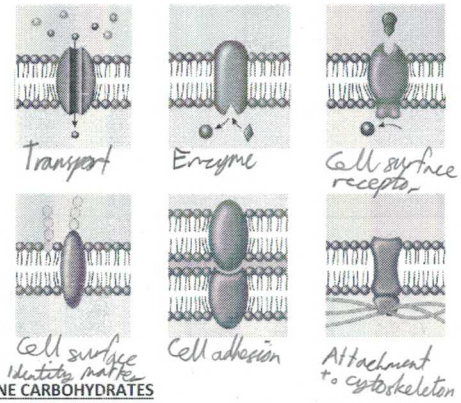
Explain why cholesterol is so important to the cell membrane:

W/o cholesterol, cell membrane is too fluid, permeable & not firm enough. Keeps membrane from turning into mush.

3. **MEMBRANE PROTEINS**. There are different types of membrane proteins:

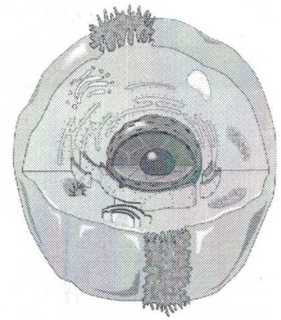
   a. **Peripheral Proteins**
      - Loosely bound to the surface (inner or outer) of membrane
      - Used as a cell surface identity marker
   b. **Integral/Transmembrane Proteins**
      - Span across the entire lipid bilayer
      - Can be used as transport proteins, channels and pumps

   Fill in the various functions of Integral Proteins in the Diagram below:



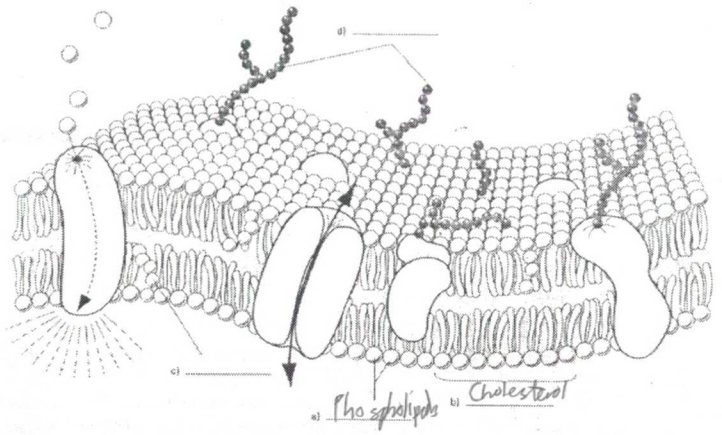
4. **MEMBRANE CARBOHYDRATES**
   a. **Glycoproteins**
      - Contain carbohydrate groups
      - Can be peripheral or integral
      - Play a structural role
      - play an important part in hormone function.
        - Glycoprotein acts as a receptor and 'recognizes' hormones to permit access to the cell
   b. **Glycolipids**
      - Lipids with a carbohydrate attached
      - Provides energy
      - Markers for cell recognition

Membrane Bound Organelles



- Membranes are also found within eukaryotic cells as part of the structure of **membranous organelles**.
- Examples of membrane-bound organelles include:
  - mitochondria
  - nucleus
  - Golgi apparatus
  - endoplasmic reticulum
  - vesicles
  - vacuoles
  - chloroplasts (not shown, this example is of an animal cell)

Label the Diagram:



Cell membranes are made of 3 different molecules: lipids, proteins, and glycocalyx (carbohydrates). In the table below, describe the structure and function of each.

Structure	Function
Lipids in the Membrane	
a. *Phospholipids* A phosphate group attached to fat, & unsat fats	Allows cell membrane to be semipermeable
b. *Cholesterol* Amphiphillic & aligns with phospholipid heads	Keeps cell membrane intact, firm, & semipermeable
Proteins in the Membrane	
a. *Integral Proteins*: Spans across the lipid bilayer aka Transmembrane protein	Transport proteins Channels & pumps
b. *Peripheral Proteins*: Loosely bound to surface of membrane	Identity markers for cells
Carbohydrates in the Membrane	
a. *Glycoproteins*: Contains carb groups	Plays a structural role & hormone function (allows hormones into the cell)
b. *Glycolipids*: Lipids with carbs attached	Provides energy Markers for cell recognition

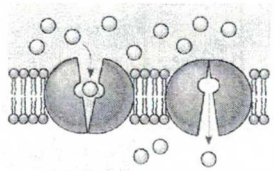
Complete the table below: **Effect of Osmosis on the Cell**

Osmotic situation of the solution	Concentration of solutes outside the cell compared to inside	Net movement of water (in or out of cell)	Effect on cell	Appearance of Cell
Isotonic	Even distribution	N/A	*Animal* Normal	*Animal* ○
			Plant Flaccid	*Plant* □
Hypotonic	Less than inside	Into cell	*Animal* Lysed (burst)	*Animal*
			Plant Turgid (Normal)	*Plant*
Hypertonic	More than inside	Out of cell	*Animal* Shriveled	*Animal*
			Plant Plasmolyzed	*Plant*

Try to answer these:

1. If you wanted to kill a weed by dehydration, what kind of solution would you use? Hypertonic
2. a) If you placed a limp piece of celery in a container of tap water overnight, how would its appearance change? Would become Turgid
   b) In the scenario in a), which has the greatest osmotic pressure: the celery or the tap water?
3. a) If you wanted to soften a slice of carrot, what kind of solution would you use?
   b) In what direction will the net movement of water be in this case?

ACTIVE TRANSPORT



- This process requires energy
  - (ATP, more on this later)
- Movement is against the concentration gradient, from high to low
- Requires carrier proteins to transport materials across membrane

Cotransport:
Definition → when two substances are simultaneously transported across a membrane by one protein.

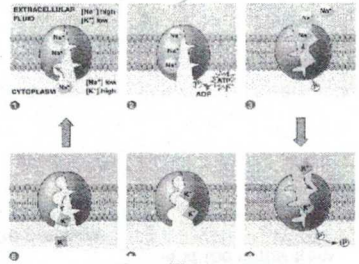
- Requires energy and moves against their gradients (therefore Active Transport)

- Two Types:
  - Symport → both substances, same direction
  - Antiport → both substances, opposite direction

*** See animation on PowerPoint Note on D2L

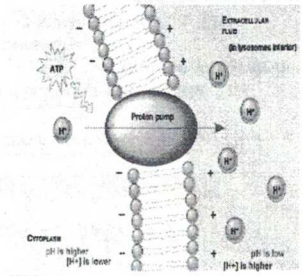
E.g. of Antiport – the Sodium-Potassium Pump

- A protein pump in the membrane that exchanges sodium and potassium ions across the membrane
  - More on this later (in the homeostasis unit)



E.g of Active Transport – Proton Pumps

- Use the energy from ATP to pump Pumps hydrogen ions across the membrane
- This creates a large difference in charge (due to the charge of the proton) or electric potential and a concentration gradient builds up
- The combination of a concentration gradient and an electrical potential = an electrochemical gradient which stores potential energy
- (important in the metabolic processes unit)



Membrane-Assisted Transport

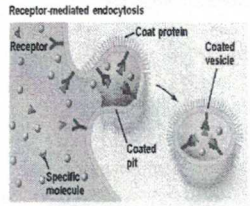
- Transport method used to move material that are too large to cross the cell membrane through a channel or carrier protein
- Requires energy (ATP)/Active Transport
- Two forms: **endocytosis** and **exocytosis**

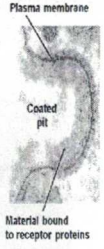
Endocytosis (Bring in → Create then eject)

- Cell engulfs material by folding the cell membrane around it and then pinching off to form a vesicle inside the cell
- Can be against or with the concentration gradient
  - Phagocytosis – involves solid particles – 'cell eating'
  - Pinocytosis – involves liquid particles - 'cell drinking'

Receptor-Mediated Endocytosis:

- Unlike the others forms of endocytosis, RME involves the engulfment and transport of specific molecules into the cell
- The cell membrane has regions of receptor proteins exposed to the extracellular environment
- The receptor proteins occur in clusters (coated pits) and have binding sites that will only bind to specific molecules.





Cell Transport

Purpose/Importance of Cell Transport:

- To regulate the passage of substances into and out of the cell
  - The cell membrane is semi permeable, that is, certain substances can move across while others cannot
  - There are many mechanisms by which materials can enter and exit the cell:
    - Some are Passive – meaning that the substance moves with the concentration gradient and doesn't require energy.
    - Some are Active – meaning that meaning that the substance moves against the concentration gradient & requires energy
  - **Concentration gradient**: the difference between the concentration on the inside of the membrane and the concentration on the outside of the membrane

PASSIVE TRANSPORT

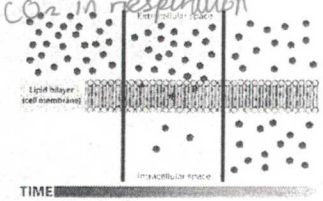
Diffusion: net movement of ions/molecules from high concentration area to low concentration area

- Process that enables substances to move in and out of cells without the input of energy
- This is due to the concentration gradient
- Aim is to achieve equilibrium

- Does not require ATP
= Eg, O_2, CO_2 in respiration

Simple Diffusion:

Definition → Molecules moving directly through the lipid bilayer



** see animation on PowerPoint note

E.g. of materials that enter /exit cell via simple diffusion:

Factors that Affect the Rate of Diffusion:

Factor	Description
Molecular Size	the larger a molecule, the more difficult ... Therefore decrease in rate
Molecular Polarity	small polar molecules can pass, generally lower rates than non-polar of the same size
Molecule or ion charge	in general, charged molecules and ions cannot diffuse through
Temperature	higher temp increases rate
Pressure	higher pressure increases rate

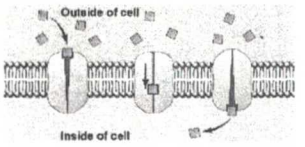
* Not tested (maybe)

Facilitated Diffusion:

Definition → Transport of ions/molecules across membrane via membrane proteins along the concentration gradient for the ion/molecule.

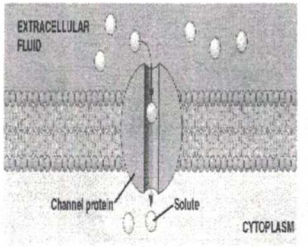
This can occur via **Channel Proteins** or **Carrier Proteins**.

Facilitated Diffusion



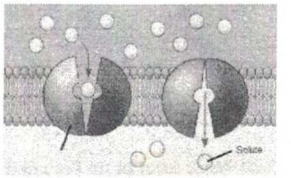
Channel Proteins:

- Highly specific, can remain open all the time so substances can 'flow' through
- E.g of material that uses channel proteins for facilitated diffusion: H_2O and ions
- Have hydrophilic interiors that provides an aqueous channel through which polar molecules can pass



Carrier Proteins:

- Bind to specific molecules, undergo conformational changes, transport them across the membrane and release on the other side.
- Mainly for larger molecules, like glucose, amino acids, and some ions
- Lower rate of diffusion than channels



Specific Type of Passive Transport – OSMOSIS

Definition→ The movement of water from high concen. area to low concent. area, across a semi-permeable membrane.

Water/osmosis uses Protein channels, therefore it is facilitated diffusion

**See animation on PowerPoint note

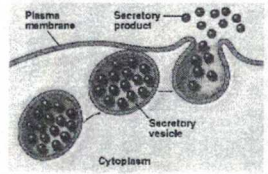
- Osmotic concentration is the concentration of all solutes in a solution.
- If two solutions have **unequal** osmotic concentrations:
  - the solution with the higher solute concentration is hypertonic
    - (hyper = 'more than')
  - The solution with the lower solute concentration is hypotonic
    - (hypo = 'less than')
  - When two solutions are the same, they are isotonic
    - (iso = 'equal')
- Direction of osmosis is determined by comparing **osmotic pressure** ← Later unit

Osmotic Pressure → pressure of solution against semipermeable membrane to prevent H_2O from flowing across

- **Isotonic solution**: The concentration of solutes on both sides of the membrane is equal. There is no net water movement, therefore no issue & equilibrium
- **Hypertonic solution**: The concentration of solutes outside the cell is higher than inside. The osmotic pressure outside the cell is therefore higher, and the water from inside the cell moves to the outside in an attempt to equalize the pressure
- **Hypotonic solution**: The concentration of solutes outside the cell is lower than inside. The osmotic pressure outside the cell is therefore lower, and the water from the solution will move into the cell in a n attempt to equalize the pressure

Exocytosis

- Transport method in which a vesicle fuses with the cell membrane and release its contents outside of the cell
  - Often the vesicles are packaged by the golgi apparatus
- Releasing: hormones, neurotransmitters, digestive enzymes



Complete this table summarizing cell transport:

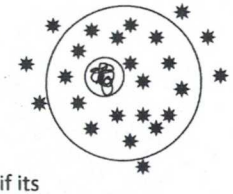
Type of Cell Transport	Is energy required?	Primary Direction of Movement	Examples of substances transported this way
Simple Diffusion	NO	From high concentration to low	CO_2 & O_2
Facilitated Diffusion	No	Across cell membrane via membrane proteins	Na^+, Cl^- (channel), glucose, amino acid (carrier)
Active Transport	Requires ATP	Against gradient from low → high concentration via carrier protein	
Endocytosis	ATP	Against gradient or with	
Exocytosis	ATP	Out of cell via vesicle fusing w/ cell & releasing out of cell	Hormones, digestive enzymes, neurotransmitters

Answer these:

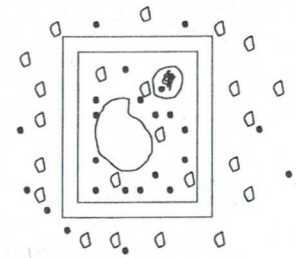
1. Draw an animal cell in an isotonic environment. Add labels and a caption to explain clearly the movement of substances in and out of the cell and the effect of this movement on the cell.
2. Compare and contrast a channel protein and a carrier protein.
3. A drop of 5% solution of NaCl is added to a leaf of an aquatic plant. When the leaf is viewed under a microscope, colourless regions appear at the edges of each cell as the cell membranes shrink from the cell wall. Describe what is happening and why.

Tonicity Practice Problems

Answer the following questions thoroughly. Include correct terminology, and specify which way water would move in each scenario.



1. In the cell to the right, the dots represent dissolved solutes in the ECF and ICF. What change would you expect to see in this animal cell?
2. *Paramecia* live in hypotonic environments. They contain a specialized structure called a contractile vacuole that allows them to maintain equilibrium in terms of solute and water concentrations with their external environments. Explain what would happen to a paramecium if its contractile vacuole stopped functioning (*Paramecia* cells closely resemble animal cells).
3. A cell has a salt concentration of 0.2%. If it is placed into a solution with a salt concentration of 0.1%.
   a. What has a higher osmotic pressure – the cell or the solution?
   b. What change will occur to the salt concentration inside the cell?
   c. What change will occur to the water concentration inside the cell?
   d. What condition will eventually result from the net movements of water and salt?



4. In the diagram of the plant cell shown to the right, the dots represent sugar molecules, and the circles represent water molecules. Explain the changes that would occur at the cellular level to this cell.
5. What is plasmolysis? Use a simple diagram and a short note to explain how plasmolysis occurs.
6. If you took a fresh water *Amoeba sp.* (single celled organism) and placed it into a drop of sea water, what changes would you expect to occur in the organism?
7. Explain why a grocer sprays lettuce and other vegetables in his store with water.
8. Red blood cells are 95% water. Create a series of drawings to indicate the cellular changes in a RBC after being placed in a:
   a. 5% NaCl solution
   b. 15% NaCl solution
9. A plant cell containing 94% water is placed into a 10% salt solution. What changes will occur in the cell if it is left overnight?
10. Explain why when you have a sore throat, gargling with salt water often helps ease your symptoms.

Ryan L

C1: 0.73g 0.79g
C2: 0.65g 0.68g
C3: 0.65g 0.65g
C4: 0.41g 0.32g
C5: 0.67g 0.53g
C6: 0.41g 0.31g

Osmosis Lab

Purpose: To investigate the effects of different environments on cells.

Materials: Celery, Salt water solutions of varying concentrations (0%, 1%, 3%, 5%, 8%, 10%), Balance, Beakers

Method:
READ THROUGH THE METHOD AND CONSTRUCT A DATA TABLE TO RECORD YOUR OBSERVATIONS

1. Cut the celery to make 6 pieces each approximately the same size – SMALL … 1cm x 1cm
2. Pat each piece dry with a paper towel.
3. Mass each of the samples and record in a data table. If any of the masses are drastically different from the others, get a new piece.
4. Place the samples into 6 different beakers. Fill each beaker with a different concentration of salt solution (about 25 mL – enough to cover the celery piece)
5. After 30 minutes remove each piece, pat it dry, and find and record the mass.
6. Calculate the **percentage change** for each cube and record in your table **(+VE OR –VE)**
   Percent change in mass = $\frac{\text{final mass - initial mass}}{\text{initial mass}}$

Salt Solution	Initial Mass	Final Mass	% Change
0%	0.73g	0.79g	8.2%
2%	0.65g	0.68g	4.6%
5%	0.65g	0.65g	0%
10%	0.41g	0.32g	-21.9%
20%	0.67g	0.53g	-20.9%
30%	0.41g	0.31g	-24.3%

Results:
Plot your data on a graph (percent change vs % salt solution). Make a **line of best fit**. Label the range of **solutions** that are hypertonic and hypotonic to your sample. Label the exact point that is isotonic to your sample. You can do this by simply drawing them onto your graph.

- **Title the graph appropriately (should be detailed and descriptive).**

DRAW/PRINT YOUR GRAPH AND BRING IT TO CLASS WITH YOU TOMORROW

Post-lab Questions to think about ahead of tomorrow's class:

1. Summarize the effects of a **hypertonic** solution on a plant cell (using the lab data). Can you explain what has happened at the *cellular level*? The following terms may be helpful: solute, water, concentration, concentration gradient, osmotic pressure, turgidity, and mass.

2. Summarize the effects of a **hypotonic** solution on a plant cell (using the lab data). Can you explain what has happened at the *cellular level*? The following terms may be helpful: solute, water, concentration, concentration gradient, osmotic pressure, turgidity, and mass.

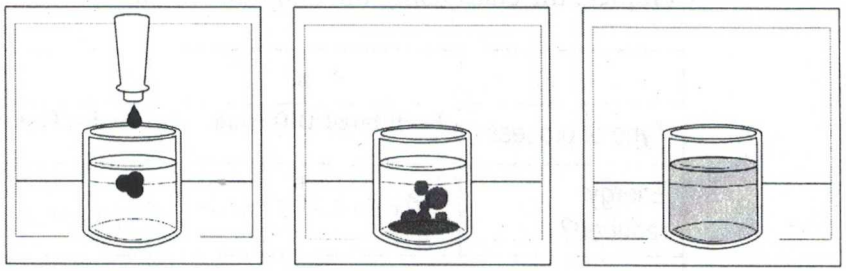
3. Summarize the effects of an **isotonic** solution on a plant cell (using the lab data). Can you explain what has happened at the *cellular level*? The following terms may be helpful: solute, water, concentration, concentration gradient, osmotic pressure, turgidity, and mass.

Diffusion and Osmosis

sing your understanding of diffusion and osmosis, answer the following:

1. Fully explain what is occurring in the diagrams to the right.

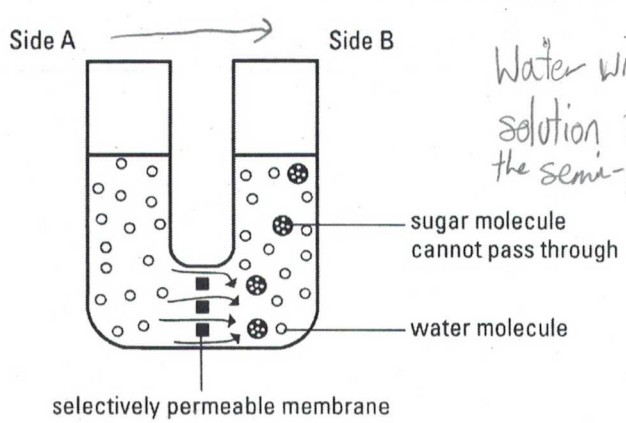
The solute dissolves into the solvent.



2. Complete the table below: **Effect of Osmosis on the Cell**

Osmotic situation of the solution	Solute Concentration		Net movement of water (in or out of cell)	Effect on cell	Appearance of Cell
	Cell	*Environment*			
Isotonic	Balanced	Balanced	N/A	*Animal* Normal	*Animal* Normal ○
				Plant Normal	*Plant* Flaccid □
Hypotonic	More	Less	Into cell	*Animal* Bursts,	*Animal* Lysed
				Plant Normal	*Plant* Turgid □
Hypertonic	Less	More	Out of cell	*Animal* Shrinked & shriveled	*Animal* Shrivelled
				Plant Shrinked & Shriveled	*Plant* Plasmolyzed

3. Explain where water will move in the diagram below.

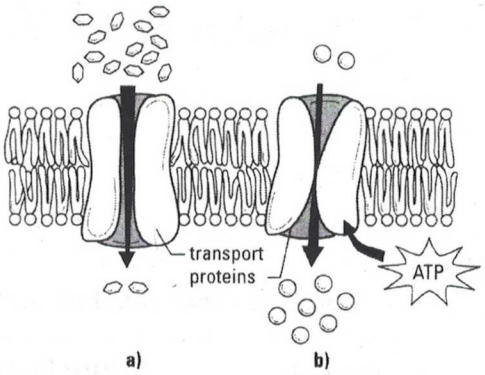


Water will move from the less concentrated side (hypotonic) solution to the more concentrated side (hypertonic) through the semi-permeable membrane via osmosis.

Cell Transport

1. Complete the chart using the diagrams to the right

	a	b
Type of process	**Facilitated Diffusion**	**Active Transport**
Energy required?	Does not require ATP	Requires ATP
With or against gradient	With	Against



2. Complete the following table. Include in your descriptions for each method whether energy is required and whether movement is with or against the concentration gradient.

Cell Transport by Vesicles Summary Table

Name	Description of Cell Transport Method	Example of Molecule/Ion Transported
Facilitated diffusion	Molecules travel with the gradient with the help of channel/carrier proteins	H_2O (channel), ions, glucose, amino acids (carrier)
Active transport	Requires ATP to transfer molecules against gradient using carrier proteins.	Glucose,
Endocytosis: Pinocytosis	Liquid particles are folded in a cell membrane & pinched into a vesicle. Requires ATP.	
Endocytosis: Phagocytosis	Solid particles are folded into cell membrane & brought in after being pinched into a vesicle. Requires ATP	
Receptor-mediated endocytosis	Binds with proteins which only accept specific molecules	
Exocytosis	Golgi apparatus forms a vesicle around the molecules which travels to edge of cell & releases molecules.	Neurotransmitters, hormones