CHAPTER 3.1 – STRUCTURE OF PLASMA MEMBRANE

The necessity of movement of substances across a plasma membrane

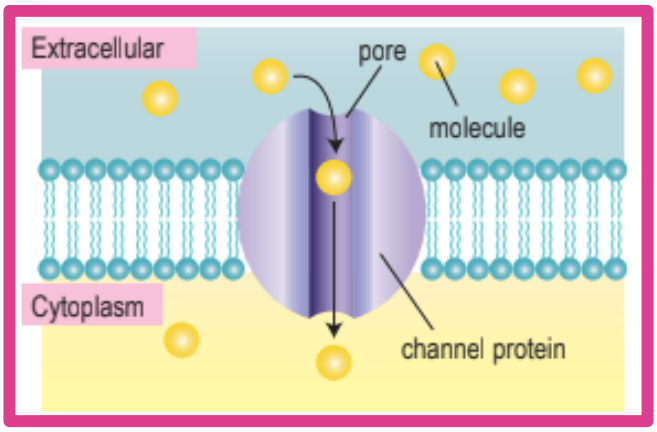
1. Living cells require substances from the external environment to carry out living processes
2. At the same time, the metabolic processes in cells produce waste that need to be disposed of from the cells
3. Cells must allow some substances to move into and out of the cells to maintain the living processes
4. The movement of substances into and out of the cell is regulated by the plasma membrane

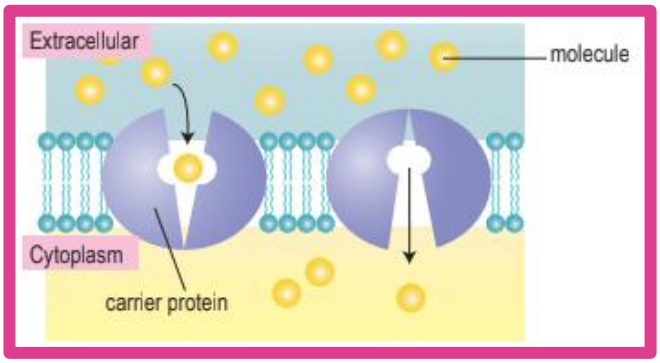
Structure of the plasma membrane

- Δ According to the fluid mosaic model, protein molecules float within the phospholipid bilayer, forming a mosaic pattern that changes frequently
- Δ Each phospholipid molecule consists of
  - » A polar head which is hydrophilic (attracted to water)
  - » A nonpolar tail which is hydrophobic (repels water)
    - » *phobic = phobia (scared of / don't like something)
- Δ The heads of the phospholipid molecule in the outer layer face the extracellular fluid
- Δ The phospholipid heads in the inner layer face the cytoplasm
- Δ The tails of the phospholipid molecule of two layers face each other
- Δ The protein molecules embedded partially or fully within the membrane
- Δ The protein molecules are widely dispersed between the phospholipid bilayer
- Δ There are two types of protein molecules
  - A) Channel proteins
  - B) Carrier proteins
- Δ Glycoprotein and glycolipid are carbohydrate chains attached on some proteins and lipids
- Δ Functions of glycoprotein and glycolipid are
  - 1) Act as receptors to hormones (insulin)
  - 2) Stabilise the membrane by forming hydrogen bonds with water
  - 3) Act as antigens for cell identification
- Δ Cholesterols that found between the phospholipid molecules make the phospholipid bilayer
  - a) Stronger

b) More flexible
c) Less permeable to water-soluble substances (ions)

Δ The phospholipid bilayer, proteins and cholesterols are not static but form a dynamic and flexible structure





FLUID MOSAIC MODEL

- Refers to a protein molecule that are suspended in the phospholipid bilayer forming an ever-changing mosaic pattern

Permeability of a plasma membrane

I. The plasma membrane is permeable if the substances is able to pass through it freely or impermeable if the substances is unable to pass through it
II. The plasma membrane is a selectively permeable membrane
III. The selectively permeable membrane is permeable to water
IV. The plasma membrane only allows free movement of certain molecules across it and prevent or limit the movement of the other substances
V. The plasma membrane has a selectively permeable property due to its building structure
VI. The phospholipid bilayer and protein determine the membrane permeability towards specific substances

WHAT WILL HAPPEN IF THERE IS NO CHOLESTEROL?

- Without cholesterols, the membrane will become too permeable to dissolved substances
- It also become too fluid at a normal body temperature that may cause it to rupture

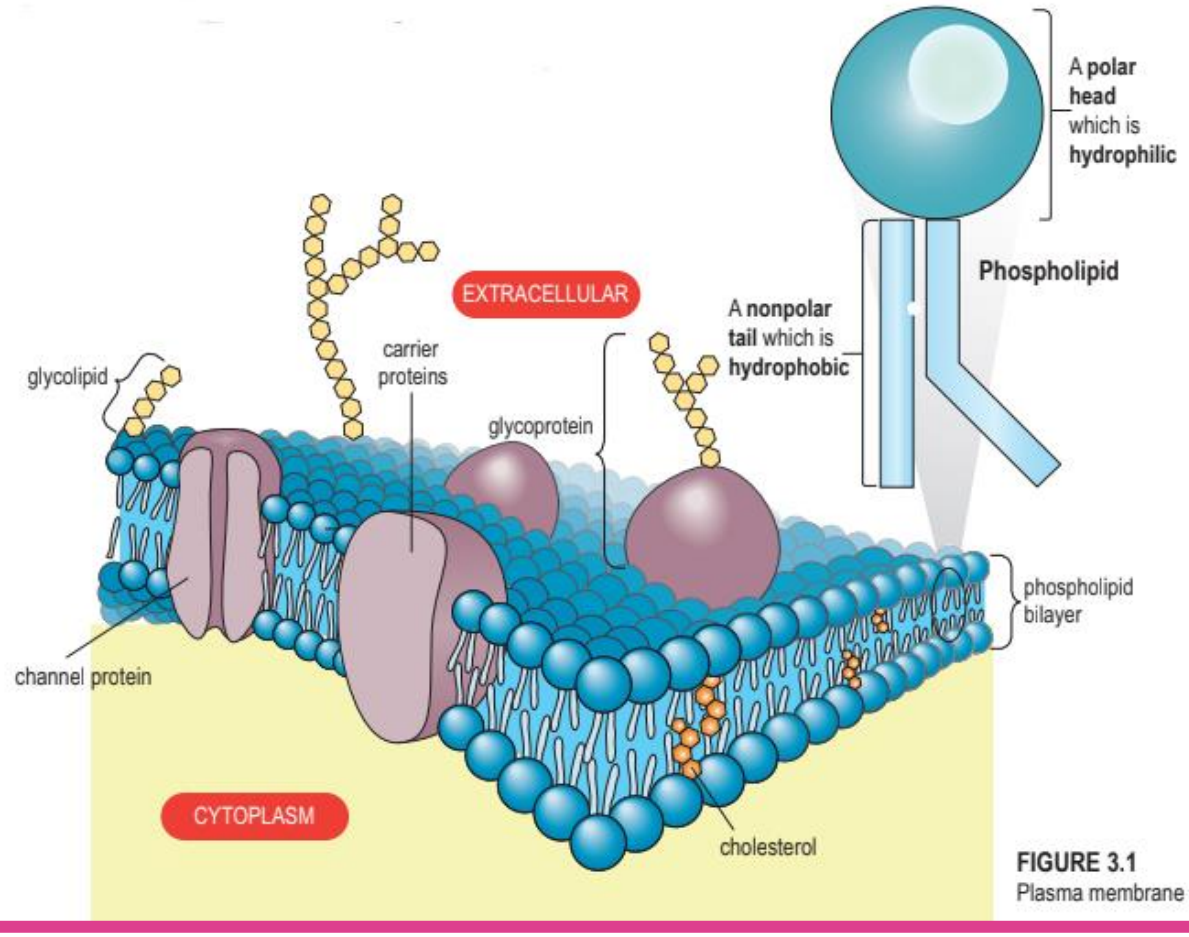


FIGURE 3.1
Plasma membrane

CHAPTER 3.2 – CONCEPT OF MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE

The characteristics of a substances that are able to move across a plasma membrane

Three common factors for a substance to pass through the plasma membrane

- Molecule size
- Polar molecule
- Ionic charge

Characteristics of movement of substances across a plasma membrane

1) Nonpolar molecules
2) Small molecule and ion
3) Large molecule

NONPOLAR MOLECULES

- Fatty acid
- Glycerol
- Fat soluble vitamins (ADEK)
- Steroid compounds

SMALL MOLECULE AND ION

◊ Polar molecules (water)
◊ Nonpolar molecules (oxygen, carbon dioxide)
◊ Ion (K^+, Na^+, Ca^+, Mg^+)

LARGE MOLECULE

- Glucose
- Amino acid

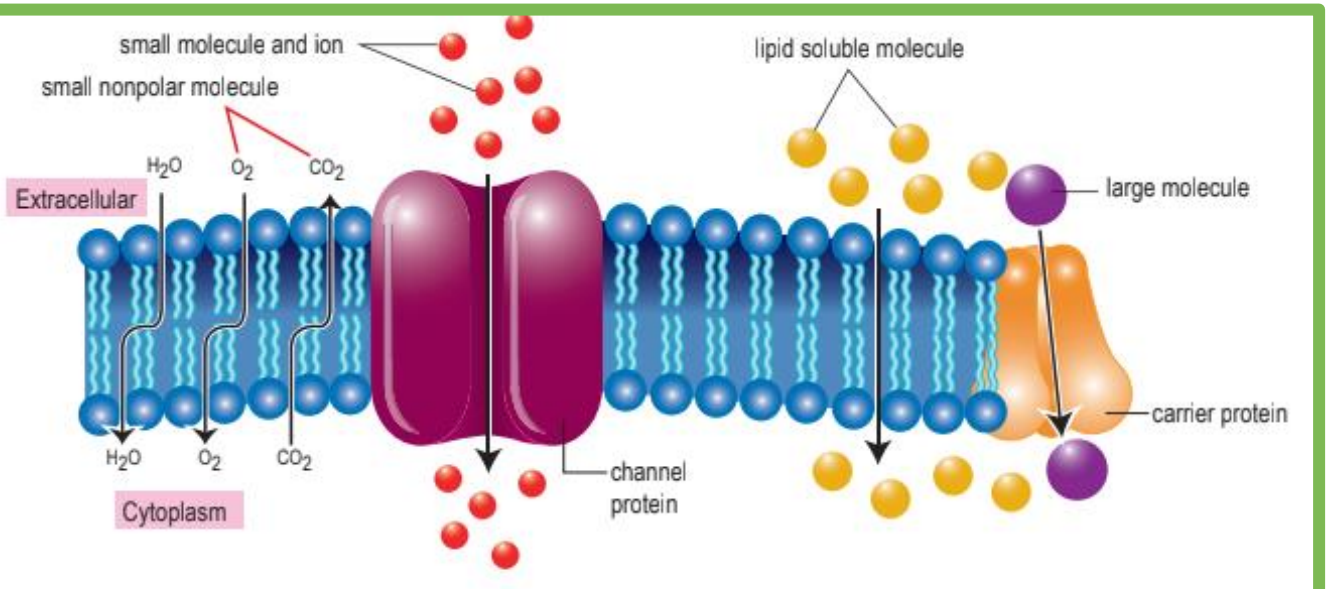


FIGURE 3.3 Movement of substances across a plasma membrane

Passive transport

- Passive transport does not require energy
- Three types of passive transport
  1. Simple diffusion
  2. Osmosis
  3. Facilitated diffusion

Simple Diffusion

- Simple diffusion is the movement of molecules or ions from an area of high concentration to an area of low concentration
- The molecules move down the concentration gradient until a dynamic equilibrium is achieved
- This may occur with or without the presence of a plasma membrane
- Does not require energy
- Molecules that can pass through the plasma membrane via simple diffusion
  A) Lipid soluble (fatty acids, glycerol)
  B) Oxygen
  C) Carbon Dioxide

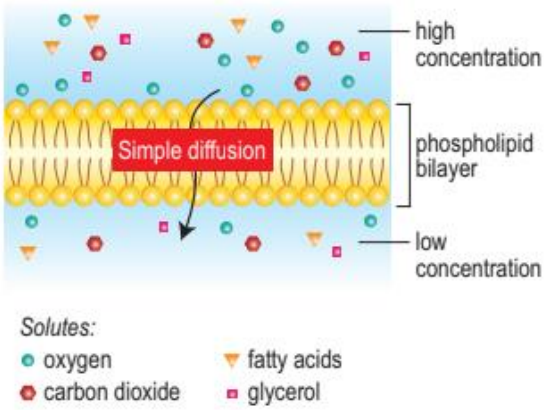


FIGURE 3.4 Simple diffusion through the phospholipid bilayer

Osmosis

- Osmosis is a process similar to simple diffusion that only involves water molecules
- Refers to the net movement of water molecules from an area of high water potential (*low solutes concentration*) to an area of low water potential (*high solutes concentration*) through a selectively permeable membrane
- Does not require energy

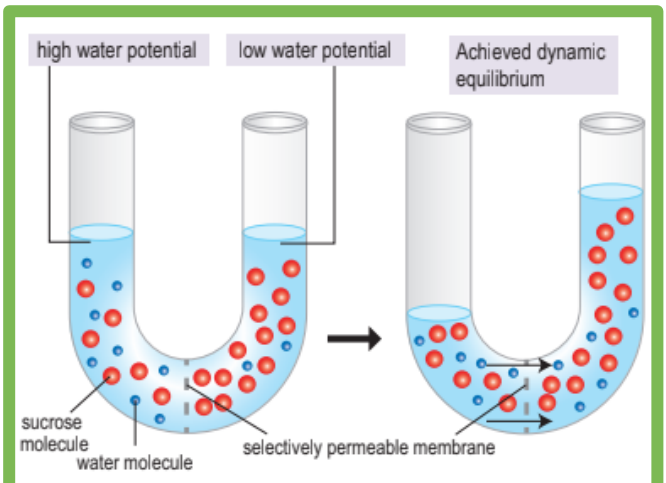


FIGURE 3.5 Osmosis

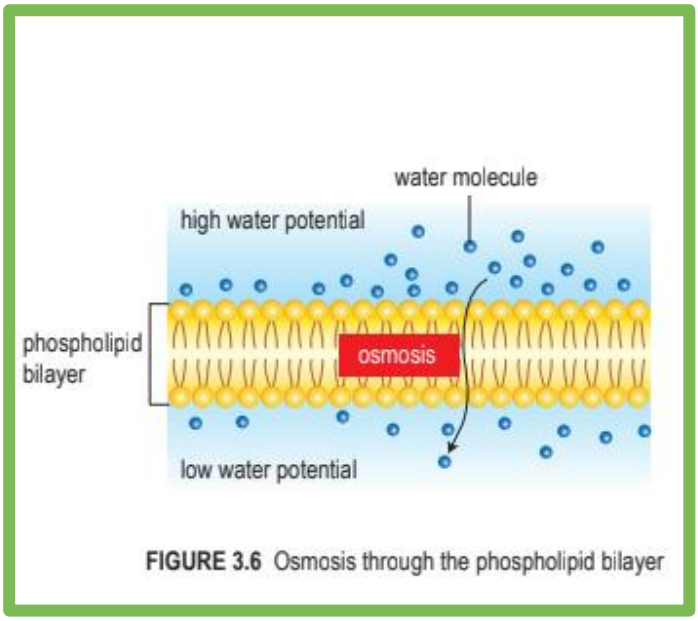


FIGURE 3.6 Osmosis through the phospholipid bilayer

Facilitated Diffusion

- Lipid-insoluble molecules (ions) and large molecules (amino acids, glucose) move across the membrane with the aid of transport proteins (carrier or channel protein) via facilitated diffusion
- Does not require energy because the transport proteins transport molecules down a concentration gradient until a dynamic equilibrium is achieved
- The transport proteins
  1. Channel proteins
  2. Carrier proteins

CHANNEL PROTEINS

- Form channels or canals to allow small-sized solutes and ions to diffuse across the plasma membrane
- Channels have specific internal characteristics that only allow specific ions to pass through it

CARRIER PROTEINS

- Have specific sites and can only bind to a specific molecule
- For example, glucose molecules can only bind to the specific site of a glucose carrier protein

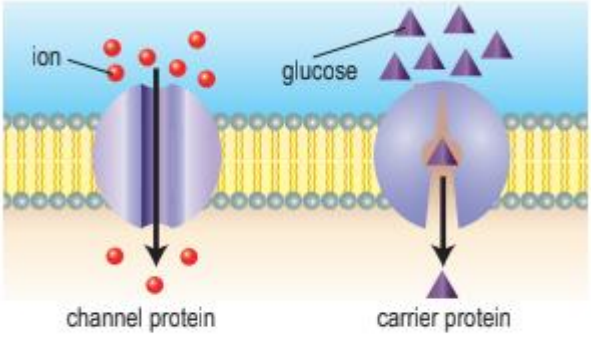


FIGURE 3.7 Facilitated diffusion through channel and carrier proteins

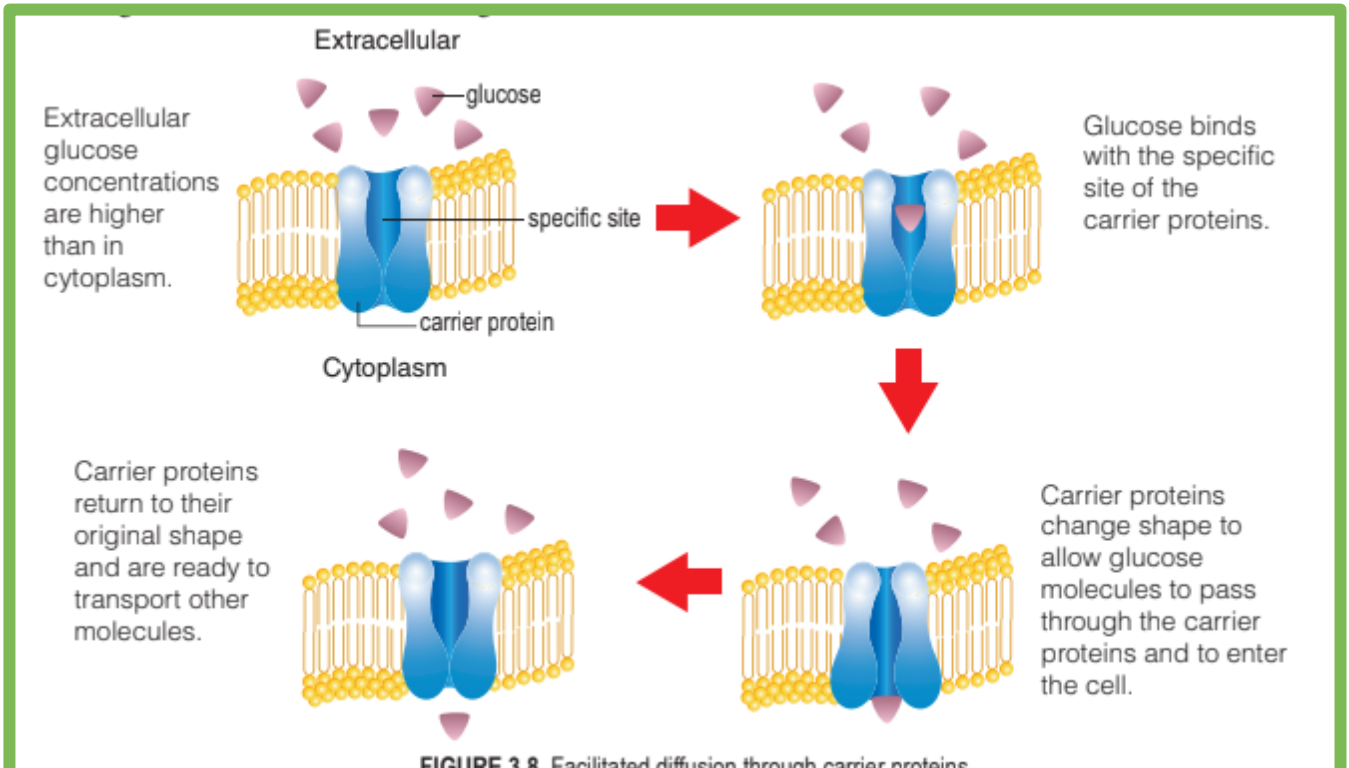


FIGURE 3.8 Facilitated diffusion through carrier proteins

Active transport

» The characteristics of movement of substances across a plasma membrane via active transport

1) The movement of molecule or ion substances are against a concentration gradient
2) Does require energy from ATP that are generated during cellular respiration
3) Does require specific carrier protein with specific sites
4) Carrier proteins also possess receptors to bind with ATP molecules
5) Carrier proteins change shape when a phosphate group attaches to it

» Active transport results in the accumulation or excretion of molecules or ions

» Carrier proteins that involved in this process are known as pumps

SODIUM-POTASSIUM PUMP

- In animal cells, the carrier proteins that transport sodium ions to extracellular and potassium ions into the cell are called sodium-potassium pump

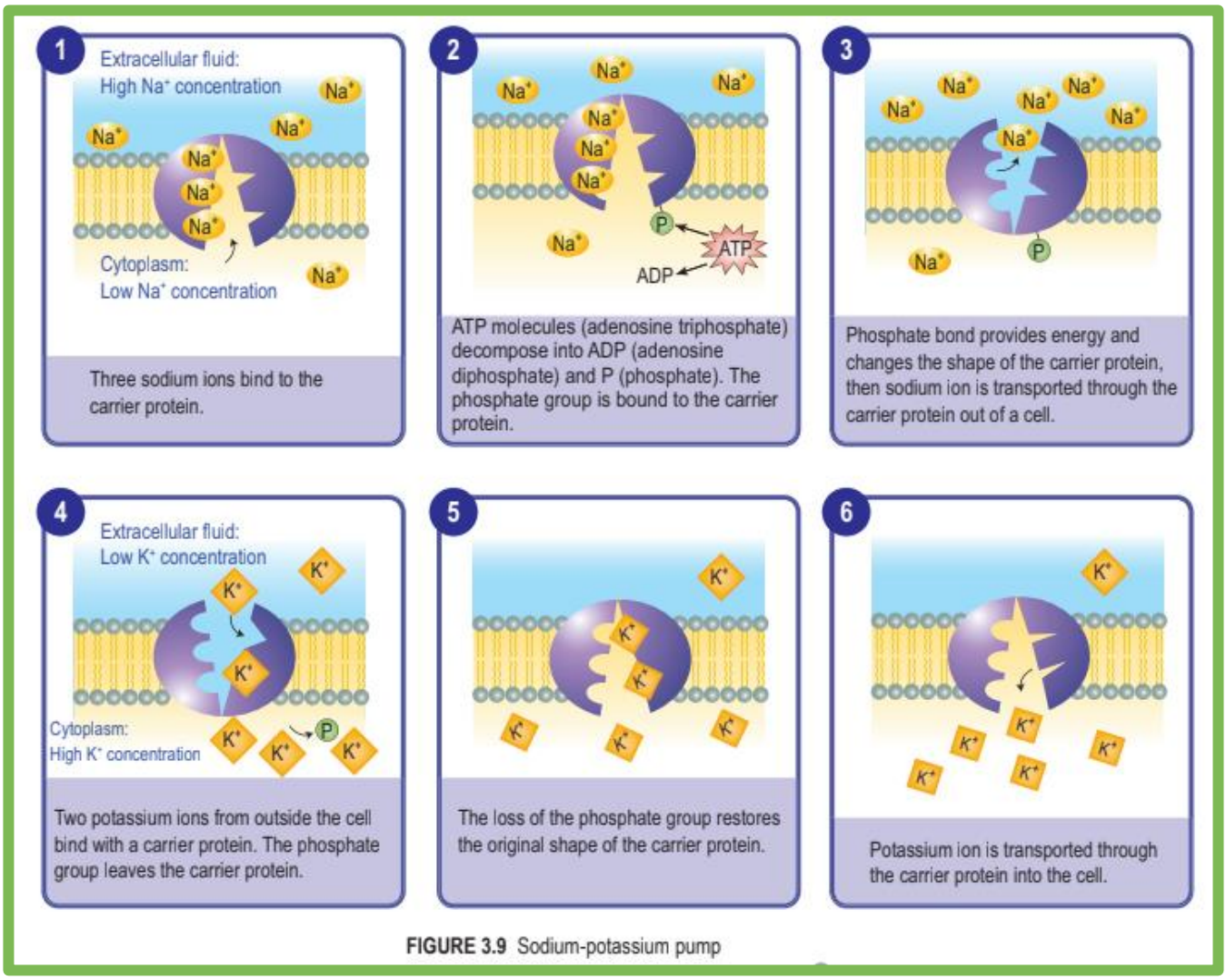


FIGURE 3.9 Sodium-potassium pump

PROTON PUMP

- Found on the epithelial cells lining the stomach cavity
- Causes the acidity of the stomach contents
- Energy from the ATP enables hydrogen ion to be transported by the carrier protein (proton pump) towards the extracellular fluid
- This causes accumulation of the hydrogen ion and acid production in the stomach cavity

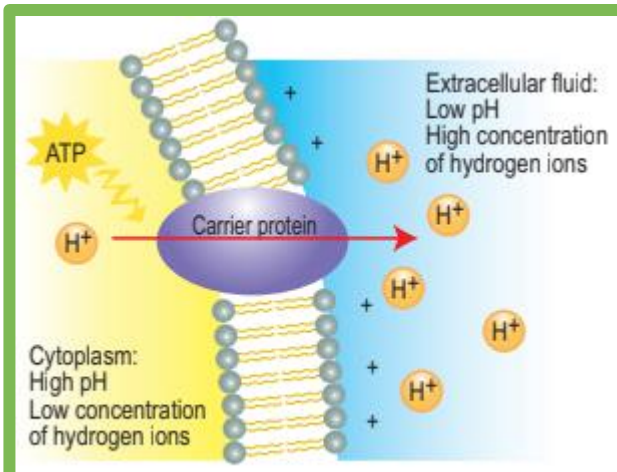


FIGURE 3.10 Proton pump

SIMILARITIES

- Moving a substance across a membrane
- Occurs through a selectively permeable membrane

DIFFERENCES

PASSIVE TRANSPORT	ACTIVE TRANSPORT
Energy is not required	Requires energy
Occurs following the concentration of the gradient	Occurs against the concentration of the gradient
Occurs until a dynamic equilibrium is achieved	There are accumulation and disposal of molecules or ions

CHAPTER 3.3 – MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE IN LIVING ORGANISMS

Active and passive transport in living organisms

PASSIVE TRANSPORT

Occurs during:

- Gaseous exchange between an alveolus and a blood capillary via simple diffusion
- Reabsorption of water via osmosis trough the renal tubule in the kidney
- Absorption of water by a plant root hair cell via osmosis
- Absorption of fructose molecule in the villus via facilitated diffusion

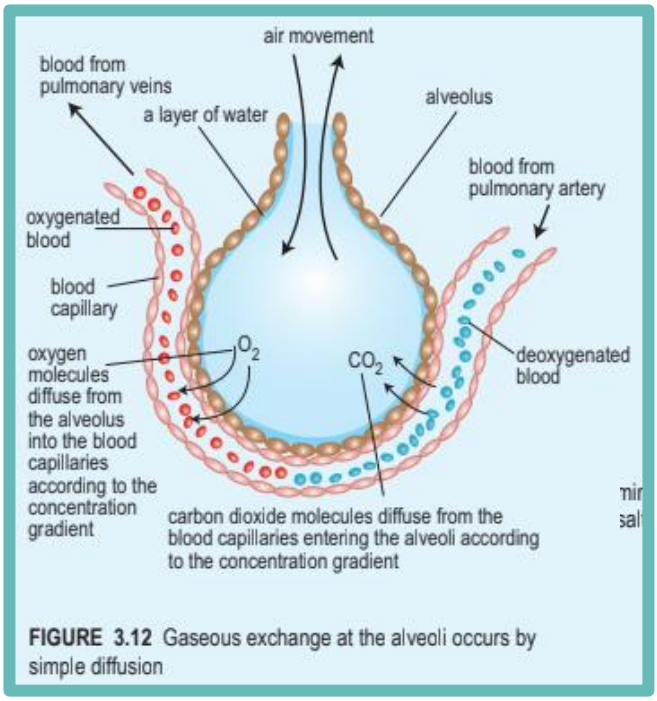


FIGURE 3.12 Gaseous exchange at the alveoli occurs by simple diffusion

ACTIVE TRANSPORT

Occurs during:

- Absorption of glucose and amino acids in the villus
- Reabsorption of glucose through the renal tubule in the kidney
- Transport of sucrose form a leaf to a phloem tissue
- Absorption of mineral ions by a plant root hair cell

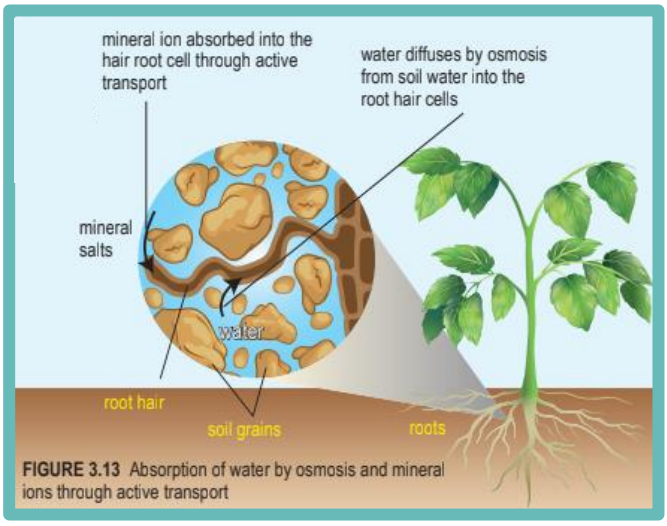
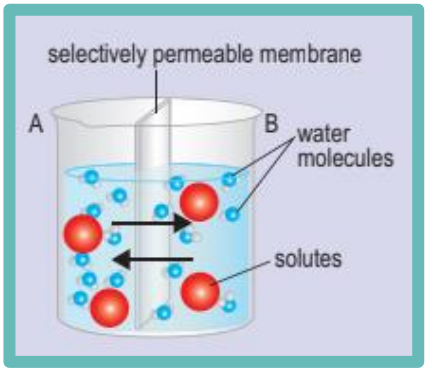


FIGURE 3.13 Absorption of water by osmosis and mineral ions through active transport

Isotonic, hypotonic and hypertonic solutions

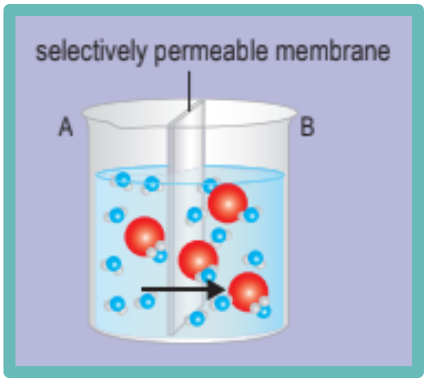
ISOTONIC SOLUTION

Definition	Solution A and B have the same concentrations of solutions
Example	1) Solutions A and B are isotonic toward each other 2) No net movement of water



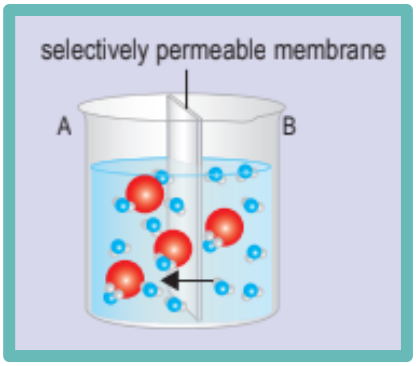
HYPOTONIC SOLUTION

Definition	Solution A has a low solutes concentration and high water potential
Example	a) Solution A is hypotonic to solution B b) Water diffuses from solution A to solution B via osmosis



HYPERTONIC SOLUTION

Definition	Solution A has a high solutes concentration and low water potential
Example	a Solution A is hypertonic to solution B b Water diffuses from solution B to solution A via osmosis



The effects of hypotonic, hypertonic and isotonic solutions on animal cells and plant cells

The Effects on Animal Cells

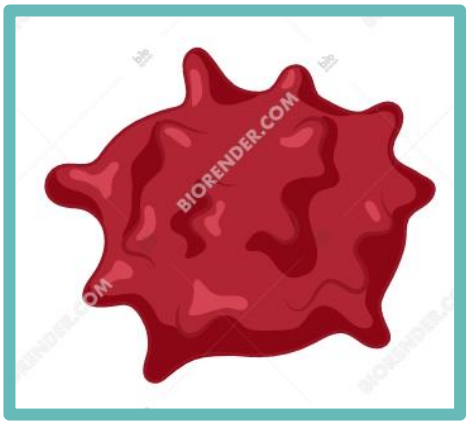
EFFECT OF HYPOTONIC SOLUTION

- Water will diffuse into the red blood cells by osmosis, causing the cells to swell and undergo haemolysis when the cells are placed in the hypotonic solution
- Haemolysis is the burst of red blood cells

- This is because the plasma membrane is too thin to withstand the osmotic pressure built up in the cells

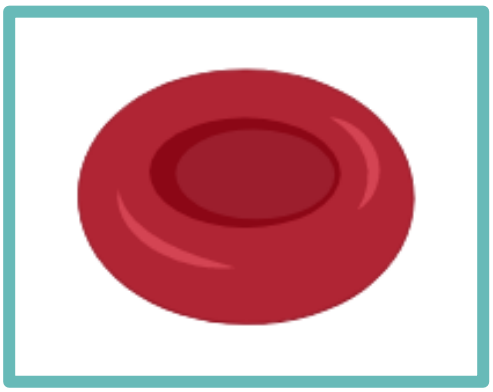
EFFECT OF HYPERTONIC SOLUTION

- Water will move out of the red blood cells by osmosis, causing the cells to undergo crenation when the cells are placed in the hypertonic solution
- Crenation is the shrink of red blood cells



EFFECT OF ISOTONIC SOLUTION

- Water diffuses into and out of the red blood cells by osmosis at the same rate
- No net movement of water across the plasma membrane
- The cells maintain their normal shape



The Effects on Plant Cells

EFFECT OF HYPOTONIC SOLUTION

- Water will diffuse into the vacuoles by osmosis when plant cells are placed in a hypotonic solution
- This will make the vacuoles to expand cause it to push the cytoplasm and plasma membrane against the cell wall and becomes turgid
- Plant cells do not burst because the cell wall is rigid and strong
- Turgor pressure is important to plant cells because it gives support and maintains the shape of cell
- Cell turgidity causes the guard cell to swell to allow the stomata to remain open for photosynthesis

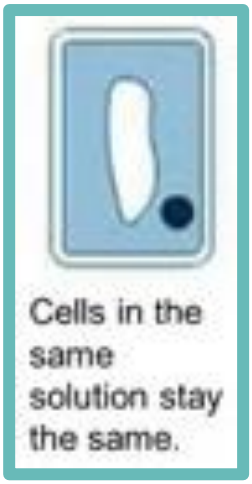
EFFECT OF HYPERTONIC SOLUTION

- Water will diffuse out of the vacuoles by osmosis when plant cells
- Plasmolysis is where vacuoles and the cytoplasm will shrink, causing the plasma membrane to be pulled away from the cell wall
- Plasmolysis also causes leaves and stems to bend downwards and wilt
- Plasmolysed plant cells can regain their turgidity by going through deplasmolysis where the cells are returned to a hypotonic solution immediately

are placed in a hypertonic solution causing the cells to undergo plasmolysis

EFFECT OF ISOTONIC SOLUTION

- When the sap of the plant cell and extracellular solution are isotonic, water potential is the same
- The movement of water diffusion in and out of the cell is the same
- Cells become flaccid



CHAPTER 3.4 – MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE AND ITS APPLICATION IN DAILY LIFE

Phenomenon of plant wilting

1. Excessive use of fertilisers may cause wilting in plants
2. Dissolved fertilisers will cause soil water to be hypertonic to the sap cell of roots
3. Water will diffuse by osmosis from the roots' cell sap to the soil consequently and cells will become plasmolysed
4. Cells in plants will recover once they are watered
5. If the period of plasmolysis is prolonged, wilted plants will eventually die

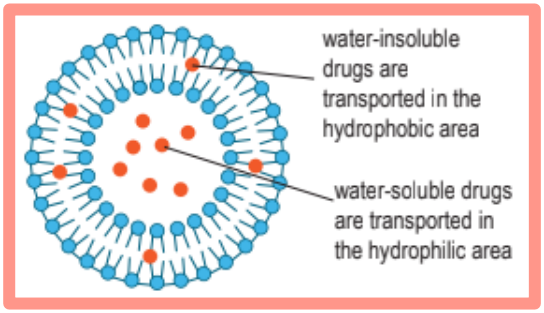
The concept of movement of substances across a plasma membrane applications

a) Rehydration Drinks (oral rehydration salts)
   → Help to recover loss of water and electrolytes in individuals with diarrhoea

b) Saline Solutions
   → Isotonic solution to the blood plasma
   → Contains 0.85-0.90 g sodium chloride per 100 ml

c) Isotonic Drinks
   → Help athletes to recover loss of water and electrolytes (potassium, sodium) through perspiration

d) Liposomes
   → Vesicles that contain aqueous solution
   → Surrounded by a phospholipid bilayer membrane
   → Used to protect drugs or active substances taken orally from being destroyed by gastric juices

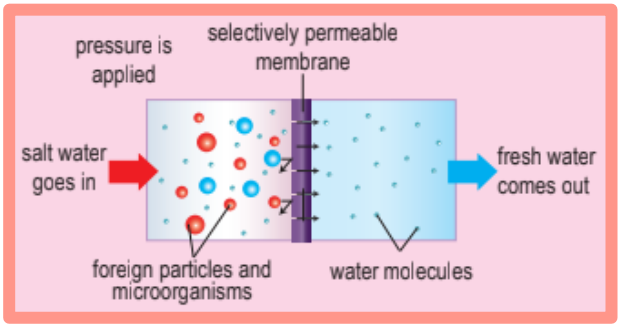


e) Reverse Osmosis
   → A technology commonly used to extract fresh water from sweater using the desalination process

→ In a reverse osmosis equipment, pressure is applied to push the seawater through a semi-permeable membrane

→ The membrane allows water molecules to pass through it but not foreign particles

→ As a result, only pure fresh water is released



Summary

MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE

Structure of Plasma Membrane
- Fluid mosaic model
- Plasma membrane consists of carrier proteins, channel proteins, phospholipid bilayer, glycoprotein, glycolipid and cholesterol

Concept of Movement of Substances Across a Plasma Membrane
- Passive transport
  - Simple diffusion
  - Osmosis
  - Facilitated diffusion
- Active transport

Movement of Substances Across a Plasma Membrane in Living Organisms
- Passive and active transport in living organisms
- Isotonic, hypotonic and hypertonic solutions
- Effect of isotonic, hypotonic and hypertonic solutions on animal cells and plant cells

Movement of Substances Across a Plasma Membrane and its Application in Daily Life
- Phenomenon of plant wilting
- Application of movement of substances across a plasma membrane in daily life
- Reverse osmosis process in water purification