

3.1 Structure of Plasma Membrane

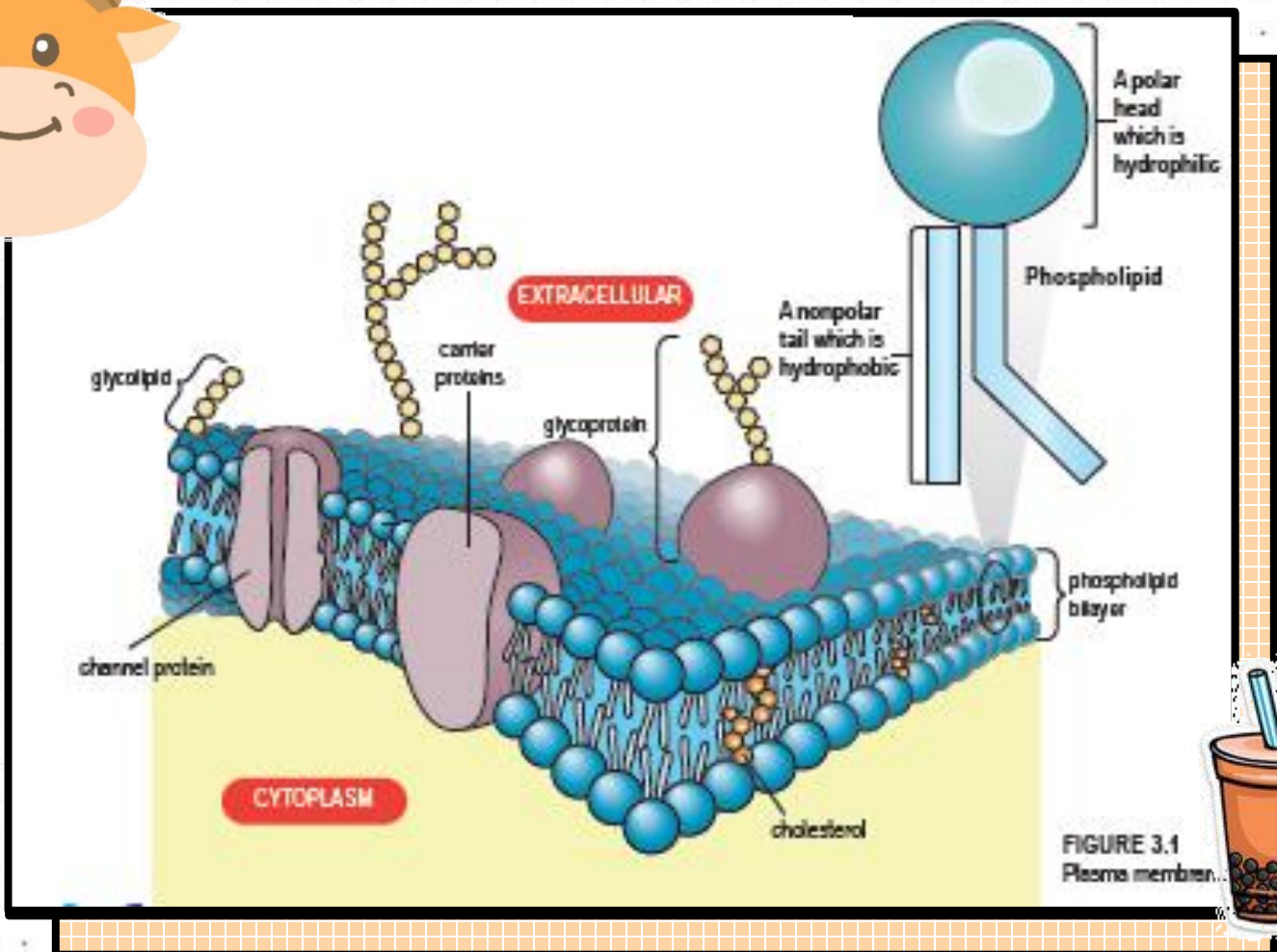
The necessity of movement of substances across a plasma membrane

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



Structure of the plasma membrane

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- According to the fluid mosaic model, protein molecules float within the phospholipid bilayer, forming a mosaic pattern that changes frequently.
- Each phospholipid molecule consists of
 - A polar head which is hydrophilic (attracted to water)
 - A nonpolar tail which is hydrophobic (repels water)
- The heads of the phospholipid molecule in the outer layer face the extracellular fluid, whereas the phospholipid heads in the inner layer face the cytoplasm .
- The tails of the phospholipid molecule of the two layers face each other
- There are various types of protein molecules embedded partially or fully within the membrane
- The protein molecules are widely dispersed between the phospholipid bilayer
- The protein molecules with channels or canals are known as channel proteins, whereas the protein molecules that function as carriers are called carrier proteins

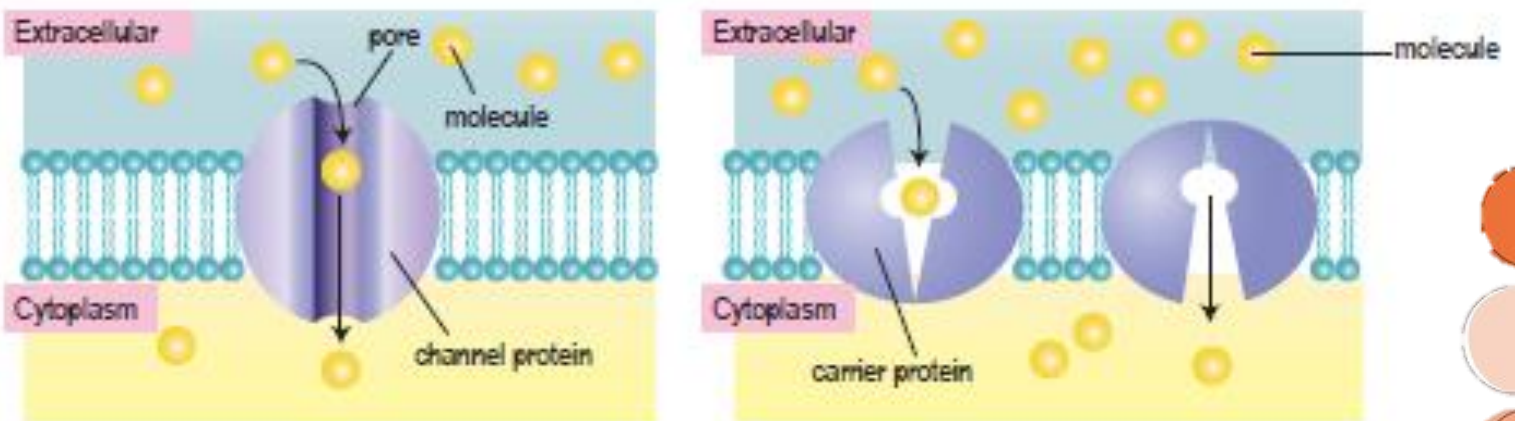


FIGURE 3.2 Models of channel and carrier proteins

- Some proteins and lipids have carbohydrate chains attached to them, known as glycoprotein and glycolipid respectively
- Glycoprotein and glycolipid act as receptors to hormones such as insulin, stabilise the membrane by forming hydrogen bonds with water and act as antigens for cell identification
- Terdapat molekul kolesterol di antara molekul fosfolipid
- Cholesterols make the phospholipid bilayer stronger, more flexible and less permeable to water-soluble substances such as ions.
- The phospholipid bilayer, proteins and cholesterols are not static but form a dynamic and flexible structure
- This contributes to the 'fluid' characteristic of the plasma membrane and makes the plasma membrane more flexible



Permeability of a plasma membrane

- A membrane is said to be permeable to a substance if the membrane allows the substance to pass through it freely.
- On the contrary, a membrane is impermeable if a substance is unable to move across it. The plasma membrane is a selectively permeable membrane.
- Selectively permeable membrane only allows free movement of certain molecules across it, and prevent or limit the movement of other substances..
- The plasma membrane has a selectively permeable property due to its building structure. The phospholipid bilayer and protein determine the membrane permeability towards specific substances

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3.2 CONCEPT OF MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE

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membrane
essed on 21 August 2019)

CHARACTERISTICS OF MOVEMENT OF SUBSTANCES ACROSS A PLASMA MEMBRANE

LIPID-SOLUBLE SUBSTANCES

Nonpolar molecules

Examples:

- Fatty acid
- Glycerol
- Fat soluble vitamins (A, D, E, K)
- Steroid compounds

LIPID INSOLUBLE SUBSTANCES

SMALL MOLECULE AND ION

- Polar molecules (Example: water)
- Nonpolar molecules (Examples: oxygen, carbon dioxide)
- Ion (Examples: K^+ , Na^+ , Ca^{2+} , Mg^{2+})

LARGE MOLECULE

Examples:

- Glucose
- Amino acid

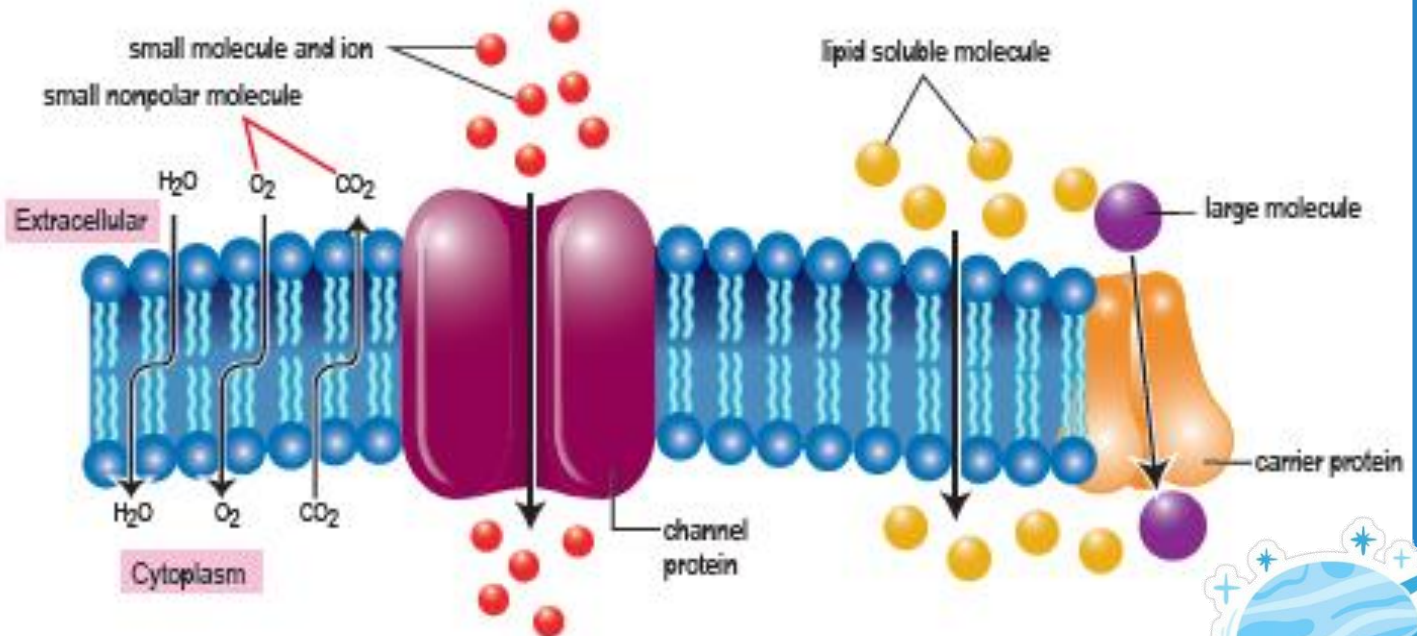


FIGURE 3.3 Movement of substances across a plasma membrane



Passive transport



- An analogy of passive transport is like riding a bicycle downhill.
- The process does not involve the use of energy.
- Simple diffusion, osmosis and facilitated diffusion are examples of passive transport



Simple diffusion

- Simple diffusion is the movement of molecules or ions from an area of high concentration to an area of low concentration. The moving molecules are said to move down the concentration gradient until a dynamic equilibrium is achieved.
- This may occur with or without the presence of a plasma membrane. Lipid soluble molecules (fatty acids and glycerol), oxygen and carbon dioxide diffuse through the phospholipid bilayer as simple diffusion

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osmosis



- Osmosis is a passive transport process that is similar to diffusion but it involves only water molecules.
- Osmosis 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) randomly through a selectively permeable membrane
- The selectively permeable membrane is permeable to water but impermeable to some solutes such as sucrose molecules
- The same situation occurs in cells through the phospholipid bilayer

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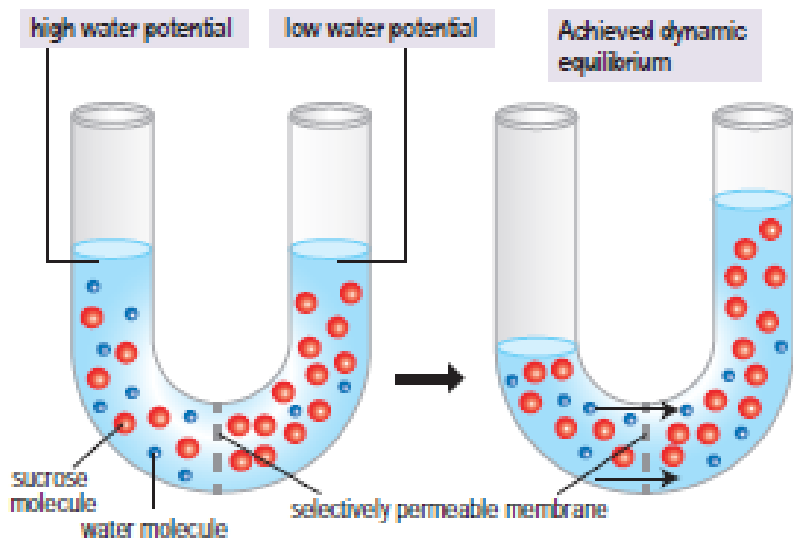


FIGURE 3.5 Osmosis

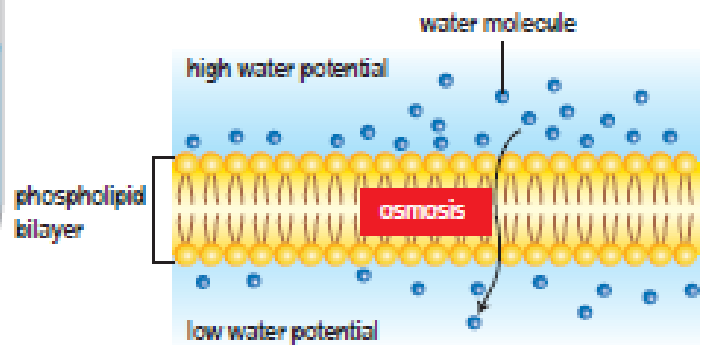


FIGURE 3.6 Osmosis through the phospholipid bilayer



Facilitated diffusion

- Lipid-insoluble molecules such as ions, large molecules such as amino acids and glucose are unable to pass through the phospholipid bilayer.
- These substances move across the membrane with the aid of transport proteins (carrier or channel proteins)
- This process is known as facilitated diffusion. Facilitated diffusion does not require energy because the transport proteins transport molecules down a concentration gradient
- The process continues until a dynamic equilibrium is achieved when the concentration of molecules is the same at both sides of membranes

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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.

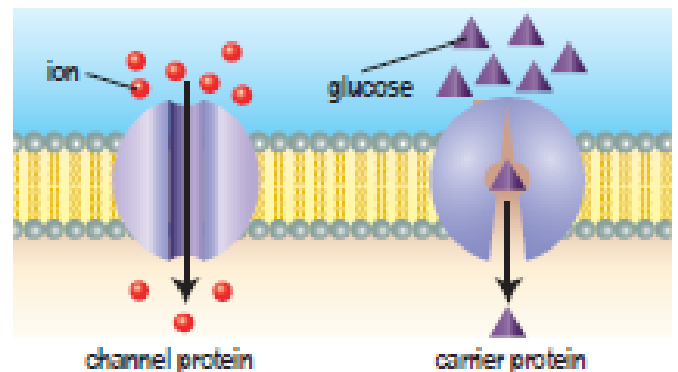


FIGURE 3.7 Facilitated diffusion through channel and carrier proteins

The process of the movement of glucose molecules across a plasma membrane occurs through a facilitated diffusion (Figure 3.8).

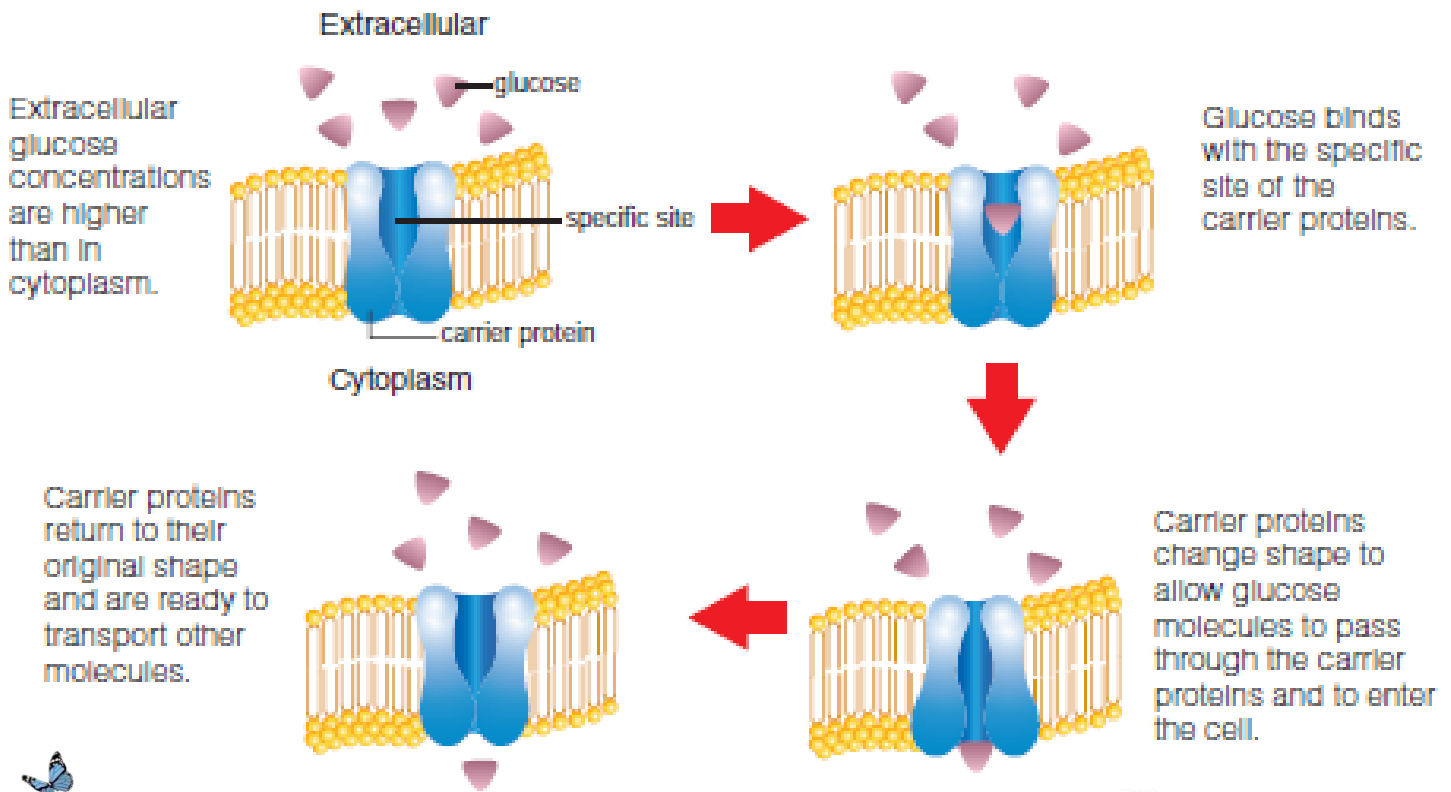


FIGURE 3.8 Facilitated diffusion through carrier proteins

Active transport

- The movement of molecule or ion substances across a plasma membrane occurs against a concentration gradient..
- It requires energy from ATP (adenosine triphosphate) molecules generated during cellular respiration
- It requires specific carrier protein with specific sites to bind with certain molecules or ions.
- carrier proteins also possess receptors to bind with ATP molecules.



- proteins change shape when a phosphate group attaches to it. As a result, molecules or ions move across a Membrane
- Active transport results in the accumulation or excretion of molecules or ions in the cell
- carrier proteins involved in active transport are known as pumps.
- For example, in animal cells, the carrier proteins that transport sodium ions to extracellular, and potassium ions into the cell are called sodium-potassium pump

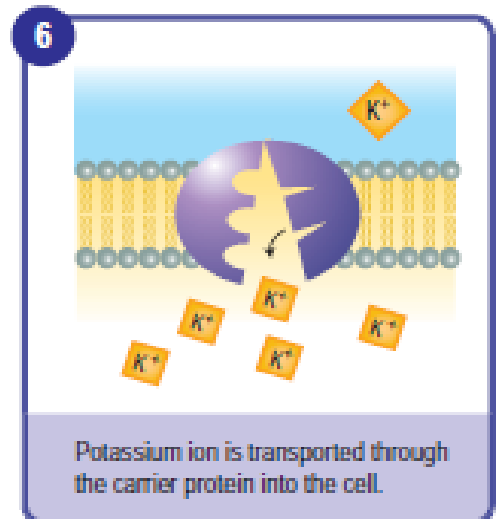
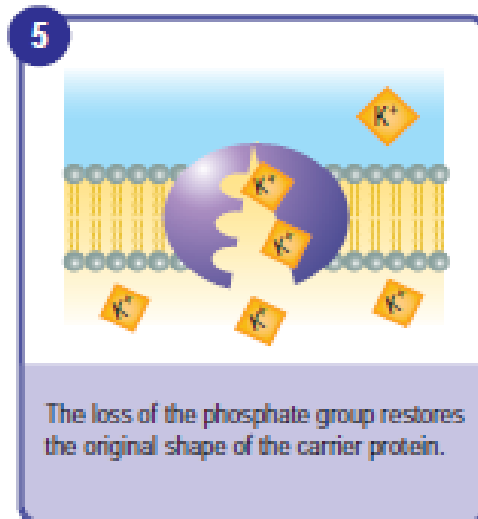
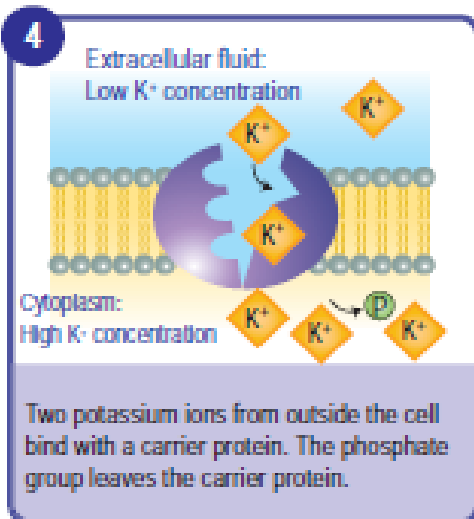
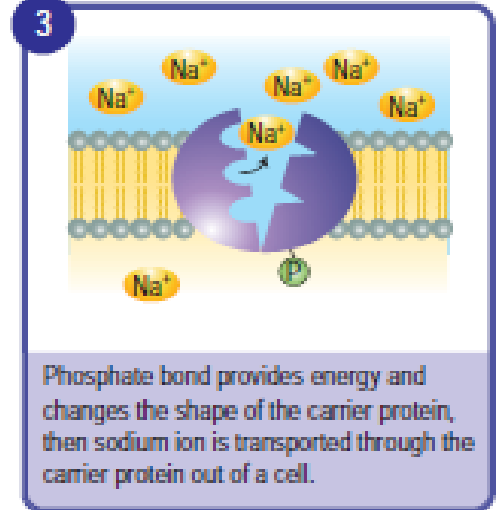
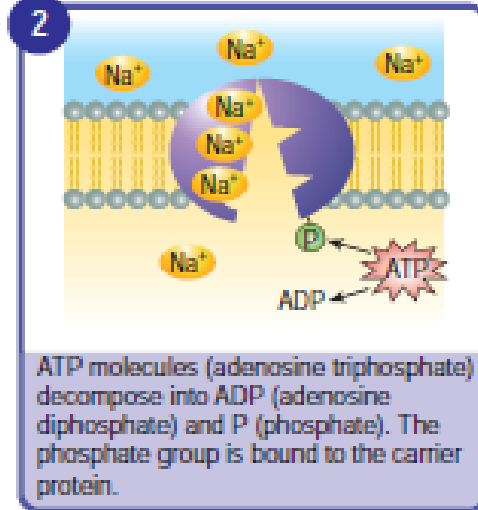
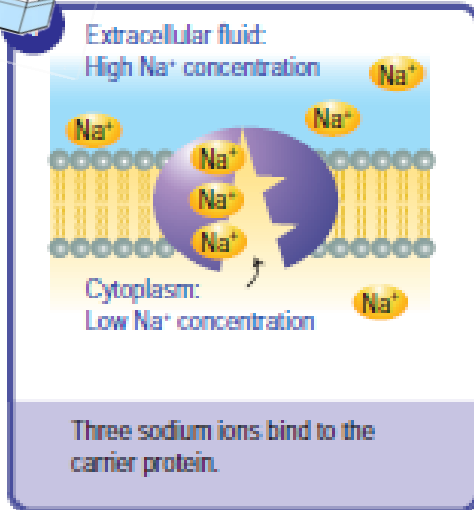
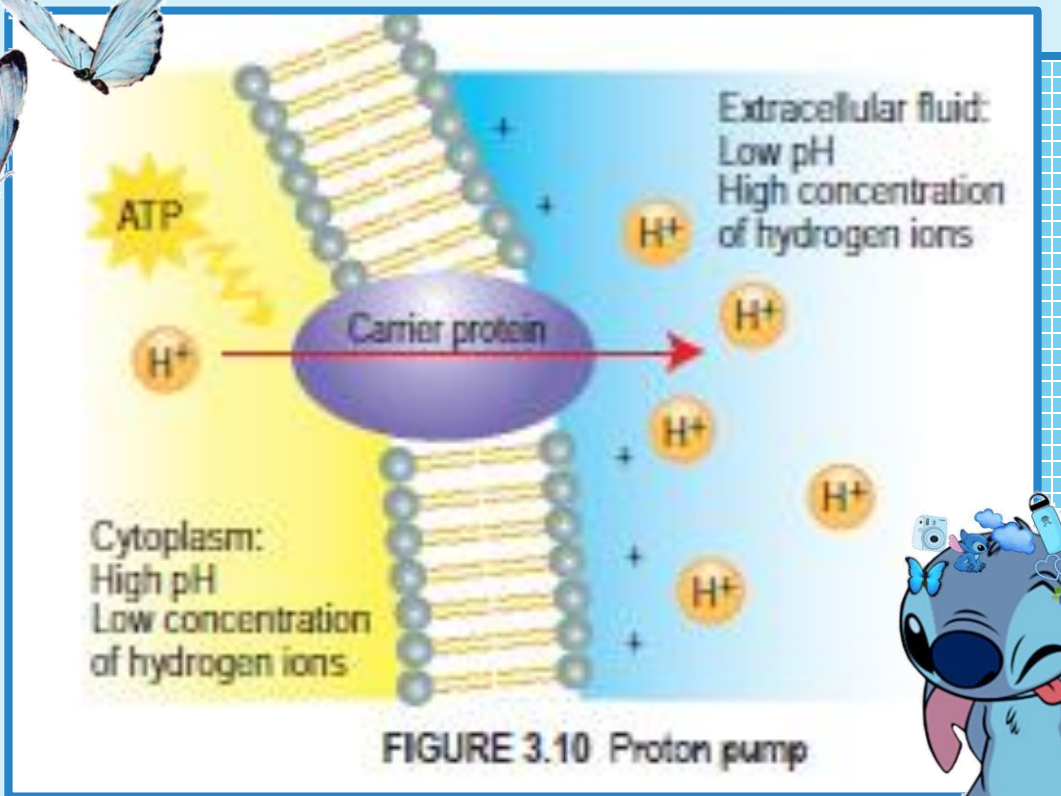


FIGURE 3.9 Sodium-potassium pump

- There is another type of pump known as the proton pump.
- For example, the proton pumps that are found on the epithelial cells lining the stomach cavity
- Proton pump causes the acidity of the stomach contents
- Energy from the ATP enables the hydrogen ion to be transported by the carrier proteins (proton pump) towards the extracellular fluid
- This causes an accumulation of the hydrogen ion and acid production in the stomach cavity.



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Similarities and differences between passive and active transports

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SIMILARITIES

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

DIFFERENCES

- **passive transport**
 - occurs until a dynamic equilibrium is achieved
 - occurs following the concentration of the gradient
 - energy is not required
- **active transport**
 - requires energy
 - occurs against the concentration of the gradient
 - there are accumulation and disposal of molecules or ions



3.3 Movement of Substances Across a Plasma Membrane in Living Organisms

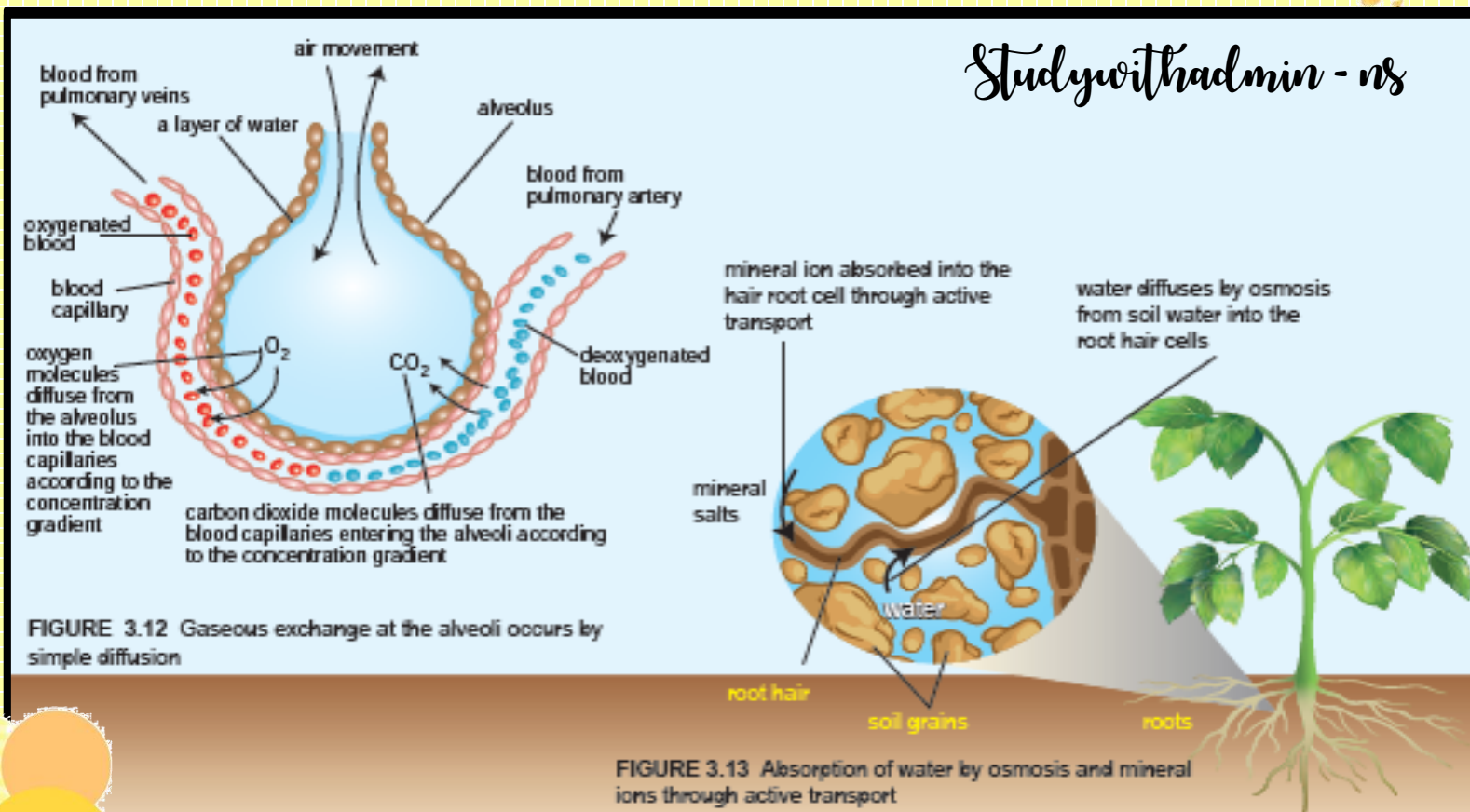


Passive transport in organisms occurs during:

- gaseous exchange between an alveolus and a blood capillary through simple diffusion
- reabsorption of water occurs by osmosis through the renal tubule in the kidney
 - absorption of water by a plant root hair cell by osmosis
- absorption of fructose molecule in the villus by facilitated diffusion

Pengangkutan aktif in organisms occurs during:

- absorption of glucose and amino acids in the villus
- reabsorption of glucose through the renal tubule in the kidney
- transport of sucrose from a leaf to a phloem tissue
- absorption of mineral ions by a plant root hair cell



ISOTONIC, HYPOTONIC and HYPERTONIC SOLUTIONS

- Generally, there are three types of solutions: isotonic, hypotonic and hypertonic.
- As you have learned, diffusion of water occurs by osmosis from an area of high water potential to an area of low water potential across a plasma membrane

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| Concept | Definition | | Explanation |
|---------------------|--|--|--|
| Isotonic solution | Solution A and B have the same concentrations of solutions. | | Solutions A and B are isotonic toward each other. No net movement of water. |
| Hypotonic solution | Solution A has a low solutes concentration and high water potential. | | Solution A is hypotonic to solution B. Water diffuses from solution A to B by osmosis. |
| Hypertonic solution | Solution A has a high solutes concentration and low water potential. | | Solution A is hypertonic to B. Water diffuses from solution B to A by osmosis. |



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

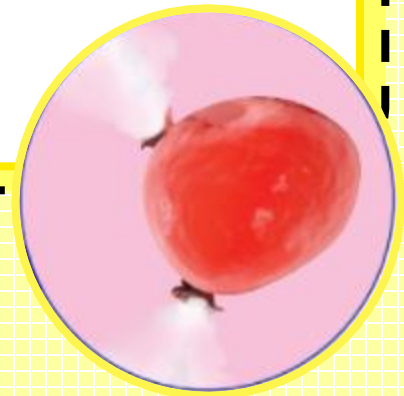


- The cell cytoplasm contains solutes such as glucose and mineral salts
- The fluid found in the cell is known as intracellular fluid.
- Each cell is surrounded by extracellular fluid.
- Therefore, the cell will always go through the osmosis process and movement of water across the plasma membrane, depending on the water potential of the extracellular fluid and intracellular fluid

THE EFFECT ON ANIMAL CELLS

EFFECT OF HYPOTONIC SOLUTION

- When red blood cells are placed in a hypotonic solution, water will diffuse into the cells by osmosis, causing the cells to swell and finally burst.
- This is because the plasma membrane is too thin to withstand the osmotic pressure built up in the cells
- The burst of red blood cells is known as haemolysis



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EFFECT OF HYPERTONIC SOLUTION



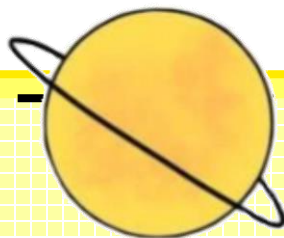
- When red blood cells are placed in a hypertonic solution, water will move out of the cells by osmosis.
- This will cause the cells to shrink.
- The red blood cells are said to undergo crenation.

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EFFECT OF ISOTONIC SOLUTION

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



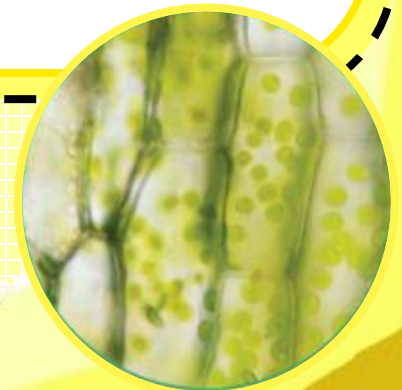
THE EFFECT ON PLANT CELLS



EFFECT OF HYPOTONIC SOLUTION

- When plant cells are placed in a hypotonic solution, water will diffuse into the vacuoles by osmosis.
- This will cause the vacuoles to expand and push the cytoplasm and plasma membrane against the cell wall.
- In this condition, the cells are said to be 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 guard cell to swell to allow the stomata to remain open for photosynthesis.

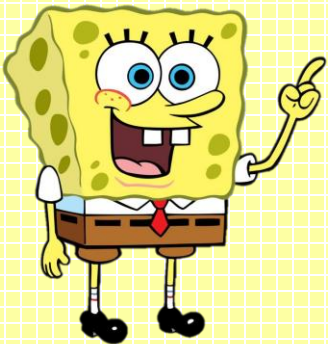
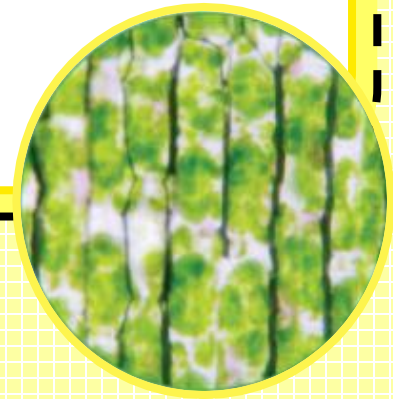
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EFFECT OF HYPERTONIC SOLUTION



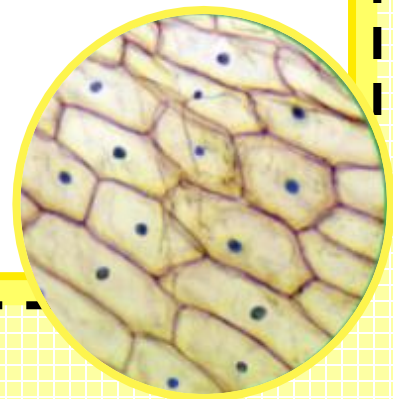
- When plant cells are placed in a hypertonic solution, water will diffuse out of the vacuoles by osmosis.
- Vacuoles and the cytoplasm will shrink, causing the plasma membrane to be pulled away from the cell wall.
- This process is known as plasmolysis. Plasmolysis causes leaves and stems to bend downwards and wilt.
- Plasmolysed plant cells can regain their turgidity if the cells are returned to a hypotonic solution immediately.
- The cells are said to undergo deplasmolysis.



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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 cells is the same.
- Cells become flaccid.



3.4 MOVEMENT OF SUBSTANCE ACROSS A PLASMA MEMBRAN AND ITS APPLICATION IN DAILY LIFE



Phenomenon of plant wilting



- Excessive use of fertilisers may cause wilting in plants.
- Dissolved fertilisers will cause soil water to be hypertonic to the sap cell of roots.
- Consequently, water will diffuse by osmosis from the roots' cell sap to the soil, and cells will become plasmolysed..
- Cells in plants will recover once they are watered..
- However, if the period of plasmolysis is prolonged, wilted plants will eventually die.

Rehydration drinks



- Rehydration drinks such as oral rehydration salts help to recover loss of water and electrolytes in individuals with diarrhoea.



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Isotonic drinks



- Isotonic drinks help athletes to recover loss of water and electrolytes such as potassium and sodium through perspiration.

Saline solutions

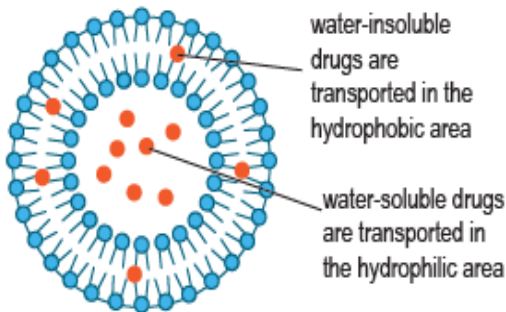


- Saline solutions, normally used in medicine, are isotonic solution to the blood plasma. It contains 0.85–0.90 g sodium chloride per 100 ml.



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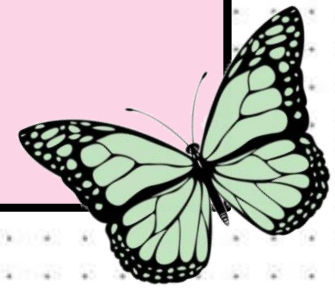
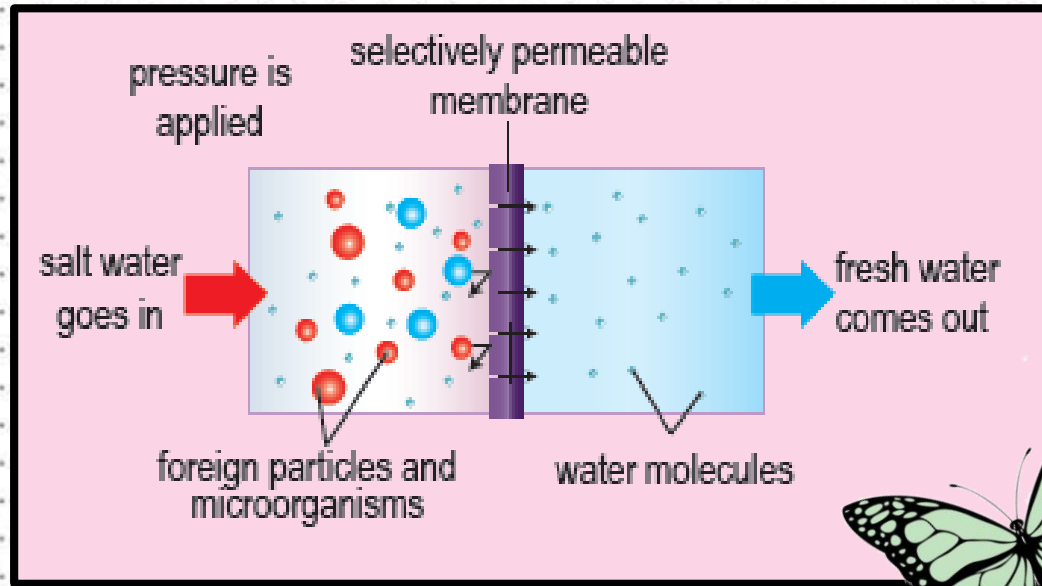
Liposomes



- Liposomes are vesicles that contain aqueous solution surrounded by a phospholipid bilayer membrane. Liposomes are used to protect drugs or active substances taken orally from being destroyed by gastric juices. This way, drugs can reach the target cells



Reverse osmosis



- Reverse osmosis is a technology commonly used to extract fresh water from seawater 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, salt and microorganisms.
- As a result, only pure fresh water is released.

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