3.2.3 Transport across cell membranes

SPECIFICATION

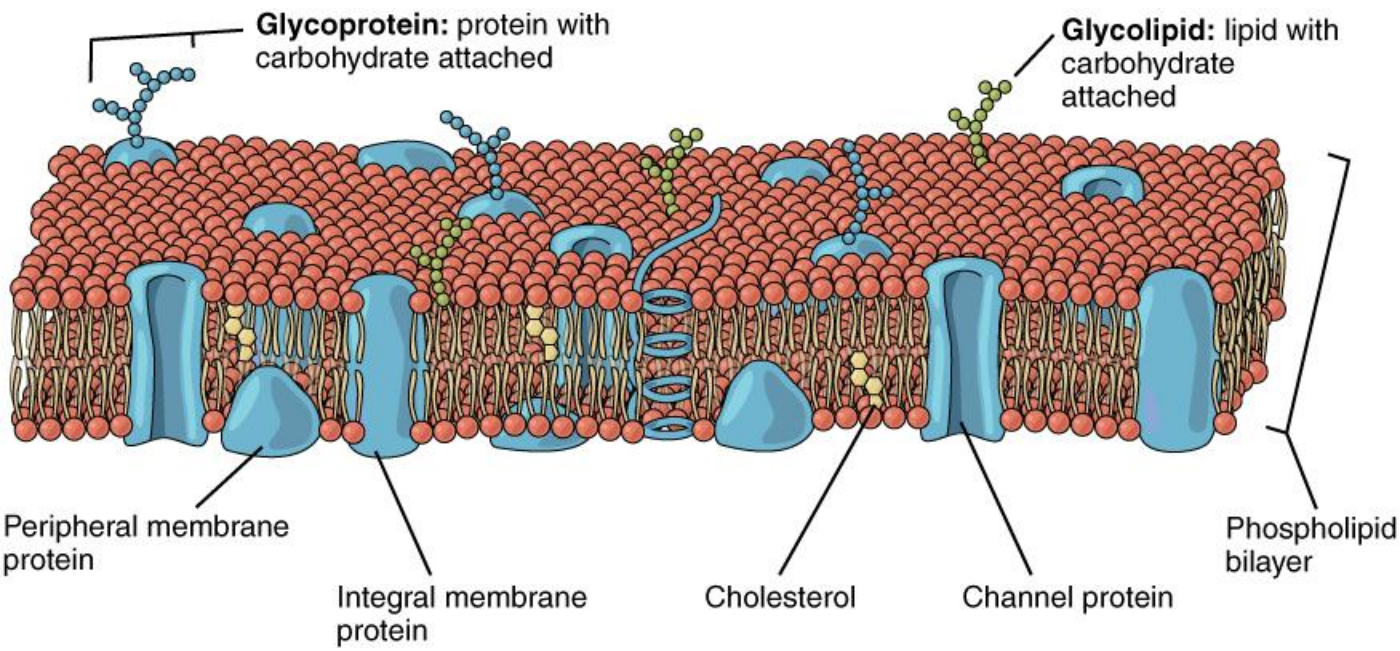
- The basic structure of all cell membranes, including cell-surface membranes and the membranes around the cell organelles of eukaryotes, is the same.
- The arrangement and any movement of phospholipids, proteins, glycoproteins and glycolipids in the fluid-mosaic model of membrane structure. Cholesterol may also be present in cell membranes where it restricts the movement of other molecules making up the membrane.
- Movement across membranes occurs by:
  - simple diffusion (involving limitations imposed by the nature of the phospholipid bilayer)
  - facilitated diffusion (involving the roles of carrier proteins and channel proteins)
  - osmosis (explained in terms of water potential)
  - active transport (involving the role of carrier proteins and the importance of the hydrolysis of ATP)
  - co-transport (illustrated by the absorption of sodium ions and glucose by cells lining the mammalian ileum).
- Cells may be adapted for rapid transport across their internal or external membranes by an increase in surface area of, or by an increase in the number of protein channels and carrier molecules in, their membranes.
- Students should be able to:
  - explain the adaptations of specialised cells in relation to the rate of transport across their internal and external membranes
  - explain how surface area, number of channel or carrier proteins and differences in gradients of concentration or water potential affect the rate of movement across cell membranes.

Source: AQA Spec

Cell Membrane

Also known as the **plasma membrane**, the cell membrane is a **semi-permeable** area in a cell that separates the interior components of the cell from the extracellular matrix. Ions and organic molecules can selectively pass through the membrane. Transport of material across the cell membrane is important in the operation of the cell.

The cell membrane is composed of a **lipid bilayer** with some proteins embedded in it. The hydrophobic tails of the lipid components of the membrane is placed in the middle of the bilayer, protected from the polar extracellular and interstitial fluids. Aside from the proteins, **cholesterol** molecules are also embedded in the cell membranes. It maintains the fluidity of the membrane and increases its stability.



Cell Membrane

Image Source: OpenStax CNX

Functions of Cell Membrane

1. Separation between the extracellular fluid and the internal components of the cell
2. Communication with other cells
3. Recognition of external substances
4. Structural support
5. Transport of materials (the subject of this chapter)

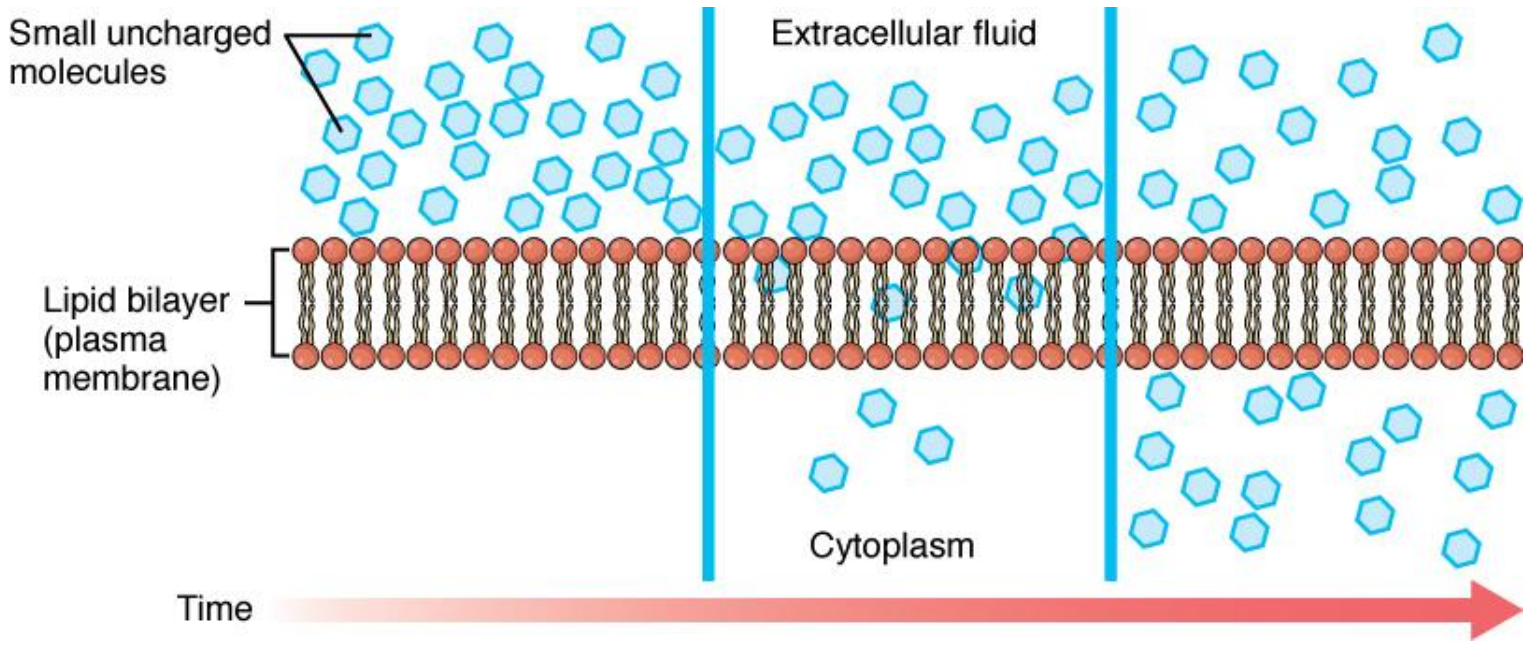
One of the important functions of the cell membrane is facilitating the transport of materials from the outside to the inside of the cells, or vice-versa. Transport of materials is accomplished via a number of possible mechanisms. These include:

- Simple diffusion
- Facilitated diffusion
- Osmosis
- Active Transport
- Co-transport

The type of transport is dependent on the concentration difference of the extracellular matrix and the interstitial fluids, the type of compound being transported, and energy requirement for the transport.

Simple diffusion

- **Diffusion,** also called **passive transport,** is the movement of particles from an area with higher concentration to an area of lower concentration.
- This is the primary mode of transport for small molecules and gases like oxygen and carbon dioxide. It is important that these two gases readily diffuse through the membrane because oxygen is needed by the cells for metabolism, and carbon dioxide need to be expelled by the cell for eventual release to the environment.

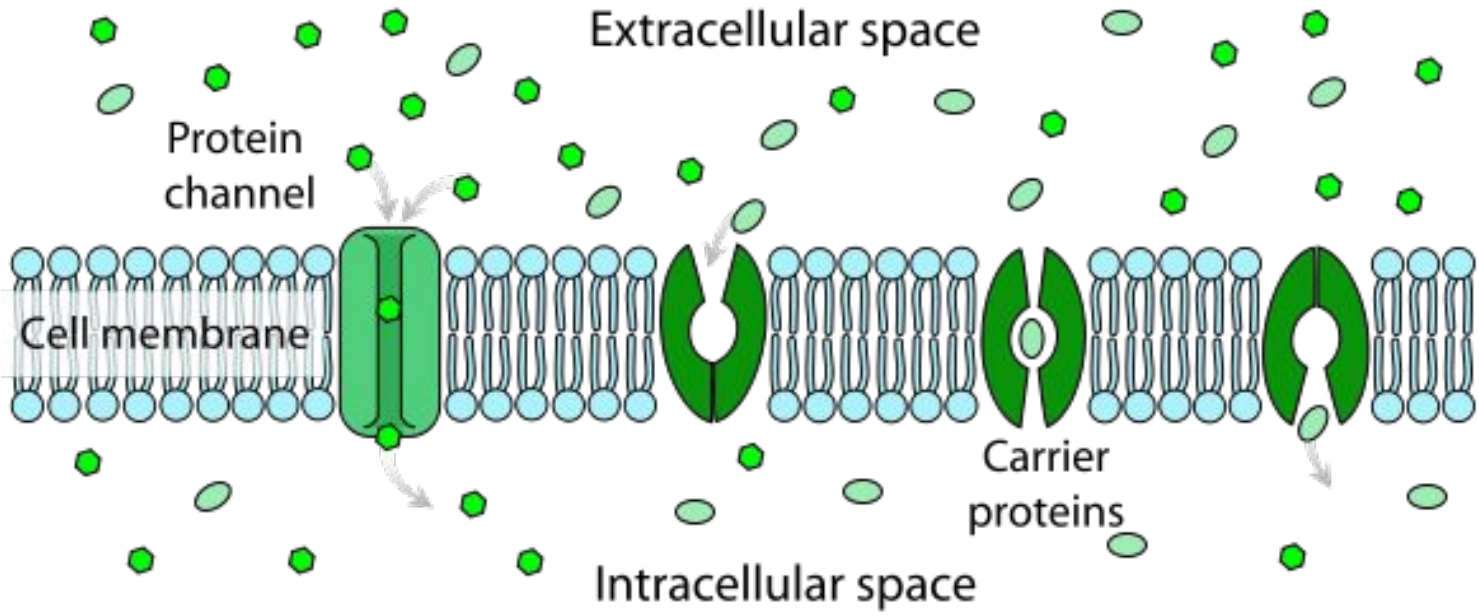


Simple diffusion

Image Source: OpenStax CNX

Facilitated diffusion

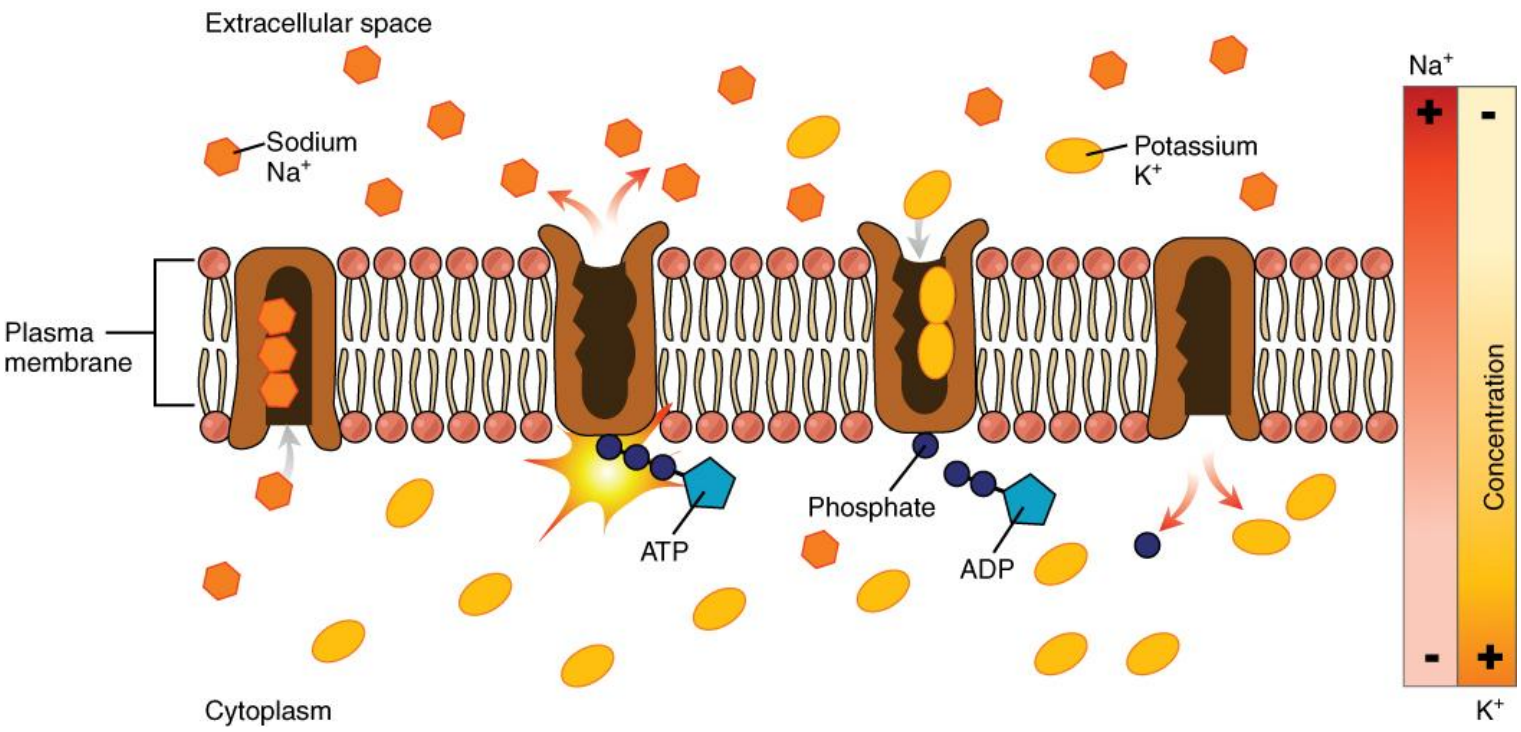
- Facilitated diffusion is the spontaneous transport of material across the cell membrane via membrane proteins embedded in it.
- The transport is dependent on the interaction of material and the channel or carrier protein.
- This type of transport is particularly important in moving large polar molecules and ions that cannot readily diffuse via simple diffusion.
- The main difference between carrier and channel proteins is carrier proteins are not open readily to both intracellular and extracellular environments, while a channel protein is open to both.
- In **carrier proteins**, binding sites are present where molecules to be transported can bind. The protein then undergoes conformational change eventually opening the protein molecule to the other side of the cell membrane. Eventually, the solute molecule is released to the other side of the membrane.
- **Channel proteins** interact weakly with the material to be transported. If the channel is open, specific solutes can freely pass through them.



Facilitated diffusion
Image Source: Wikimedia commons

Active transport

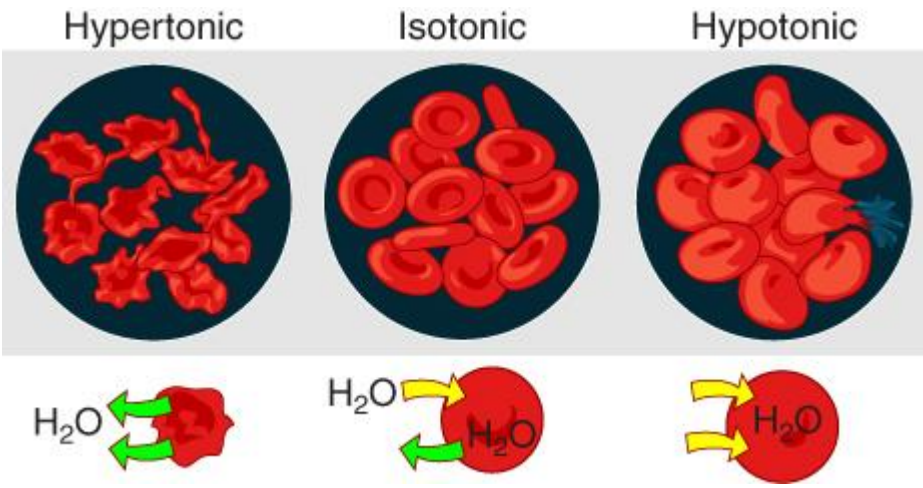
- This is the type of transport where solute is transported from an area of **lower concentration to an area of higher concentration**.
- This type of transport is needed to accumulate solute in a specific area where cellular metabolic process may occur.
- Active transport may be classified as either primary or secondary active transport. Primary active transport requires energy in the form of **ATP** for the transport of material. Secondary active transport, on the other hand, uses an **electrochemical gradient** for the transport of material to occur.
- An example of active transport is the transport of potassium and sodium ions through the **sodium potassium pump**. An electrochemical gradient is present because of the imbalance in the concentration of positive charges across the membrane. ATP provides the energy needed to produce conformational change for the eventual release of the ions to the other side of the membrane.



Sodium - Potassium Pump
Image Source: OpenStax CNX

Osmosis

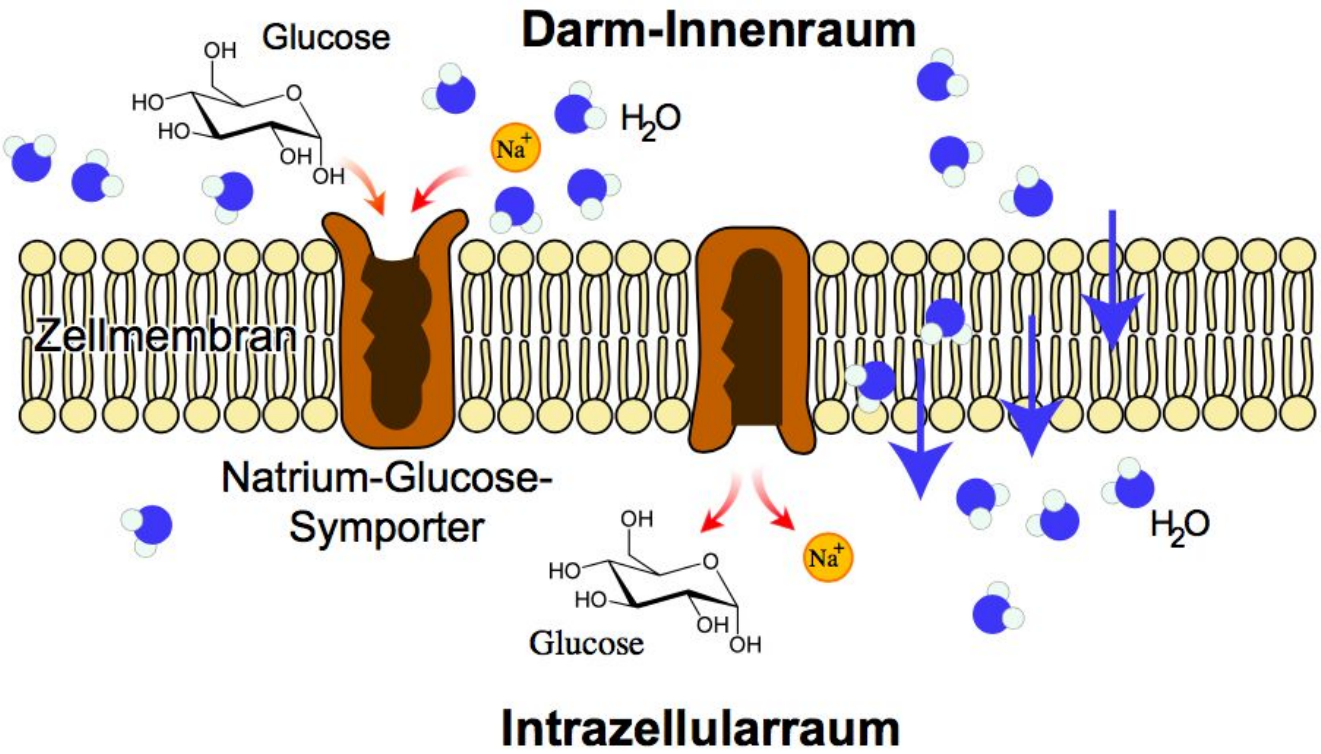
- This is the type of transport where water molecules (solvent) diffuse through the membrane down its concentration gradient.
- In the process of transport, the concentration in both sides of the membrane is equalised.
- This type of transport occurs when there the solute concentrations are not equal, and water molecules have higher tendency to diffuse than the solute molecules.
- Depending on the condition of the extracellular environment, different things can happen to the cell. If the cell is exposed to an **isotonic** environment (same concentration inside and outside the cell), the movement of water into and out of the cell occur at the same rate. If the cell is exposed to a **hypertonic** environment (outside of the cell has higher solute concentration than the inside), the cell will shrivel because of loss of water. If the cell is exposed to a **hypotonic** environment (inside of the cell has higher concentration than outside), the cell take up more water and becomes bloated and will eventually burst.



Osmosis in Red Blood Cells
Image Source: OpenStax CNX

Co-transport

- This is the type of transport where two substances are simultaneously transported across a membrane.
- This is a specific type of secondary active transport.
- This is facilitated by **symporters**, which can transfer two substances in the same direction. An example of a symporter is the sodium-glucose symporter. It uses the sodium ions to move glucose into the cell. The flow of sodium ions through the symporter provides the needed energy for the glucose to move also through the symporter.



Co-transport
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