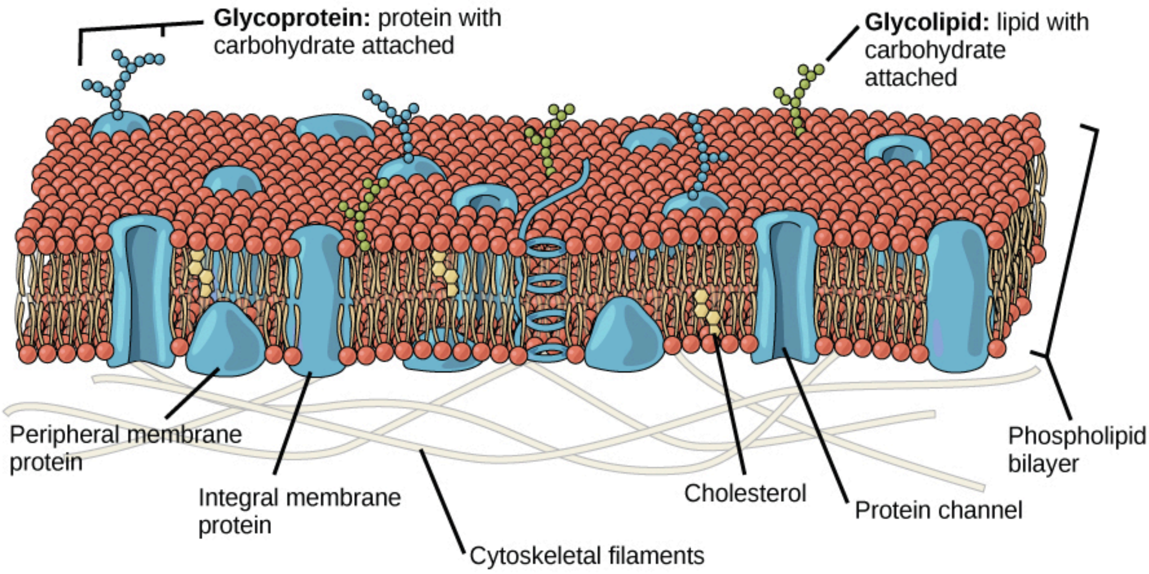
CAIE Biology A-level

Topic 4: Cell membranes and transport

Notes

All cells are surrounded by a **partially permeable membrane** composed of a sea of phospholipids with carbohydrate and protein molecules between the phospholipids. The main function of the membrane is to **control the movement of substances into and out of the cell or organelle**. However, it also contains **receptors** for other molecules such as hormones, and enables adjacent cells to stick together. The fluidity of the membrane and the mosaic arrangement of the proteins give the structure of the membrane its name – **fluid mosaic model**.



Structure and functions of the cell membrane:

- **Glycoproteins** - glycoproteins act as recognition sites and receptors for signaling molecules; some serve as antigens for immune recognition.
  - **Main stages of cell signaling**:
    1. **Secretion** of specific chemicals (ligands) from cells.
    2. **Transport** of ligands to target cells.
    3. **Binding** of ligands to cell surface receptors on target cells.
- **Phospholipids** - form a bilayer and contribute to membrane fluidity. They have non-polar tails and hydrophilic heads, thus forming a barrier to most water-soluble substances. However, small non-polar molecules such as O_2 and CO_2 can diffuse freely through the bilayer.
- **Cholesterol** - cholesterol helps maintain membrane stability by regulating fluidity — preventing the membrane from becoming too rigid at low temperatures or too fluid at high temperatures.
- **Intrinsic proteins** - pass through the membrane, some form channels or carriers for water-soluble molecules.
- **Extrinsic proteins** - found on the surface only, some act as enzymes.
- **Glycolipids -** lipids with attached carbohydrate chains involved in cell recognition and cell adhesion.

Three factors affect the permeability of a cell membrane:

- **Heat**
  - Increasing temperature gives phospholipids more kinetic energy, causing them to move more. This increases membrane fluidity, making it less stable. At high temperatures, intrinsic membrane proteins denature and phospholipid bilayers lose integrity, causing permeability to increase.

- **Ethanol**
  - Ethanol is a lipid-soluble molecule that disrupts the phospholipid bilayer. This reduces membrane stability and increases fluidity and permeability. Higher concentrations of ethanol cause more disruption, leading to leakage of cell contents.

- **pH**
  - Changes in pH alter ionic bonding and protein tertiary structure. This can denature and change the structure of carrier and channel proteins. The overall membrane stability decreases, and selective permeability is lost.

Movement across membranes:

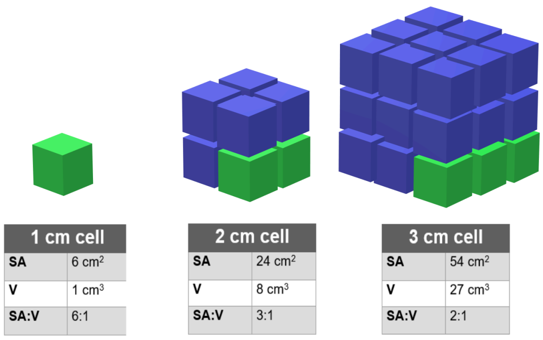
The movement of molecules through the cell membrane depends on the properties of the molecule as well as the requirements of the cell. There are several types of movement:

Name of movement	Molecules moved	Concentration Gradient	Energy required
Diffusion	Small, non-polar lipid-soluble molecules	High to low through a phospholipid bilayer	No - passive process
Facilitated diffusion	Polar, charged, water-soluble molecules	High to low through a channel protein	No - passive process
Osmosis	Water molecules	From higher to lower water potential through a partially permeable membrane	No - passive process
Active transport	All molecule types	Low to high (against concentration gradient) through a carrier protein	Yes - in the form of ATP

Exocytosis	Large particles enclosed in vesicles (out of the cell)	Low to high using vesicles formed from outfoldings of the cell membrane.	Yes - in the form of ATP
Endocytosis	Large particles enclosed in vesicles (into the cell)	Low to high using vesicles formed from infoldings of the cell membrane.	Yes - in the form of ATP

Fick's law:

Rate of diffusion ∝ (surface area × concentration difference) / diffusion distance.



The rate of **gas exchange** by diffusion becomes more rapid as:

- **Surface area** increases
- **Diffusion distance** decreases
- **Diffusion gradient** becomes steeper

Water potential is the **pressure exerted by water molecules that are free to move in a system**. It is measured in **kPa**. Pure water has a water potential of 0 kPa, the higher the water potential the larger the number of water molecules that are free to move. Water always moves from a region of higher water potential to lower water potential, down the water potential gradient. **A solution's water potential falls as solutes are added**, as water molecules cluster around the solute, reducing the number of free water molecules.