Smart revision topic taster

Summaries and support for answering exam questions

Exam questions types by increasing complexity and marks:

1. Name/state example of each (1 mark)
2. Describe how polymers of a biomolecule are formed (2-3 marks)
3. Compare and contrast 2 different types of polymer (3 marks)

Biomolecules Summary Table

Biomolecule	Elements	Monomer / Building Block	Polymer	Chemical Bonding Type	Main Function & Metabolic Role	Common Examples
Carbohydrates	C, H, O	Monosaccharide (e.g., glucose)	Polysaccharide (e.g., starch, cellulose, glycogen)	Glycosidic bonds (alpha & beta linkages)	Primary fuel for cellular respiration; short-term energy storage in plants (starch) and animals (glycogen).	Glucose, starch, cellulose, glycogen
Lipids	C, H, O (P in phospholipids)	Fatty acids, glycerol, or steroid rings	Does not form true polymers (assembles into large complexes/bilayers)	Ester linkages (and phosphoester bonds in phospholipids)	High-density long-term energy storage; structural component of cell membranes; cellular signaling.	Triglycerides (fats/oils), phospholipids, cholesterol
Proteins	C, H, O, N (sometimes S)	Amino acid	Polypeptide	Peptide bonds	Catalyses reactions as enzymes; regulates pathways; structural support.	Amylase, hemoglobin, insulin
Nucleic Acids	C, H, O, N, P	Nucleotide	DNA / RNA strands	Phosphodiester & Hydrogen bonds	Stores and transmits genetic information; directs protein synthesis.	DNA, RNA, ATP

Properties of Water Summary Table

Property of Water	Underlying Chemical Cause	Biological & Ecological Function	Real-World / Living Example
High Specific Heat Capacity	**Hydrogen bonds** absorb a lot of heat before breaking, resisting rapid temperature changes.	Stabilises environmental and internal body temperatures, creating a buffer against harsh weather.	Oceans and lakes maintain stable temperatures for aquatic life; bodies resist overheating.
High Latent Heat of Vaporisation	Breaking numerous **hydrogen bonds** requires significant energy to turn liquid water into gas.	Serves as an efficient cooling mechanism for living organisms (evaporative cooling).	**Sweating** in humans and panting in animals cools the body down to maintain homeostasis.
Cohesion & Surface Tension	Water molecules stick strongly to *each other* via **hydrogen bonding**.	Allows water to pull itself upward through narrow tubes and creates a resilient surface layer.	Helps pull columns of water up through tall trees; allows insects like **pond skaters** to walk on water.
Adhesion & Capillary Action	Water molecules stick to *other polar surfaces* (like plant cell walls).	Works together with cohesion to drive water transport up from roots against gravity.	**Capillary action** pulls water up through the xylem tissue in plant stems.
Lower Density as a Solid (Ice)	Water expands upon freezing, forming a crystalline **lattice structure** that spreads molecules further apart.	Prevents bodies of water from freezing solid from the bottom up, preserving life underneath.	**Ice floats** on top of lakes, acting as an insulating blanket that keeps the liquid water below warm enough for fish to survive.
Universal Solvent	Its **polar nature** (partial positive/negative charges) allows it to easily surround and dissolve ionic and polar solutes.	Serves as the primary medium for metabolic chemical reactions and nutrient transport.	Blood plasma (mostly water) dissolves and transports **glucose, oxygen, and minerals** throughout the body.

Exam questions types by increasing complexity and marks:

1. Link named properties of water to functions (1-2 marks)
2. Explain why the functions are important in metabolic/life processes in plants and animals (6 marks)

1. Membrane Structure

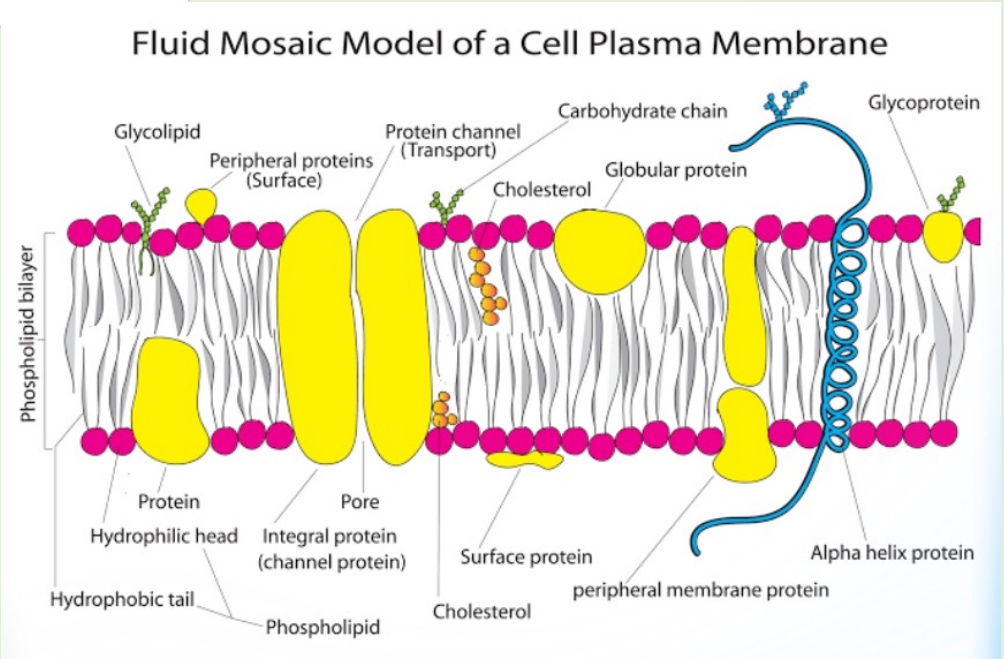
The cell membrane is a "mosaic" of different molecules that float fluidly within the lipid environment:

- **Phospholipid Bilayer:** The core framework. It consists of two layers of phospholipids.
  - **Hydrophilic (water-loving) heads** face outward toward the water inside and outside the cell.
  - **Hydrophobic (water-fearing) fatty acid tails** face inward, away from the water, creating a hydrophobic core.
- **Membrane Proteins:** Embedded within or attached to the bilayer.
  - **Integral/Transmembrane proteins** span across the entire membrane to form channels or pumps.
  - **Peripheral proteins** sit on the inner or outer surface, often anchoring the cytoskeleton or acting as enzymes.
- **Cholesterol:** Tucked between the hydrophobic tails of phospholipids. It acts as a **fluidity buffer**, keeping the membrane stable—preventing it from becoming too fluid in the heat or too rigid in the cold.
- **Carbohydrates (Glycoproteins and Glycolipids):** Short carbohydrate chains attached to proteins or lipids on the outer surface. They act as **cellular ID tags** for recognition and communication.

2. Membrane Functions

The structure of the membrane directly dictates how it functions to keep the cell alive:

- **Selective Permeability:** The hydrophobic core blocks large or charged molecules (like ions or glucose) but allows small, non-polar molecules (like oxygen and carbon dioxide) to pass right through.
- **Cellular Transport:** It controls the movement of substances via two main routes:
  - **Passive Transport:** Movement down a concentration gradient without using energy (e.g., simple diffusion, or facilitated diffusion via protein channels).
  - **Active Transport:** Movement against a concentration gradient using energy in the form of **ATP** via protein pumps.
- **Cell Signaling and Communication:** Receptor proteins on the membrane catch chemical signals (like hormones) from outside the cell and trigger a response on the inside.
- **Protection and Compartmentalisation:** It physically separates the chaotic outside world from the highly regulated internal environment of the cell, maintaining **homeostasis**.



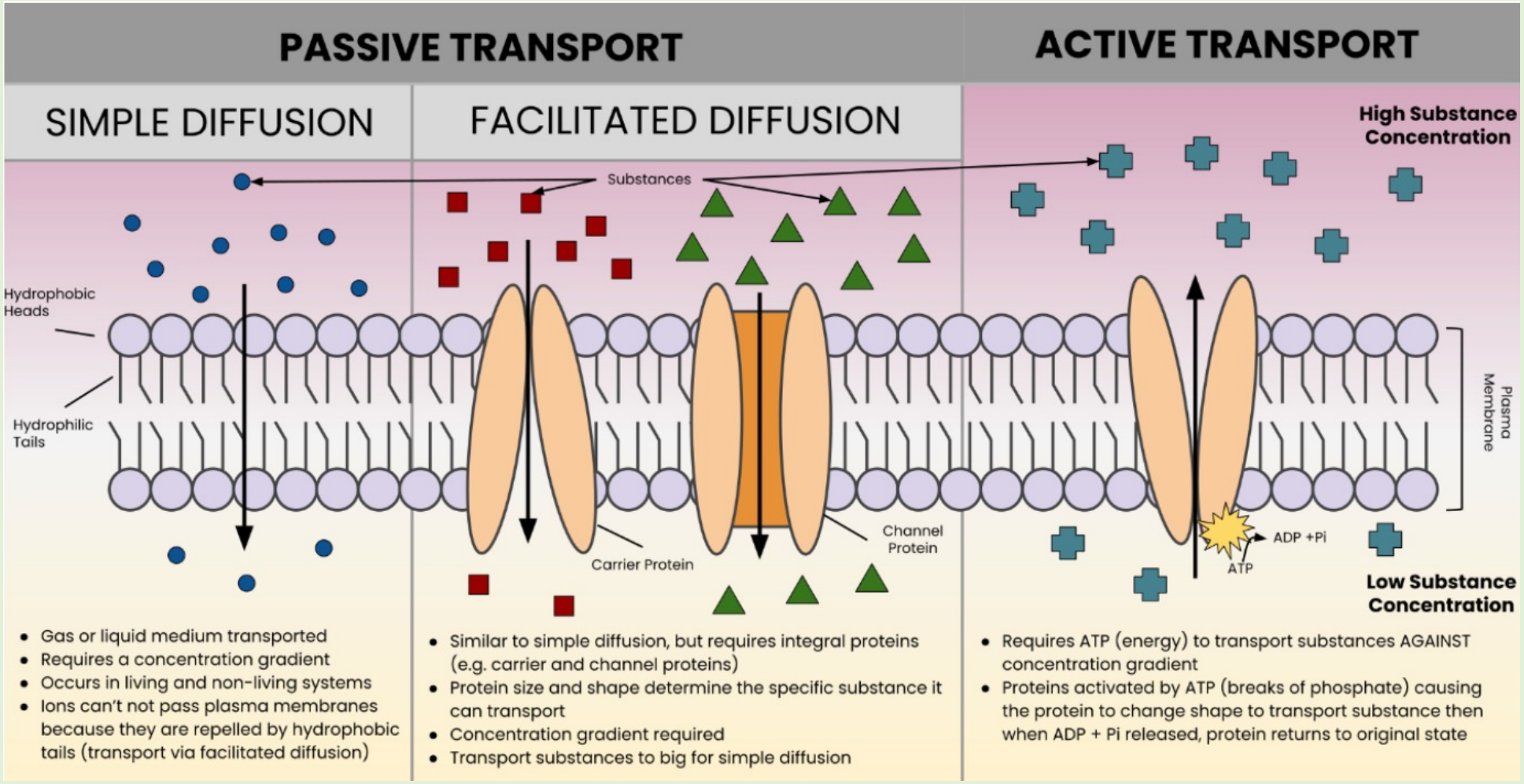
Membrane transport mechanisms

- **Simple Diffusion:** Small, non-polar molecules (like O_2 and CO_2) pass directly through the phospholipid bilayer without assistance.
- **Facilitated Diffusion (Channel Proteins):** Hydrophilic pores that allow specific ions or polar molecules (like Na^+ or water via aquaporins) to pass straight through.
- **Facilitated Diffusion (Carrier Proteins):** Transmembrane proteins that bind to a specific larger solute (like glucose), changing shape to release it on the other side.

2. Active Transport (Against concentration gradient, requires ATP)

- **Protein Pumps (Primary Active Transport):** Carrier proteins use energy directly from **ATP hydrolysis** to change shape and force specific molecules or ions (like the Sodium-Potassium pump) against their concentration gradient.
- **Bulk Transport (Endocytosis & Exocytosis):** Energy-dependent movement of large particles or large volumes of fluid wrapped inside lipid vesicles.
    - *Exocytosis* moves materials out of the cell.
    - *Endocytosis* invaginates the membrane to bring materials in.

Transport across membranes



Transport Method	Energy Needed? (ATP)	Direction of Movement	Type of Molecules Transported	Key Membrane Component Involved	Exam Example
Simple Diffusion	❌ No (Passive)	**Down** gradient *(High to Low)*	Small, non-polar, lipid-soluble	Phospholipid bilayer (directly through tails)	Oxygen (O_2), Carbon Dioxide (CO_2), steroids
Osmosis	❌ No (Passive)	**Down** water potential gradient	Water molecules only	Phospholipid bilayer & **Aquaporins** (specialised channels)	Water entering root hair cells
Facilitated Diffusion	❌ No (Passive)	**Down** gradient *(High to Low)*	Large, polar, or charged (ions)	**Channel proteins** or **Carrier proteins**	Glucose into cells, Sodium ions (Na^+)
Active Transport	Yes (Active)	**Against** gradient *(Low to High)*	Polar, charged, or specific nutrients	**Carrier proteins** (Pumps) with ATP-binding sites	Sodium-Potassium pump (Na^+/K^+), absorption of amino acids in the ileum
Endocytosis	Yes (Active)	Into the cell	Bulk liquids or large solid particles	Entire cell membrane (vesicle formation)	White blood cells engulfing a pathogen (phagocytosis)
Exocytosis	Yes (Active)	Out of the cell	Large molecules, proteins, or waste products	Secretory vesicles fusing with the cell membrane	Secretion of insulin from pancreas cells

Key Differences Between Transport Proteins

For your exams, you must be able to contrast the structural and mechanical differences between **channel proteins** and **carrier proteins**:

1. Channel Proteins (Passive Only)

- **Structure:** They form fixed, hydrophilic, water-filled pores that span across the membrane.
- **Mechanism:** They act as open gates. When open, specific ions or water molecules move through rapidly via simple **facilitated diffusion** down their concentration gradient.
- **Selectivity:** Highly selective based on the diameter and electrical charge of the amino acids lining the inner pore (e.g., *aquaporins* specifically for water). Many are **gated**, meaning they open or close in response to electrical or chemical signals.

2. Carrier Proteins (Passive or Active)

- **Structure:** They possess specific binding sites that match the unique shape of the target molecule (like a lock and key).
- **Mechanism:** When a solute binds, the protein undergoes a **conformational change** (a shift in its 3D shape). This flip moves the binding site from one side of the membrane to the other, releasing the solute.
- **Dual Roles:**
  - In **Facilitated Diffusion**, they flip spontaneously without using energy, moving molecules (like glucose) down their concentration gradient.
  - In **Active Transport**, they function as **pumps**. They require energy directly from **ATP hydrolysis** to forcefully flip their shape and push molecules (like sodium or potassium) *against* their concentration gradient.

Membrane transport MCQ

1. **Why is the hydrophobic interior of the phospholipid bilayer a major barrier to the free diffusion of hydrophilic molecules such as glucose and sodium ions?**

A. It actively repels all molecules using continuous electrostatic forces.

B. Hydrophilic molecules are charged or polar and are energetically unfavourable within the non-polar fatty acid tail region.

C. It binds permanently to hydrophilic molecules, trapping them inside the core.

D. It contains tightly packed protein gates that actively block all molecular movement unless ATP is hydrolyzed.

2. **Which of the following features distinguishes facilitated diffusion from simple diffusion across a biological membrane?**

A. Facilitated diffusion requires a direct input of metabolic energy in the form of ATP.

B. Facilitated diffusion moves molecules from an area of low concentration to an area of high concentration.

C. Facilitated diffusion utilizes specific transmembrane proteins to allow polar or charged molecules to cross down their concentration gradient.

D. Facilitated diffusion only occurs in animal cells, whereas simple diffusion occurs exclusively in plant cells.

Membrane transport questions continued

3. How do active transport mechanisms utilize transmembrane carrier proteins and cellular energy to maintain solute gradients distinct from equilibrium?

A. Carrier proteins form wide, permanently open aqueous pores that let ions rush in both directions until equal concentration is reached.

B. ATP directly increases the fluidity of the phospholipid hydrophobic core to allow molecules to dissolve through it in reverse.

C. Carrier proteins undergo conformational changes driven by ATP hydrolysis, allowing specific solutes to be pumped against their electrochemical gradient.

D. Active transport uses passive carrier proteins that alter their binding affinity spontaneously without energy coupling.

Factors that affect diffusion rate

- Extent of the Concentration Gradient
- Mass of the Molecules Diffusing
- Temperature
- Solvent Density
- Solubility
- Plasma Membrane Surface Area and Thickness
- Distance Travelled

Osmosis

- Osmosis is the movement of water through a semipermeable membrane according to the water's concentration gradient across the membrane, which is inversely proportional to the solutes' concentration
- While the term diffusion refers to the transport of material (other than water) across membranes and within cells, the term osmosis refers **specifically to the transport of water across a membrane**

- https://www.labxchange.org/library/items/lb:LabXchange:b336eb0e:lx_simulation:1?fullscreen=true