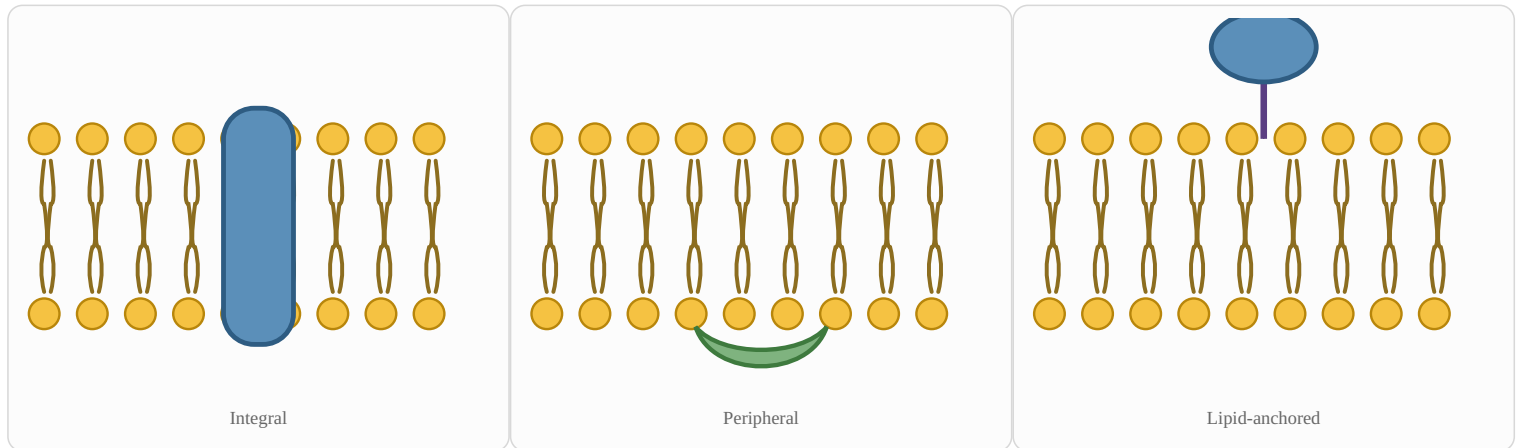


Structure of the Plasma Membrane

The Fluid Mosaic Model — composition, architecture & function

Scope: Undergraduate (B.Sc.) cell biology / zoology examination preparation.

Covers: chemical composition, historical membrane models, the Singer–Nicolson fluid mosaic model, membrane fluidity, protein types, glycocalyx, cholesterol, and core functions.



Introduction & Chemical Composition

The **plasma membrane** (cell membrane) is a selectively permeable boundary, roughly **7.5–10 nm** thick, that separates the intracellular environment from the extracellular milieu. It is composed mainly of **lipids, proteins, and carbohydrates**, held together largely by non-covalent interactions — the hydrophobic effect, van der Waals forces, and hydrogen bonding. Far from being a static wall, it is a dynamic, fluid structure central to compartmentalization, transport, signalling, and cell recognition.

Approximate composition by mass



■ Phospholipids, cholesterol, glycolipids ■ Integral, peripheral & anchored proteins ■ Glycoproteins / glycolipid sugars

Note: exact proportions vary considerably by cell/organelle membrane type — e.g. the inner mitochondrial membrane is protein-rich (>70% protein), while myelin is lipid-rich.

The three building blocks

Component	Key points
Phospholipids	Amphipathic molecules — hydrophilic phosphate "head" + two hydrophobic fatty-acid "tails." Common types: phosphatidylcholine, phosphatidylethanolamine, phosphatidylserine, phosphatidylinositol, sphingomyelin.
Cholesterol	Intercalates between phospholipids in animal-cell membranes; acts as a fluidity buffer (§4).
Glycolipids	Lipids with attached carbohydrate chains; found exclusively on the outer leaflet ; contribute to the glycocalyx.
Proteins	Integral, peripheral, or lipid-anchored (§5) — transport, receptor, enzymatic, and structural roles.
Carbohydrates	Attached only to the outer surface as glycoproteins/glycolipids, forming the glycocalyx (§6).

Historical Models of Membrane Structure

Understanding of membrane architecture developed through several revisions, each responding to new experimental evidence — from lipid solubility of permeant molecules to freeze-fracture electron microscopy.



Why the sandwich model was rejected: it could not explain the diversity of protein size/function, membrane asymmetry, or freeze-fracture EM images showing discrete globular particles (proteins) embedded *within* the bilayer rather than coating it externally.

The Fluid Mosaic Model — core idea

Singer & Nicolson (1972, *Science*) proposed that phospholipids form a continuous **bilayer**, with proteins embedded within or attached to this lipid matrix like tiles in a **mosaic**. The whole assembly behaves as a two-dimensional fluid, allowing lateral movement of both lipids and proteins — this is illustrated in full on the next page.

The Fluid Mosaic Model — Labelled Diagram

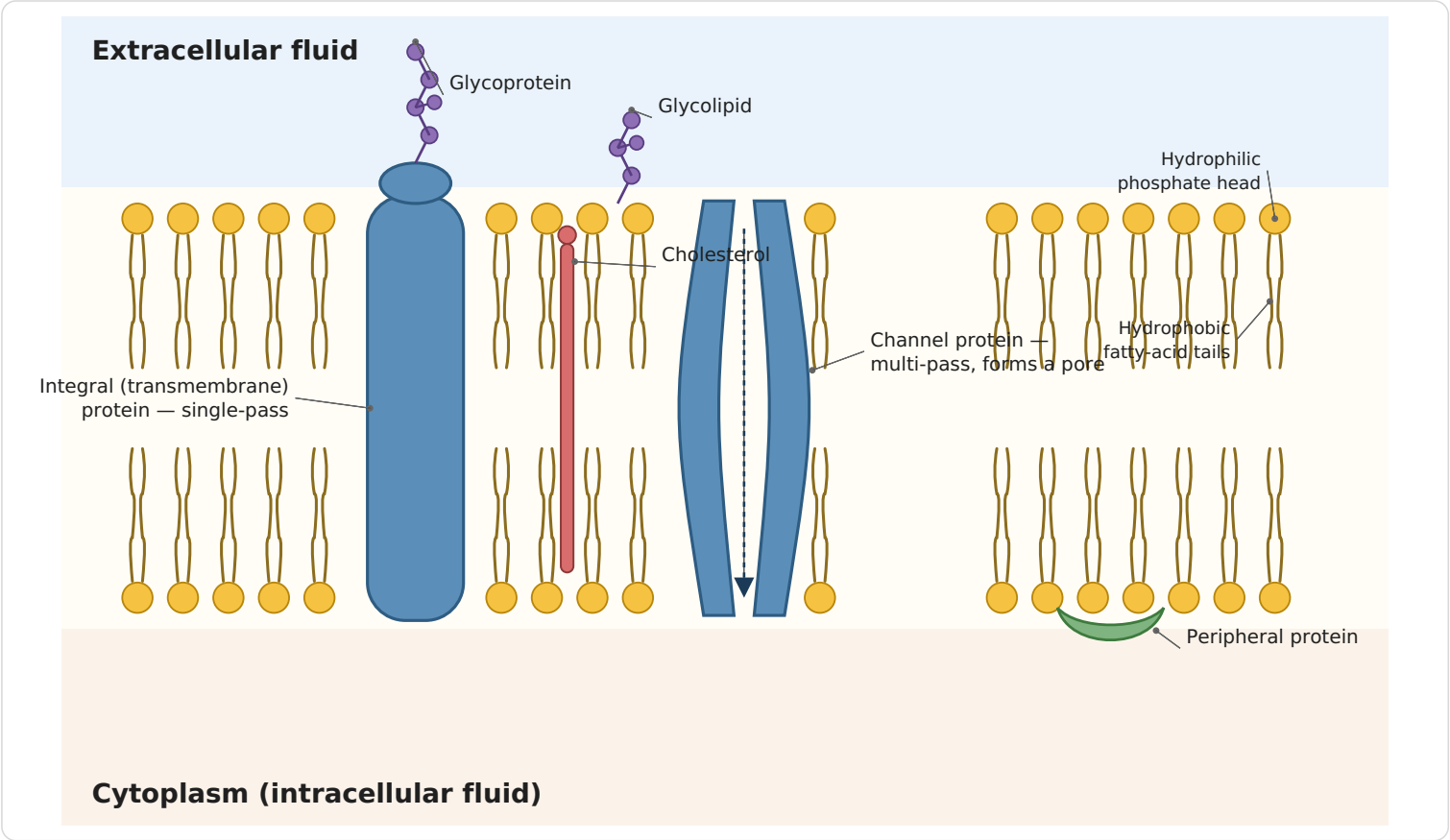


Fig. 1 — Cross-section of the plasma membrane showing the phospholipid bilayer, cholesterol, integral (single-pass & channel) proteins, a peripheral protein, and outer-surface glycoprotein / glycolipid carbohydrate chains.

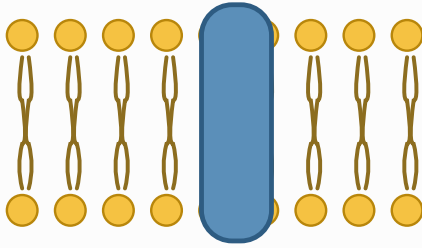
Membrane Fluidity & Membrane Proteins

Factors affecting fluidity

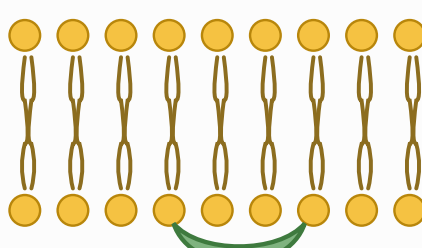
- 1. **Fatty-acid saturation** — unsaturated (kinked) tails increase fluidity; saturated (straight) tails pack tightly and decrease it.
- 2. **Chain length** — shorter chains → greater fluidity.
- 3. **Cholesterol** — restrains movement at high temperature, prevents tight packing at low temperature (a fluidity buffer).
- 4. **Temperature** — higher temperature increases fluidity; below a transition point the membrane can gel.

Movement: lateral diffusion is rapid and common; transverse (*flip-flop*) movement is rare and typically enzyme-mediated (*flippases*, *floppases*, *scramblases*). Protein mobility can be restricted by the underlying spectrin–actin membrane skeleton (fence/picket model).

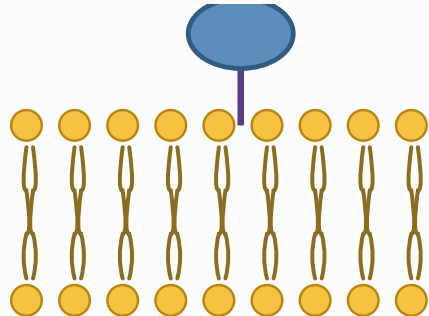
Types of membrane proteins



Integral protein
Spans the bilayer; needs detergent to extract



Peripheral protein
Bound to the surface; removable by pH/ionic-strength change



Lipid-anchored protein
Covalently tethered via a lipid anchor (e.g. GPI)

Functions of membrane proteins

Transport Channels, carriers, pumps (e.g. Na⁺/K⁺-ATPase) Enzymatic activity Catalysis at the membrane surface Intercellular joining Junctional proteins — cadherins, connexins	Receptors Hormone / signal reception (e.g. GPCRs) Cell–cell recognition Glycoproteins acting as identity markers Cytoskeleton anchoring Structural stability, e.g. integrins
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Glycocalyx, Cholesterol & Overall Functions

Membrane carbohydrates & the glycocalyx

Carbohydrates occur only on the **outer surface**, as **glycoproteins** (oligosaccharides on proteins) or **glycolipids** (oligosaccharides on lipids, e.g. gangliosides), together forming the **glycocalyx** — a carbohydrate-rich surface coat.

- Cell–cell recognition and adhesion
- Mechanical/chemical protection of the cell surface
- Determinant of ABO blood-group antigens
- Immune recognition (self vs. non-self)
- Sperm–egg recognition during fertilization

Role of cholesterol

Cholesterol intercalates between phospholipids, oriented with its hydroxyl group near the phospholipid head groups. It reduces permeability to small water-soluble molecules and acts as a **fluidity buffer** — restraining movement at high temperature while preventing tight packing at low temperature. It is largely absent from plant and prokaryotic membranes (which use phytosterols or hopanoids instead).

Membrane asymmetry

The two leaflets differ in composition: the **outer leaflet** is richer in phosphatidylcholine, sphingomyelin and glycolipids; the **inner leaflet** is richer in phosphatidylserine and PIP₂. Exposure of phosphatidylserine on the outer face, for instance, is a recognized signal for apoptotic cell clearance.

Functions of the plasma membrane — summary

- **Compartmentalization** of the cell interior
- **Selective permeability** & regulated transport (passive and active)
- **Signal transduction** via surface receptors
- **Cell recognition and adhesion** via the glycocalyx
- **Enzymatic activity** at membrane-bound complexes
- **Mechanical support**, anchoring the cytoskeleton and maintaining cell shape
- **Endocytosis / exocytosis** for bulk transport

Quick Revision — Exam Flashcards

Fluid Mosaic Model → Singer & Nicolson, 1972 , published in <i>Science</i> .	Membrane thickness ≈ 7.5–10 nm .
Bilayer lipids are amphipathic ; arrangement driven by the hydrophobic effect.	Flip-flop movement is rare/enzyme-mediated; lateral diffusion is common.
Cholesterol = fluidity buffer ; absent in plants & prokaryotes.	Glycocalyx is on the outer surface only ; basis of ABO blood grouping.
Membrane is asymmetric — leaflets differ in lipid & protein composition.	Freeze-fracture EM evidence supported the fluid mosaic model over the sandwich model.

This is a condensed structural overview suitable for undergraduate (graduation-level) exam preparation. Each section can be expanded further — e.g. lipid raft biology, transport kinetics, or receptor signalling cascades — on request.