

Physiology Lecture 3

The cell membrane

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Lecture Objectives

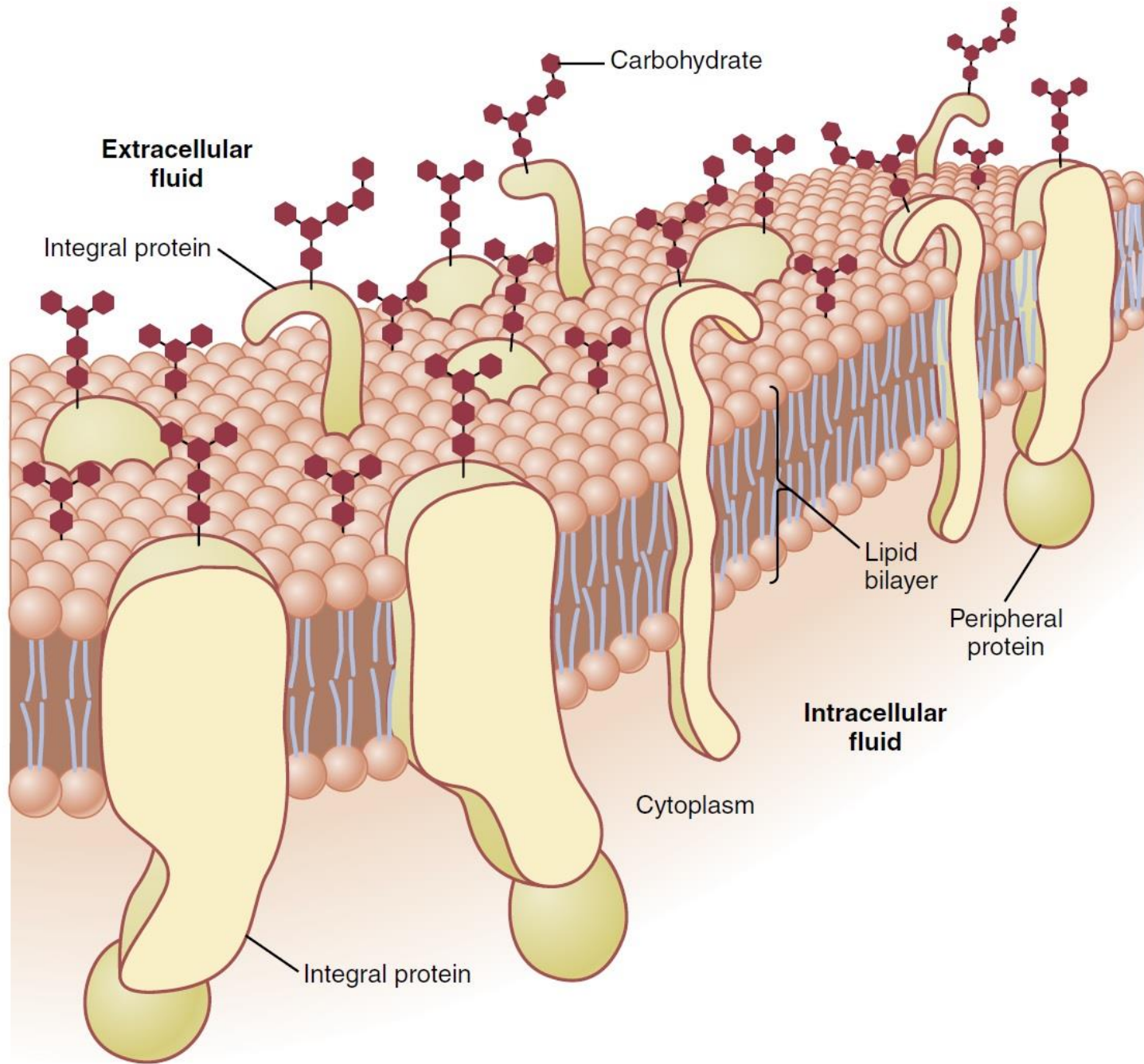
- Review the fluid mosaic model of cell membrane structure and describe the organization of the phospholipid bilayer and associated proteins in a biologic membrane.
- Understand the physiological importance of the cell membrane selective permeability.
- Recognize the integral and peripheral cell membrane proteins and understand their physiological function.
- Identify various forms membrane channels, gates and their selective permeability.
- Differentiate between membrane protein carriers and channels (voltage-gated, ligand-gated, and mechanical channels).
- Distinguish between symport and antiport.

The cell membrane

- Is a lipid bilayer structure of about 7.5-10 nm thick composed of proteins and lipids (approximately 55% proteins, 25% phospholipids, 13% cholesterol, 4% other lipids, and 3% carbohydrates).
- Each layer is only one molecule thick that is continuous over the entire cell surface. Scattered in this lipid film are large globular proteins.
- One end of each phospholipid molecule is hydrophilic and soluble in water. The other end is hydrophobic and soluble only in fats.
- The phosphate end of the phospholipid is hydrophilic, and the fatty acid portion is hydrophobic.
- The lipid bilayer is not a rigid structure but is fluid in nature. The fluidity of the lipid bilayer enables many membrane proteins to move within the membrane.

The cell membrane

- The hydrophobic fatty acyl chains form the core of the bilayer, and the polar head groups are exposed on the surface.
- The lipid layer in the middle of the membrane is **impermeable** to the usual water-soluble substances, such as ions, glucose, and urea.
- Fat-soluble substances, such as oxygen, carbon dioxide, and alcohol, can **penetrate** this lipid layer with ease.
- Cholesterol molecules in the cell membrane controls much of the **fluidity** of the membrane.
- The cholesterol molecules are tucked in between the phospholipid molecules, where they **prevent** the fatty acid chains from packing together and crystallizing.

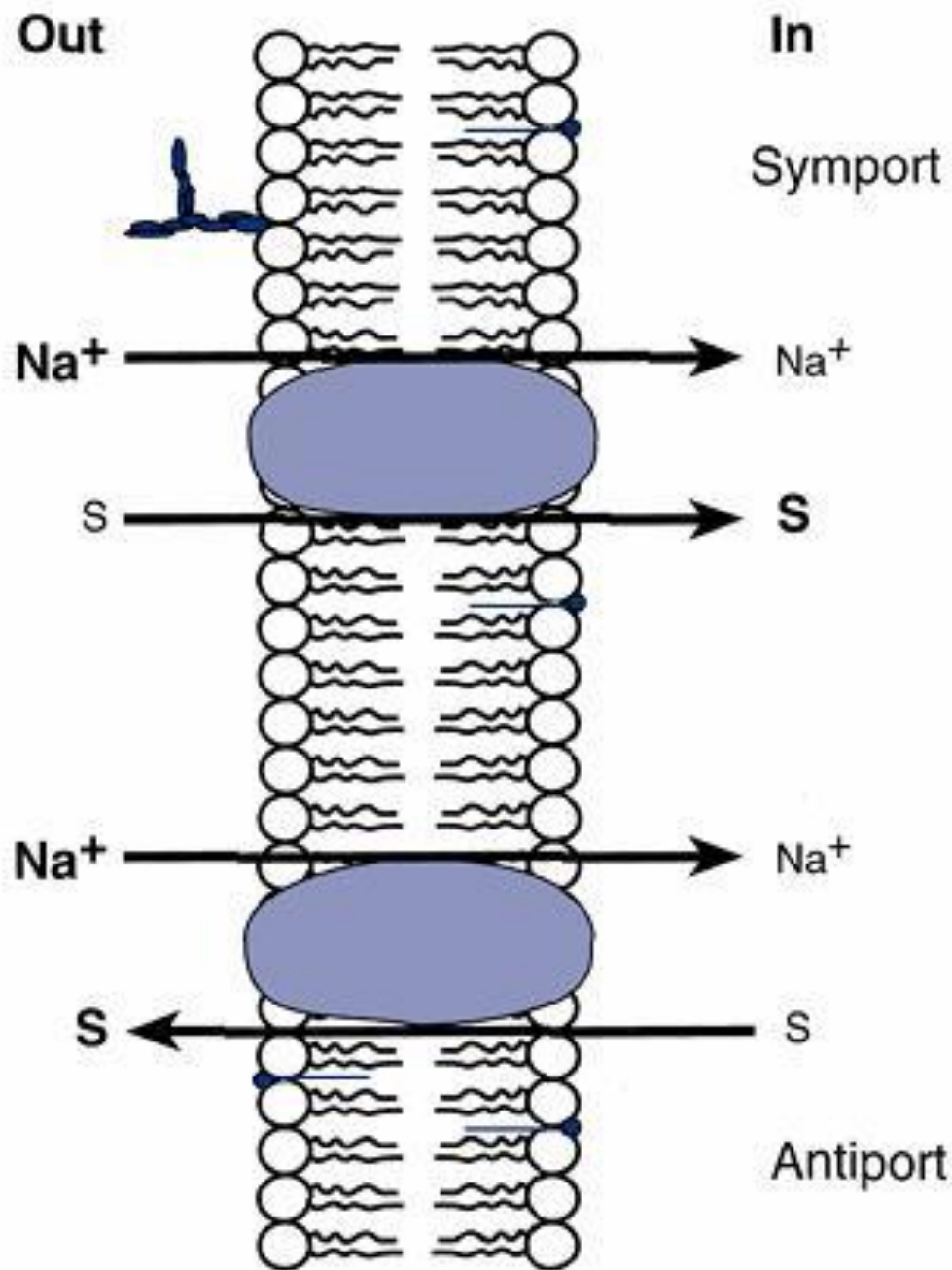


Cell Membrane Proteins

Membrane proteins are classified as integral, lipid-anchored, or peripheral.

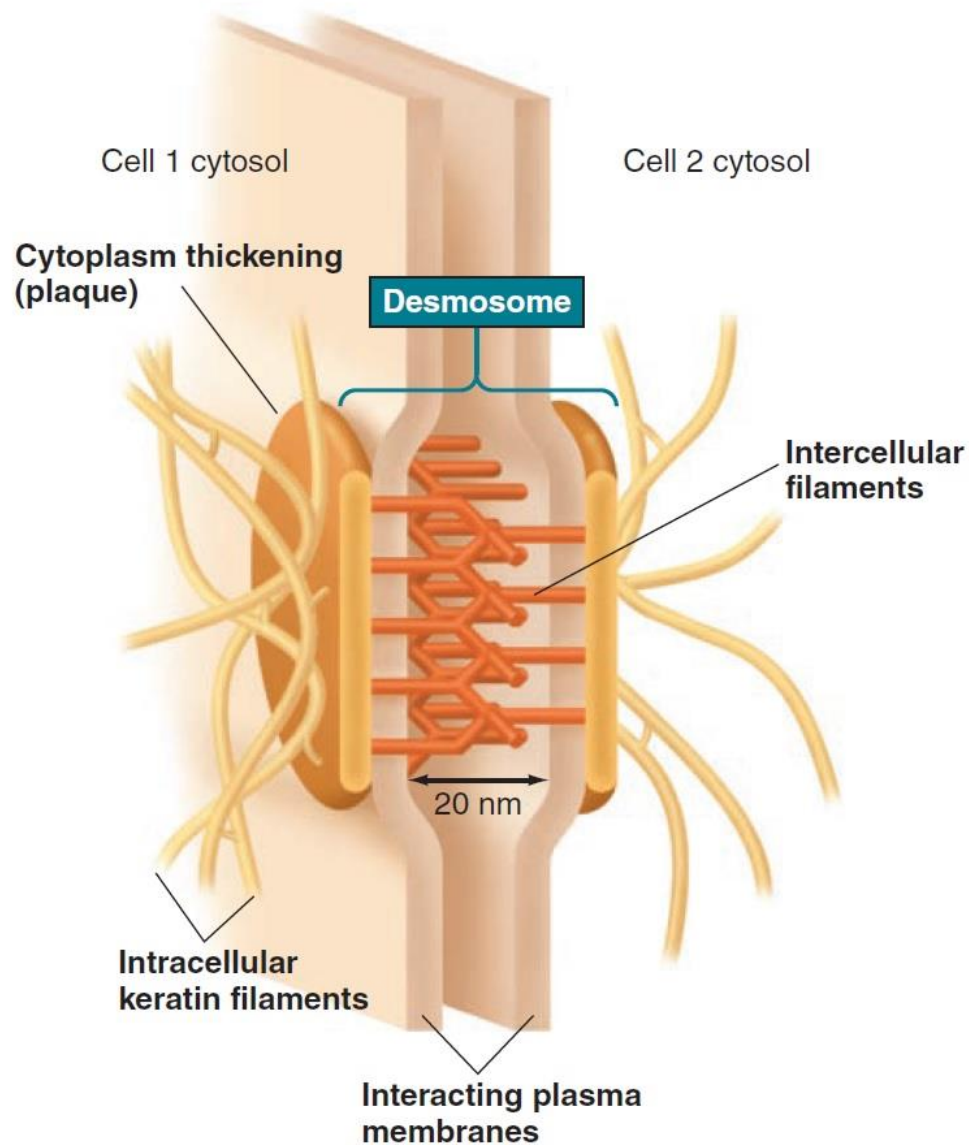
A. Transmembrane proteins; are integral proteins serve as:

1. Channels (when open, they facilitate the movement of water molecules and water-soluble substances only down their **electrochemical gradients**). Ion channels (≤ 0.8 nm in diameter) are for K^+ , Na^+ , Ca^{2+} , and Cl^- and each exists in multiple forms.
2. Carriers (transport substances that otherwise could not penetrate the lipid bilayer). When bind to ions and other molecules they change their configuration and move the bound molecule or ion from one side of the cell membrane to the other.
 - Uniport carrier- a carrier protein that transport only one substance
 - Symport carrier- a carrier protein that transport more than one substance
 - Antiport carrier- a carrier protein that exchange one substance for another

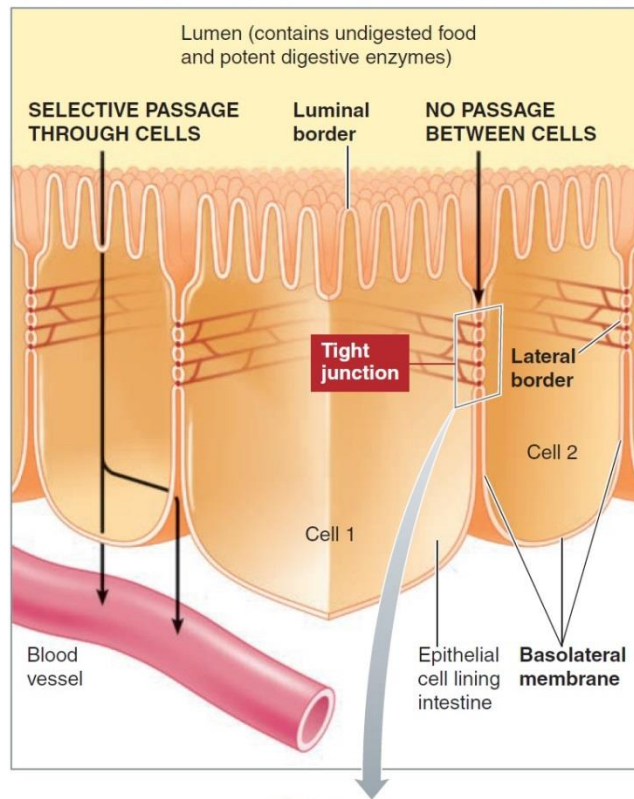


Cell Membrane Proteins (cont.)

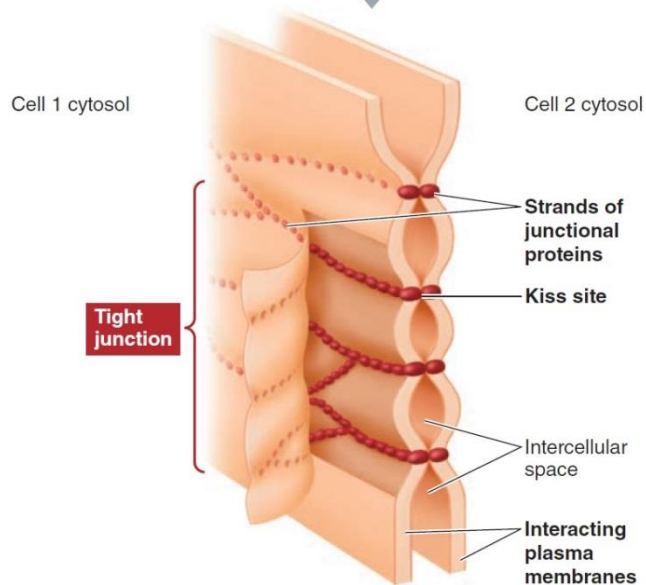
3. Pumps; they are ATP-ase enzymes that transport ions up their **electrochemical gradient** at the expense of consuming **ATP**.
4. Receptors for water-soluble chemicals (bind neurotransmitters and hormones, initiating physiologic changes inside the cell)
5. Cell adhesion molecules (CAMs); they attach cells to the basal lamina and to each other (**desmosomes & tight junctions**). The CAMs **integrins** affix the cell membrane to the **cytoskeleton** inside the cell.
The junctions that permit transfer of ions from one cell to another are the **gap junctions**. The protein unit is called **connexons**. Gap junctions do not allow entering of ECF. They allow ions, sugars, amino acids, and other solutes with molecular weight up to about 1000.

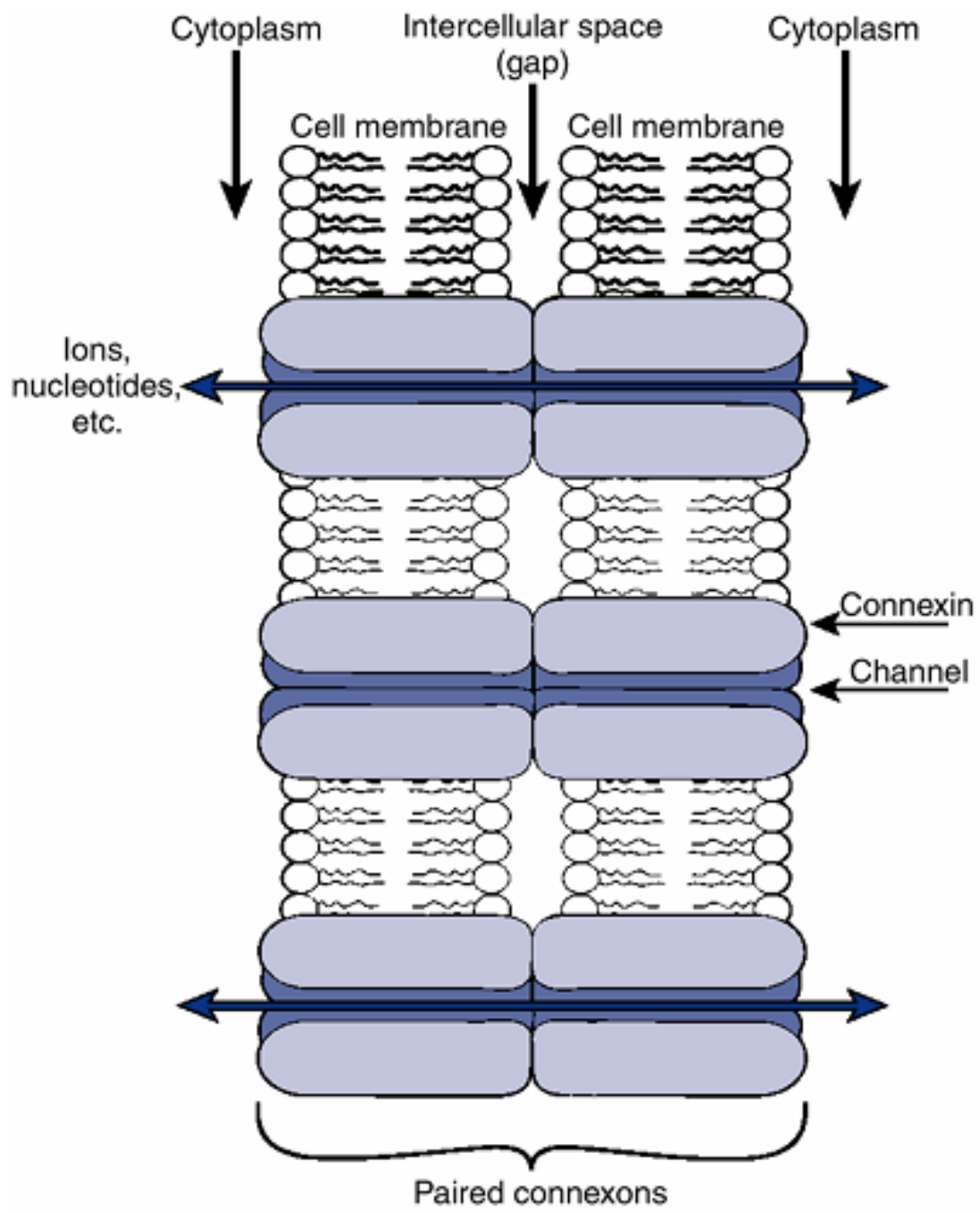


Desmosome. Desmosomes are adhering junctions that spot-rivet cells, anchoring them together in tissues subject to considerable stretching.



Tight junction. Tight junctions are impermeable junctions that join the lateral edges of epithelial cells near their luminal borders, thus preventing materials from passing between the cells. Only regulated passage of materials can occur through these cells, which form highly selective barriers that separate two compartments of highly different chemical composition.





Cell Membrane Proteins (cont.)

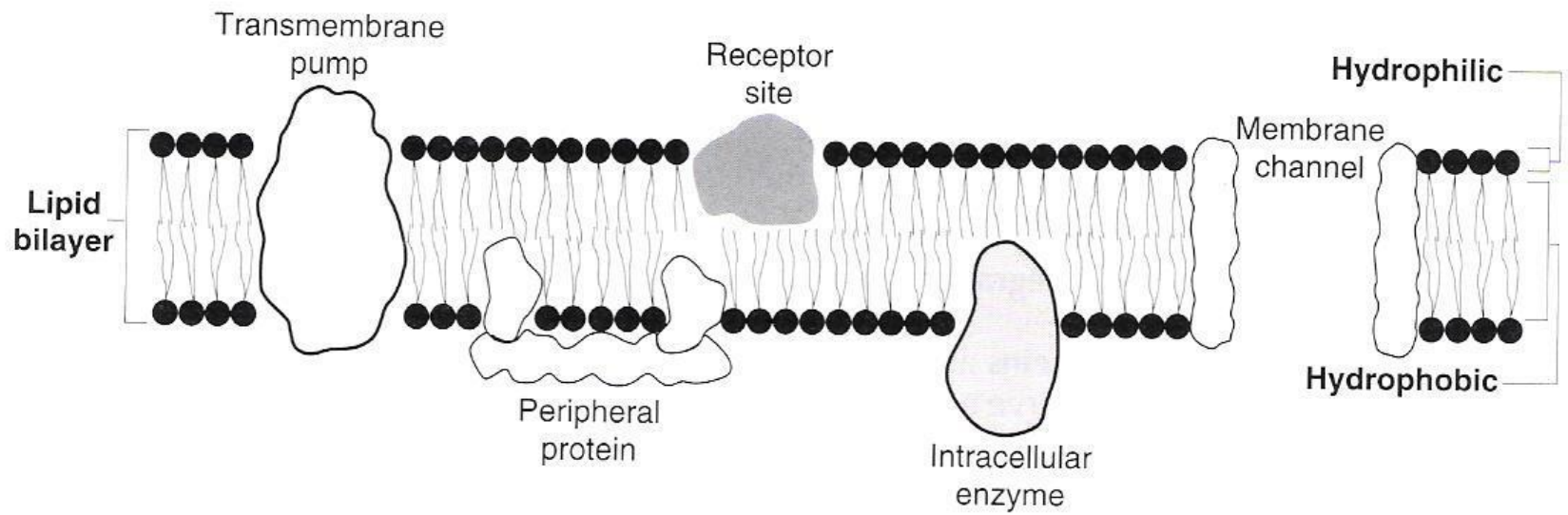
- B. Channels are non-gated (continuously open) and gated (ionic channels), gated channels are:
1. Mechanosensitive channels (involved in sensory processes, These channels open when the membrane of the sensory cell is stretched)
 2. Voltage-sensitive channels or voltage-gated (involved in action potential propagation, These channels open in response to a change in membrane potential)
 3. Chemosensitive channels or ligand-gated. The ligand is often external such as neurotransmitters (involved in synaptic transmission) or hormone. The transmitters bind to these channels, causing them to open. Or the ligand can be internal such as intracellular Ca^{2+} , cAMP, and G protein.

Cell Membrane Proteins (cont.)

- C. Lipid-anchored integral proteins are present on only one side of the membrane. They are embedded in one leaflet of the bilayer. They serve primarily as **membrane-bound enzymes** that activate or inactivate various metabolic processes.
- D. Peripheral proteins. They are bound to the hydrophilic polar heads of the lipids or the integral proteins. They function almost entirely as enzymes and contribute to the external glycocalyx (glycoprotein that covers cell membranes).

The Glycocalyx:

- Some lipids and many of the proteins exposed on the outer surface of the cell membrane are glycosylated (i.e., have short chains of sugars, called oligosaccharides, attached to them like tiny antennas).
- Thus, the entire outside surface of the cell often has a loose carbohydrate coat. This coat is called the glycocalyx.
- The glycocalyx is negatively charged, which gives most cells an overall negative surface charge that repels other negatively charged objects.
- The glycolipids and glycoproteins may be involved in antibody processing and distinguishing self from non-self (e.g., surface antigens).



Some of the functions performed by proteins within the lipid bilayer of cell membranes

Test Question:

Q. The term “glycocalyx” refers to what?

- A. The negatively charged carbohydrate chains that protrude into the cytosol from glycolipids and integral glycoproteins.
- B. The layer of anions aligned on the cytosolic surface of the plasma membrane.
- C. The large glycogen stores found in active skeletal muscles.
- D. The pericellular matrix the body uses to distinguish between its own cells and transplanted tissues.
- E. A mechanism of cell-cell attachment