Introduction to Zoology Lecture 7

Plasma membrane (= Cell membrane = Plasmalemma)

- Thin semi-permeable membrane surrounds the cytoplasm in a cell of both prokaryote and eukaryote organisms.
- About 8 nm in thickness.
- Seen only by electron microscope.

Functions of Plasma membrane

- Selective permeability:
  - It controls traffic into & out of cell it surrounds.
  - It allows some substances to cross it more easily than others; therefore, its function is to protect the integrity of the interior of the cell.
- Supporting the cell: it helps support the cell and maintain its shape because it serves as a base of attachment for the cytoskeleton.

Structure of cell membrane

- Mix of lipids, proteins and some carbohydrates.
- The membrane is composed of a phosphate bilayer (two layers) in which protein molecules are either partially or wholly embedded.

Lipids

- can make up anywhere from 20 to 80% of the membrane depending on location and function, with the remainder being proteins.
- Lipids help to give membranes their flexibility.

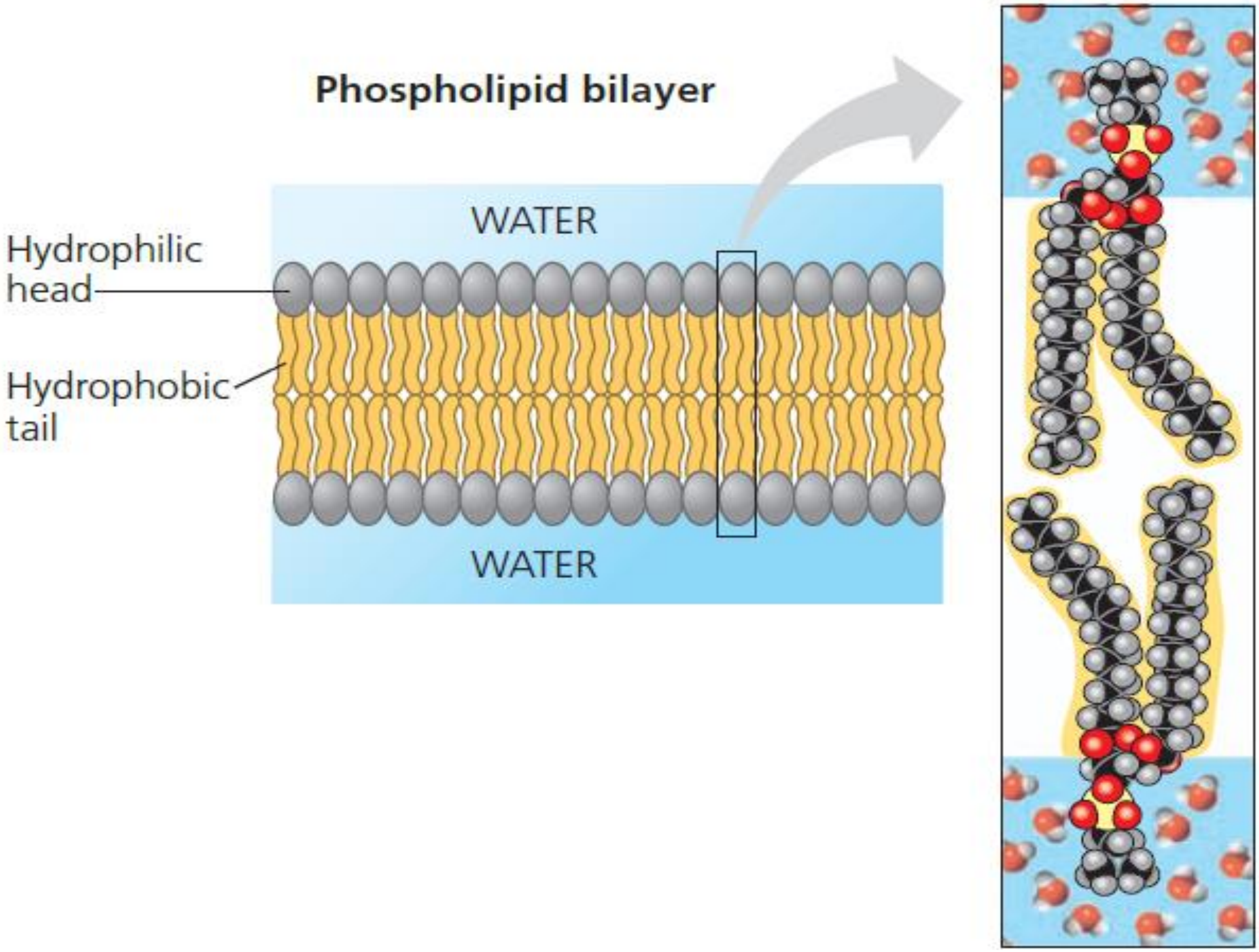
Proteins

(A) Monitor and maintain the cell's chemicals.

(B) Assist in the transfer of molecules across the membrane.

Phospholipid bilayer

Phospholipids are the most abundant lipid in the plasma membrane.



Phospholipid has:

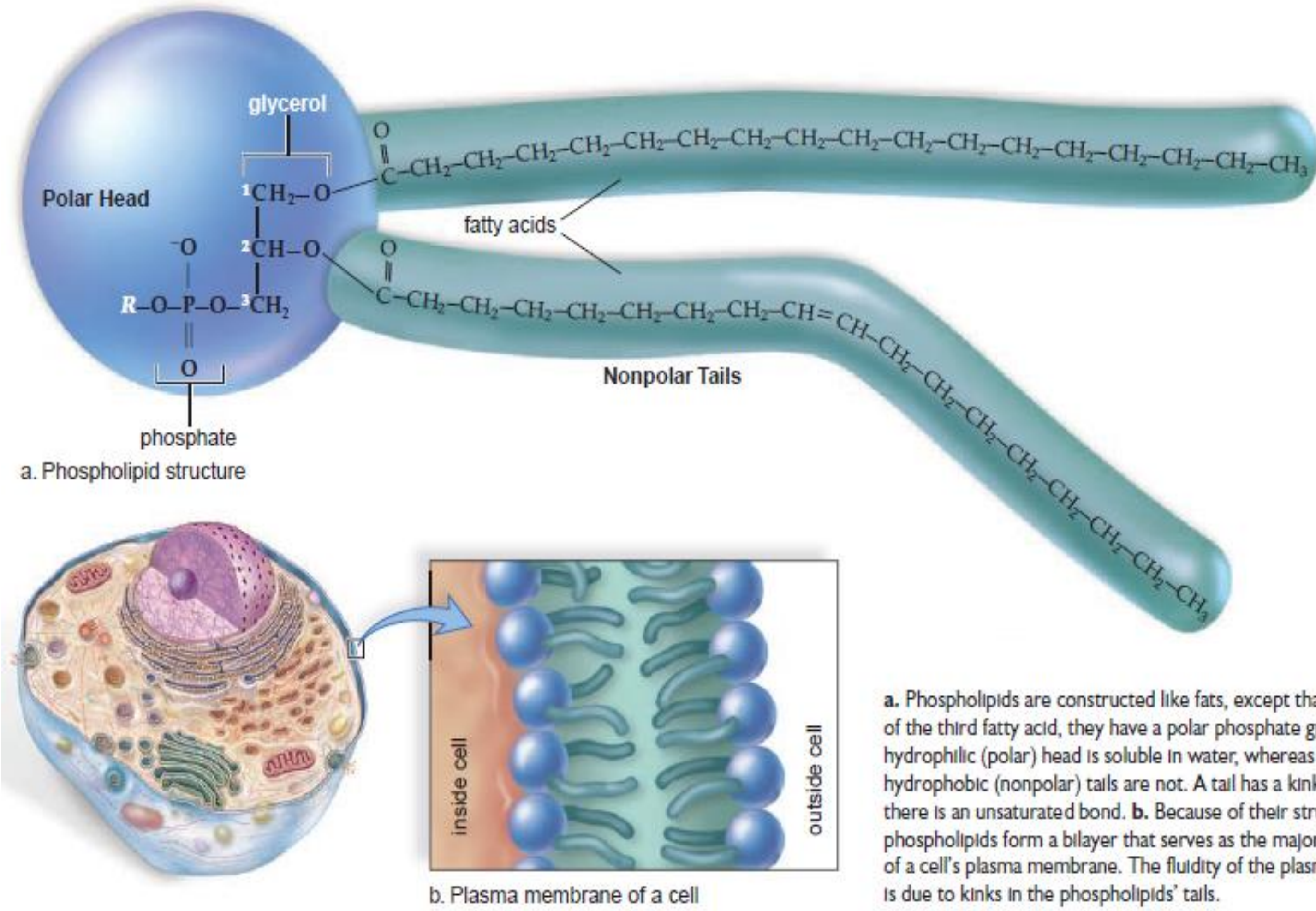
- **Hydrophilic head (water-loving) areas (composed of glycerol and phosphate) naturally face outside and inside of the cell (the cytosol), where water is found.**
- **Hydrophobic tail (water-fearing) areas (composed of *two* fatty acids) that face away from the cytosol and outside of the cell; they face each other. This Explains why the membrane is a bilayer.**

Cholesterol

- **Another type of lipid found in animal membrane.**
- **Not found in the membranes of plant cells.**

It helps:

- **Maintain the integrity of cell membrane.**
- **Plays a role in facilitating cell signaling (the ability of cells to communicate with each other).**



a. Phospholipids are constructed like fats, except that in place of the third fatty acid, they have a polar phosphate group. The hydrophilic (polar) head is soluble in water, whereas the two hydrophobic (nonpolar) tails are not. A tail has a kink wherever there is an unsaturated bond. **b.** Because of their structure, phospholipids form a bilayer that serves as the major component of a cell's plasma membrane. The fluidity of the plasma membrane is due to kinks in the phospholipids' tails.

Phospholipid from cell membrane

Protein in cell membrane

- **Proteins are scattered throughout the membrane in an irregular pattern that varies from membrane to another**

Type of proteins in cell membrane

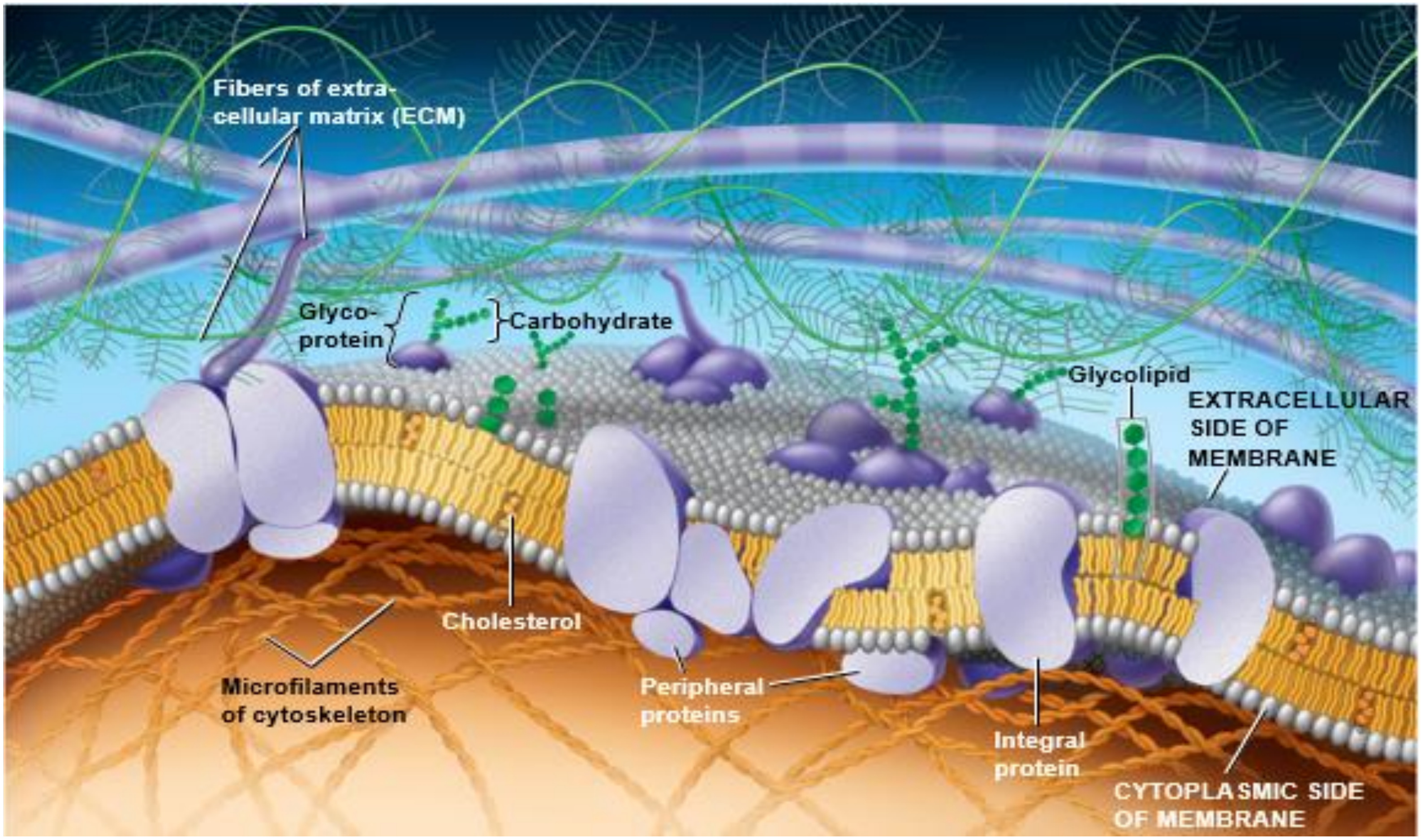
According to position of the proteins in cell membrane, there are two main types of proteins:

1) **Integral proteins (Integrin protein) are embedded in a fluid matrix of lipid bilayer which, most of them protrude from both sides of bilayer membrane.**
2) **Peripheral proteins, which occur only on the cytoplasmic side of the membrane.**

- **Both Integral and Peripheral proteins are attached to protein fibres of cytoskeleton (inside cell) and extracellular matrix fibres (outside cell).**
- **Proteins give:**

1. Stability to the structure of the cell.

2. Contributing to possible movement and shape change in cells as well.



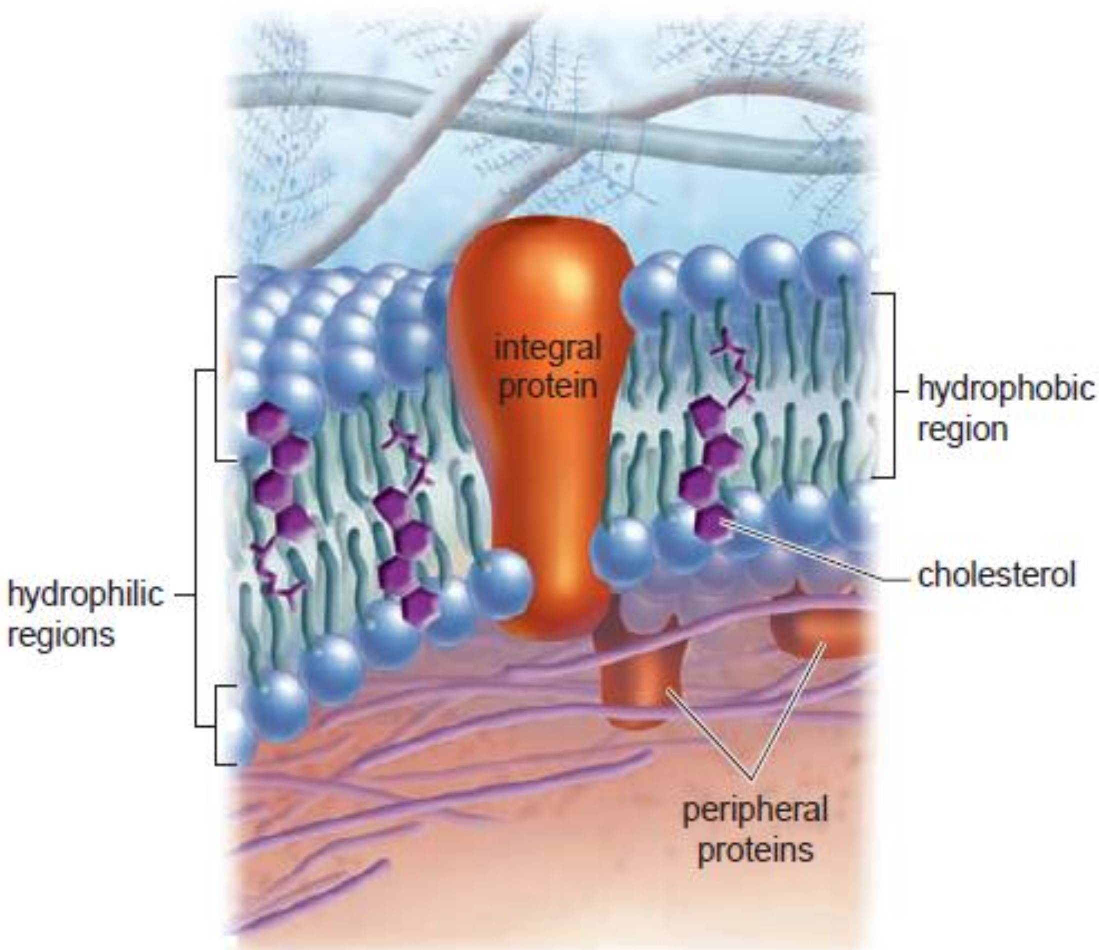
- **More than 50 types of proteins are found in the cell membrane of RBC.**
- **Phospholipids form the main fabric of the membrane, but proteins determine most of the membrane's functions.**
- **Different types of cells contain different sets of membrane proteins.**
- **Various membranes within a cell each have a unique collection of proteins.**

Types & functions of protein in cell membrane

A. Structural proteins help to give the cell support and shape.

B. Receptor proteins help cells communicate with their external environment through hormones, neurotransmitters and other signalling molecules.

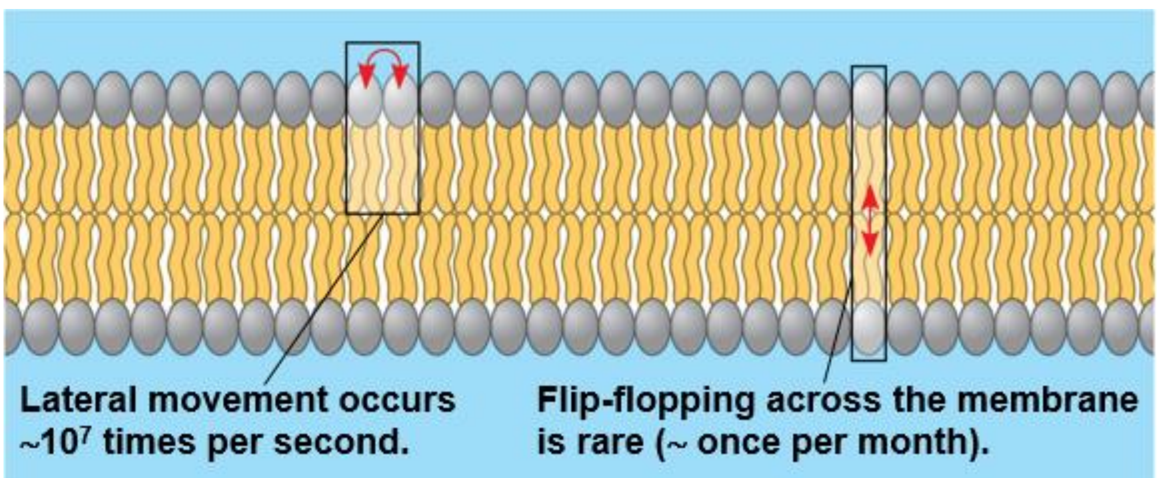
C. Transport proteins, such as globular proteins, transport molecules across cell membranes through facilitated diffusion.



Fluid-Mosaic Model

- A model which describes the arrangement of molecules in the cell membrane.
- Fluid = the membrane is soft (flexible) and easily changes its shape and easily moves due to the presence of lipids.
- Mosaic = Mix = different types of proteins.
- The fluid mosaic model states that a membrane is a "fluid structure" with a "mosaic" of various proteins embedded in it.

- The number and kinds of proteins can vary in the plasma membrane and in the membrane of the various organelles.
- Membranes are Not static sheets of molecules locked rigidly in place.
- Membranes are joined together by hydrophobic interactions (interaction between lipid and water), which are much weaker than covalent bonds.
- The fluidity of the membrane is due to its lipid component.
- The phospholipid bilayer of the plasma membrane has the consistency of olive oil at body temperature (37° C).
- High concentration of unsaturated fatty acid (CH=CH) makes the bilayer more fluid.
- In each monolayer, the hydrocarbon tails wiggle, and the entire phospholipid molecule can move sideways in the plane of the membrane at a rate averaging about 2 μm / second.
- Very rarely, a lipid may flip-flop across the membrane, switching from one phospholipid layer to the other.



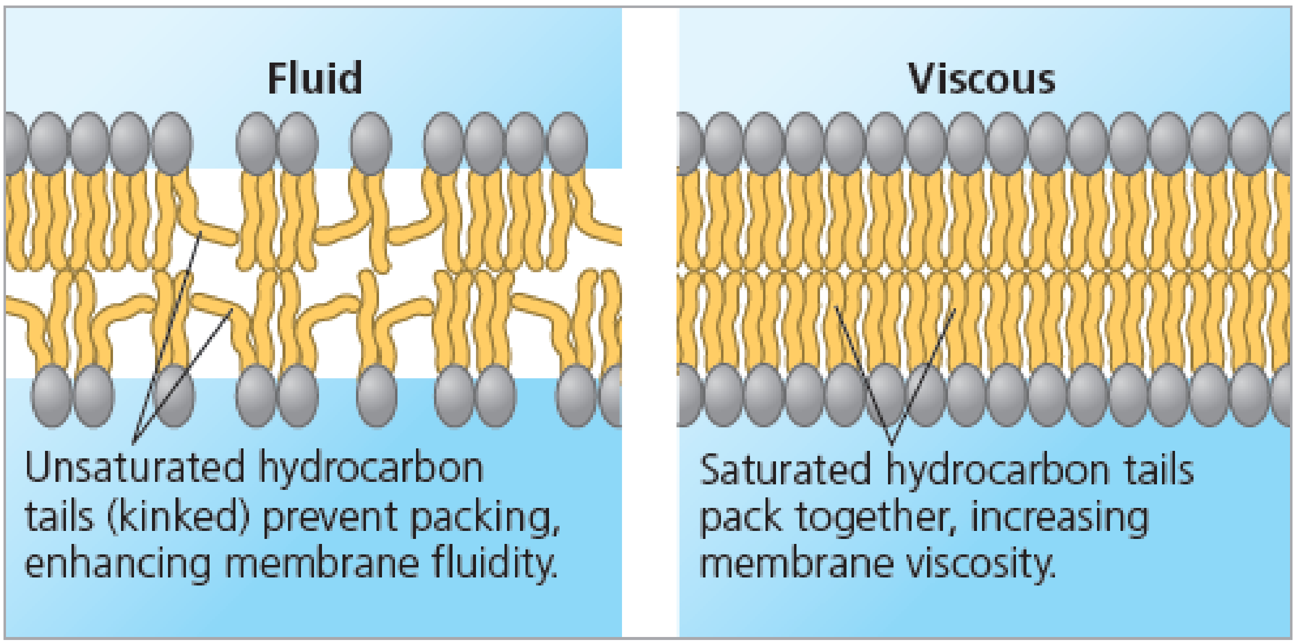
- Fluidity of a phospholipid bilayer means that cells are pliable.
- If the cell membrane is NOT pliable, the long nerve fibres in the neck would crack whenever the head is nodded.
- Fluidity of the membrane prevents it from solidifying as external temperatures drop (cold).
- Proteins are much larger than lipids, and some of them are able to move more slowly.
- But many other membrane proteins are often bonded to the cytoskeleton and prevent them from moving in the fluid phospholipid bilayer.

Effects of lipid on membrane fluidity

- When the temperature decreases (cold), the membrane remains fluid until the phospholipids settle into a closely packed arrangement and the membrane solidifies.
- The temperature at which a membrane solidifies depends on the types of lipids that the membrane is made of.

Effects of unsaturated lipid

- The membrane remains fluid to a lower temperature if it is rich in phospholipids with unsaturated hydrocarbon tails (CH=CH) due to the kink in the tails.

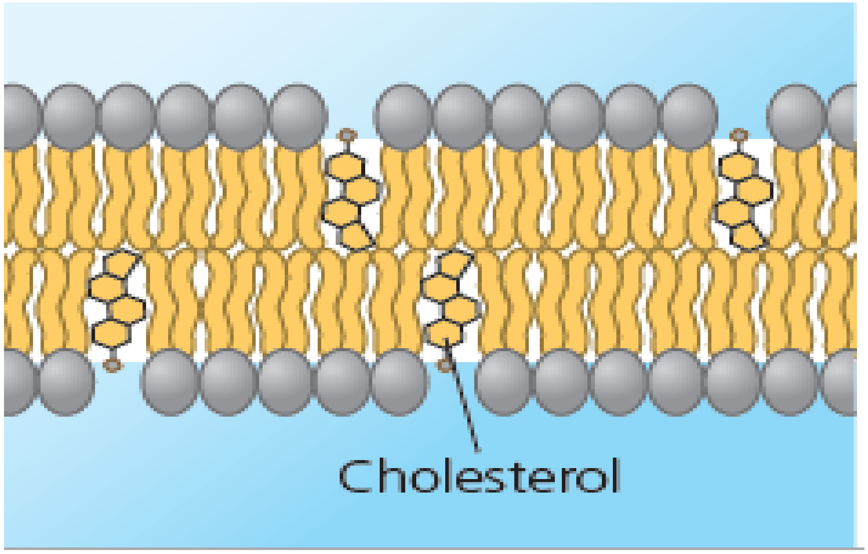


- Example: Fishes that live in extreme cold have membranes with a high proportion of unsaturated hydrocarbon tails, enabling their membranes to remain fluid.

The role of cholesterol in membrane fluidity

- Cholesterol, which is wedged between phospholipid molecules in the plasma membranes of animal cells, affects membrane fluidity at different temperatures but in a different way.
- At 37°C, cholesterol makes the membrane less fluid by restraining phospholipid movement.
- Cholesterol hinders the close packing of phospholipids; it lowers the temperature required for the membrane to solidify.

- Cholesterol can be thought of as a "fluidity buffer" for the membrane, resisting changes in membrane fluidity caused by changes in temperature.



Fluid-Mosaic Model

- Ability to change the lipid composition of cell membranes in response to changing temperatures has evolved in organisms that live where temperatures vary.

Examples:

- Plants (winter wheat) that tolerate extreme cold, the percentage of unsaturated phospholipids increases in autumn, an adjustment that keeps the membranes from solidifying during winter.
- Bacteria that live in hot springs with extremely high temperatures (<90° C) can change the proportion of unsaturated phospholipids in their cell membranes, depending on the temperature they are growing.

Carbohydrate chains in cell membrane

- Occur outside of cell surface (Extracellular side).
- Membrane carbohydrates are usually short and branched chains.
- Membrane carbohydrate chain can vary by:

A. Number of sugars (15 sugar units to several hundred).

B. Sequence of sugars.

C. The chain is branched or unbranched.

Types of carbohydrate chain:

- **Glycolipids: Carbohydrates covalently bond to lipids.**
- **Glycoproteins: Carbohydrates covalently bond to proteins.**

Membrane carbohydrates vary:

- **From species to species of animal.**
- **Among individuals of the same species.**
- **From one cell type to another in a single individual.**

The diversity of the molecules and their location on the cell's surface enable membrane carbohydrates to function as markers that help cell – cell recognition by distinguishing one cell from another.

Example: human blood cell, type A, B, AB & O.

Cell surfaces in animals

Animal cell surface has two types of features:

(1) Extracellular matrix (ECM) outside cells.

(2) Junctions between some types of cells.

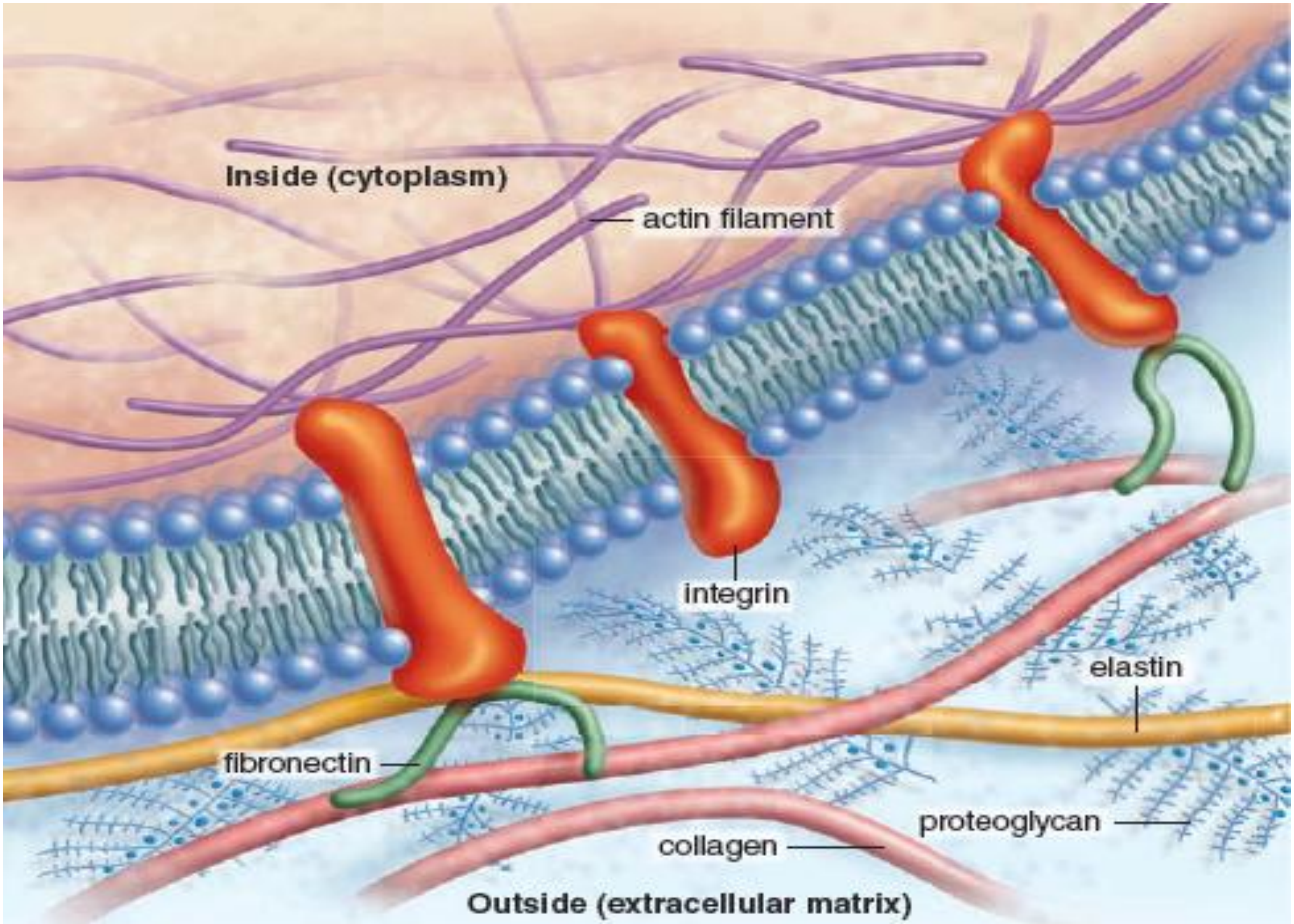
- **Both can connect to the cytoskeleton and contribute to communication between cells and, therefore, tissue formation.**

Extracellular matrix (ECM)

- **Only animal cells have an extracellular matrix containing various protein fibres and also very large and complex carbohydrate molecules.**
- **ECM has various functions, from lending support to the plasma membrane to assisting communication between cells.**

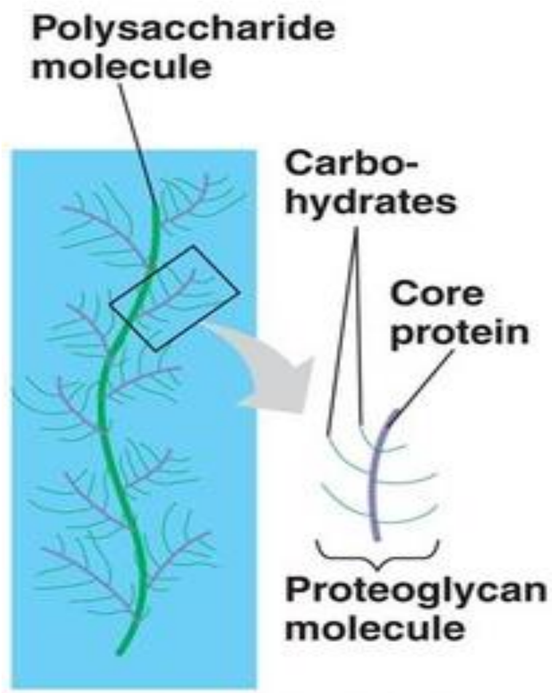
Types of protein fibres in Extracellular matrix (ECM)

- **Collagen**
- **Proteoglycan**
- **Elastin**
- **Fibronectin**



Structure of Extracellular matrix

- ECM is a meshwork of glycoproteins (proteins with covalently bonded carbohydrates, usually short chains of sugars).
- Collagen: The most abundant glycoprotein in the ECM of most animal cells (40% of total protein in human body), which forms strong fibres outside the cells and resists stretching.
- Collagen fibres are embedded in a network woven out of proteoglycan complex.
- Proteoglycan complex: multiple polysaccharide chains (up to 95%) that covalently attach to a small protein] that looks like a bottle brush and resists compression of the ECM.
- Elastin fibre is another protein type that gives ECM elasticity.
- Fibronectin protein fibres (works as adhesive protein).



Proteoglycan complex

- Fibronectin fibre in ECM (outside cell) binds collagen fibre to integrin protein (composed of integral protein embedded in the cell membrane).
- Integrins attached to the actin fibre (type of microfilament) of cytoskeleton (inside the cell cytoplasm)
- By connecting integrin with both the ECM and the cytoskeleton, it plays a role in cell signaling, permitting the ECM to influence the activities of the cytoskeleton and, therefore, the shape and activities of the cell.

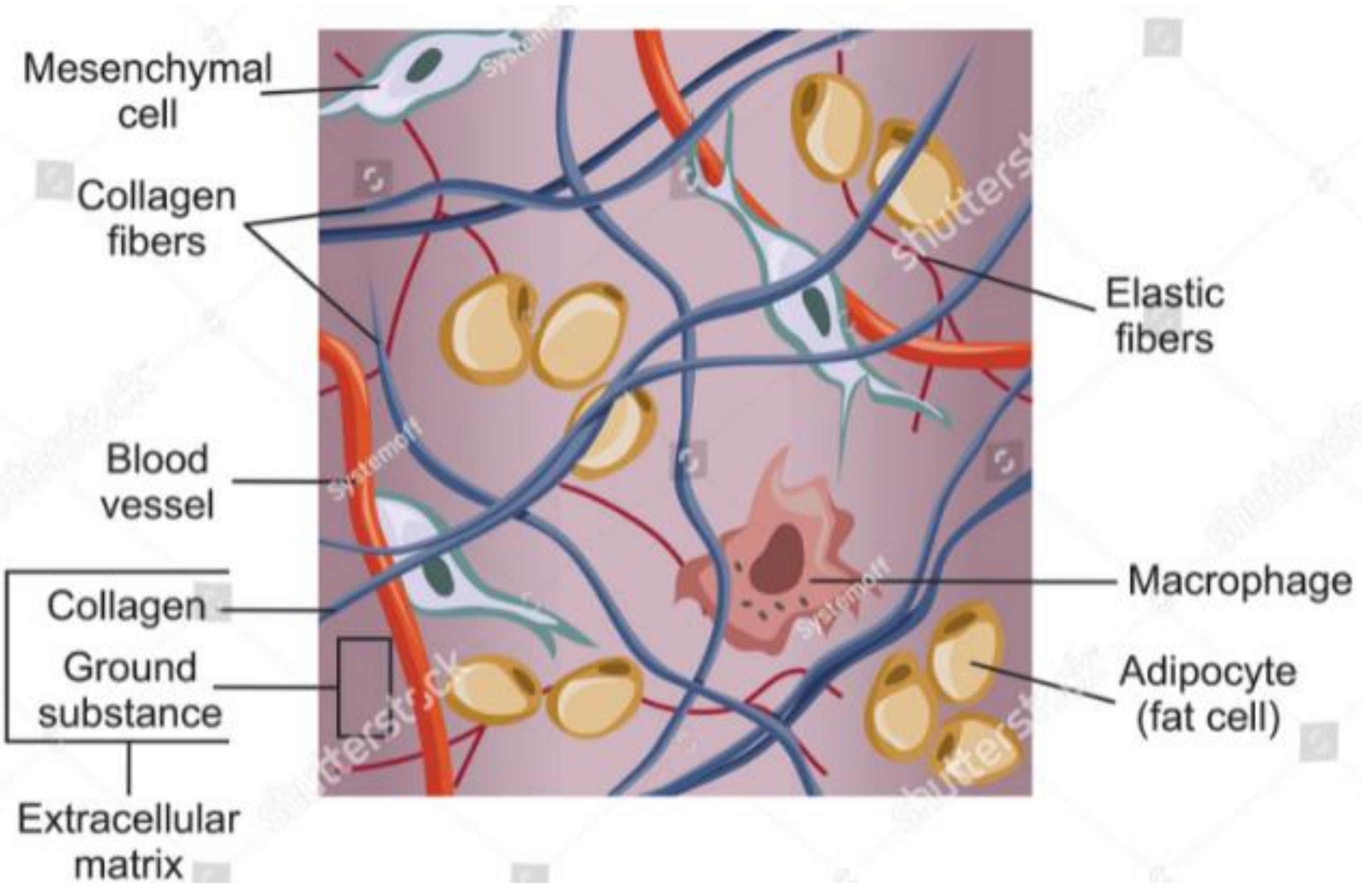
Quantity and consistency of Extracellular matrix

D. Extracellular matrix varies in quantity and consistency.

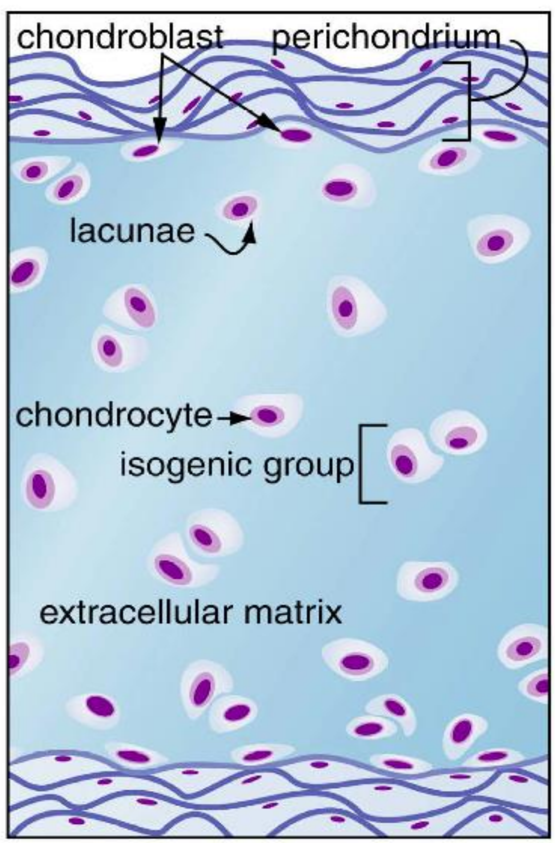
It can be:

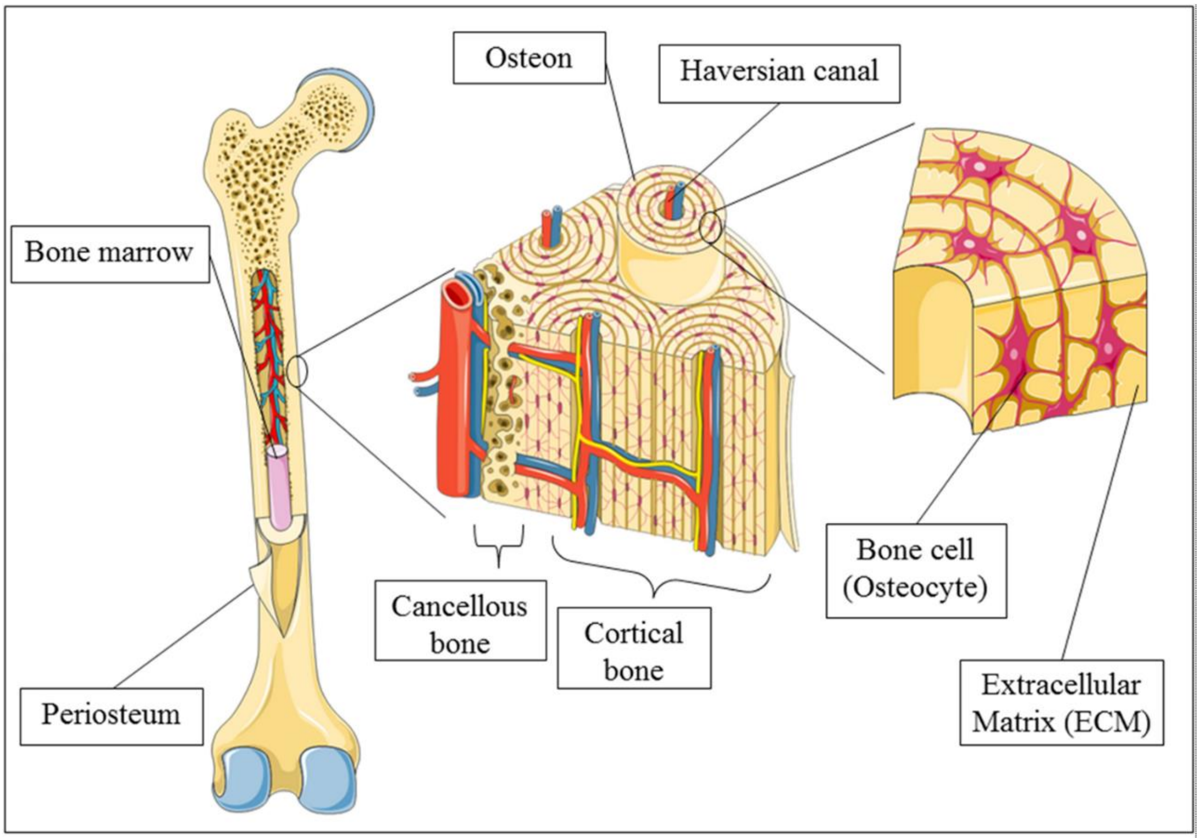
- Quite flexible, as in loose connective tissue.
- Semi-flexible, as in cartilage.
- Rock-solid, as in bone.

- The extracellular matrix of bone is hard because, in addition to the components mentioned, mineral salts (calcium salts) are deposited outside the cell.



Hyaline Cartilage

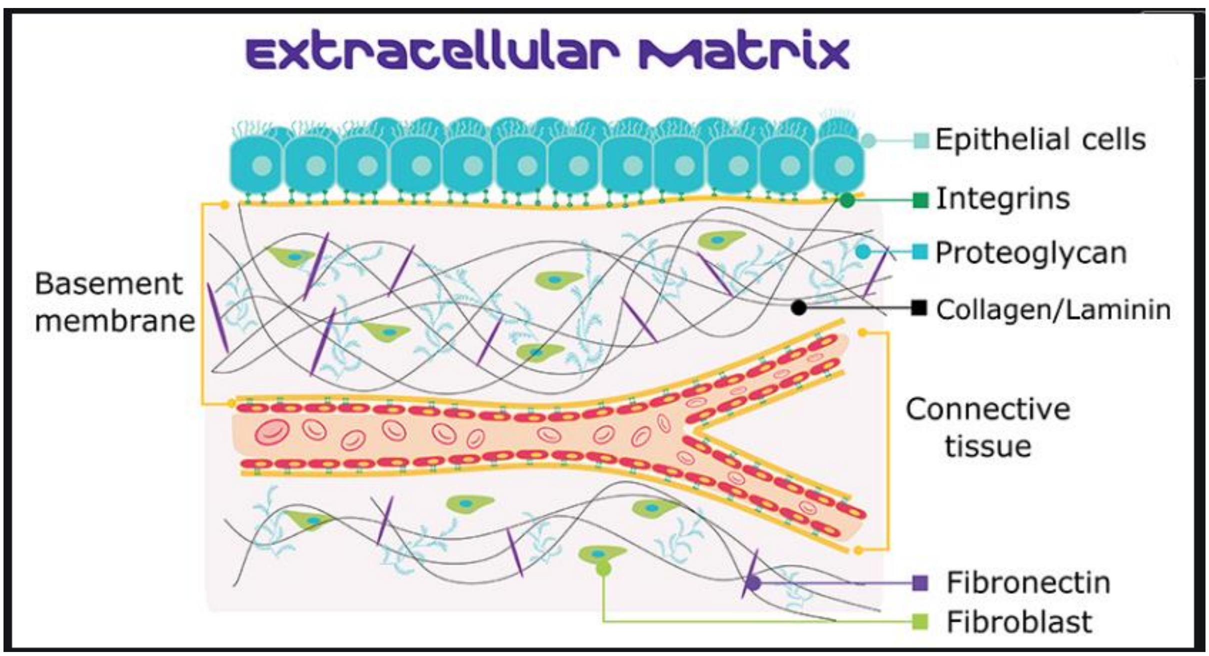




- **The proportion of cells to ECM varies.**

Example:

- **In the small intestine, epithelial cells constitute the majority of the tissue, and the ECM is a thin sheet beneath the cells (basement membrane).**
- **In bone, the ECM makes up most of the tissue, with comparatively fewer cells.**

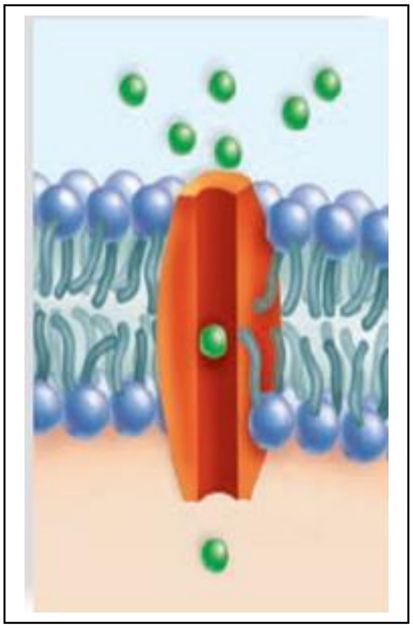


Functions of the plasma membrane proteins

- Plasma membrane of the cell and membrane of organelles contains various proteins.
- The proteins of a single-cell membrane might have different functions.
- The membrane is not only a structural mosaic but also a functional mosaic.

Types of plasma membrane proteins

Channel proteins:

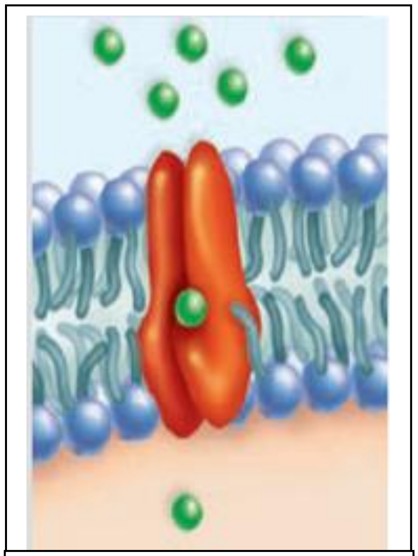


- Involved in the passage of molecules through the membrane.
- They have a channel that allows a substance to simply move across the membrane.

Example:

A channel protein allows hydrogen ions to flow across the inner mitochondrial membrane. Without this movement of hydrogen ions, ATP would never be produced.

Carrier proteins:

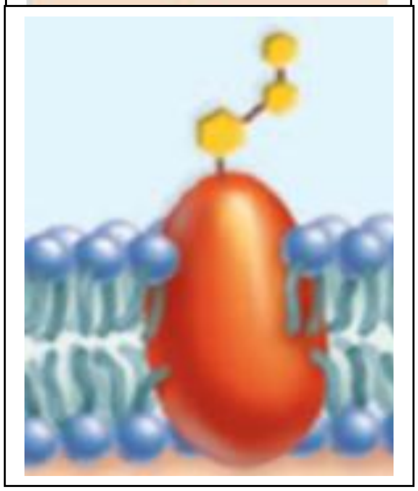


- It is also involved in the passage of molecules through the membrane.
- They combine with a substance and help it move across the membrane.

Example:

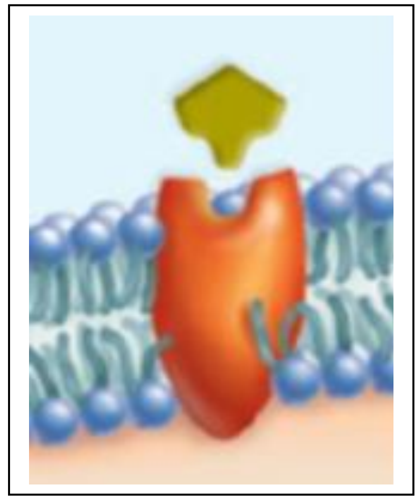
A carrier protein transports sodium and potassium ions across the plasma membrane of a nerve cell. Without this carrier protein, nerve conduction would be impossible.

Cell recognition proteins:



- Are glycoproteins. Among other functions, these proteins help the body recognize when it is being invaded by pathogens so that an immune response can occur.

- Without this recognition, pathogens would be able to freely invade the body.

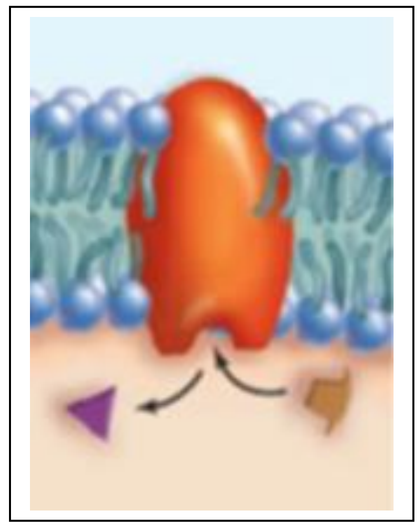


Receptor proteins:

- They have a shape that allows a specific molecule to bind to it.
- The binding of this molecule causes the protein to change its shape and thereby bring about a cellular response.
- The coordination of the body's organs is totally dependent on such signaling molecules.

Example:

The liver stores glucose after it is signaled to do so by insulin.

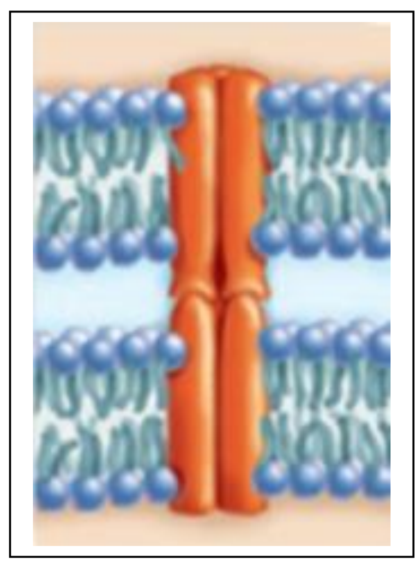


Enzymatic proteins:

- Some plasma membrane proteins are enzymatic proteins that carry out metabolic reactions directly. Without the presence of enzymes, some of which are attached to the various membranes of the cell, a cell would never be able to perform the metabolic reactions necessary for its proper function.

Junction proteins:

- Proteins are involved in forming various types of junctions between animal cells.
- Signalling molecules that pass-through gap junctions allow the cilia of cells that line your respiratory tract to beat in unison.



Definitions

Selective permeability: is controlling traffic into and out of the cell through plasma membrane, thus allowing some substances to cross it more easily than others; therefore, its function is to protect the integrity of the interior of the cell.

Phospholipids: The most abundant lipids in most membranes, which are arranged as bilayers. It has both hydrophilic head areas and hydrophobic tail areas.

Integral proteins: The embedded proteins in plasma membrane that mostly protrude from both surfaces of bilayer cell membrane.

Peripheral protein: A loosely protein that is bound only on the surface of cytoplasmic side of the plasma membrane.

Fluid mosaic model: The currently accepted model which describes the arrangement of molecules in the plasma membrane structure. It defines the membrane as a mosaic of protein molecules drifting laterally in a fluid bilayer of phospholipids.

Membrane Carbohydrate chains: Carbohydrate groups present in the extracellular side of plasma membrane. It helps cell – cell recognition.

Extracellular matrix: A substance which present only in the outer side of animal cells. It contains various protein fibers and also very large and complex carbohydrate molecules. It has various functions, from lending support to the plasma membrane to assisting communication between cells.

Collagen: The most abundant glycoprotein in the extracellular matrix of most animal cells, which forms strong fibers outside the cells and resists stretching.

Proteoglycan complex: A large molecule consisting of a network collagen protein fiber with many carbohydrate chains attached, found in the extracellular matrix of animal cells. It looks like a bottle brush. This fiber resists compression.

Fibronectin: An extracellular glycoprotein secreted by animal cells. It is an adhesive and helps them attach to the extracellular matrix.

Channel proteins: are type of proteins involved in the passage of molecules through the plasma membrane. They have a channel that allows a substance such as hydrogen ions to simply move across the membrane.

Carrier proteins: are types of proteins involved in the passage of molecules through the plasma membrane. They combine with a substance such as sodium and potassium ions and help it move across the membrane.

Cell recognition proteins: are glycoproteins in the plasma membrane and help the body recognise when it is being invaded by pathogens so that an immune response can occur.

Receptor proteins: are types of proteins present in the plasma membrane and have a shape that allows a specific molecule to bind to it. The binding of this molecule causes the protein to change its shape and thereby bring about a cellular response.

Enzymatic proteins: are types of proteins carry out metabolic reactions directly in the plasma membrane.

Junction proteins: are type of proteins in plasma membrane which involved in forming various types of junctions between animal cells.