Al-Mustaqbal University

College of Engineering and Technologies

Biomedical Engineering Department

Biology

Lecture: 2

The Cell and Cell Membrane Functions

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The Cell

Cells are the structural and functional unit of the living organisms, from the **unicellular** organism like **amoeba**, which are made of one cell to the **multicellular** organisms, such as **human**, whom there body made up of 50-100 trillion cells.

The cell has been known in the **6th century** by **Robert Hook** with discovery of light microscope.

Cell Theory

The principles of cell theory includes:

1. All living organisms are composed of one or more cells.
2. Cells are the basic units of structure and function in an organism.
3. Cells come only from the replication of existing cells.

Cellular diversity

Cells are found in different organisms, and are very diverse in their size, shape and their internal structure and this also applies to cells found in the same organism. This diversity is influenced by their roles and function within organism's body.

Cell Shape

Cells have different shapes due to appropriate function. It is possible to find other cells which are flat, most of these cells are body cells and their function is protecting and covering body surface. Nerve cells have long extensions. Skin cells have a shape which is flat. Egg cells have shape

which is like sphere, and some bacteria are rod in shape. Some plant cells are rectangular.

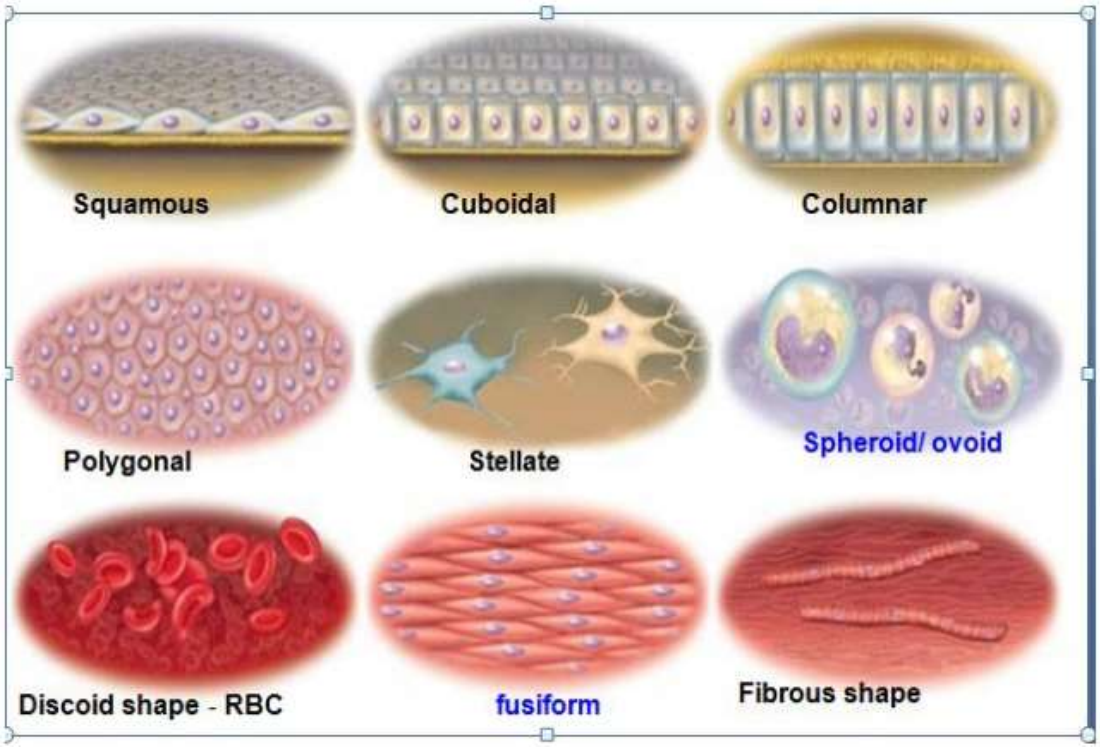

Figure 1. Various types of animal cells (shape)

Cell Size

Some cell can be seen without using magnification instruments as they are enough to be seen by the naked eye.

Example, egg of birds/reptiles and a neuron cell of giraffe, which is 2 meters in length.

Structure of Cell

A typical cell under the light microscope show three distinct parts:

1. Plasma/cell membrane.
2. Cytoplasm.
3. Nucleus.

1. Plasma/cell membrane

The plasma membrane is extremely thin layer of **lipids** and **proteins** forming outermost boundary of living cell and enclosing the intracellular fluid **(ICF)**.

It serves as:

1. Mechanical barrier that traps needed molecules within the cell.

2. Plasma membrane plays an active role in determining the composition of cell by **selective permeability** of substances to pass between the cell and its extracellular fluid (**ECF**) environment.

The Structure of Plasma Membrane

The plasma membrane is a fluid lipid bilayer embedded with proteins. It appears as **''trilaminar''** layer structure having two dark layers separated by a light middle layer as a result of specific arrangement of the constituent molecules.

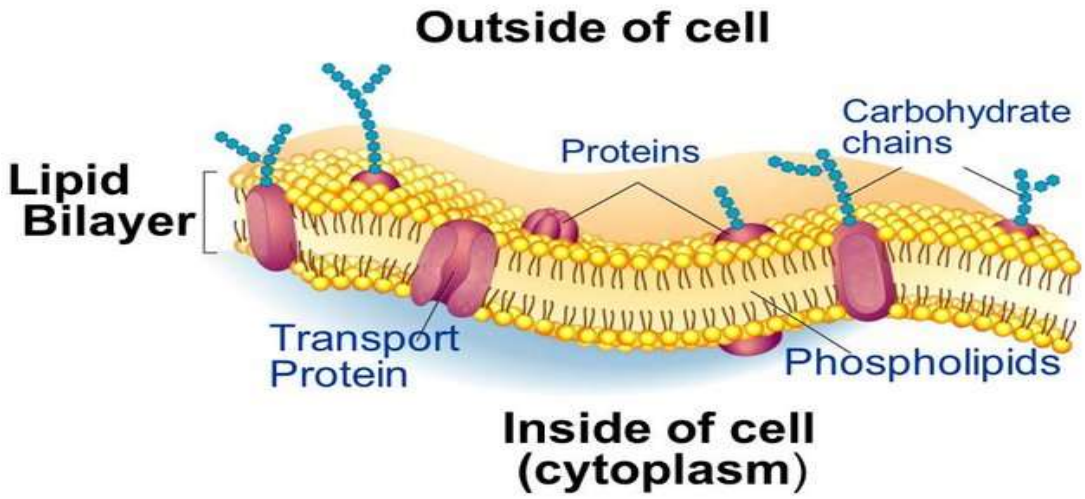

Figure 2. Structure of plasma membrane.

All plasma membrane are made up of **lipids** and **proteins** plus small amount of **carbohydrates**.

1. Lipids

- **Phospholipids:** are the most abundant.

Phospholipids have a polar head having a negatively charged phosphate group and two non-polar fatty acid tails. The polar end is **hydrophilic** (water loving) because it can interact with water molecule, which is also polar; the non-polar end is **hydrophobic** (water fearing) and will not mix with water. The outer surface of the layer is exposed to (ECF), whereas the inner layer is in contact with the intracellular fluid (ICF). The lipid is fluid in nature like liquid cooking oil.

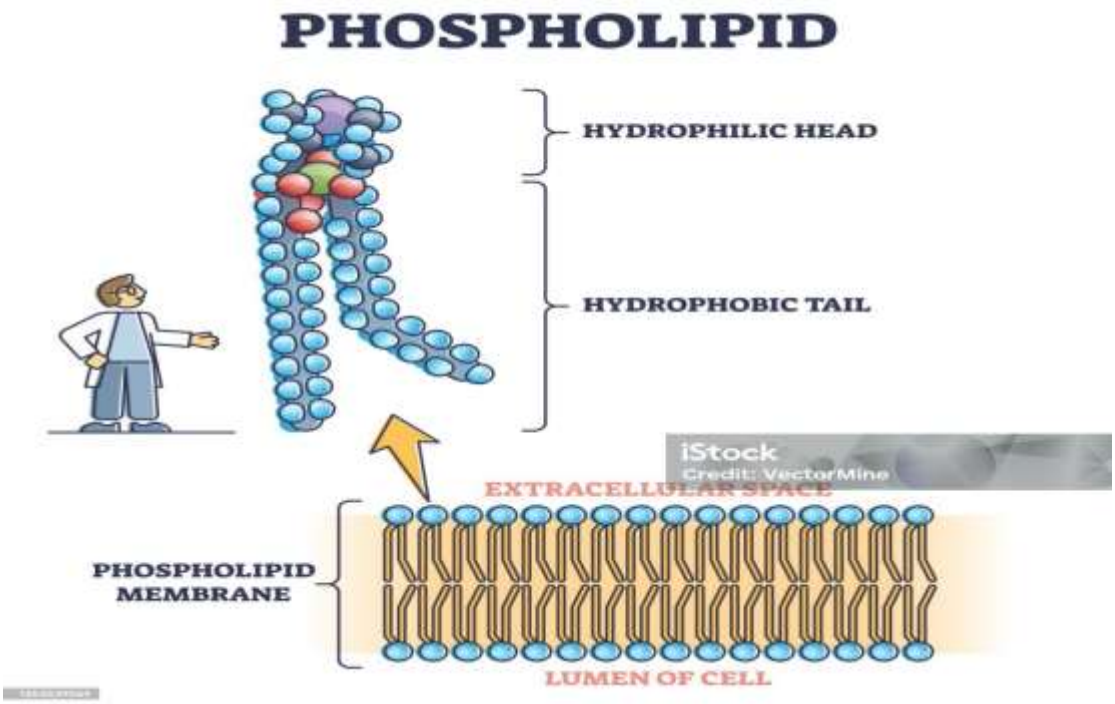

Figure 3. Phospholipids components.

- **Cholesterol:** present in a lesser amount.

Cholesterol provides to the **fluidity** as well as the **stability**; cholesterol lies in between the phosphate molecules, preventing the fatty acid chain from packing together and crystallizing that could decrease fluidity of the

membrane. Cholesterol also exerts a regulatory role on some of the membrane proteins. For fluidity of the membrane, it gives flexibility to the cell to change its shape; transport process are also dependent on the fluidity of the lipid bilayer.

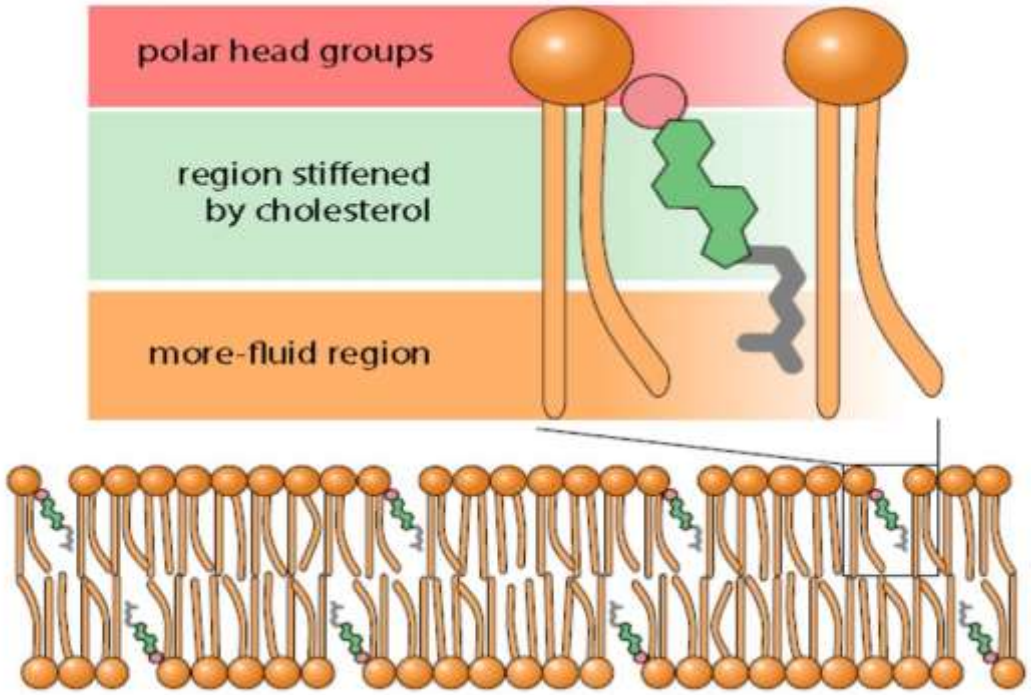

Figure 4. Cholesterol position within plasma membrane.

2. Proteins

The membrane proteins are either **attached** to or **inserted** within the lipid bilayer; some extending through the entire membrane thickness; they have **polar region** at both ends joined by a **non-polar central portion**. Other proteins are on either the outside or inner surface. On account of membrane fluidity, many proteins float freely, although the mobility of protein that have special function in a particular area of the membrane is restricted - this gives ever changing **mosaic pattern** of the protein embedded in the lipid layer.

3. Carbohydrates

Only the outer surface of the plasma membrane contains a small amount of carbohydrate. Short-chain carbohydrates are bound primarily to membrane proteins and to a lesser extent to lipids, forming **glycoproteins** and **glycolipids**.

The plasma membrane is actually **asymmetrical**; the two surfaces are not the same; carbohydrate is only on the outer surface; different amount of different proteins are on the outer and inner surfaces and even the lipid structures of the outer and inner half is not the same.

Lipid bilayer: forms the basic structure of the membrane, is a barrier to passage of water soluble substances between the ICF and ECF; and is responsible for the fluidity of the membrane.

Membrane proteins: are variety of different proteins within the plasma membrane; have the following special functions:

1. Some form water-filled passage ways or channels, across the lipid bilayer; such channels allow ions to pass through without coming in direct contact with lipid interior. The channels are highly selective; they can selectively attract or repel particular ions. Number and kind of channels vary in cells. Channels open and close in response to a controlling mechanism.

2. Other proteins serve as carrier molecule that transport specific molecule that cannot cross on their own. They differ in cells, e.g., thyroid epithelial cell possesses carriers for iodine.

3. Many proteins on the outer surface serve as "receptor sites" that recognize and bind with specific molecules in the cell environment.

4. Another group of proteins act as membrane-bound enzymes that control specific chemical reactions on either side of the plasma membrane e.g., outer layer of the plasma membrane of skeletal muscle contains enzyme ACh-esterase that destroys the chemical messenger that triggers contraction.

5. Some proteins are arranged as filaments network/meshwork on the inner side and are secured to certain internal protein elements of the cytoskeleton. They maintain cell shape.

6. Other proteins function as cell adhesion molecules (CAMs).

7. Some proteins, especially in conjunction with carbohydrate are important in the cell ability to recognize "self" and in cell-to-cell interactions.

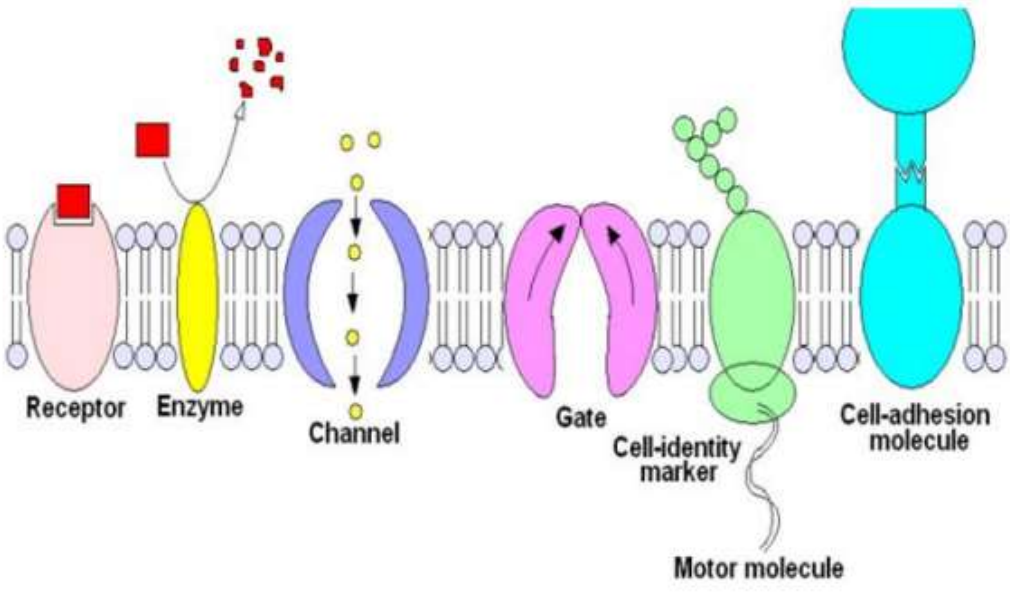

Figure 5. Membrane Proteins.

Membrane Carbohydrate: Short-chain carbohydrate on the outer membrane surface serves as self-identity marker enabling cells to identify and interact with each other in the following ways:

- Recognition of "self" and cell-to-cell interactions.
- Carbohydrate-containing surface markers are important in growth. Abnormal surface markers present in tumor cells, and abnormality may underline uncontrolled growth.
- Some CAMS have carbohydrate, on the outermost tip where they participate in cell adhesion activity.

Functions of biological membranes

The **phospholipid bilayers** provides the basic structure of the membrane and they also restrict entry and exit of polar molecules and ion. The other molecules in the membrane have a variety of function:

- **Channel protein and carrier protein:** these proteins are involved in the selective transport of polar molecule and ion across the membrane.
- **Enzymes:** membrane proteins sometimes act as enzymes, For example, the microvilli on epithelial cells lining some part of the gut contain digestive enzymes in their cell surface membrane.
- **Receptor molecules:** proteins have very specific shapes and this makes them ideal as receptor molecules for chemical signaling between cells.
  - **For example**, hormones are chemical messengers, which circulate in the blood but, only bind to specific target cells, which have the correct receptors sites. Neurotransmitters, the chemicals that enable nerve impules from one nerve cell to the next, also fit into specific receptor proteins in nerve cells.

- **Antigens:** these act as cell identity markers or "name tag". They are glycoproteins that is proteins with branching carbohydrates side chains like antennae
- **Glycolipids**: also have branching carbohydrate side chain and are involved in cell-cell recognition. They may act as a receptor sites for chemical signals.
- Energy Transfer in photosynthesis and respiration proteins take part in the energy transfer systems that exist in the membranes of chloroplast and mitochondria respectively.
- **Cholesterol:** acts like a plug, reducing even further the escape or entry of polar molecules through the membrane.

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