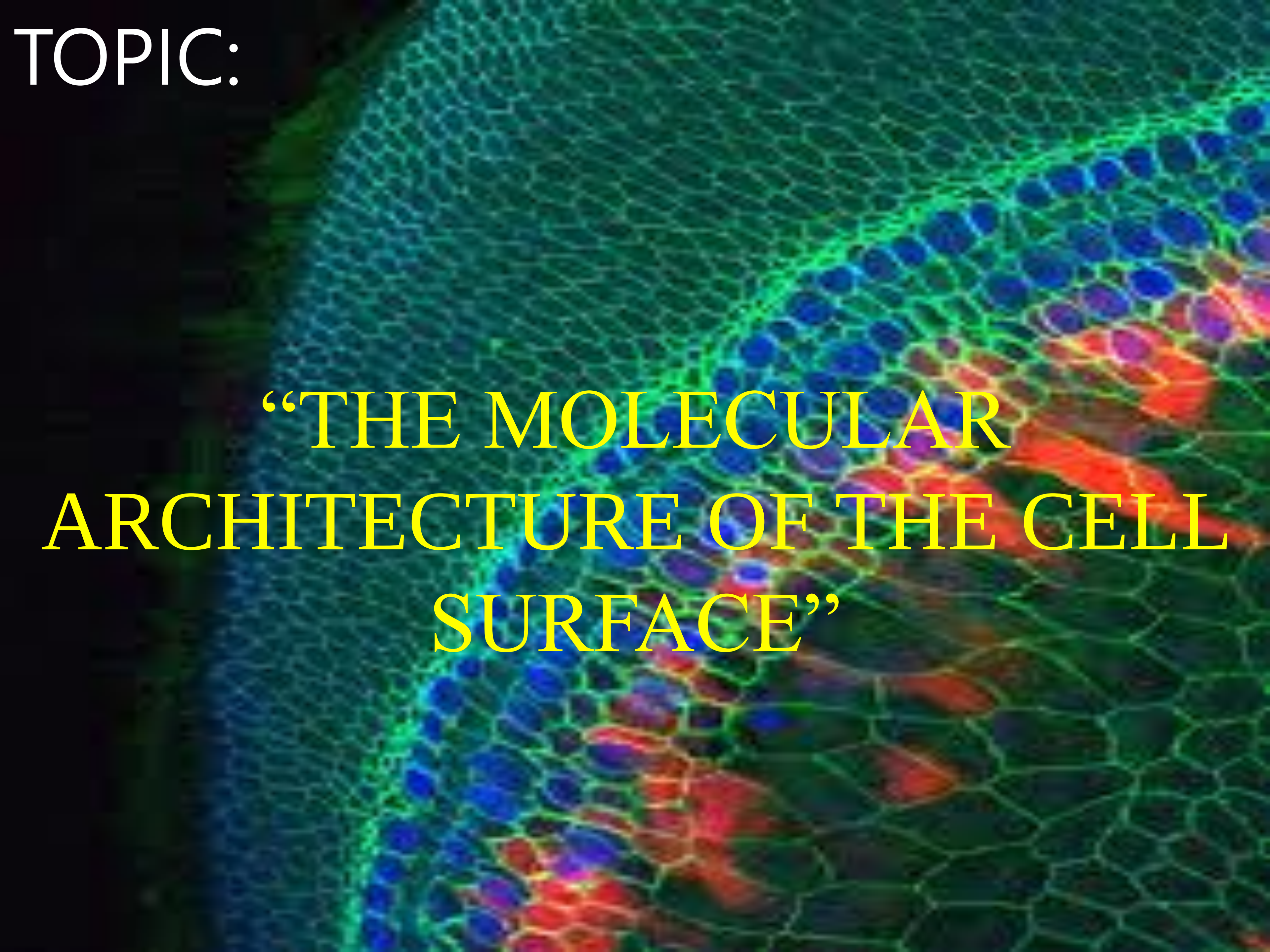
CELLULAR AND MOLECULAR BIOLOGY


COURSE WORK PRESENTATION
By: Muunda Mudenda

TOPIC:

“THE MOLECULAR ARCHITECTURE OF THE CELL SURFACE”



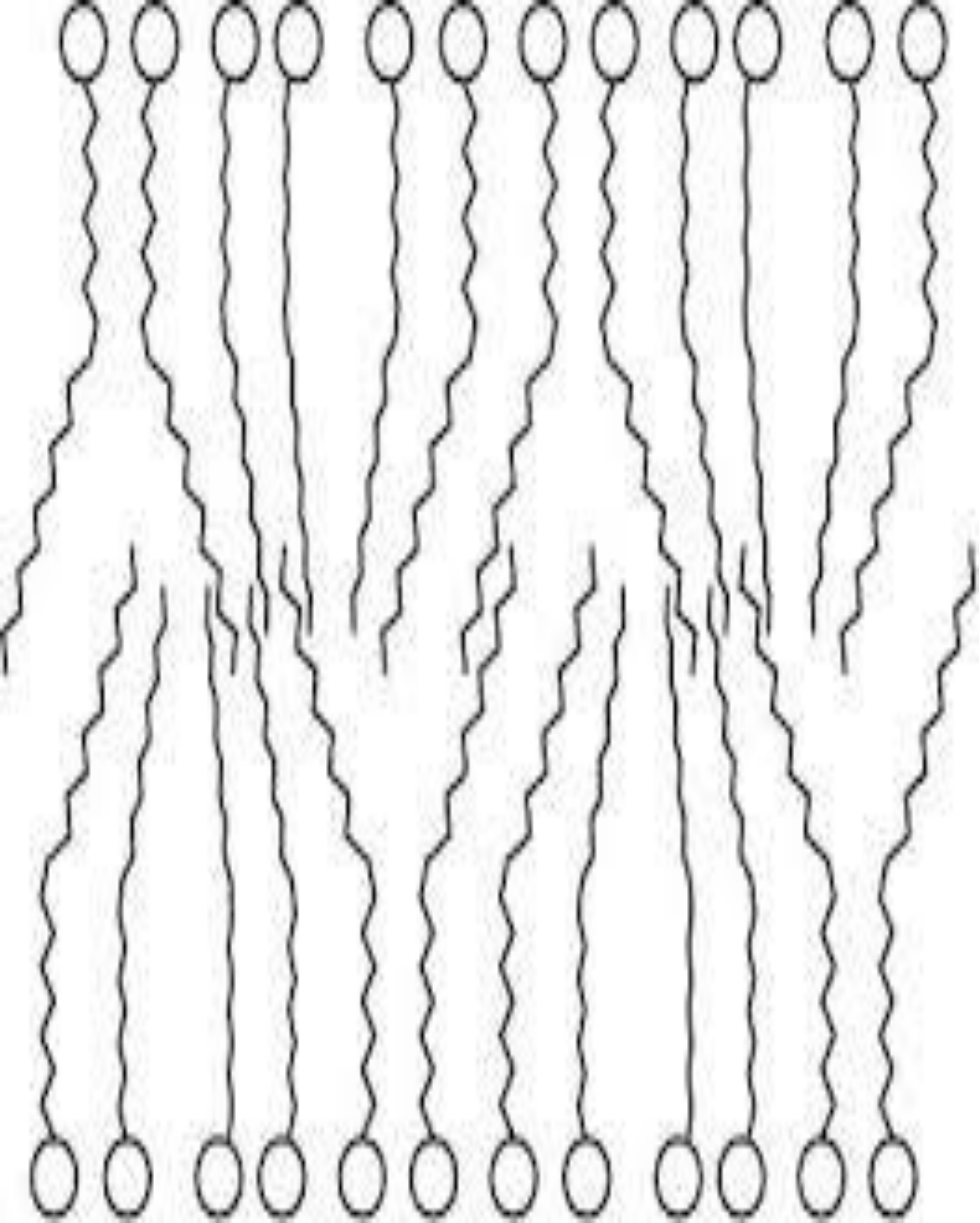
OBJECTIVES

1. EXPLAIN THE LIPID CONSTITUENTS OF THE LIPID BILAYER.
2. DISCUSS THE MEMBRANE PROTEINS IN THE PLASMA MEMBRANE.
3. DESCRIBE THE ASYMMETRY OF PLASMA MEMBRANE COMPONETS.
4. RELATE THE STRUCTURE OF PROTEINS TO THEIR FUNCTIONS.

SOMETHING TO KNOW ABOUT THE CELL MEMBRANE

1. Cell membranes are crucial to the life of the cell.
2. While all the cell components are all vital, it is going to be evident from our 10 minutes presentation that the "cell membrane" is arguably the most important.
3. Cell membranes occur in the cells of both prokaryotic and eukaryotic cells.
4. In both these types of cells they perform varied and yet very important functions.
5. The various functions of cell membranes include;

- Isolation of the cell's contents from the environment.
- Regulating exchange of essential materials, for example ions, oxygen, pyruvate etc…
- Communication with other cells through the carbohydrates on their surface.
- Creation of attachments within and between other cells and
- Regulation of biochemical reaction, for example; oxidative phosphorylation.

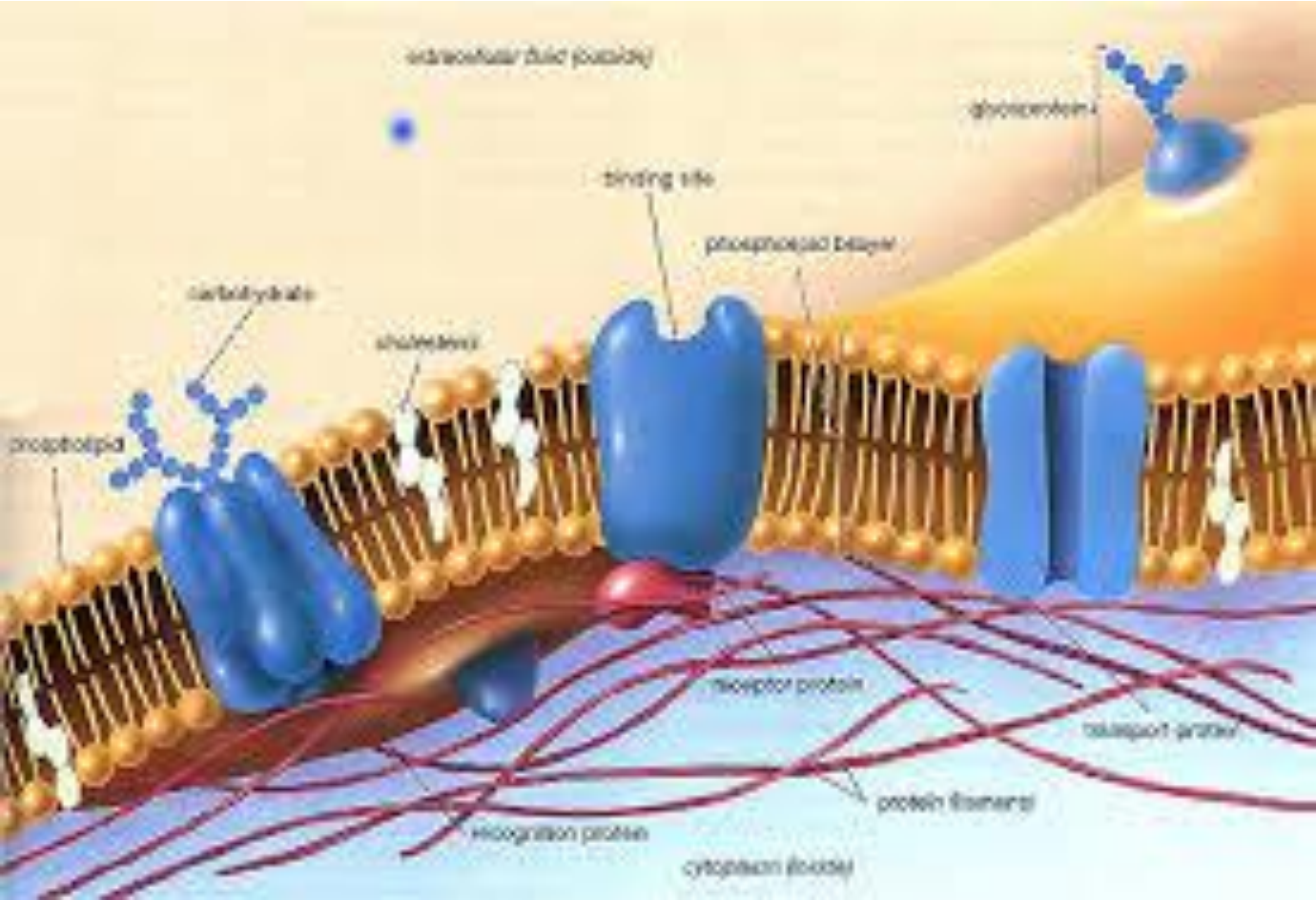


1. EXPLAIN THE LIPID CONSTITUENTS OF THE LIPID BILAYER.

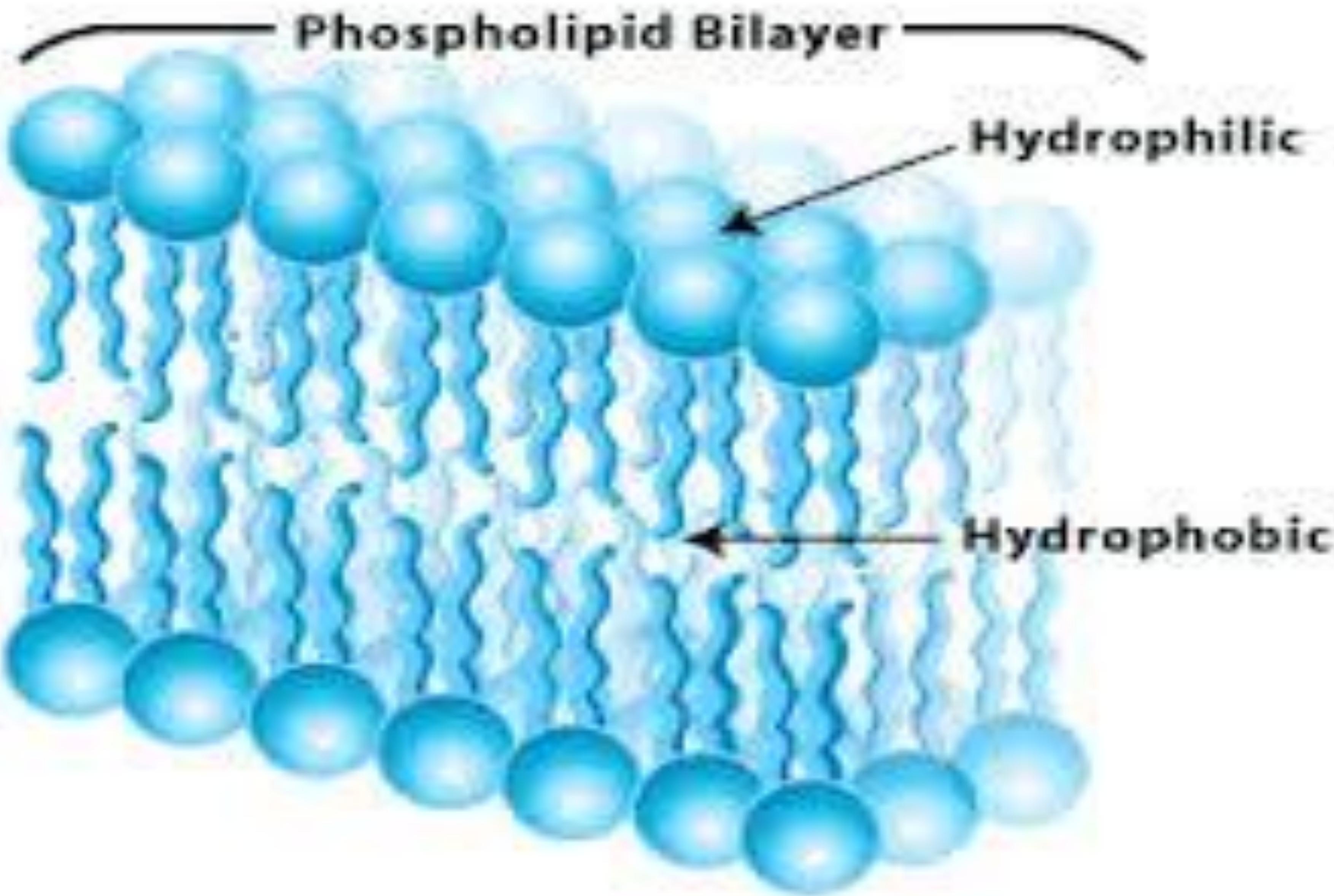
The "cell membrane" or otherwise known as the Plasma membrane is composed of "Lipid Bilayers". The basic foundation of biological membranes is a lipid bilayer, which forms spontaneously. The lipid bilayer are a composition of various components including the following;

- Phospholipids
- Proteins
- Carbohydrates
- Cholesterol

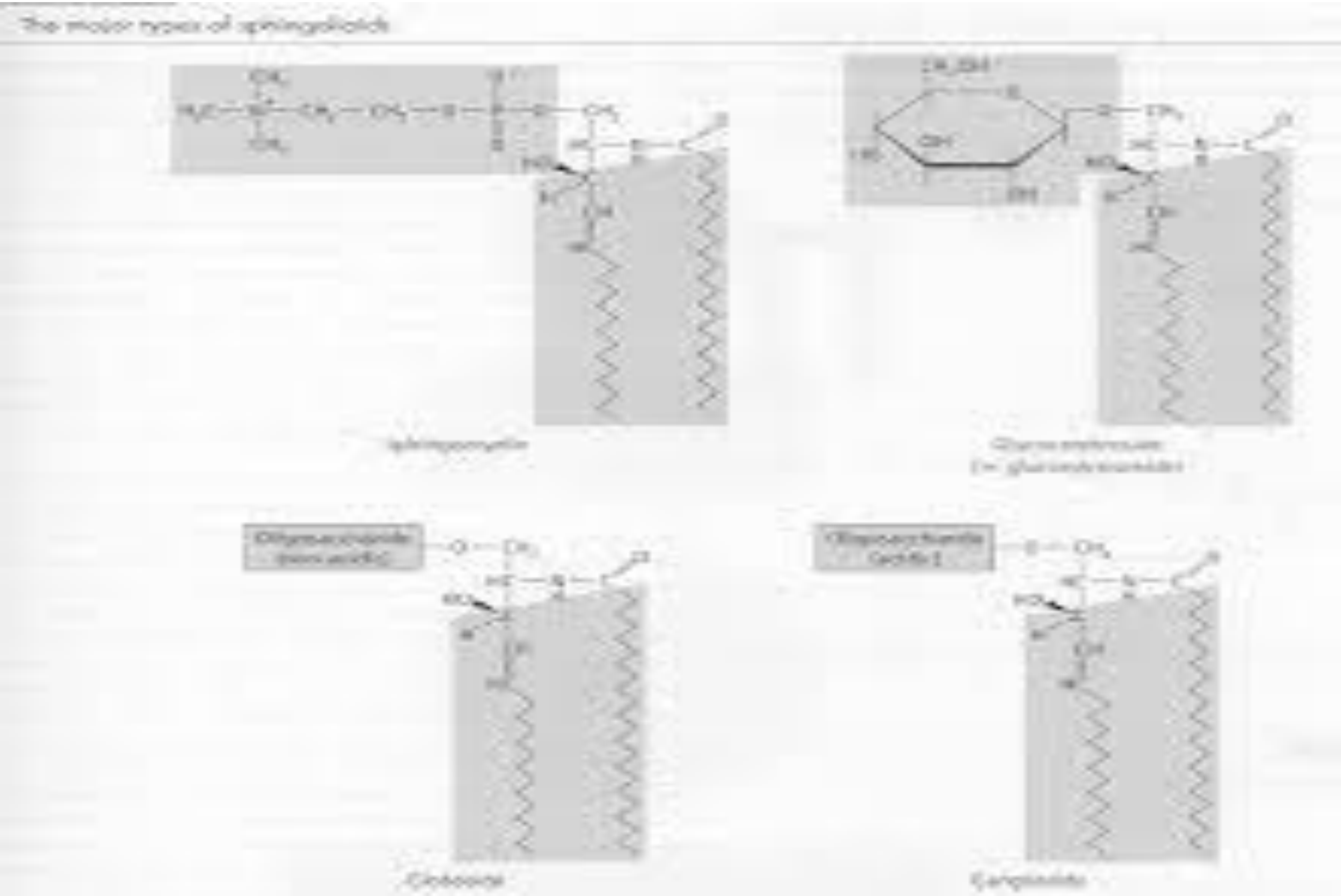
GENERAL STRUCTURE OF THE LIPID BILAYER

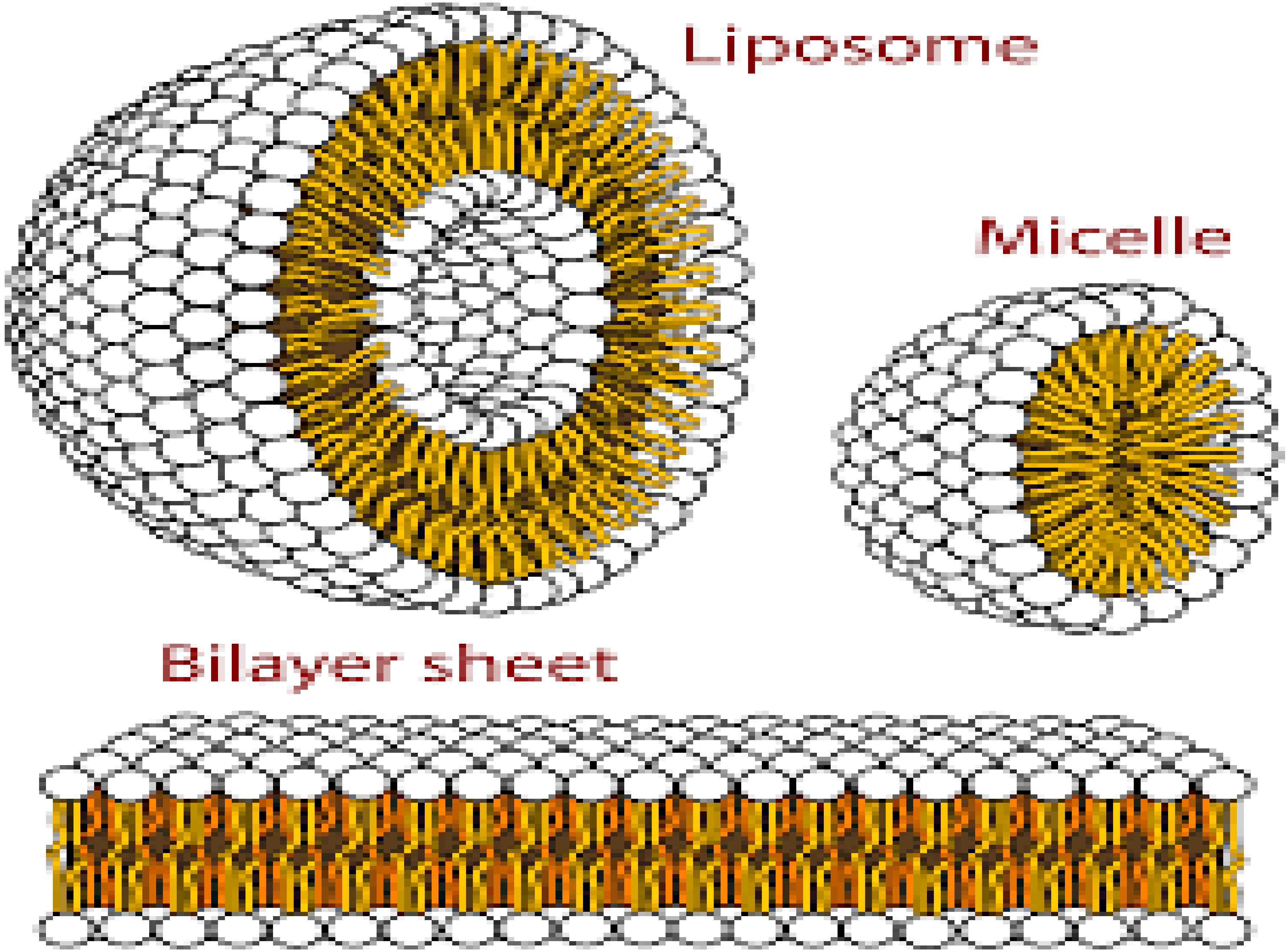


PHOSPHOLIPIDS



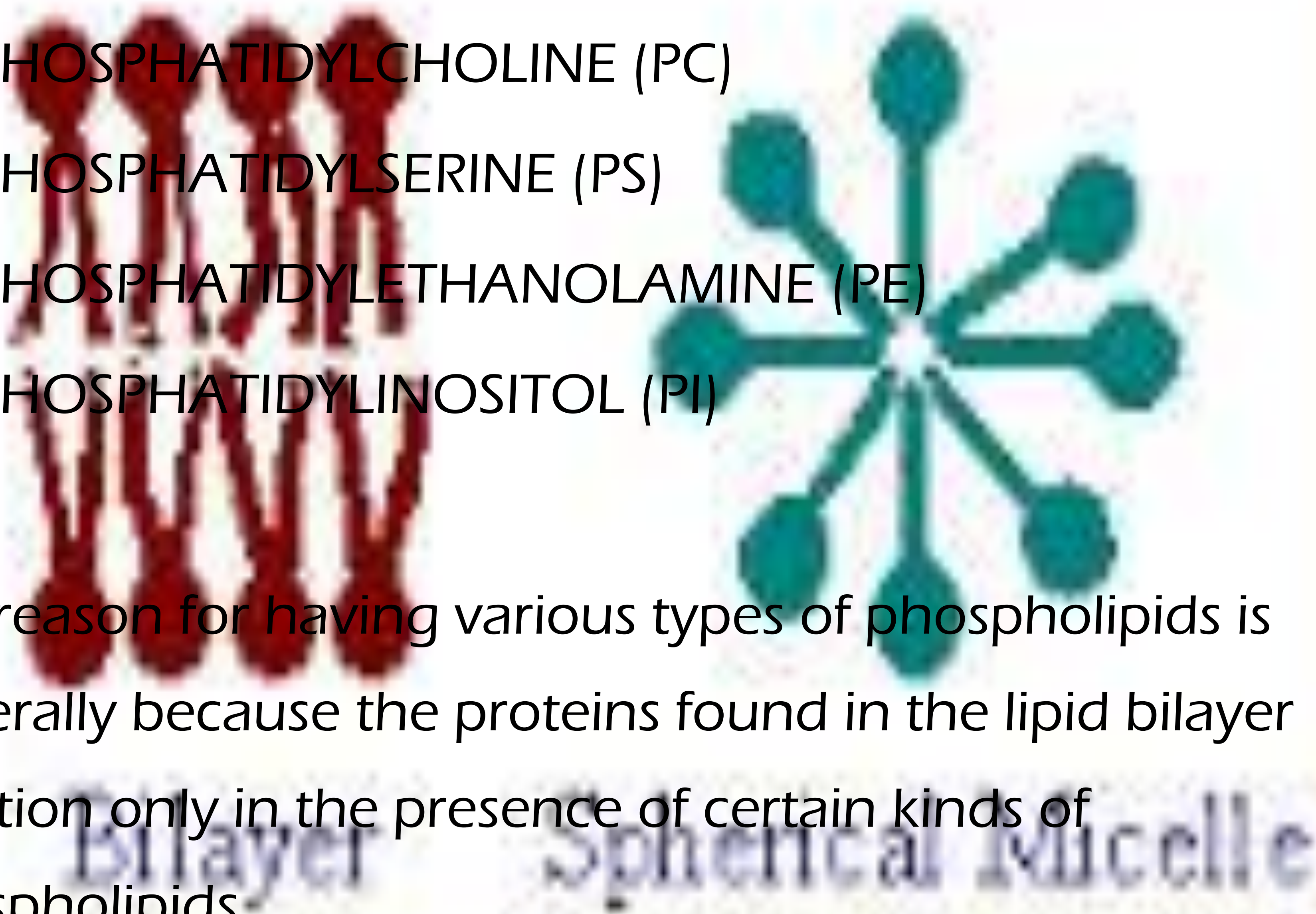
Phospholipids




Liposome
Micelle
Bilayer sheet

TYPES OF PHOSPHOLIPIDS

1. PHOSPHATIDYLCHOLINE (PC)
2. PHOSPHATIDYLSERINE (PS)
3. PHOSPHATIDYLETHANOLAMINE (PE)
4. PHOSPHATIDYLINOSITOL (PI)



The reason for having various types of phospholipids is generally because the proteins found in the lipid bilayer function only in the presence of certain kinds of phospholipids.

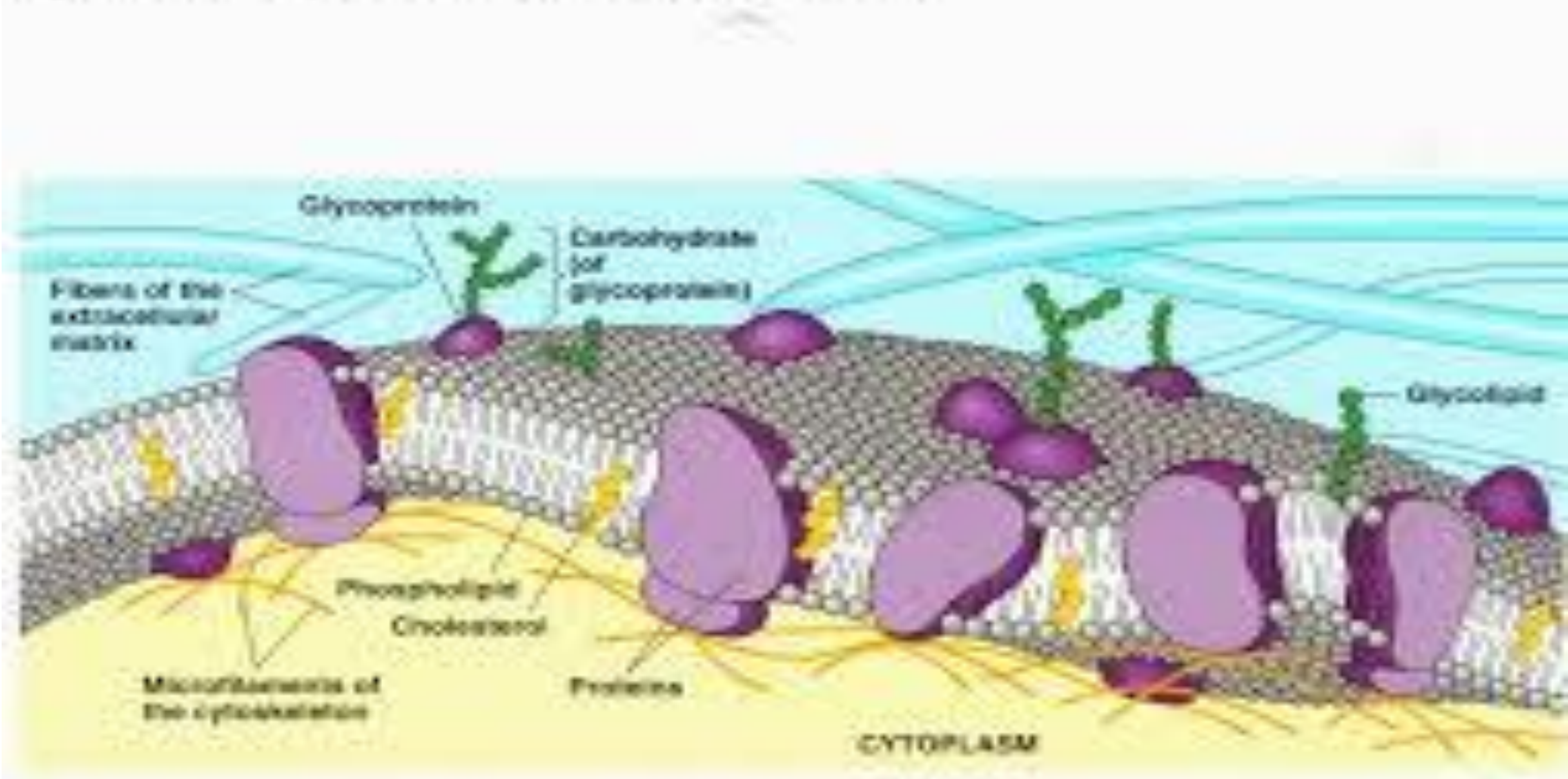
MEMBRANE PROTEINS

Although the basic structure of the biological membranes is provided by the lipid bilayer, membrane proteins perform most of the specific functions of membranes. It is proteins therefore that give each types of membrane in the cell it's characteristic functional properties.

The number of protein varies depending of the membrane. For example, the myelin protein which serves as a electrical insulation for the nerve cell axon, less than 25% of the membrane mass is protein. This is however contrary to the membranes involved in ATP production such as those of the mitochondria and chloroplast, which are approximately 75% protein.

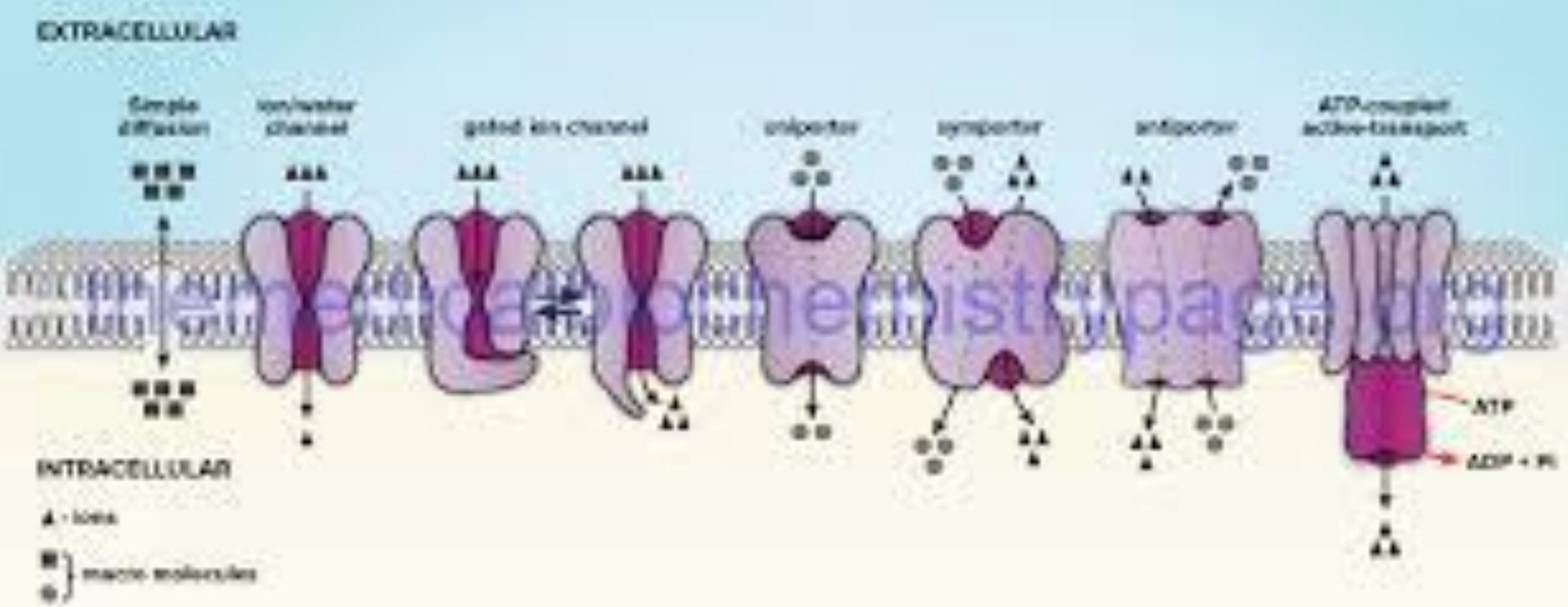
TWO FORMS OF PROTEIN MEMBRANES

Figure 5.12 The plasma membrane of an animal cell



From the above diagram

1. INTERGRAL PROTEINS (Intrinsic): These are found within the membrane and have hydrophilic regions embedded within the membrane and hydrophobic regions that project from both surfaces of the bilayer. Many integral proteins are glycoproteins which have an attached carbohydrate chain. Synthesis of integral proteins occurs in the Rough Endoplasmic Reticulum and many of them wind up as glycoproteins by the process of glycosylation in the Golgi Apparatus.
2. PERIPHARAL PROTEINS (Extrinsic): These do not penetrate the phospholipid bilayer. They are located on both sides the extracellular and intracellular sides of the membranes and link membrane to non-membrane structures. These proteins are characterized by the following criteria; (i). they require only mild treatments to dissociate them molecularly intact from membranes. (ii). They dissociate free from membranes and of lipids and (iii). In dissociated from they are relatively soluble in neutral aqueous buffers. Synthesis of peripheral proteins is cytoplasmic and also extracellular.



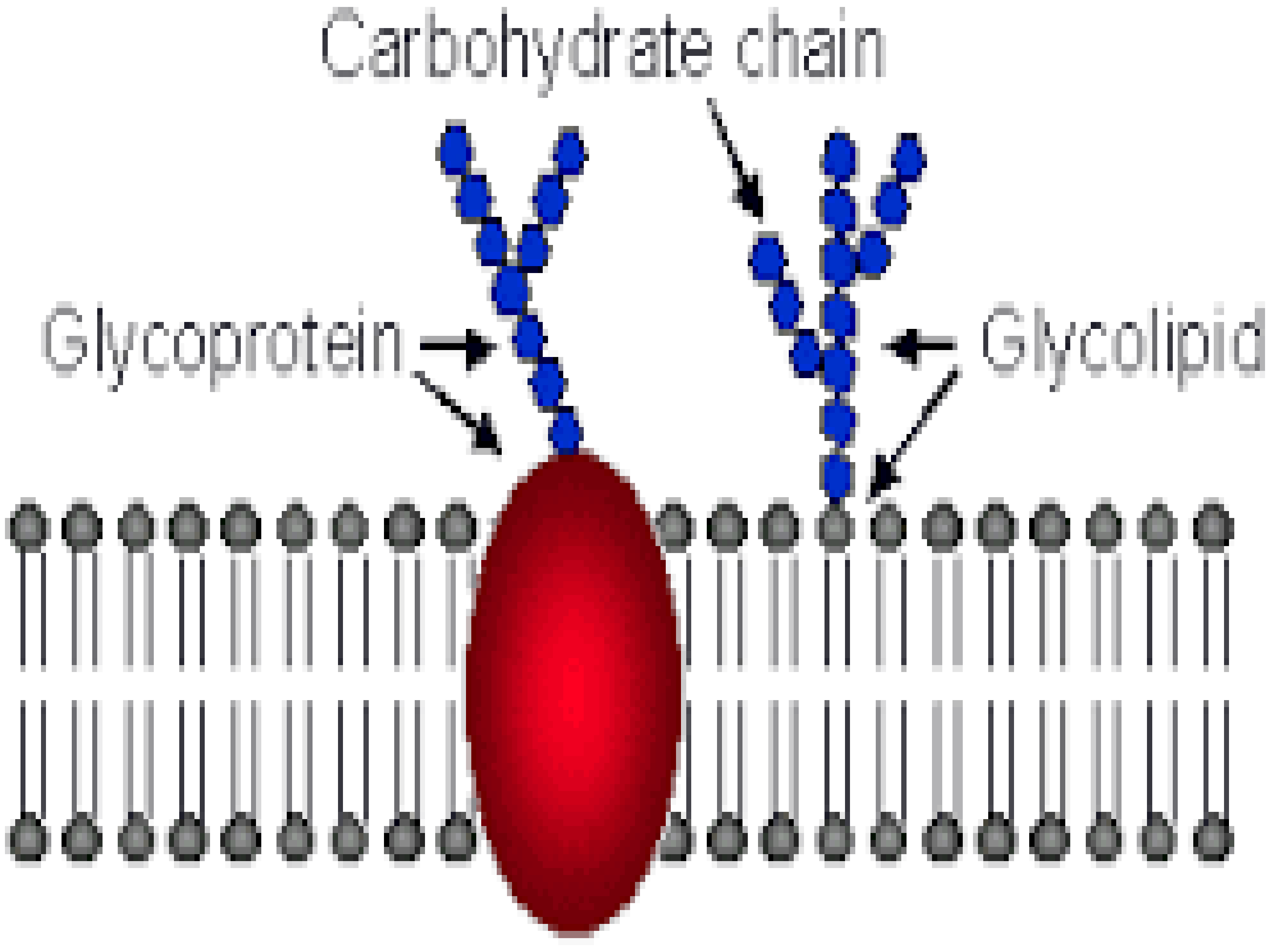
VARIOUS FUNCTIONS OF PROTEINS

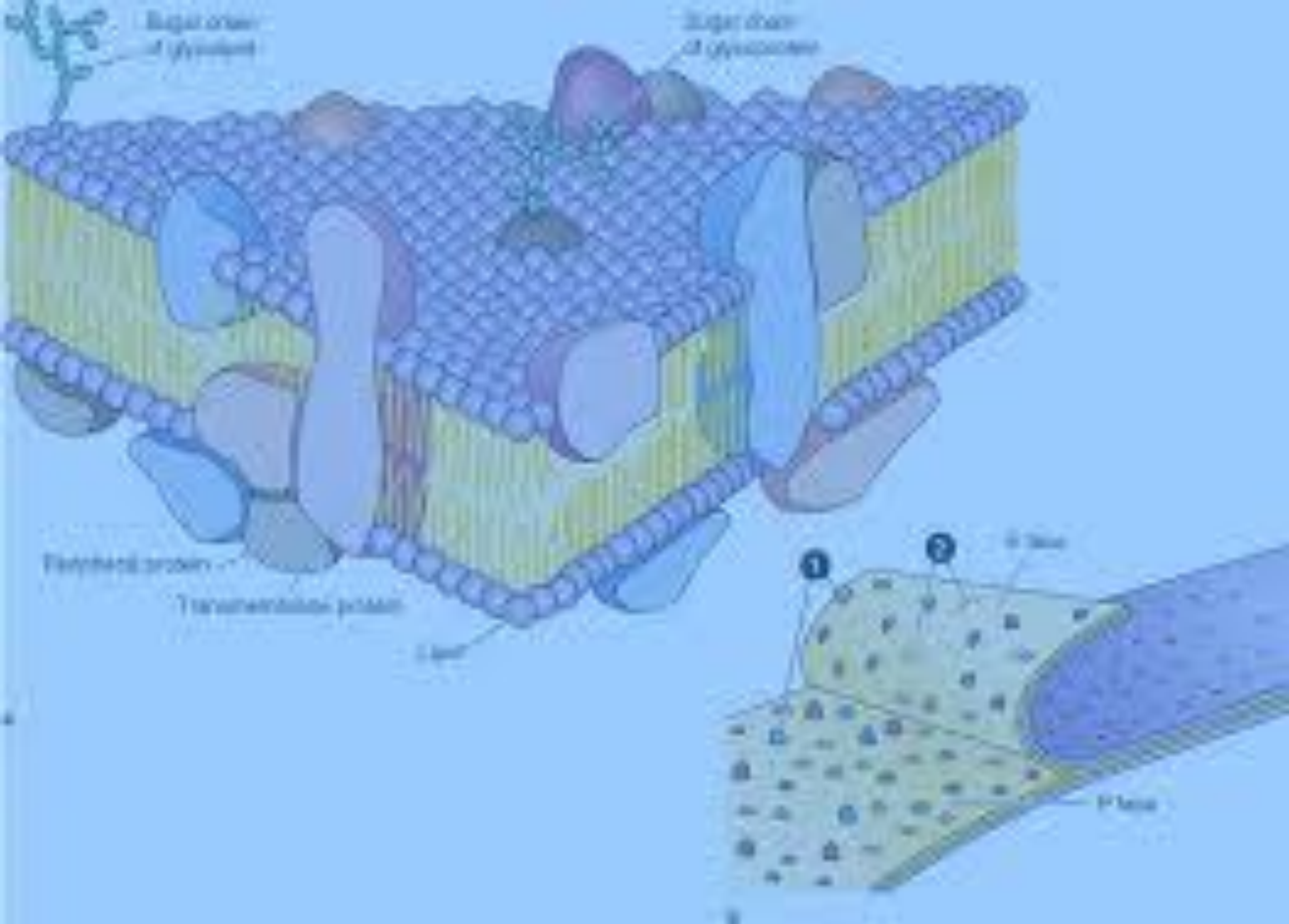
1. CHANNEL RPOTEINS
2. CARRIER PROTEINS
3. CELL RECOGNITION
4. RECEPTOR PROTEINS
5. ENZYMATIC PROTEINS
6. ATTACHMENT TO CYTOSKELETONS

CARBOHYDRATES

Carbohydrates are the another very important aspect of the cell. In fact carbohydrates are not just essential in the cell membrane but in many aspects of life too. For example, they are am essential part of our diet as grains, fruits and vegetables. Without consumption of carbohydrates, the whole body, including cells where mitochondria produce energy would be affected.

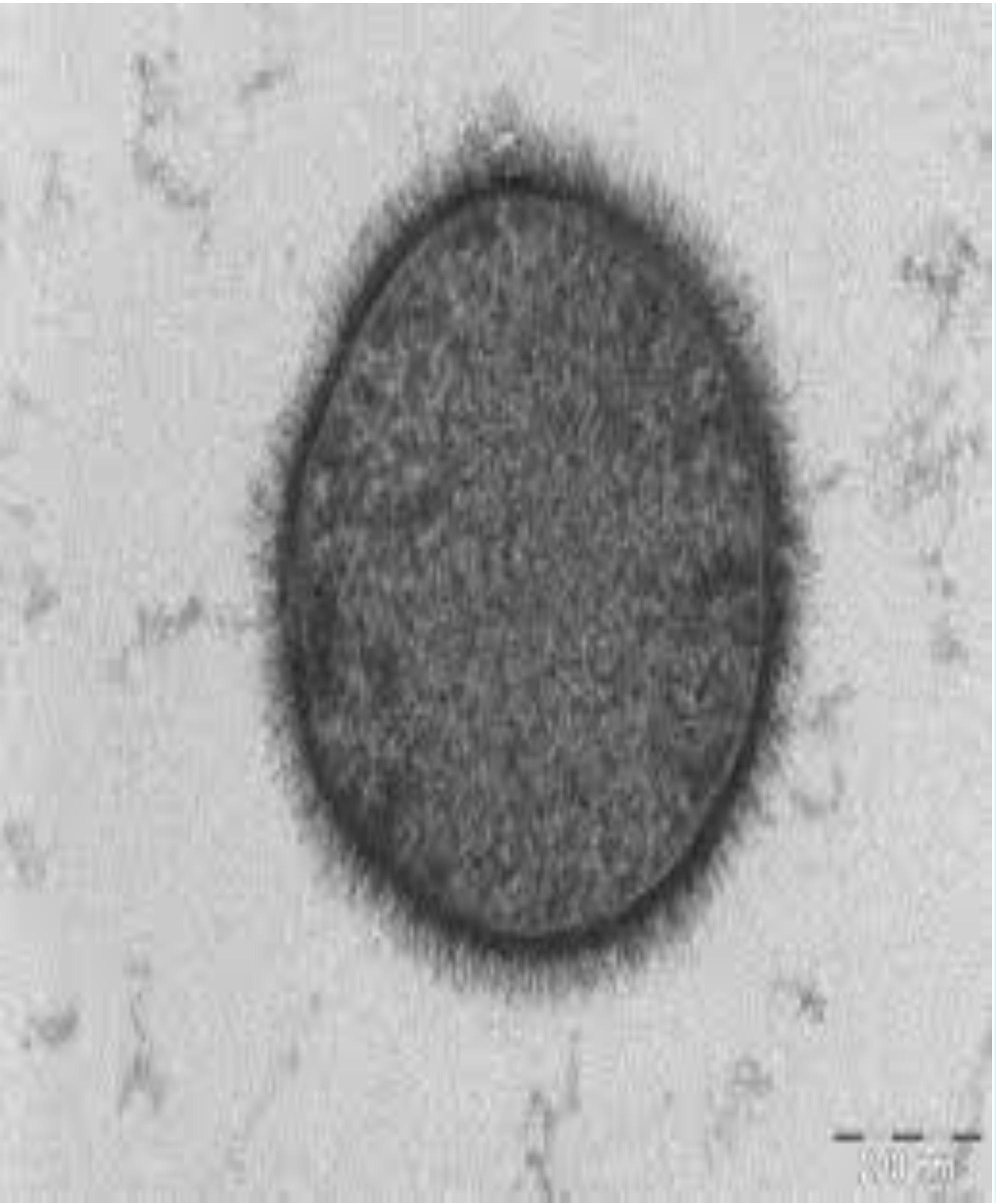
However when it comes to the cell membrane will that the periphery of the cell membrane is covered by a layer of material rich in carbohydrates.

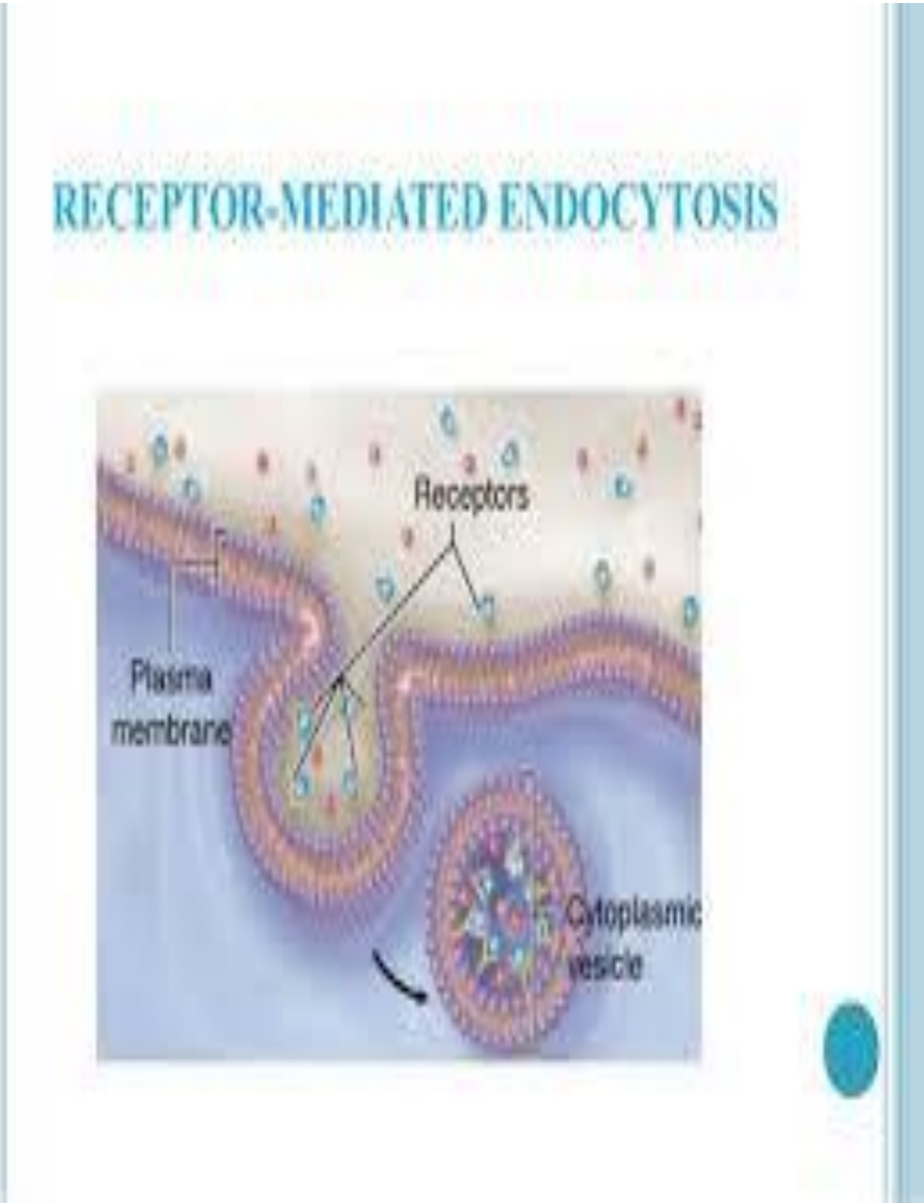

Carbohydrate chain
Glycoprotein
Glycolipid


Sugar chain of glycolipid
Sugar chain of glycoprotein
Peripheral protein
Transmembrane protein
E face
P face

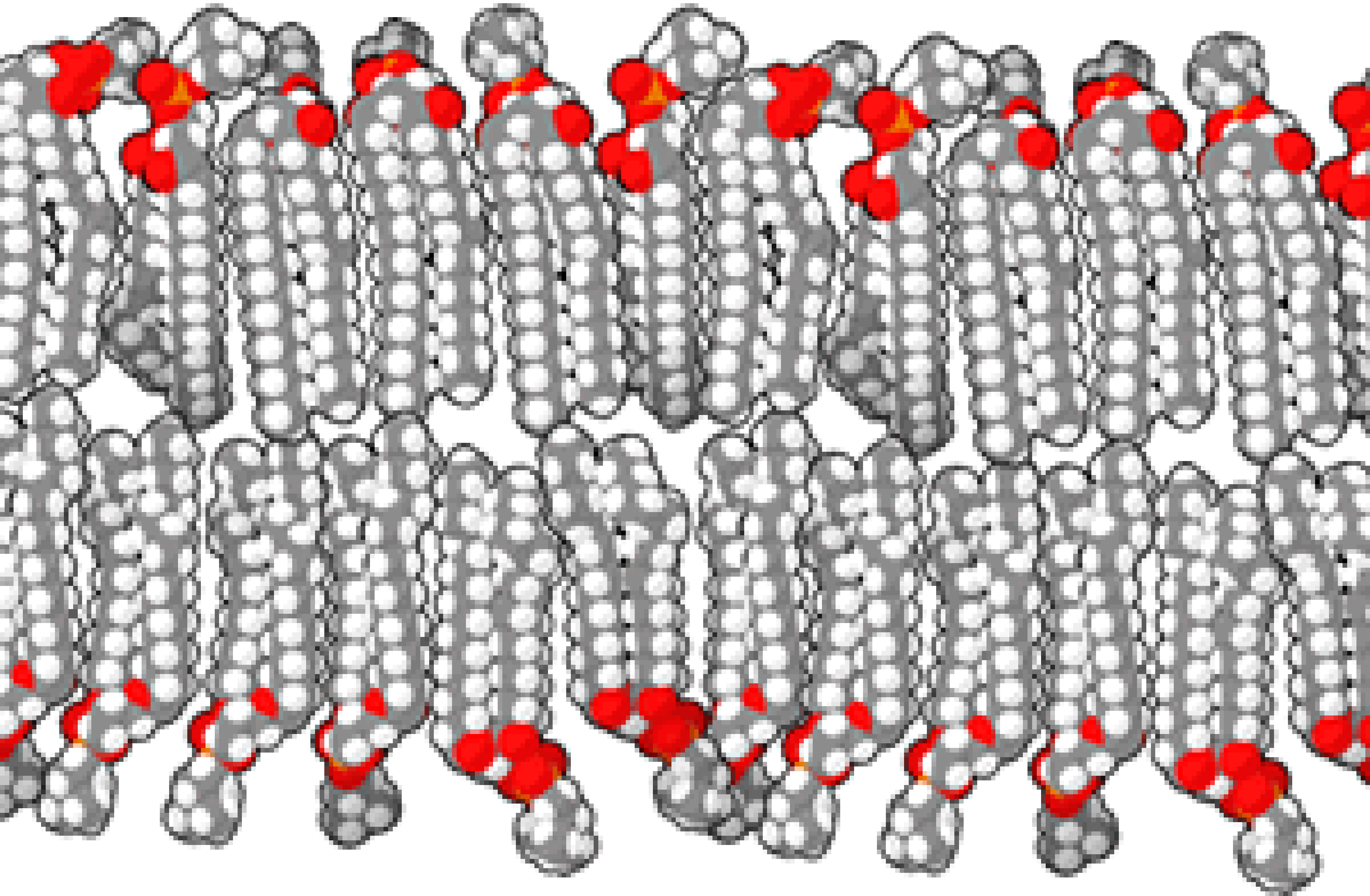
The carbohydrates on the exterior surface of the cell, both the glycoproteins and the glycolipids are collectively called the or referred to as the "glycocarlyx" which means "sugar coating". The glycocarlyx is highly hydrophilic and attracts large amounts of water to the surface of the cell. This is very functional in aiding the interactions of the cell with it's environment and to obtain substances dissolved in water, for example, ions. Ultra-structurally the cell surface appears "Fuzzy".

"Fuzzy Appearance of the Cell Surface"





FLUIDITY OF THE MEMBRANE

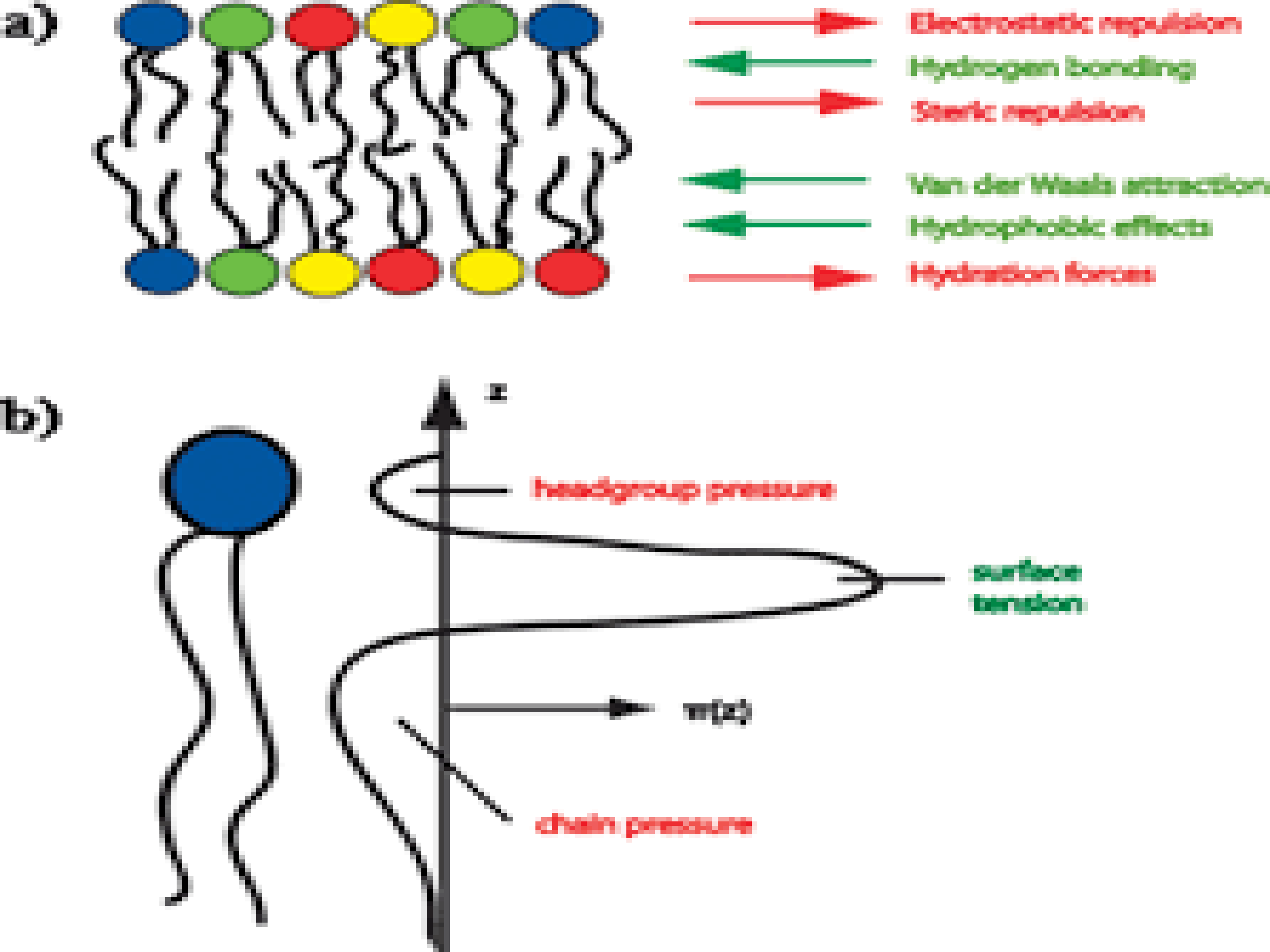


WHAT CONTRIBUTES TO MEMBRANE FLUIDITY…?

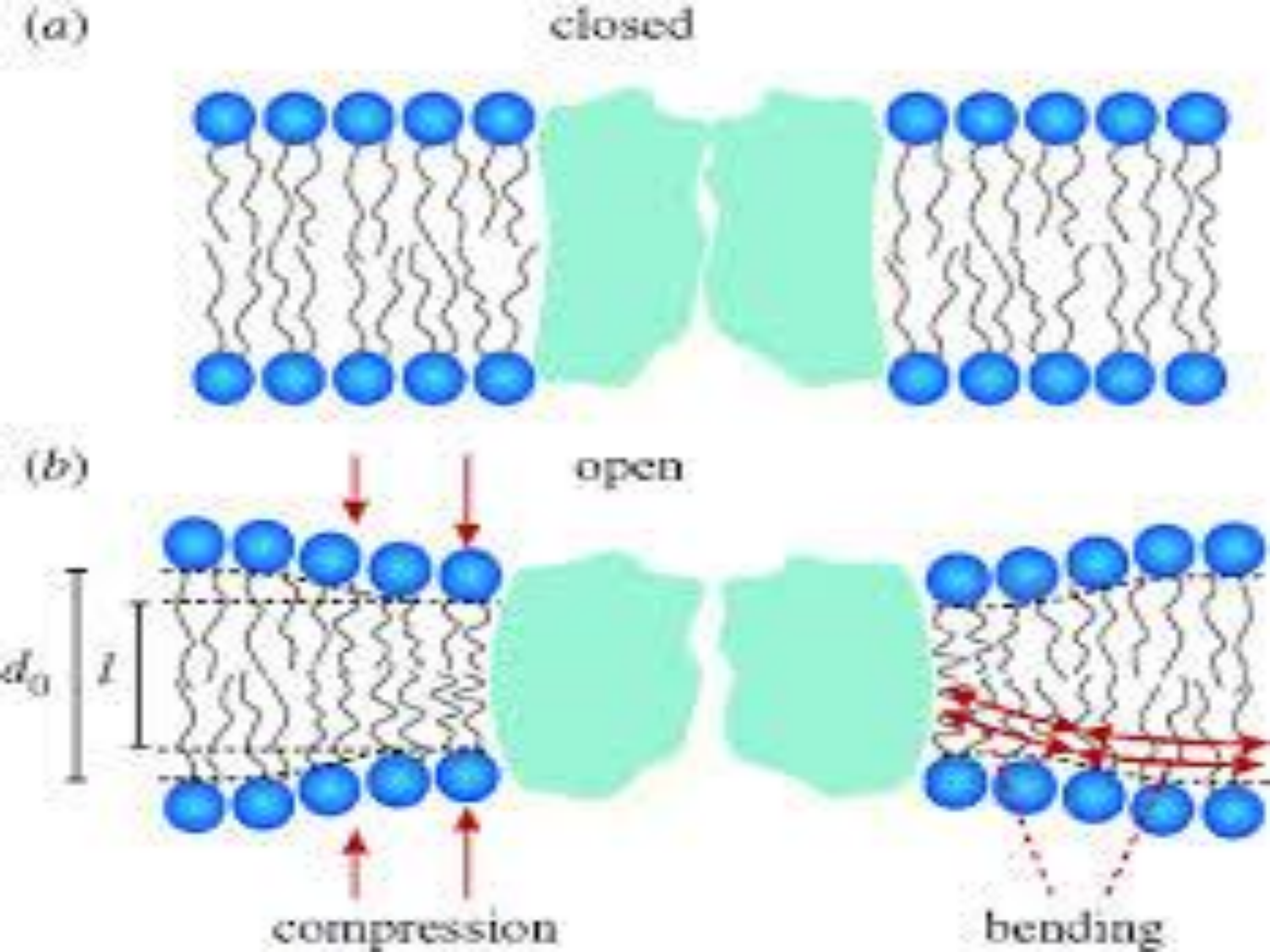
1. The fluidity of the lipid bilayer depends on both its components and its temperature.

2. The Membrane Phospholipids: The membrane phospholipids are capable of certain kinds of movement. They can rotate very rapidly around a certain axis, they can move laterally across biological membranes. This is what is termed as "flip-flop".

3. The molecules that are embedded in the plasma membrane also serve a purpose. For example, the *cholesterol* that is stuck in there *makes the membrane more stable and prevents it from solidifying when your body temperature is low.*



a)
Electrostatic repulsion
Hydrogen bonding
Steric repulsion
Van der Waals attraction
Hydrophobic effects
Hydration forces
b)
z
headgroup pressure
surface tension
π(z)
chain pressure


(a)
closed
(b)
open
d_0
l
compression
bending

Membranes and Heat

- Increasing **temperature** increases **molecular kinetic energy**. This means that the Phospholipid Molecules in the Bilayer **vibrate more** and so are **more unstable**. This makes the membrane more '**leaky**', as it will allow **more molecules through** that wouldn't normally be able to. Once a certain temperature has been reached, the **membrane breaks**.
- Some organisms however have adapted to live in environment with **extreme temperatures**, and so have membranes that are more **resistant to heat**. One way of increasing resistance to heat is by increasing the amount of **Cholesterol** in the membrane.

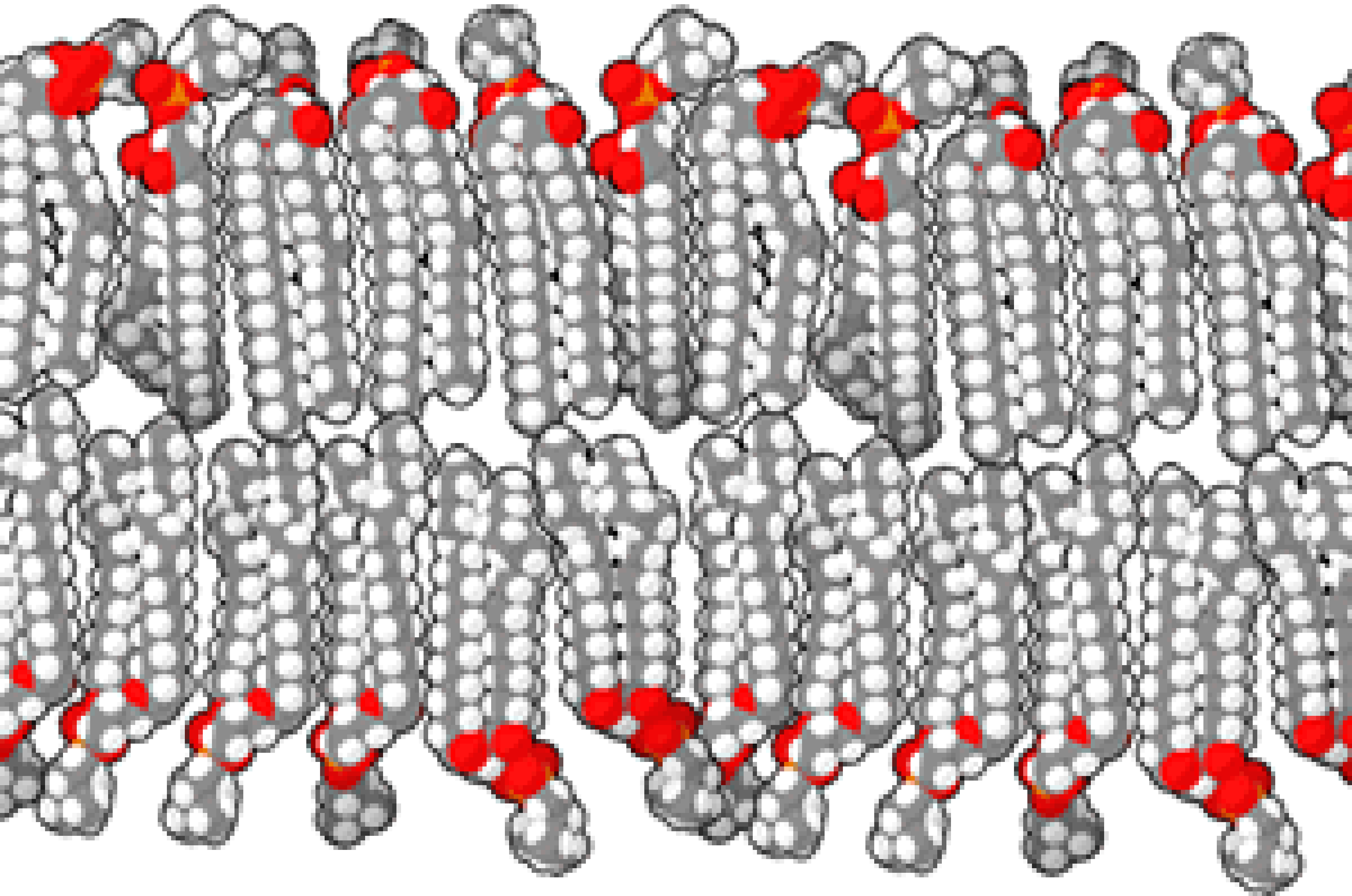
IN SUMMING UP THE REASONS FOR FLUIDITY..

1. The arrangement of the fatty acids, with the kinks in their structures causes fluidity as they are not even packed.
2. The lateral and vertical movements of the phospholipids also cause fluidity.
3. The presence of cholesterol – which becomes fluid at low temperatures and harden at high temperature also causes fluidity in the membrane.

CHOLESTEROL

1. The lipid bilayer is not composed exclusively of phospholipids, however, it often also contains cholesterol and glycolipids. Eukaryotic plasma membranes contain especially large amounts of cholesterol – up to one molecule of cholesterol for every phospholipid molecule.
2. The cholesterol molecule enhance the permeability-barrier properties of the lipid bilayer. They orient themselves in the bilayer with their hydroxyl groups close to the polar head groups of the phospholipids molecules. In this position, their rigid, plate-like steroid rings interact with and partly immobilize those regions of the hydrocarbon chains closest to the polar head groups.
3. By decreasing the mobility of the first few CH2 groups of the hydrocarbon chains of the phospholipid molecules, cholesterol makes the lipid bilayer less deformable in this region and thereby decreases the permeability of the bilayer to small water-soluble molecules.

CHOLESTEROL IN THE MEMBRANE



CONTINUATION…

4. Although cholesterol tends to make lipid bilayers less fluid, at the high concentrations found in most eukaryotic plasma membranes. It also prevents the hydrocarbon chains from coming together and crystallizing. In this way, it inhibits possible phase transitions.

5. The **Steroid Molecule Cholesterol** gives the Plasma Membrane in some Eukaryotic Cells **stability** by **reducing the fluidity** and making the **Bilayer more complete**.

THE FLUID MOSAIC MODEL

1. The phospholipid structure of the cell membrane has well been described by a model of the proposed earlier scientists *S. J Singer* and *Garth L. Nicolson* in 1972. this model also known as the “Fluid Mosaic Model” describes the structure f the plasma membrane as a mosaic of components that include phospholipids, cholesterol, proteins and carbohydrates and these give the fluid character of the Plasma membrane.

2. the **Fluid Mosaic Model** is generally accepted as describing how membranes are arranged.

3. The Fluid Mosaic Model states that membranes are composed of a **Phospholipid Bilayer** with **various protein molecules** floating around within it. The '**Fluid**' part represents how some parts of the membrane can move around **freely**, if they are **not attached to other parts of the cell**. The 'mosaic' part illustrates the '**patchwork' of proteins** that is found in the Phospholipid Bilayer.

MEMBRANE PUMPS AND ION CHANNELS

Many proteins in the cell membrane act as active pumps moving molecules against concentration gardeints. The best known cellular pumps are several polypeptide chains that aggregate together to form the Na+ - K+ pump.

This pump maintains the high potassium and low sodium intracellular levels relative to the extracellular medium.

Protein channel permit the "rapid flux" of ions across membranes without expending energy. The ion channels influence the rate but not the direction of ion flow across membranes. Movement of non-ionic solute through a channel is strictly passive – that is to say they are determined only by its concentration gradient across the membrane.

For an ion however the direction of flow depends on both the chemical concentration gradient and the electrical potential across the membrane.

Ion channels are proteins that exist in two or more conformation, a stable open state and a stable closed state.

There are those that are open specifically to change in electrical field, these are voltage gated channels.

There are those that open in response to chemical substances like the neurotransmitter.

The third type the opening is controlled by cellular deformation.

Lastly is the gap junction: this enables flow between adjacent cell without traversing the extracellular space. Gap junctions open and close in response to changes in the intracellular concentration of calcium ions. The gap junctions are composed of six polypeptides surrounding a 15-20A diameter channel.

In the channel most small molecules, for example; sugars, amino acids and nucleotides flow unimpeded from one cell to another. Gap junctions do not necessarily remain open. When the low usually calcium levels rise, the gap junctions undergo conformational change that closes the gap.

CONCLUSION

It is estimated that about 30% of proteins that are encoded in an animal cell's genome are membrane proteins. This fact therefore, plus the above discussed information, implies that 30% of the work of the nucleus in the cell is to produce membrane proteins. This interesting point should tell us of the importance of the membrane proteins and the cell membrane itself.


The End!