Section B and C

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2. CELLULAR ORGANIZATION

A. MEMBRANE STRUCTURE AND FUNCTION

Introduction

All living cells, prokaryotic and eukaryotic have a plasma membrane that encloses their contents and serves as a semi-porous barrier to the outside environment. The membrane acts as a boundary, holding the cell constituents together and keeping other substances from entering.

The cell membrane consists of the plasmalemma along with surrounding cell cement. The plasma membrane is so thin that it can not be resolved with the light microscope, but in some cells it is covered by thicker protective layers within the limits of light microscope. The structure seen under the light microscope is called the cell membrane. Most plant cells have thick cellulose (Cellulose is one of many polymers found in nature it is made of repeat units of the monomer glucose) wall that covers and protects the true plasma membrane. Some animal cells are surrounded by cement like substances that constitutes visible cell walls. Such layers, also called cell coats (glycocalyx), play any role in permeability but have most other important functions.

Molecular Organization (Chemical Composition) of the Cell Membrane

In the study of the molecular organization of the cell membrane, the first step is to isolate it from the rest of the cytoplasm in the wholesome form possible. The isolated membrane is then studied by biochemical and biophysical technique.

Plasma membranes are more effortlessly obtained from erythrocytes subjected to hemolysis. The cells are treated with hypotonic solutions- solutions that have a lesser osmotic pressure than a reference solution such as blood, plasma, or interstitial fluid it produce swelling and then loss of hemoglobin content (i.e., hemolysis).

The resulting membrane is generally called a red cell ghost. Two main types of ghosts may be produced: resealed ghosts and white ghosts. The resealed ghosts are produced when haemolysis is milder. The ghosts can be treated with substances that produce restoration of the permeability functions. White ghosts are formed if hemolysis is more drastic. There is complete removal of the hemoglobin, and the ghosts cannot be resealed. These ghosts can be used for biochemical, but not physiological studies.

More is known about the chemical composition of the plasma membrane of the human red cell than about that of any other cell. Protein represents approximately 52% of its mass, lipids 40% and carbohydrates 8%. Oligosaccharides are bound to lipids (i.e., glycolipids) and, mainly to proteins (i.e., glycolproteins).

Table.1: Lipid and Protein ratios in some membranes:

Species and tissue	Protein %	Lipid %
Human- CNS myelin	20	79
Bovine-PNS myelin	23	76
Rat- skeletal muscle	65	35
Rat Liver	60	40
Human erythrocytes	60	40
Rat- Live mitochondrion	70	30

There is a wide variation in lipid-protein ration between different cell membranes. Myelin is an exception, in the sense that the lipid predominates. In the other cell membranes there is higher protein/lipid ratio. In myelin the area occupied by the protein is insufficient to recover that of the lipids, where as in a red cell ghost the opposite situation is found.

Lipids, proteins, carbohydrates and enzymes are asymmetrically distributed in the cell membrane. One of the main characteristics of the molecular organization of the plasma membrane is the asymmetry of all of its chemical components.

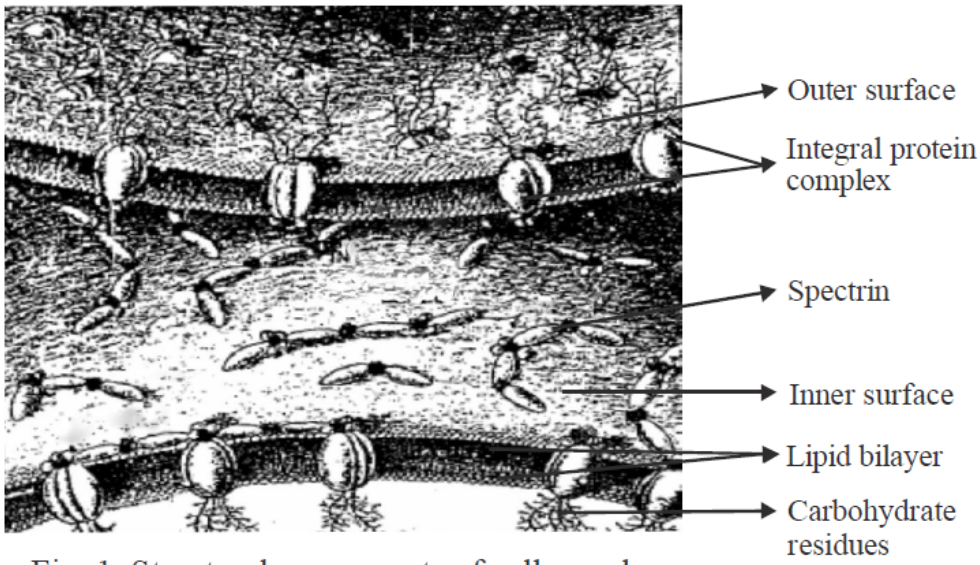

Fig. 1: Structural components of cell membrane

Lipids:

There are several essential types of membrane lipids. They are amphiphatic, as they have hydrophilic and hydrophobic portions within a single lipid molecule. The main lipid components of the plasma membrane are phospholipids, galactolipids (glycolipids) and sterols (cholesterol).

Phospholipids

Phospholipids are a class of lipids and are a major component of all cell membranes. Most phospholipids have a diglyceride, a phosphate group and a simple organic molecule such as choline; one exception to this rule is sphingomyelin, which is derived from sphingosine instead of glycerol. They are a type of molecule. They form a lipid bilayer within a cell membrane.

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The major percentage of membrane phospholipids is represented by phosphatidylcholine, phosphatidylethanolamine and sphingomyelin, all of which have no net change at neutral pH (i.e., neutral phospholipid) and are tightly packed in the bilayer, 5 to 20 per cent of the phospholipids are acidic, including phosphatidyl-inositol, phosphatidylserine, phosphatidyl glycerol, and sulfolipids. Acidic phospholipids are negatively charged and are allied principally with proteins by way of lipid-protein interactions.

1. Glycerophospholipids: These contain a glycerol backbone. The parent compound is phosphatidic acid. Examples: phosphatidyl serine, phosphatidyl ethanolamine (cephalin), phosphatidyl choline (lecithin), phosphatidyl glycerol, diphosphatidyl glycerol (cardiolipin), phosphatidyl inositol, plasmalogens, etc.

2. Sphingophospholipids: The central compound is 4-sphingenine (sphingosine), a derivative of sphinganine. Sphingolipids are also amphiphatic. Examples: 4-D-hydroxysphinganine (found in plants, sphingomyelin (glycerol moiety is replaced by 4-sphingenice). Using non permanent reagents and a variety of phospholipases, it has been demonstrated that the distribution of the phospholipids is highly asymmetrical. The outer or external surface (Es) consists mainly of lecithin and sphingomyelin. The inner or protoplasmic surface (Ps) is composed mainly of phosphatidylethanolamine and phosphatidyl serine.

Glycolipids: The glycolipids are carbohydrate-containing lipids. They are all derivatives of sphingosine. The glycolipids have a hexose (either glucose or glactose) or a more complex oligosaccharide linked to the hydroxyl group of sphingosine. The glycolipids are present mainly in the outer half of the bilayer.

1. Cerebrosides: These are ceramide sugars contain a single monosaccharide unit which is usually galactose (monoglactosyl ceramide), although glucose (monoglucosyl ceramide) or other sugars may also be found.