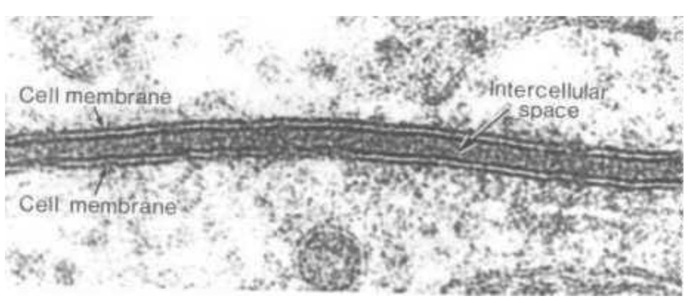
BIOMEMBRANE

Dr Poonam Kumari
Dept of Zoology
(M.Sc Semester I CC 02)

A biological membrane or biomembrane is a selectively permeable barrier which defines a living cell or a cellular organelle. It provides a microenvironment in which a cell or individual organelle can function and maintain its identity. All biomembranes have the same basic phospholipid bilayer structure and certain common functions, each type of cellular membrane also has certain distinctive activities determined largely by the unique set of proteins associated with that membrane. The most abundant lipid components in most membranes are phospholipids, which are amphipathic molecules (i.e., they have a hydrophilic and a hydrophobic part). Biological membranes are thin, flexible, selectively permeable surfaces that separate cells and their organelles from their environments. Biomembranes form closed struc- tures with an internal face oriented toward the interior of the compartment and an external face presented to the environment. Each type of cellular membrane has cer- tain distinctive activities determined largely by the unique set of proteins associated with that membrane. We can distinguish two different types of membrane proteins (i) integral proteins, which partly or entirely penetrate the membrane, and (ii) peripheral proteins, which are laterally attached to one side of the membrane. Biomembranes are typically asymmetric, their interior and exterior faces can carry different proteins and have different properties.

Although biological membranes may have different properties and functions, all mem- branes share a common structural architecture that we will address in this chapter. They are rich in phospholipids, which spontaneously form a characteristic bilayer structures in water. Membrane proteins and lipids can diffuse laterally or sideways throughout the membrane, giving them their characteristic appearance of a fluid rather than a solid.



Electron microscopy of the cell membrane

Structure

Biomembranes consist of a phospholipid bilayer and different embedded Proteins. The Phospholipidbilayer is made up out of two amphophil phospholipids. While the tails, which are hydrophobic (or lipophil) face each other the hydrophilic heads build the outer parts of the membrane. Proteins can be linked to carbohydrate chains and are mainly responsible for the activity of the membrane. They are not bound to certain parts of the cells but float around freely and so keep changing the face of the membrane. Biomembranes can be characterized from their density which lies between 1,12 and 1,22 g.cm-^{3}. It reprensents the relation of the weight between lipids and proteins. The higher the density, the higher is the part reprensenting proteins.

Lipid bilayers

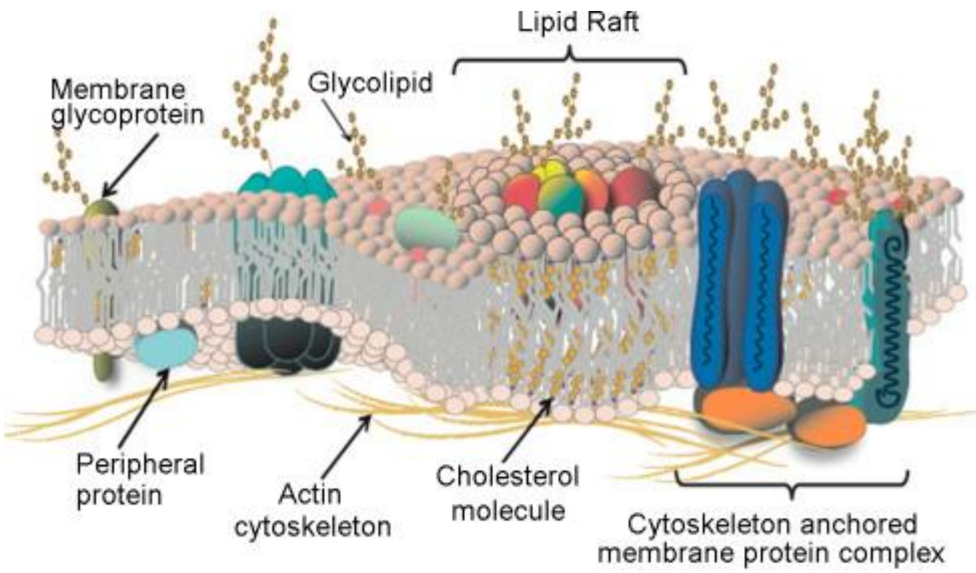
In cell biology, the notion membrane is typically associated with the phospholipid bilayer and the proteins associated with it. In aqueous solutions, these proteins essentially display two kinds of non-covalent interactions which are referred to as hydrophobic and hydrophilic. Long polymer molecules typically tend to adopt confirmations, in which non-polar residues are predominantly sequestered such that they avoid contact with water. The non-polar residues are said to be hydrophobic or water-avoiding. Polymer molecules favor confirmations, in which the polar head groups are exposed to water. The polar head groups are referred to as being hydrophilic or water-loving. A typical example is the arrangement of fatty acids at an oil water interface, where the hydrophilic polar heads would typcially be oriented towards the water phase while the hydrophobic tails would be oriented towards the oil phase.

From an energetic point of view, lipid bilayers show an attractive arrangement since they display both hydrophobic and hydrophilic interactions. The nonpolar fatty acid chains of the phospholipid molecules are sequestered together away from the water sandwiched between the polar head groups to maximize hydrophobic interactions. At the same time, the ionic polar head groups are in direct contact with the aqueous phase to maximize hydrophilic interactions. This dual nature of the molecules is referred to as amphiphilic.

For energetic reasons, each lipid bilayer has an inherent optimal microstructure with and optimal spacing between the lipid molecules. Any perturbation to this optimal arrangement disturbes this energetically favorable microstructure. The lipid bilayer thus exhibits an inherent resistance to deformations that cause shape changes. Typical examples are extension, for which the spacing between the head groups would increase throughout the membrane, or bending for which the head group spacing would increase on the outside while it would decrease on the inside.

Membrane Proteins

Different kinds of membrane proteins are responsible for the different traits of each biomembrane. For exmaple glycoproteins which often function as receptors and are very important in the immune response. Even the membranes which are facing outward (e.g. extracellular matrix) and those facing inward (e.g. cytoplasm) can differ very much in their functions although they are part of the same membrane. Generally we can divide the proteins in three different types : Intergral proteins, periphery proteins and lipid bound proteins. Integral proteins are mainly responsible for transport of molecules. As the phospholipids they are also amphipathic, their aminoacid tail interacts with the lipidchains while the hydrophilic heads interacts with the watery surface. Periphery Proteins are outside of the membrane. They are linked to the peripheral proteins or lipids on the membrane but do not reach the hydrophobic core. Lipidbound proteins are also on the outside of the membrane but are kovalently linked with a lipid embedded in the membrane. Most of them are GPI-anchored. The main functions of membrane proteins are transport of nutrients, extracellular signal reception and also the selective transport of ions and other molecules.



Cell membranes

The most intriguing of all biomembranes is the cell membrane, a semipermeable phospholipid bilayer common to all living cells. This lipid bilayer which is approximately 6 nm thick consists of a variety of different biopolymers the most common of which are proteins, lipids and oligosaccharides.

On the inside, the lipid bilayer serves as attachment for the cytoskeleton which is primarily responsible to control the cell shape. On the outside, the cell membrane plays an important role in attaching to the extracellular matrix. Specific proteins embedded in the cell membrane can act as molecular signals and to allow for cell to cell interaction. In funghi, bacteria and plants, the cell membrane is further sur- rounded by the cell wall. In an aqueous environment, the intact cell membrane seeks to attain its lowest energy level. Accordingly, the nonpolar aminoacid residues of its proteins and the fatty acid chains of its phospholipids will typically be sequestered fur- thest away from the aqueous solvent. The ionic and polar head groups of the proteins, the lipids and the oligosaccharides, in turn, will seek to be in contact with water.

Energy

From a structural mechanics point of view, biomembranes are characterized through their very thin structure. The lipid bilayer of the cell membrane has a thickness of approximately 6 nm. The typical dimensions of a cell are at least of the order of μm. Therefore, it is quite common to treat biomembranes as shell structures. In general, the notion of shells is associated with thin, curved structures that are subjected to loads that can cause in plane stretches and shear and out of plane bending. A special case of shells, a flat shell of zero curvature, would be referred to as a plate. Shells are structural elements for which one dimension, the thickness, is much smaller than their two other dimensions, the length and the width.

Functions

- compartmentation (divides cells from extracellular matrix and organells from cytoplasm, so that these can maintain their own specific environment)

- transport (through the selective permeability they only allow certain substances to gothrough the membrane)

- receptors (the biomembrane are important receptors for external signals and also redirects these signals inside so they arrive where they are needed)

In general one can say that the biomembrane plays an important role in protect the cell or organells and is also an important place for the exchange of molecules.