Lec. 2 – Cell Membranes

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STRUCTURE OF THE CELL

Each cell is formed by a cell body and a cell membrane or plasma membrane that covers the cell body. The important parts of the cell are (Fig. 1-1)

a. Cell membrane
b. Nucleus
c. Cytoplasm with organelles

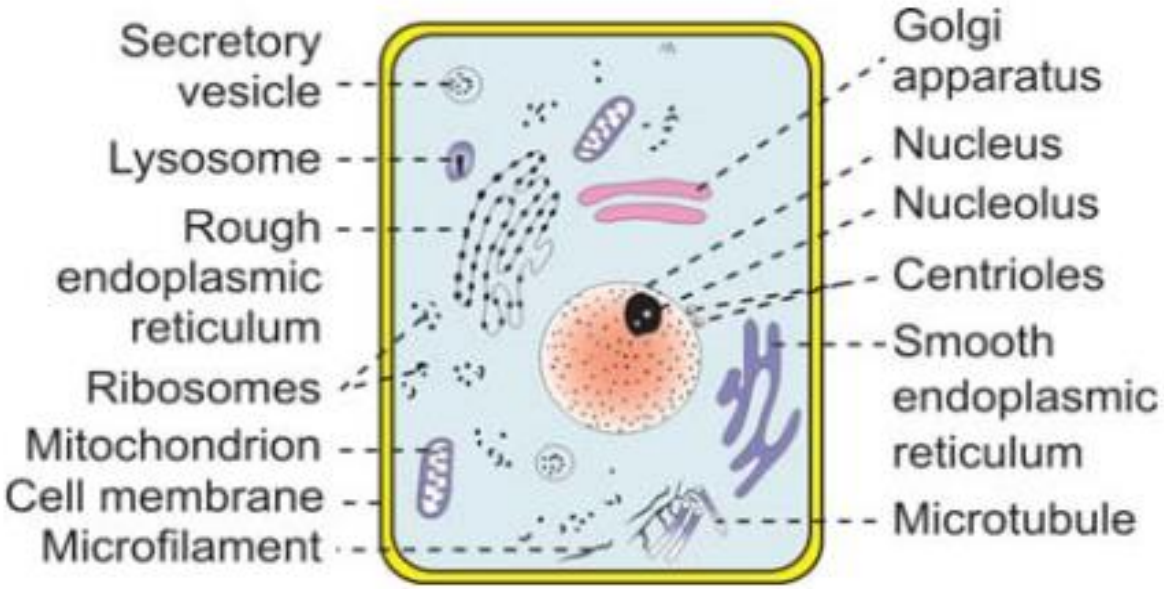


FIGURE 1-1: Structure of the cell

The cell membrane is a protective sheath that envelops the cell body. It separates the fluid outside the cell called extracellular fluid (ECF) and the fluid inside the cell called intracellular fluid (ICF). It is a semipermeable membrane and allows free exchange of certain substances between ECF and ICF (Fig. 1-2).

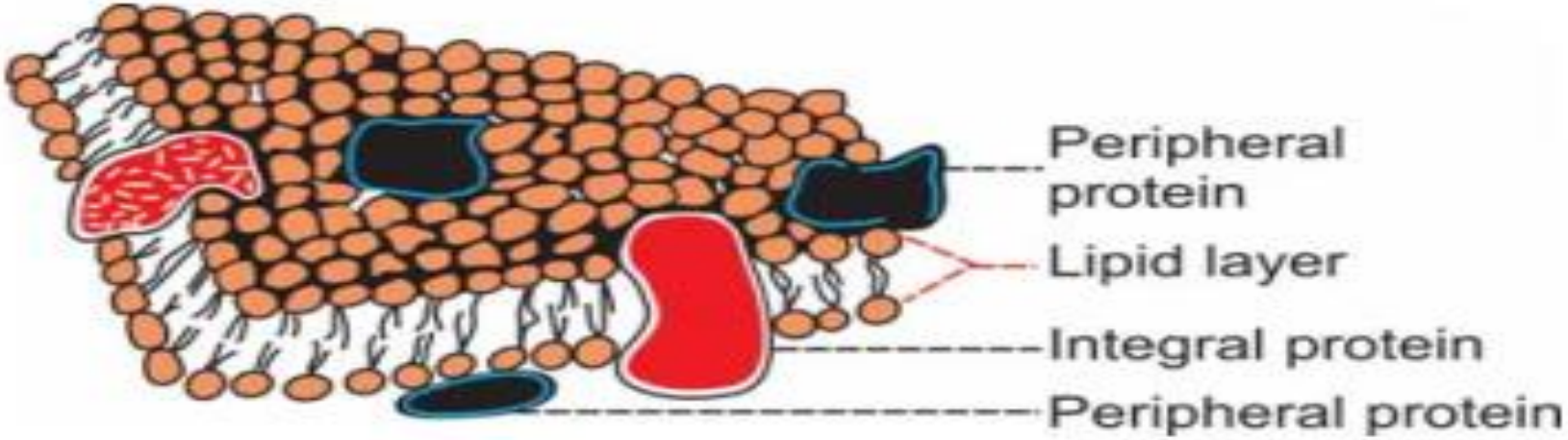


FIGURE 1-2: Diagram of the cell membrane

However…

- The membrane isn't just a phospholipid bilayer
- It is composed of a huge array of phospholipids, regular lipids, proteins, and other molecules
- This is called the **fluid mosaic model**

COMPOSITION OF CELL MEMBRANE

The cell membrane is composed of three types
of substances:

1. Proteins (55%)
2. Lipids (40%)
3. Carbohydrates (5%).

STRUCTURE OF CELL MEMBRANE

The cell membrane is a unit membrane having the ‘fluid mosaic model’ i.e., the membrane is a fluid with mosaic of proteins (mosaic means pattern formed by arrangement of different colored pieces of stone, tile, glass or other such materials) lipids and carbohydrates. The electron microscopic study reveals three layers in the cell membrane namely, one electron lucent lipid layer in the center and two electron dense layers on either side of the central layer. Carbohydrate molecules are found on the surface of the cell membrane.

Lipid Layer of Cell Membrane

It is a bilayered structure formed by a thin film of lipids. It is fluid in nature and the portions of the membrane along with the dissolved substances move to all areas of the cell membrane. The major lipids are:

a. Phospholipids

b. Cholesterol

1. *Phospholipids*

The phospholipid molecules are formed by phosphorus and fatty acids. Each phospholipid molecule resembles the headed pin in shape (Fig. 1-3). The outer part of the phospholipid molecule is the head portion which is water soluble (hydrophilic) and the inner part is the tail

portion that is not soluble in water (hydrophobic).
The hydrophobic tail portions meet in the center of the membrane. The hydrophilic head portions of outer layer face the ECF and those of the inner layer face the cytoplasm.

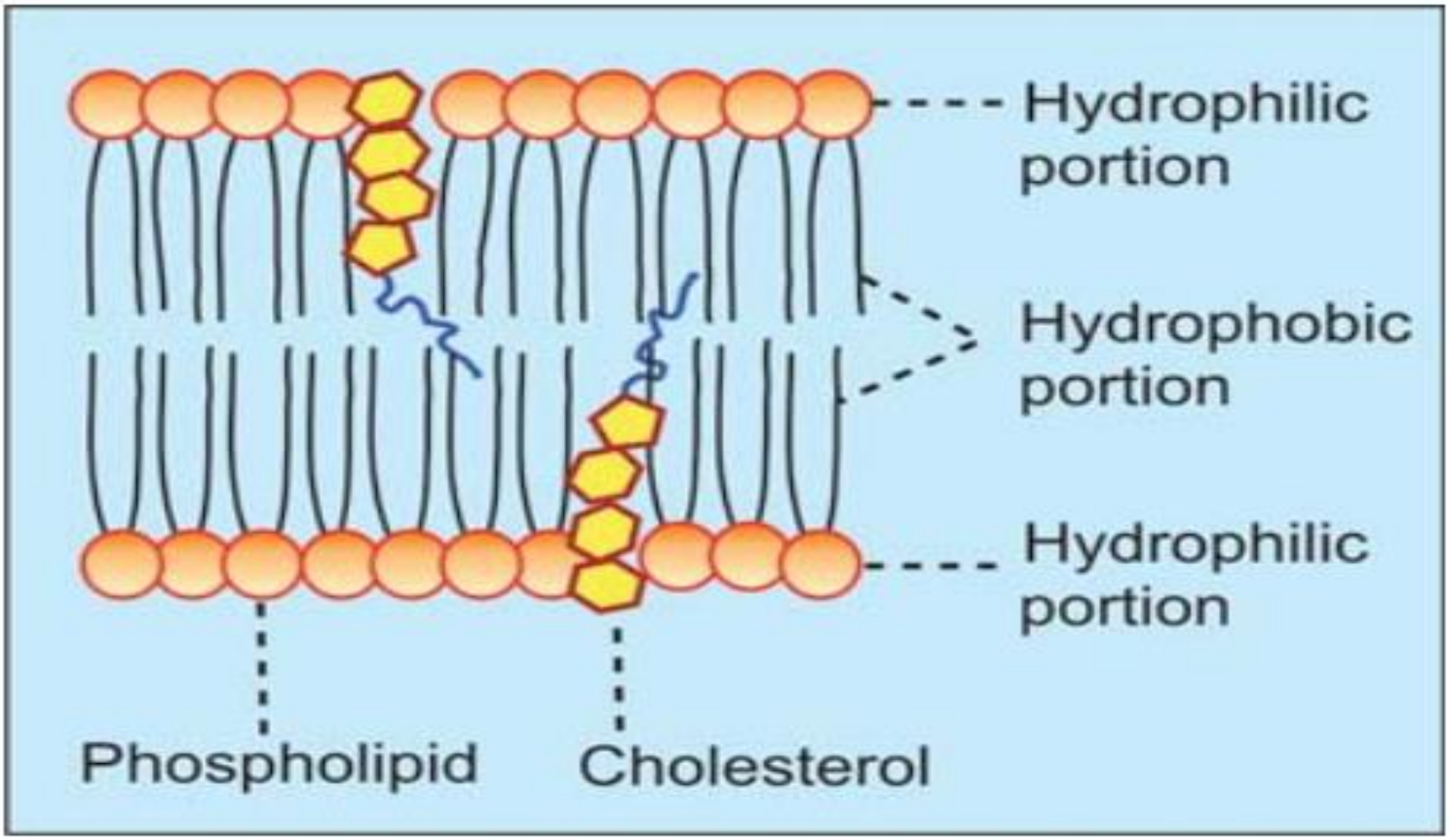


FIGURE 1-3: Lipids of the cell membrane

2. *Cholesterol*

The cholesterol molecules are arranged in between the phospholipid molecules. As phospholipids are soft and oily in nature, cholesterol helps to “pack” the phospholipids in the membrane and maintain the structural integrity of cell membrane.

Cholesterol

- Cholesterol is a "fluidity buffer"
  - Restrains phospholipid movement at body temps
  - Also hinder close packing, so lowers the temp required for membranes to solidify

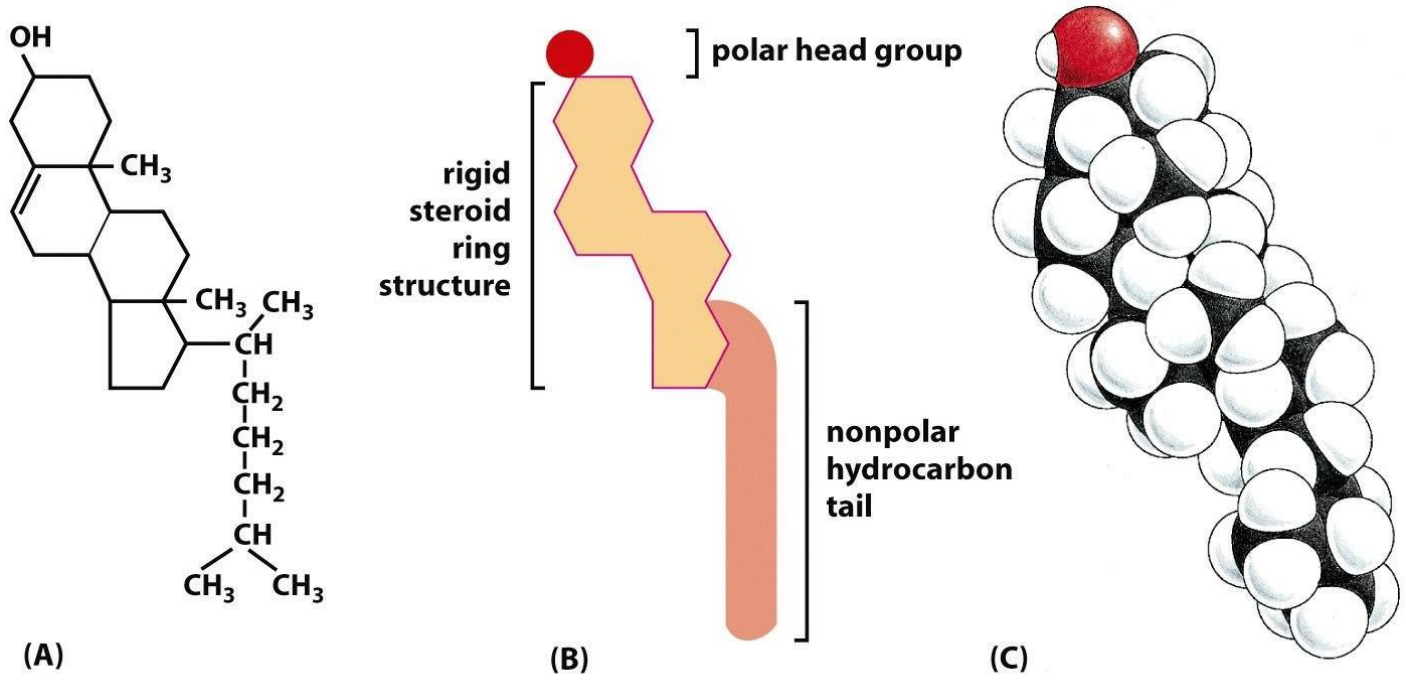


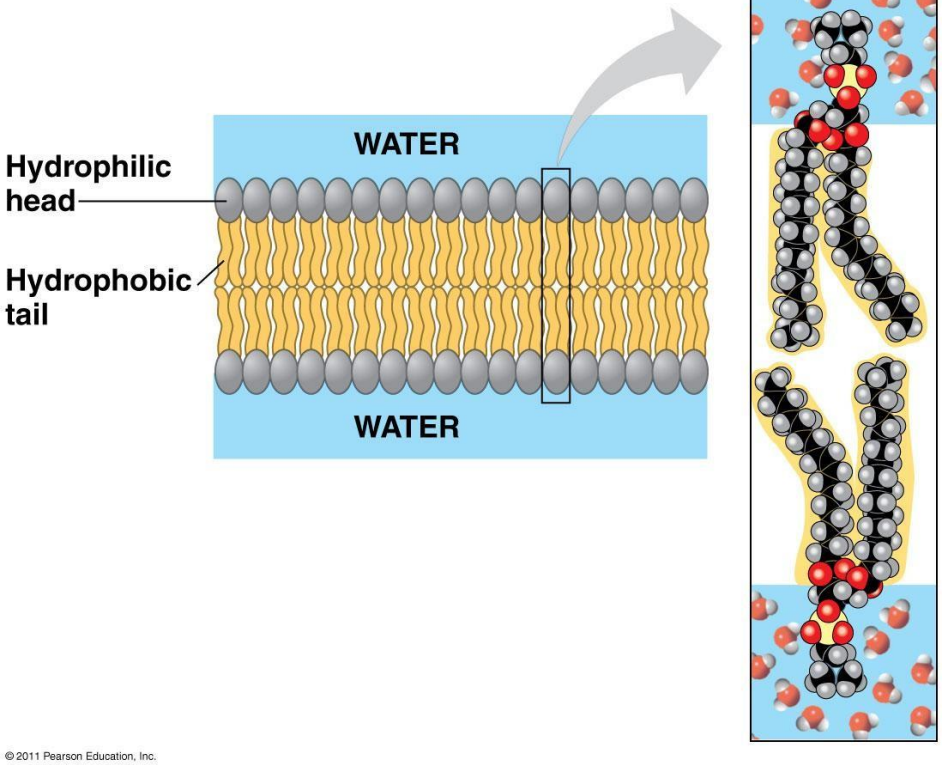
Figure 10-4 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Functions of lipid layer

The lipid layer is semi permeable in nature and allows only the fat soluble substances like oxygen, carbon dioxide and alcohol to pass through it. It does not allow the water soluble materials like glucose, urea and electrolytes to pass through it.

What are membranes made of? Phospholipids!

- Phospholipids are **amphipathic molecules**, containing hydrophobic and hydrophilic regions



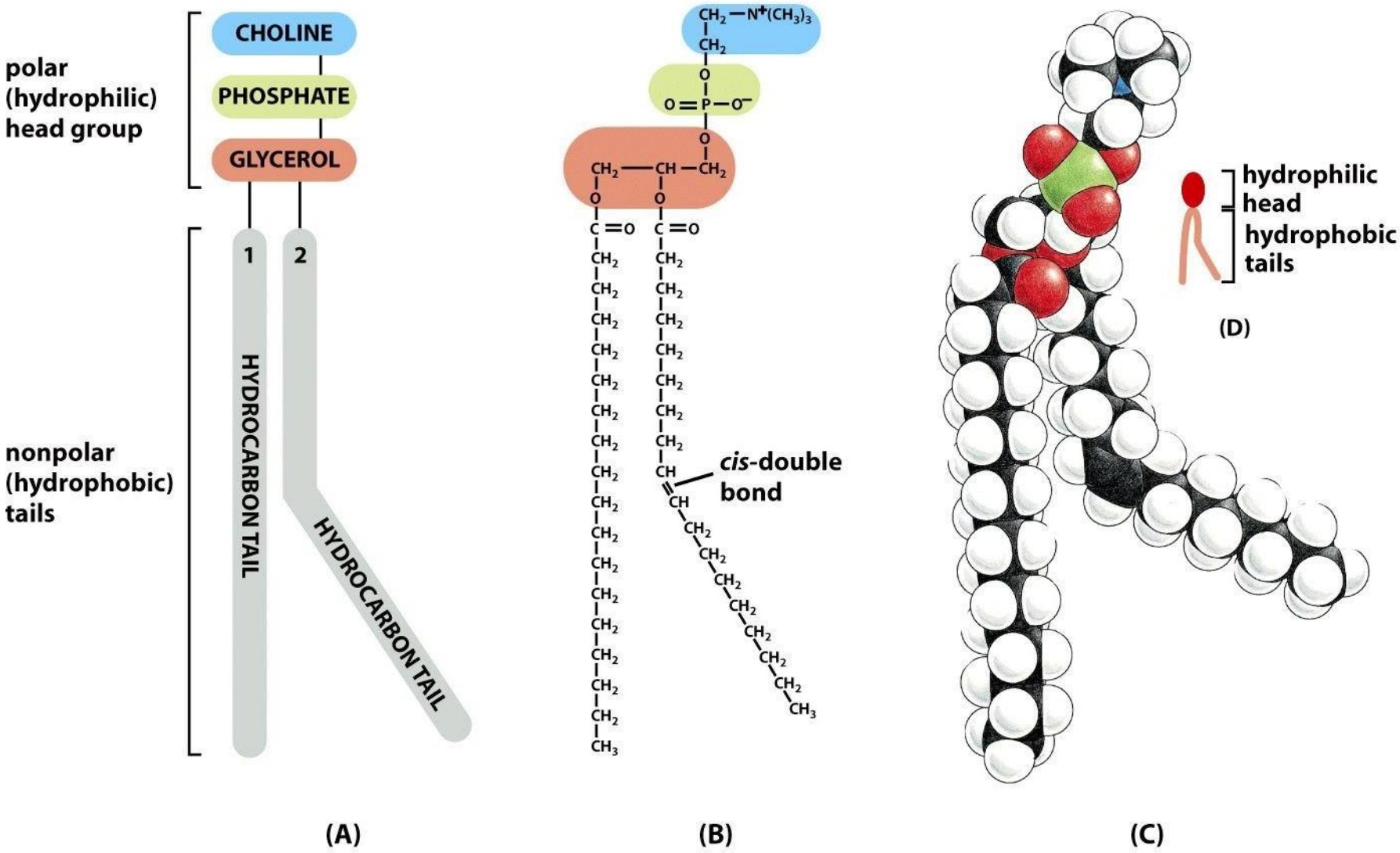
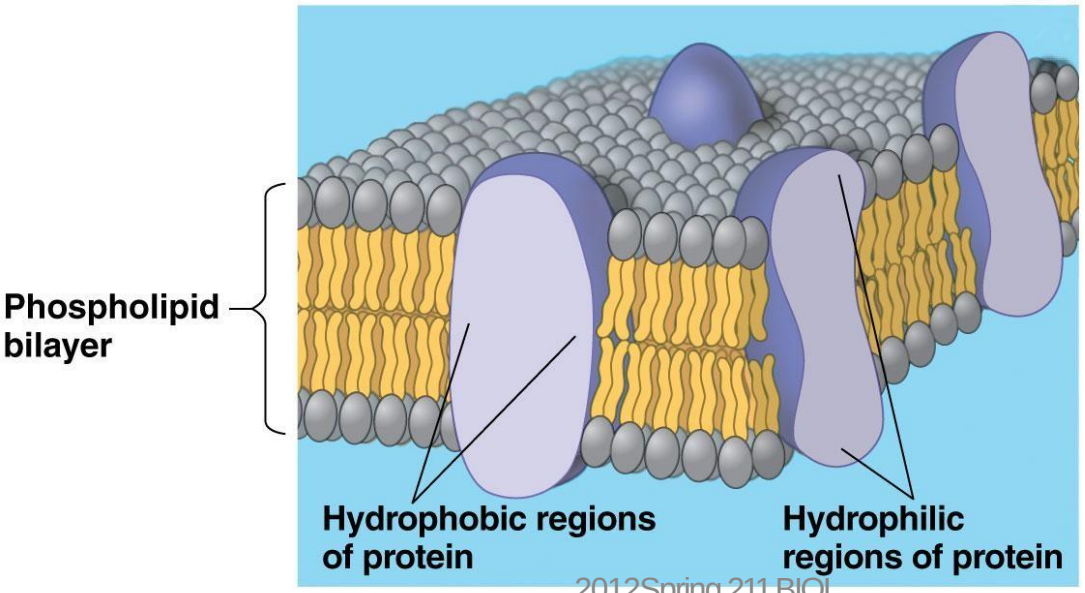


Figure 10-2 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Fluid Mosaic Model

- The **fluid mosaic model** states that a membrane is a fluid structure with a "mosaic" of various proteins embedded in it
- Phospholipids and some proteins can drift laterally
  - Very rarely does someone "flip"
- How do proteins stay embedded?



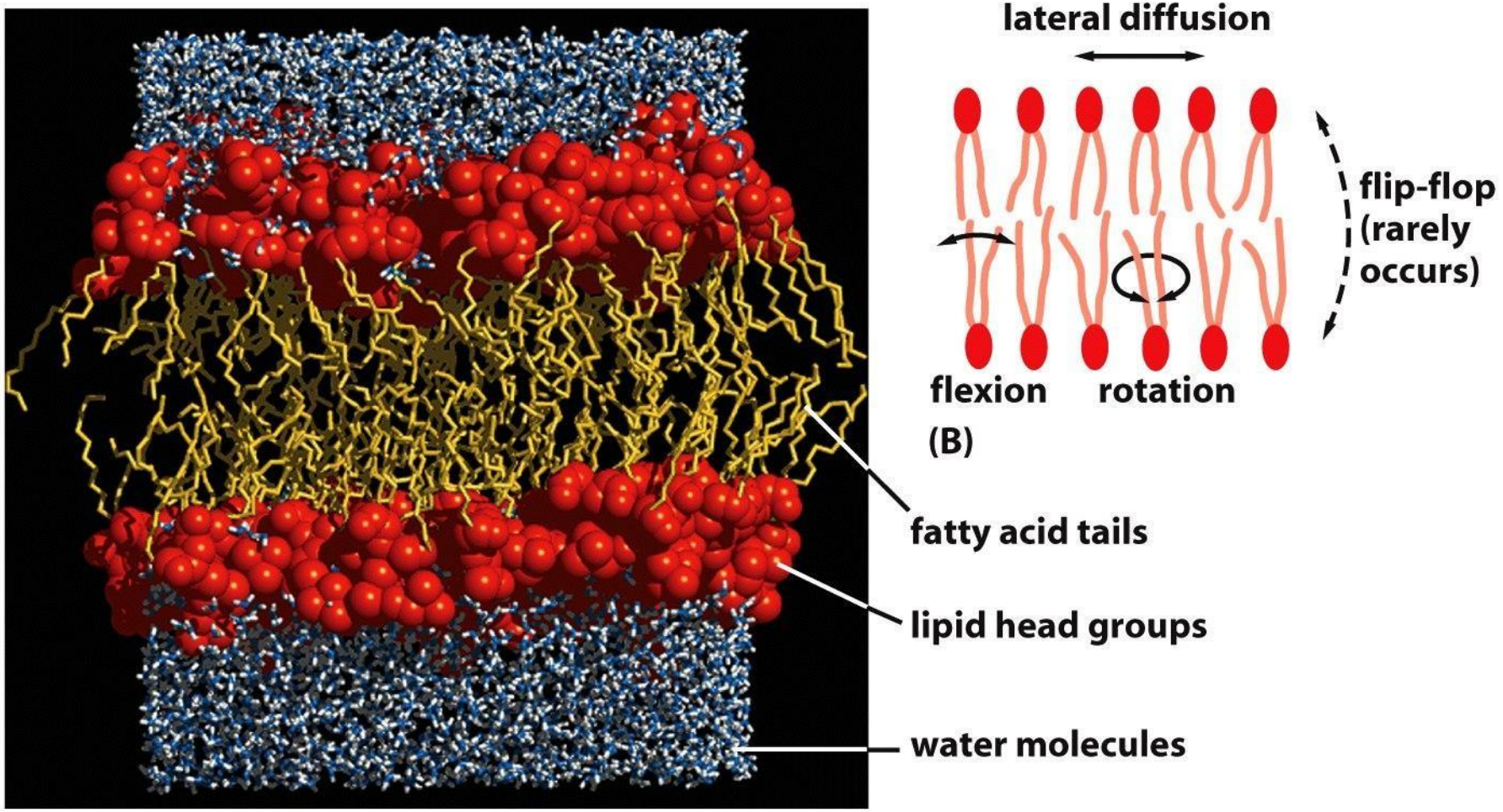
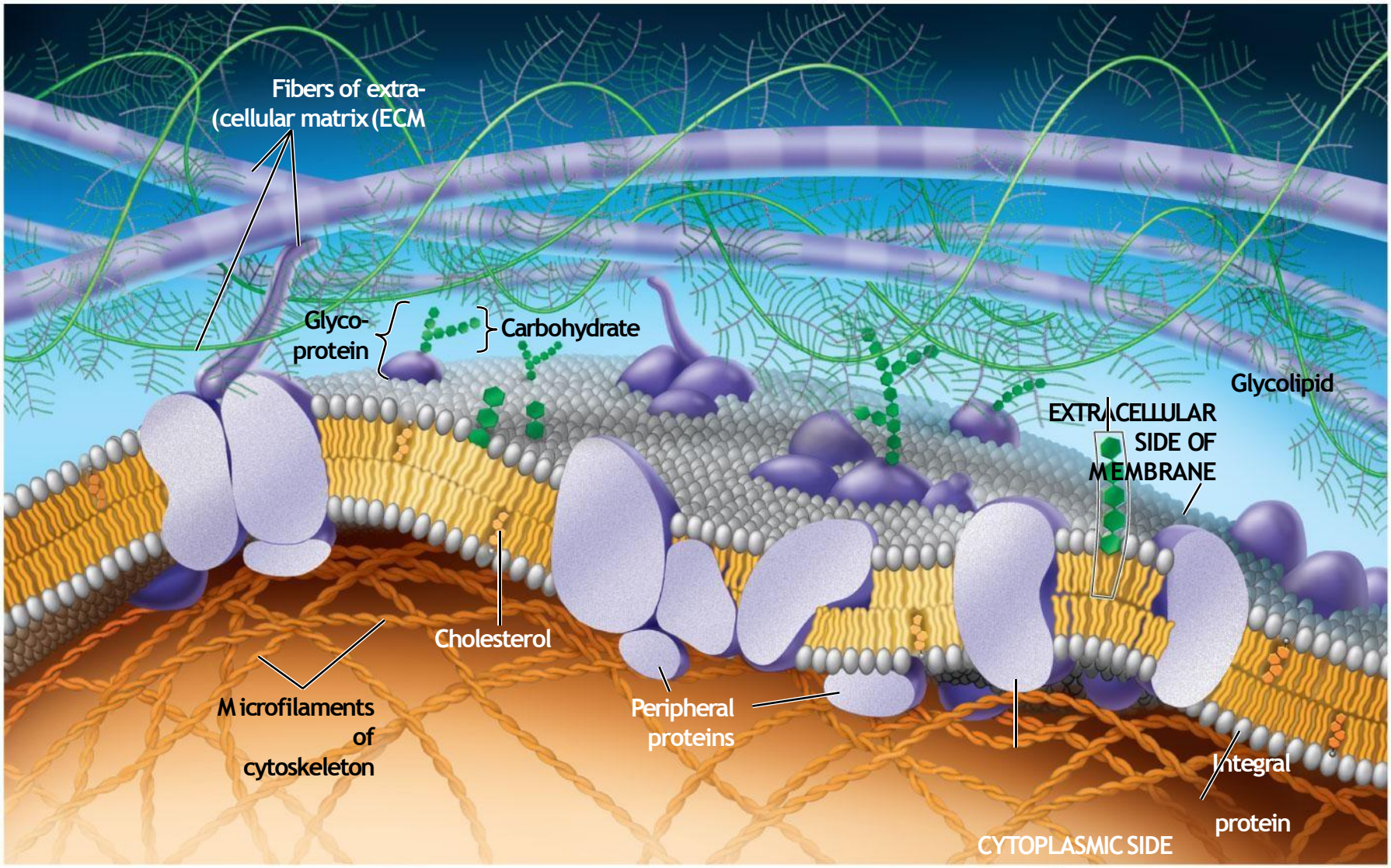


Figure 10-11 Molecular Biology of the Cell 5/e (© Garland Science 2008)

7.5Figure



Protein Layers of the Cell Membrane

The protein layers of the cell membrane are the electron dense layers situated on either side of the central lipid layer. The protein substances present in these layers are mostly glycoproteins.

These protein molecules are classified into twocategories:

a. Integral proteins

b. Peripheral proteins

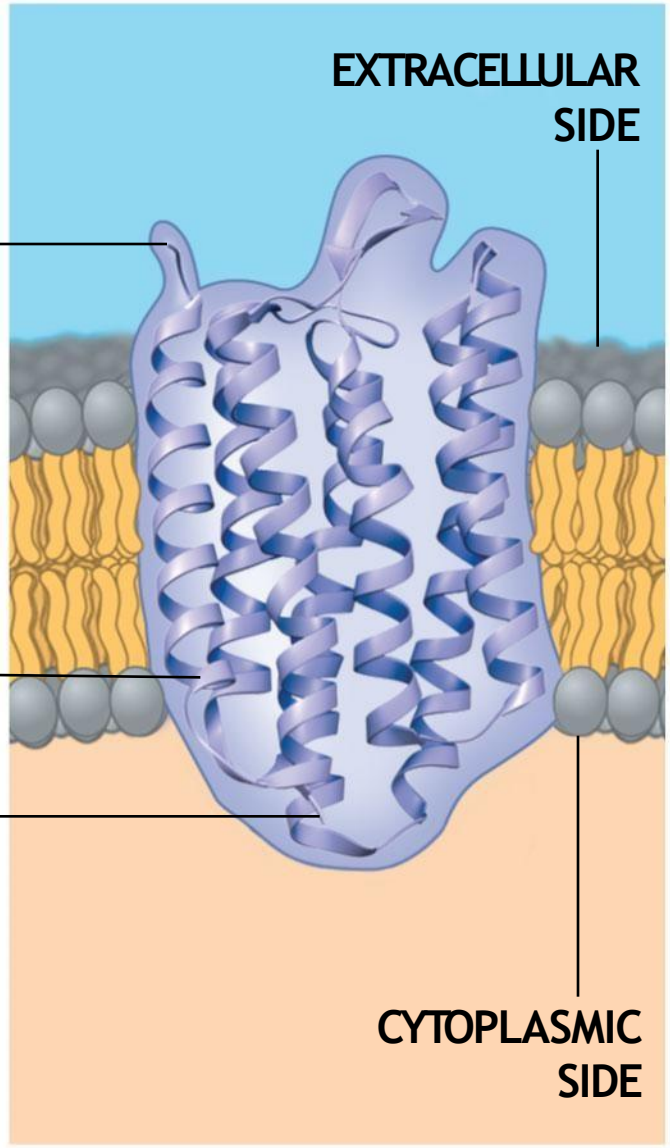
a. *Integral proteins*

The integral proteins, also known as transmembrane proteins, are tightly bound with the cell membrane. These protein molecules pass through the entire thickness of the cell membrane from one side to the other side.

7.9Figure

Structure of a membrane protein

- Integral or peripheral



This protein has secondary and tertiary structure, but no quaternary structure

B-Peripheral proteins

The peripheral proteins, also known as peripheral membrane proteins do not penetrate the cell membrane but are embedded partially in the outer and inner surfaces of the cell membrane.
These protein molecules are loosely bound with the cell membrane and so dissociate readily from the cell membrane

Functions of protein layers

Functionally, the proteins in the cell membrane exist in different forms such as integral proteins, channel proteins, carrier proteins etc.

1. *Integral proteins* provide structural integrity of the cell membrane

2. *Channel proteins* provide route for diffusion of water soluble substances like glucose and electrolytes

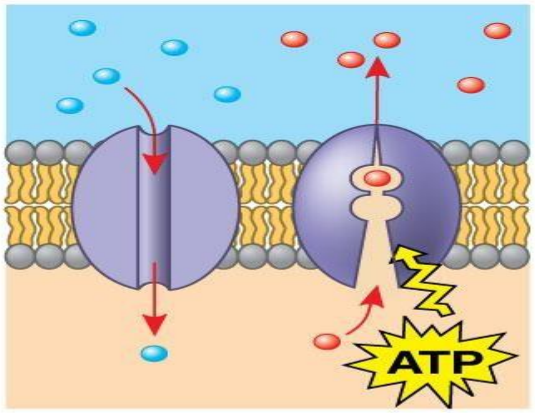
3. *Carrier proteins* help in transport of substances across the cell membrane

4. *Receptor proteins* serve as receptor sites for hormones and neurotransmitters

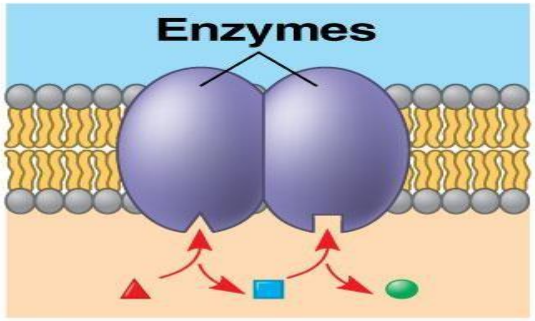
5. *Enzymes:* some of the protein molecules form the enzymes which control chemical reactions within the cell membrane

6. *Antigens:* Some proteins act as antigens and induce the process of antibody formation.

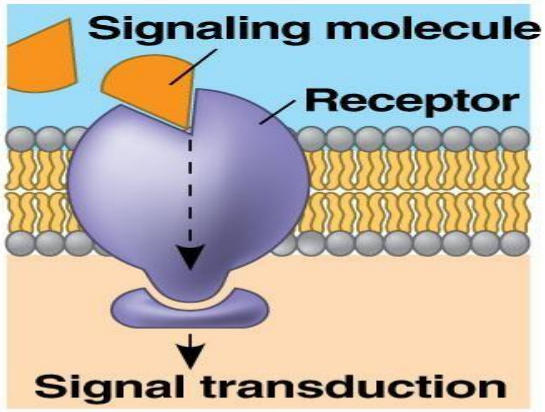
Six Abilities of Membrane Proteins



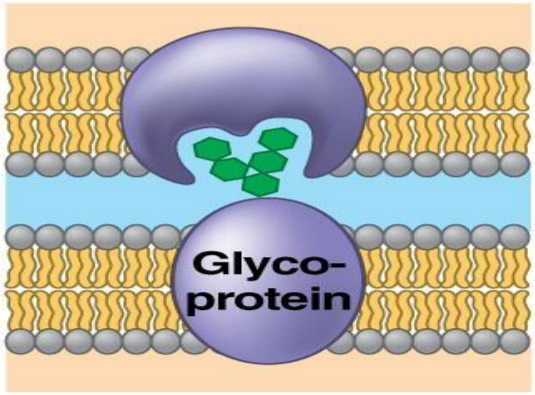
(a) Transport



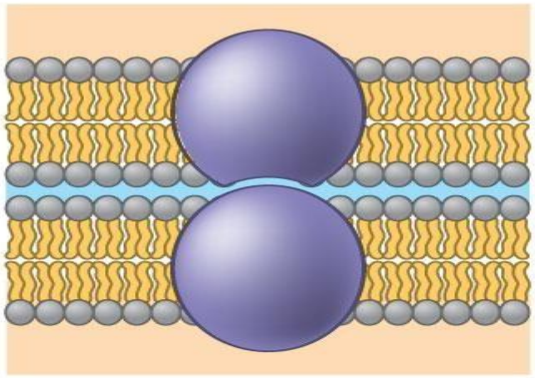
(b) Enzymatic activity



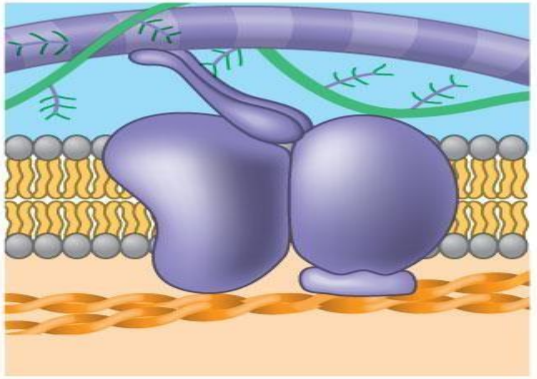
(c) Signal transduction



(d) Cell-cell recognition



(e) Intercellular joining



(f) Attachment to the cytoskeleton and extracellular matrix (ECM)

Carbohydrates of the Cell Membrane

Carbohydrate molecules form a thin loose covering over the entire surface of the cell membrane called glycocalyx. Some carbohydrate molecules are attached with proteins and form glycoproteins and some are attached with lipidsand form glycolipids.

Functions of carbohydrates

1. The carbohydrate molecules are negatively charged and do not permit the negatively charged substances to move in and out of the cell.
2. The glycocalyx from the neighboring cells helps in the tight fixation of cells with one another.
3. Some of the carbohydrate molecules form the receptors for some hormones.

Membrane carbohydrates in cell-cell recognition

- Cells recognize each other by binding to surface molecules, often containing carbohydrates, on the extracellular surface of the plasma membrane

- Membrane carbohydrates may be covalently bonded to lipids (forming **glycolipids**) or more commonly to proteins (forming **glycoproteins**(

- Carbohydrates on the external side of the plasma membrane vary among species, individuals, and even cell types in an individual

FUNCTIONS OF CELL MEMBRANE

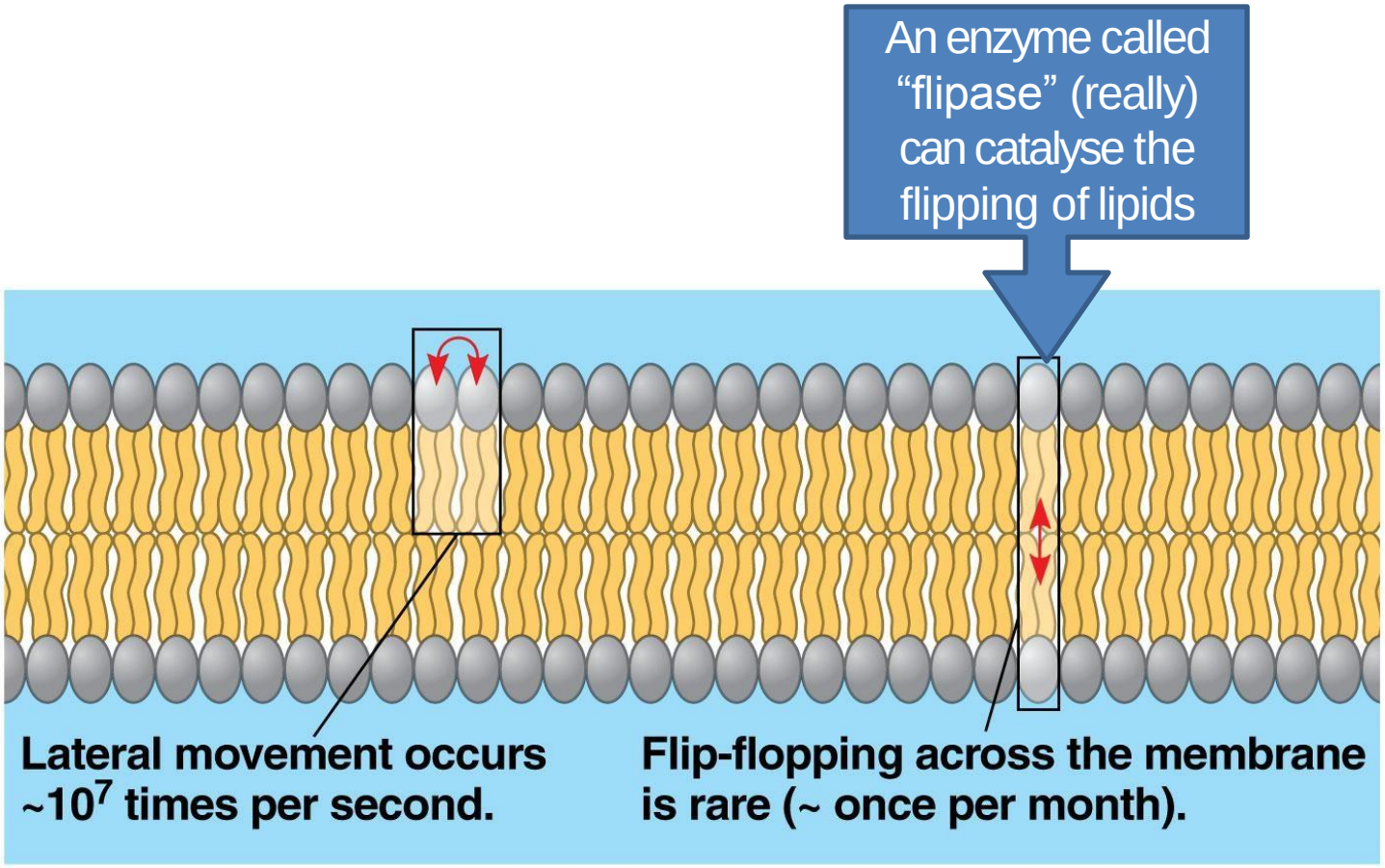
1. *Protective function:* Cell membrane protects the cytoplasm and the organelles present in the cytoplasm.
2. *Selective permeability:* Cell membrane acts as a semipermeable membrane which allows only some substances to pass through it and acts as a barrier for other substances.
3. *Absorptive function:* Nutrients are absorbed into the cell through the cell membrane

4. *Excretory function:* Metabolites and other waste products from the cell are excreted out through the cell membrane.

5. *Exchange of gases:* Oxygen enters the cell from the blood and carbon dioxide leaves the cell and enters the blood through the cell membrane.

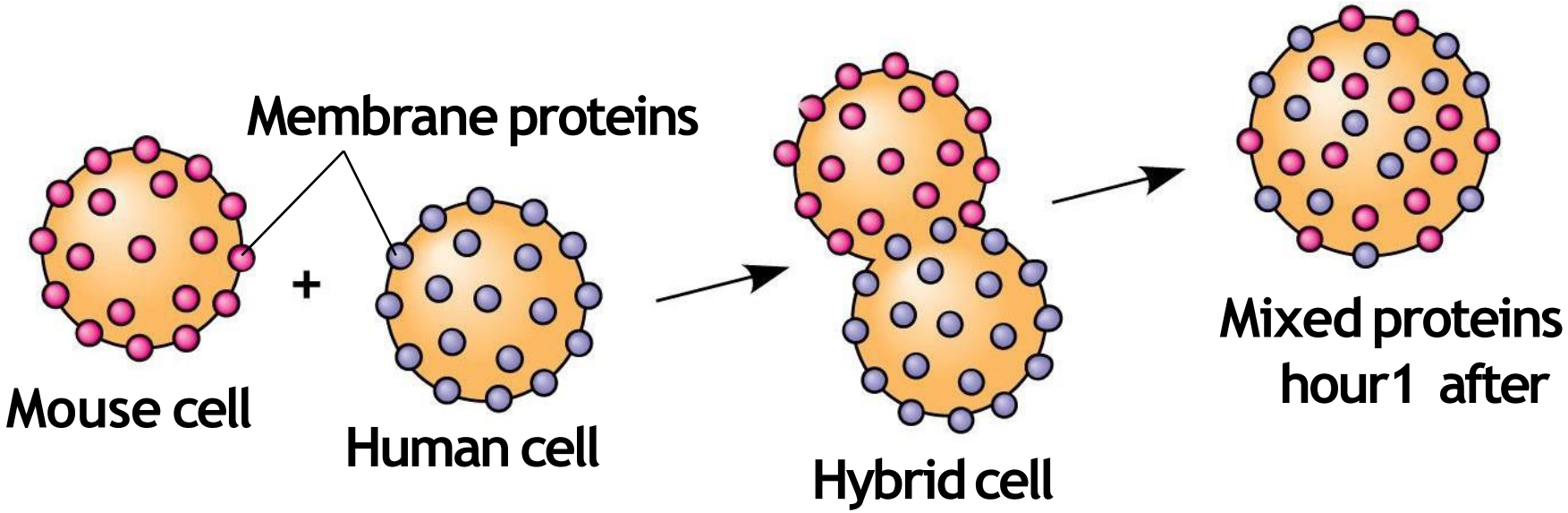
6. *Maintenance of shape and size of the cell:* Cell membrane is responsible for the maintenance of shape and size of the cell.

Movement within the membrane



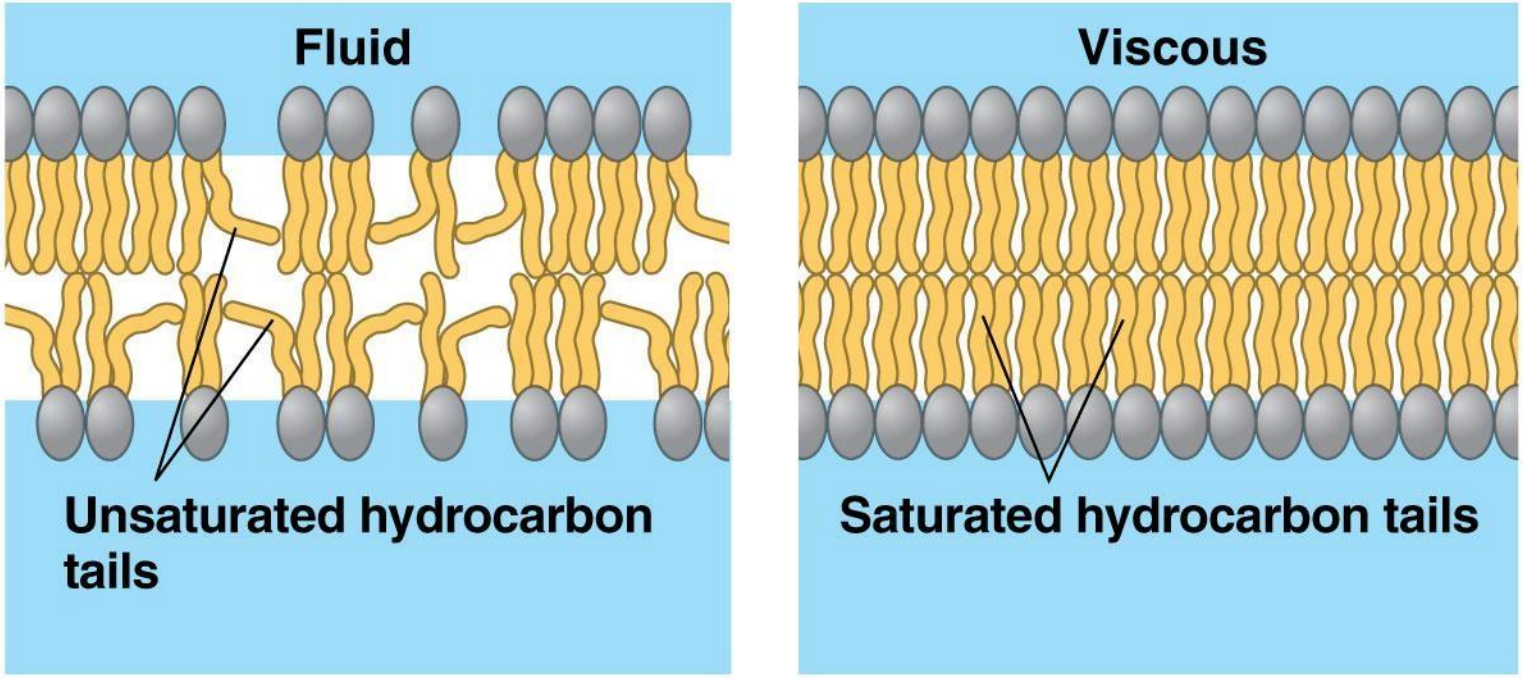
How was membrane movement demonstrated?

RESULTS



What factors influence fluidity?

- Membranes start solidifying at cool temps
- The temperature at which a membrane solidifies depends on the degree of saturation in the fatty acid tails
  - Membranes rich in unsaturated fatty acids are more fluid than those rich in saturated fatty acids
- Membranes must be fluid to work properly; they are usually about as fluid as salad oil



(a) Unsaturated versus saturated hydrocarbon tails

(b) Cholesterol within the animal cell membrane