M.Sc.- I Semester-I CBOP-1: CHG – 190

General Chemistry-I, Semester-I (4 Credits)

SECTION-I: Theory Course (2 Credits, 24 L, 6T)

(Any one option is to be selected by candidate)

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Department of Chemistry

Elective Option-C: Introduction to Chemical Biology-I

Chemistry of Biomembranes

2. Chemistry of Biomembranes (06 L)

- The plasma membrane is an envelope surrounding the cell (Refer Fig.1.1).
- It separates and protects the cell from the external hostile environment.
- Besides being a protective barrier, plasma membrane provides a connecting system between the cell and its environment.
- The subcellular organelles such as nucleus, mitochondria, lysosomes are also surrounded by membranes.

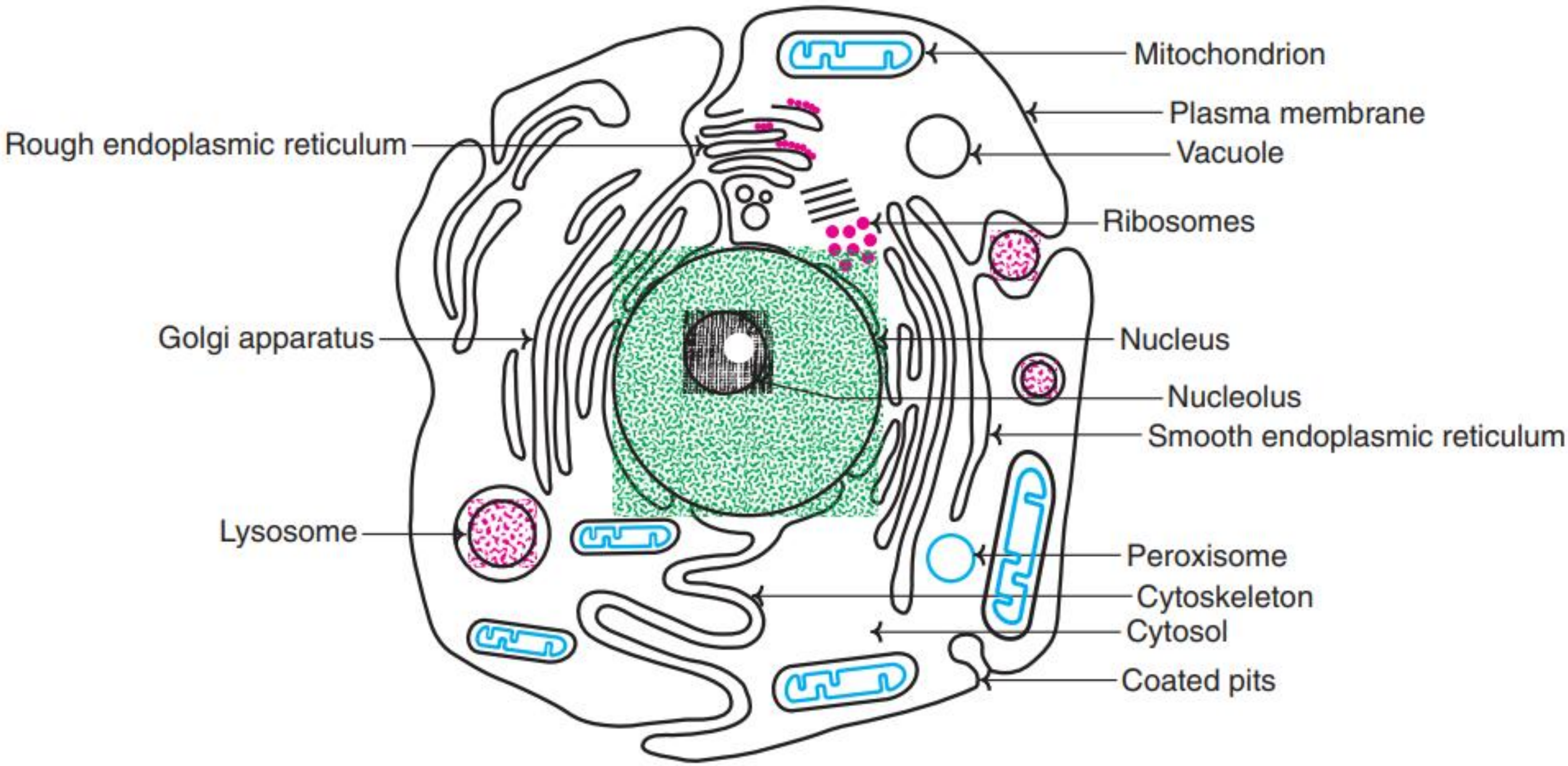

Fig. 1.1 : *Diagrammatic representation of a rat liver cell.*

Chemical composition:

- The membranes are composed of lipids, proteins and carbohydrates.
- The actual composition differs from tissue to tissue.
- Among the lipids, amphipathic lipids (containing hydrophobic and hydrophilic groups) namely phospholipids, glycolipids and cholesterol, are found in the animal membranes.
- Many animal cell membranes have thick coating of complex polysaccharides referred to as glycocalyx. The oligosaccharides of glycocalyx interact with collagen of intercellular matrix in the tissues.

Structure of membranes:

- A lipid bilayer model originally proposed for membrane structure in 1935 by Davson and Danielle has been modified.
- Fluid mosaic model, proposed by Singer and Nicolson, is a more recent and acceptable model for membrane structure.
- The biological membranes usually have a thickness of 5-8 nm.
- A membrane is essentially composed of a lipid bilayer.
- The hydrophobic (nonpolar) regions of the lipids face each other at the core of the bilayer while the hydrophilic (polar) regions face outward.
- Globular proteins are irregularly embedded in the lipid bilayer (Fig.33.1). Membrane proteins are categorized into two groups.

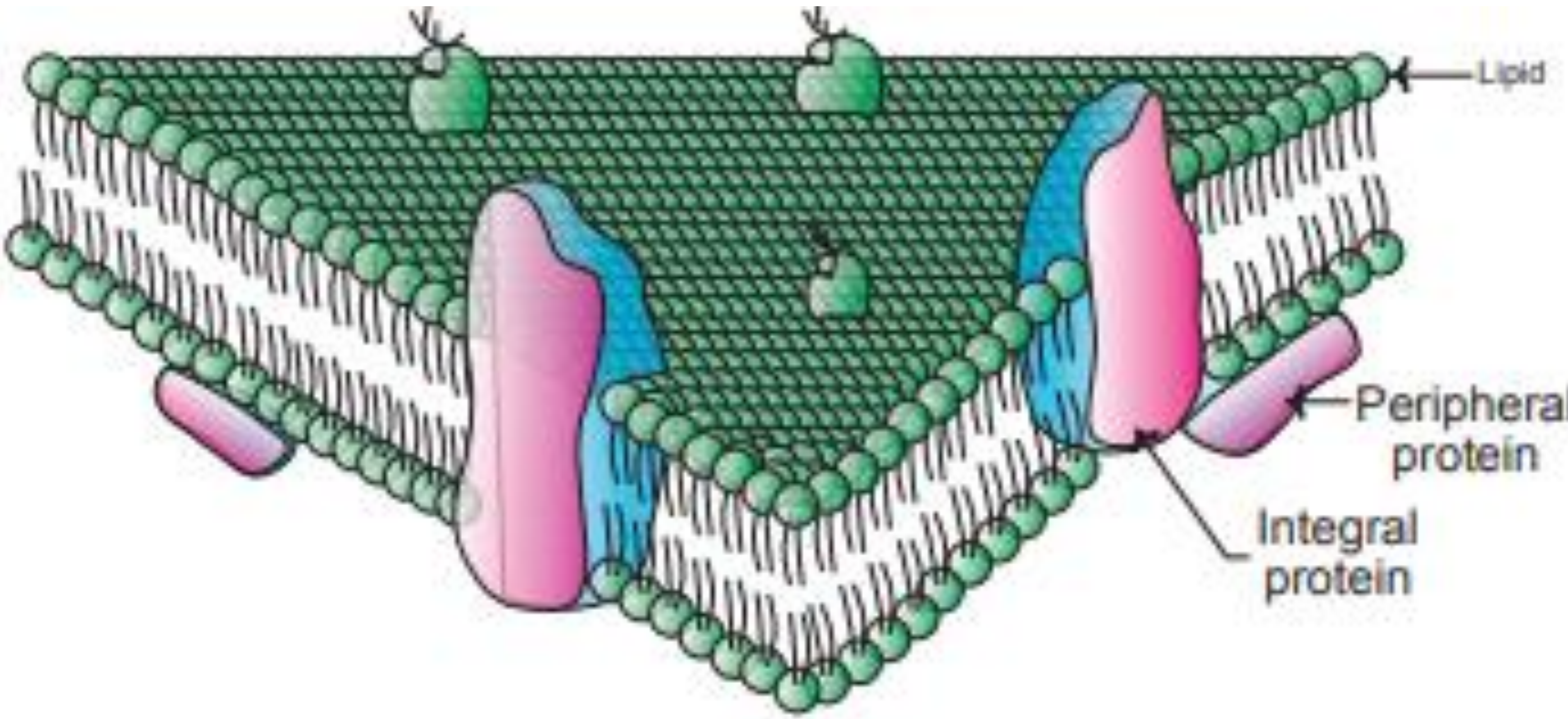

Fig. 33.1 : The fluid mosaic model of membrane structure.

1. Extrinsic (peripheral) membrane proteins are loosely held to the surface of the membrane and they can be easily separated e.g. cytochrome c of mitochondria.
2. Intrinsic (integral) membrane proteins are tightly bound to the lipid bilayer and they can be separated only by the use of detergents or organic solvents e.g. hormone receptors, cytochrome P_{450}.
3. The membrane is asymmetric due to the irregular distribution of proteins. The lipid and protein subunits of the membrane give an appearance of mosaic or a ceramic tile. Unlike a fixed ceramic tile, the membrane freely changes, hence the structure of the membrane is considered as fluid mosaic.

Transport across membranes:

•The biological membranes are relatively impermeable.

•The membrane, therefore, forms a barrier for the free passage of compounds across it.

•At least three distinct mechanisms have been identified for the transport of solutes (metabolites) through the membrane (Fig.33.2).

1. Passive diffusion
2. Facilitated diffusion
3. Active transport.

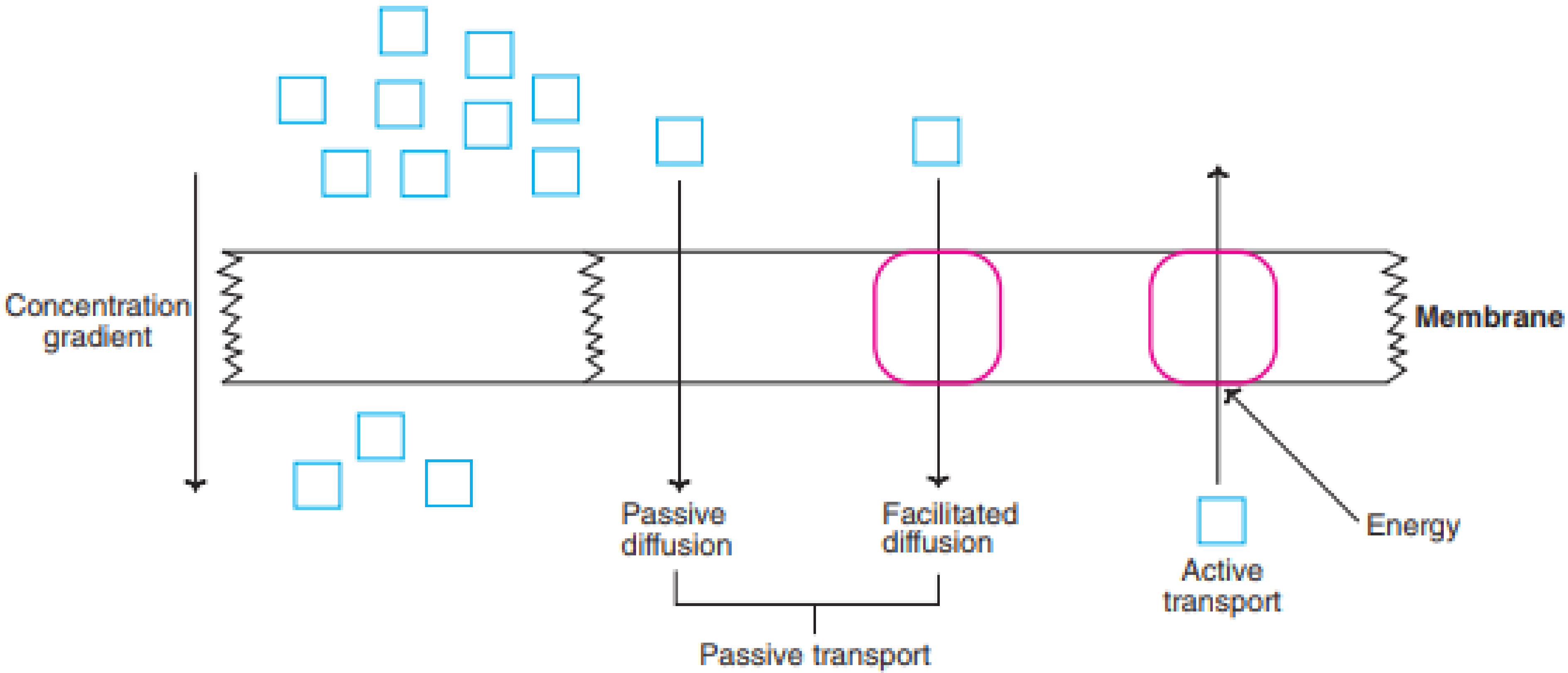

***Fig. 33.2 :** Mechanism of transport across biological membrane*
*(**Note :** Transport molecule are represented in blue; the carrier proteins in red).*

1. Passive diffusion :

a. This is a simple process which depends on the concentration gradient of a particular substance across the membrane.

b. Passage of water and gases through membrane occurs by passive diffusion. This process does not require energy.

2. Facilitated diffusion:

a. This is somewhat comparable with diffusion since the solute moves along the concentration gradient (from higher to lower concentration) and no energy is needed.

b. But the most important distinguishing feature is that facilitated diffusion occurs through the mediation of carrier or transport proteins.

a. Specific carrier proteins for the transport of glucose, galactose, leucine, phenylalanine etc. have been isolated and characterized.

b. Mechanism of facilitated diffusion :

I. A ping-pong model is put forth to explain the occurrence of facilitated diffusion (Fig.33.3).

II. According to this mechanism, a transport (carrier) protein exists in two conformations.

III. In the pong conformation, it is exposed to the side with high solute concentration.

IV. This allows the binding of solute to specific sites on the carrier protein.

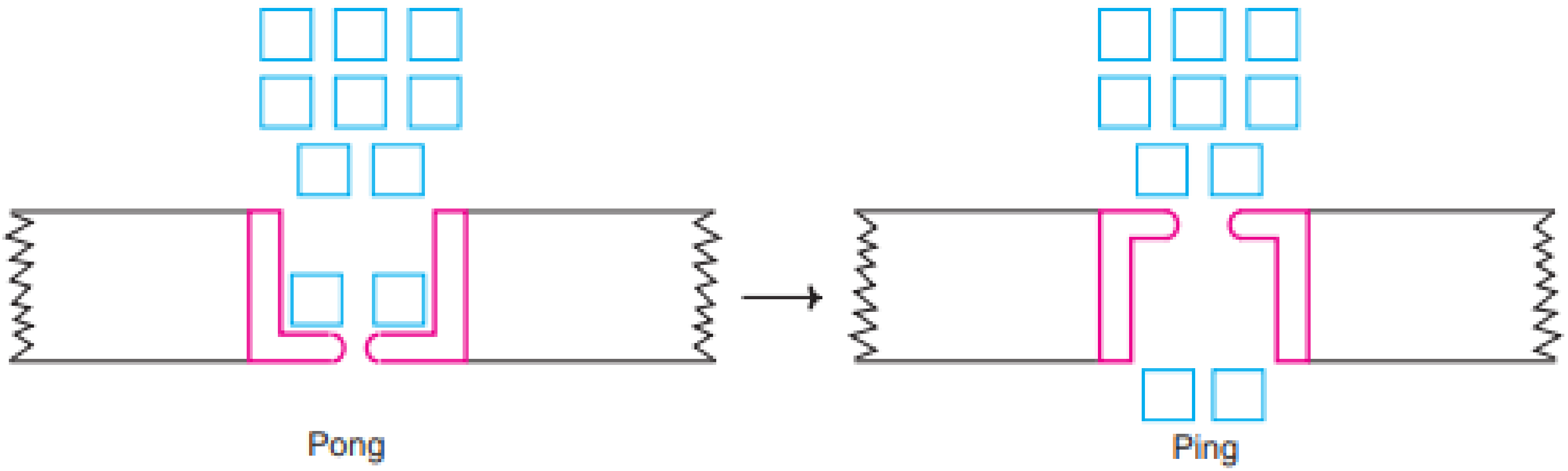

***Fig. 33.3 :** A diagrammatic representation of 'ping-pong' model for facilitated diffusion.*

I. The protein then undergoes a conformational change (ping state) to expose to the side with low solute concentration where the solute molecule is released.
II. Hormones regulate facilitated diffusion.
III. For instance, insulin increases glucose transport in muscle and adipose tissue; amino acid transport in liver and other tissues.

3. Active transport :

•Active transport occurs against a concentration gradient and this is dependent on the supply of metabolic energy (ATP).

•Active transport is also a carrier mediated process like facilitated diffusion.

•The most important primary active transport systems are ion-pumps (through the involvement of pump ATPases or ion transporting ATPases).

Na^+-K^+ pump :

- The cells have a high intracellular K^+ concentration and a low Na^+ concentration. This is essentially needed for the survival of the cells.
- High cellular K^+ is required for the optimal glycolysis (pyruvate kinase is dependent on K^+) and for protein biosynthesis.
- Further, Na^+ and K^+ gradients across plasma membranes are needed for the transmission of nerve impulse.
- The Na^+ - K^+ pump is responsible for the maintenance of high K^+ and low Na^+ concentrations in the cells.