24.1 Structure and Classification of Lipids

- ***Lipids*** are naturally occurring molecules from plants or animals that are soluble in nonpolar organic solvents.
- Lipid molecules contain large hydrocarbon portion and not many polar functional group, which accounts for their solubility behavior.

$R{-}COOH + R'{-}OH$

$R{-}C(=O){-}O{-}R'$

Classification of Lipids

Lipids that are ester or amides of fatty acids:

- *Waxes* – are carboxylic acid esters where both R groups are long straight hydrocarbon chain. Performs external protective functions.
- *Triacylglycerol* – are carboxylic acid triesters of glycerols. They are a major source of biochemical energy.
- *Glycerophopholipids* - triesters of glycerols that contain charged phosphate diesters. They help to control the flow of molecules into and out of cells.

$+ 3\ R{-}C(=O){-}OH$

- *Sphingomyelins* – amides derived from an amino alcohol, also contain charged phosphate diester groups. They are essential to the structure of cell membranes.
- *Glycolipids* – amides derived from sphingosine, contain polar carbohydrate groups. On the cell surface, they connect with by intracellular messengers.

Lipids that are not esters or amides:

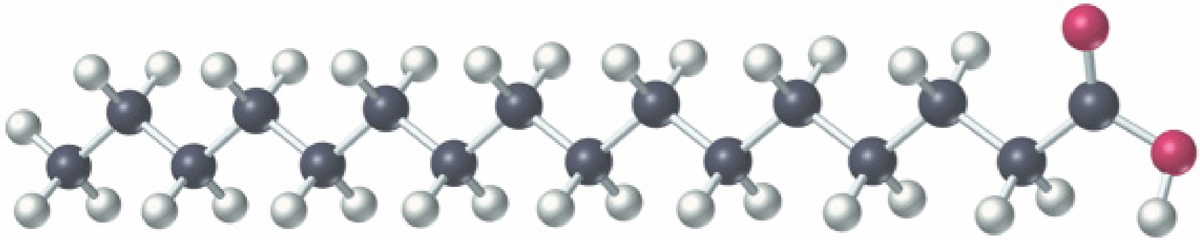
- *Steroids* – They performs various functions such as hormones and contributes to the structure of cell membranes.
- *Eicosanoids* – They are carboxylic acids that are a special type of intracellular chemical messengers.

24.3 Properties of Fats and Oils

Oils: A mixture of triglycerols that is liquid because it contains a high proportions of unsaturated fatty acids.

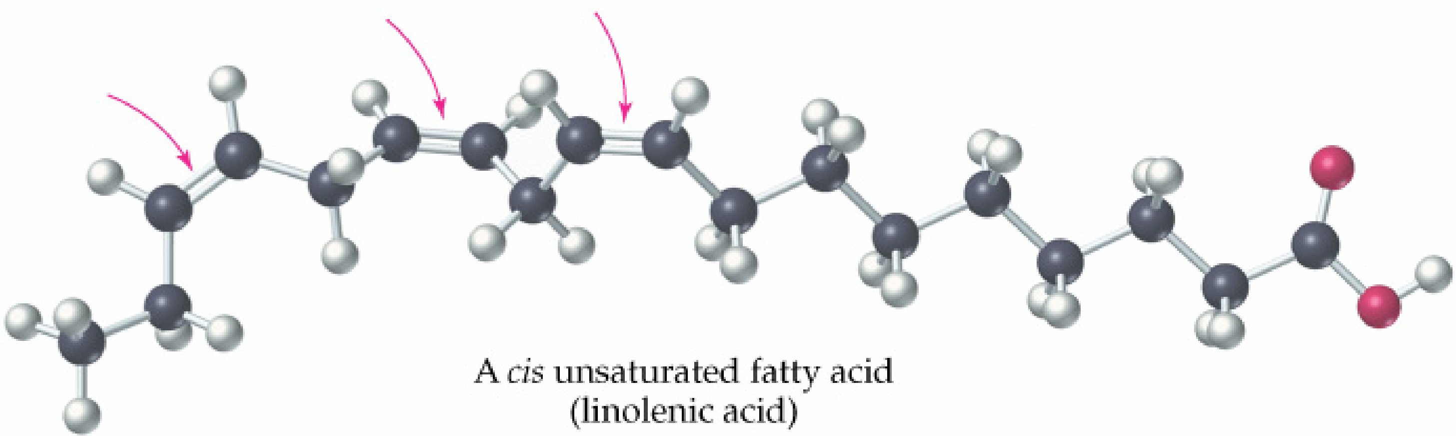
Fats: A mixture of triglycerols that is solid because it contains a high proportions of saturated fatty acids.

$$\mathrm{CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}{-}OH}$$



A saturated fatty acid
(palmitic acid)

$$\mathrm{CH_3CH_2CH{=}CHCH_2CH{=}CHCH_2CH{=}CHCH_2CH_2CH_2CH_2CH_2CH_2CH_2\overset{\displaystyle O}{\overset{\|}{C}}{-}OH}$$



A *cis* unsaturated fatty acid
(linolenic acid)

Properties of triglycerols in natural fats and oils:

- Nonpolar and hydrophobic
- No ionic charges
- Solid triglycerols (Fats) - high proportions of saturated fatty acids.
- Liquid triglycerols (Oils) - high proportions of unsaturated fatty acids.

24.4 Chemical Reactions of Triglycerols

Hydrogenation: The carbon-carbon double bonds in unsaturated fatty acids can be hydrogenated by reacting with hydrogen to produce saturated fatty acids. For example, margarine is produced when two thirds of the double bonds present in vegetable oil is hydrogenated.

Hydrolysis of triglycerols: Triglycerols like any other esters react with water to form their carboxylic acid and alcohol – a process known as hydrolysis.

- In body, this hydrolysis is catalyzed by the enzyme hydrolase and is the first step in the digestion of dietary fats and oils.
- In the laboratory and commercial production of soap, hydrolysis of fats and oils is usually carried out by strong aqueous bases such as NaOH and KOH and is called saponification.

24.5 Cell Membrane Lipids: Phosphilipids and Glycolipids

- Cell membranes establish a hydrophobic barrier between the watery environment in the cell and outside the cell. Lipids are ideal for this function.
- The three major kinds of cell membrane lipids in animals are *phospholipids*, *glycolipids*, and *cholesterol*.

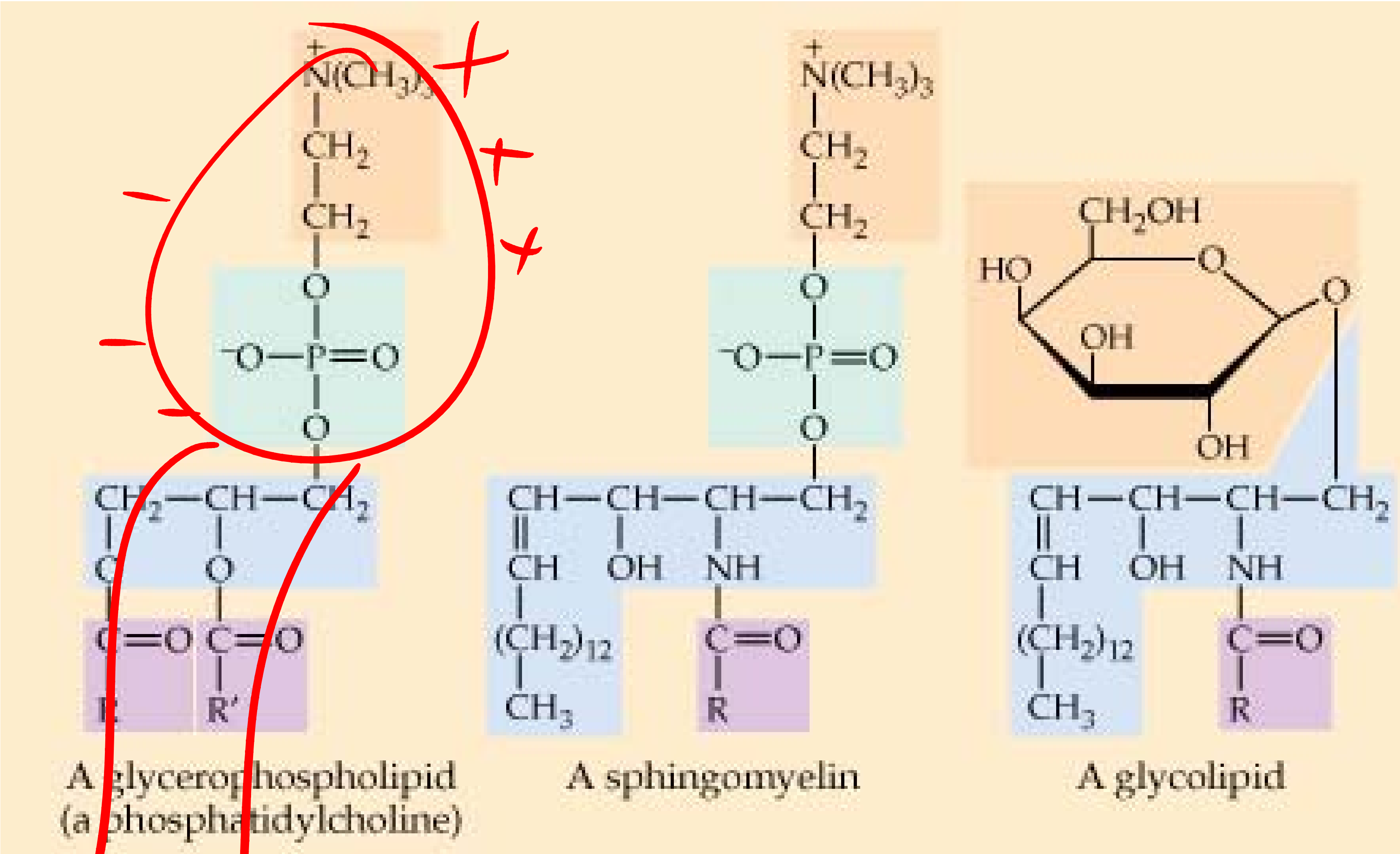
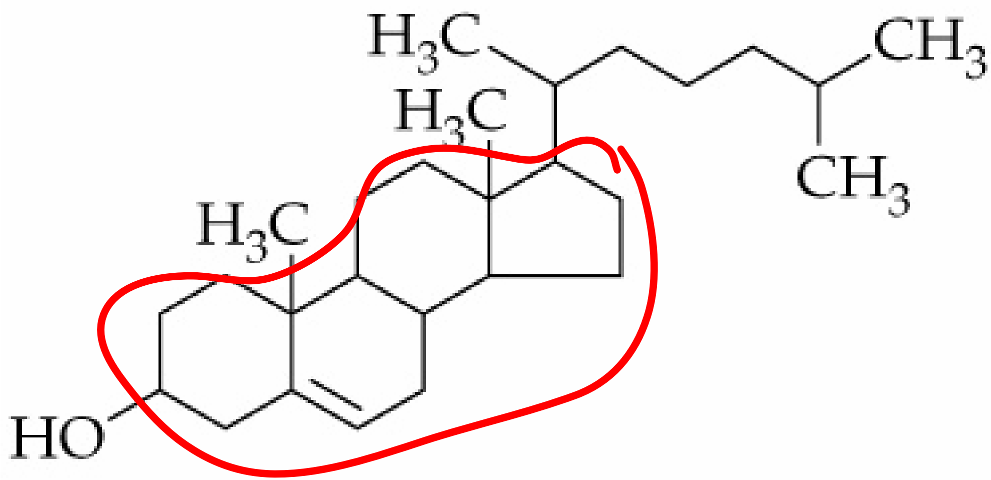


Fig 24.4 Membrane lipids

- Phosphoilipids contain an ester link between a phosphoric acid and an alcohol. The alcohol is either a glycerol to give a glycerophopholipid or a sphingosine to give sphingomyelins.
- Glycolipids: Glycolipids are derived from sphingosine. They differ from sphingomyelins by having a carbohydrate group at C1 instead of a phosphate bonded to a choline.

24.5 Cell Membrane Lipids: Cholesterol

- Animal cell membranes contain significant amount of cholesterol.

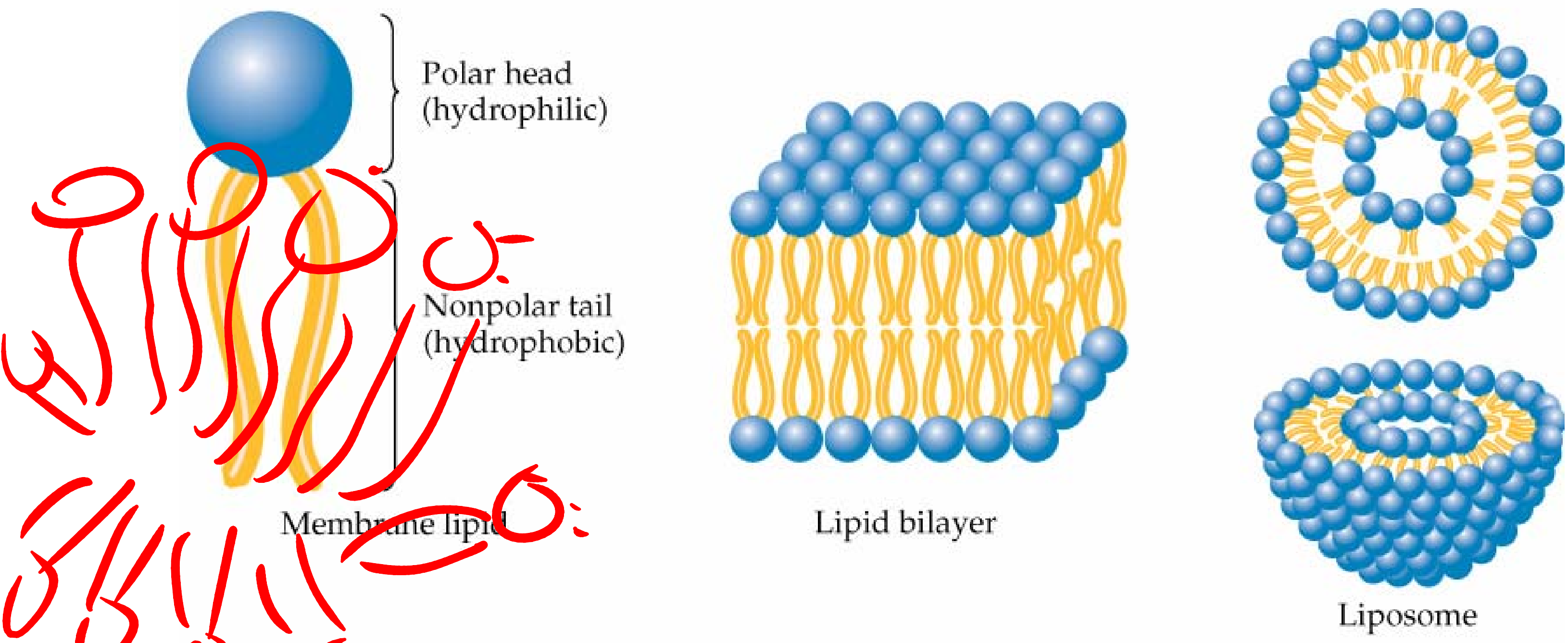


Cholesterol

- Cholesterol is a steroid, a member of the class of lipids that all contain the same four ring system.
- Cholesterol serves two important purposes: as a component of cell membranes and as a starting materials for the synthesis of all other steroids.

24.7 Structure of Cell Membranes

The basic structural unit of cell membrane is lipid bilayer which is composed of two parallel sheets of membrane lipid molecules arranged tail to tail. Bilayers are highly ordered and stable, but still flexible.



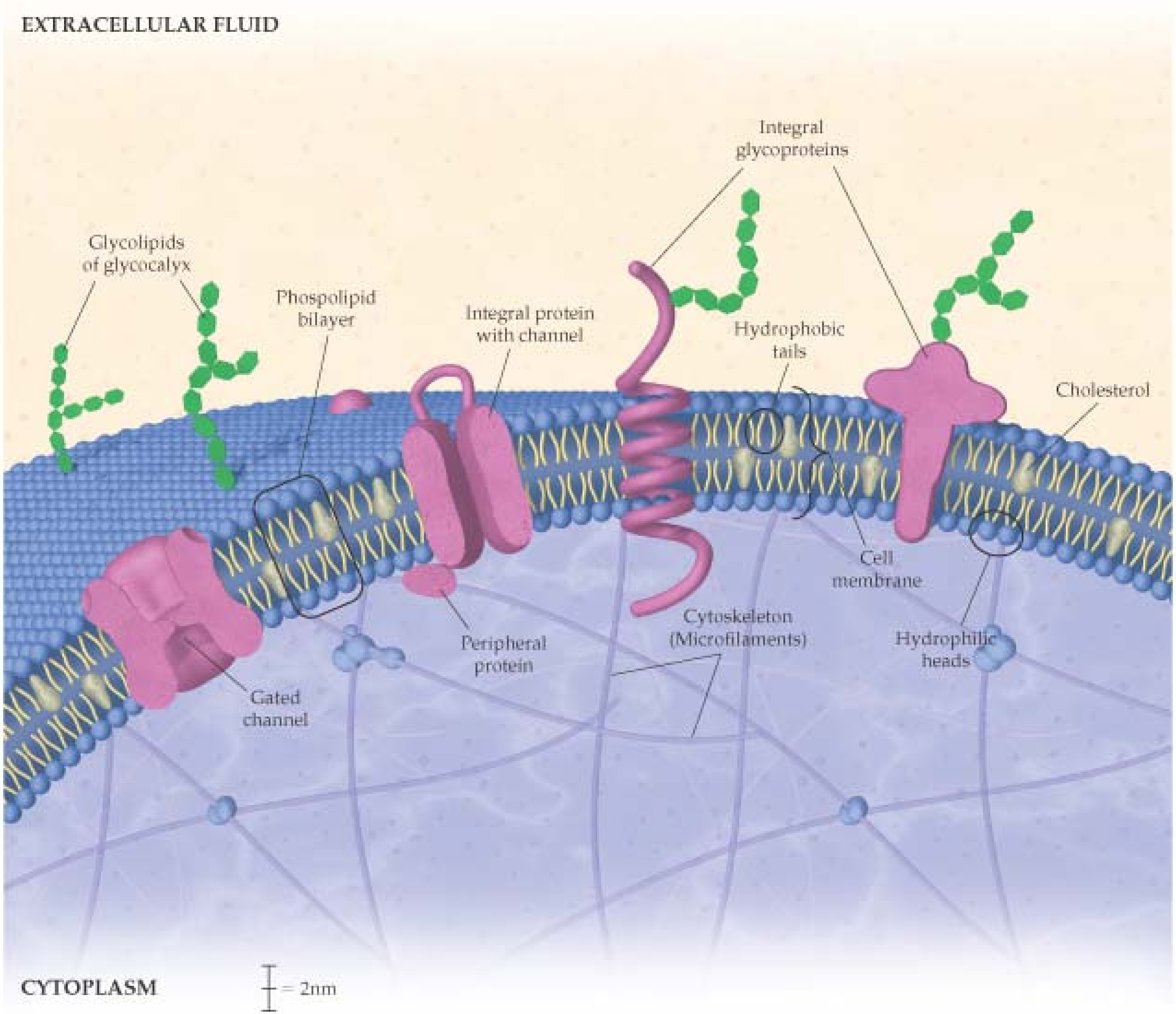


Fig 24.7 The cell membrane

When phospholipids are shaken vigorously with water, they spontaneously form liposome – small spherical vesicle with lipid bilayer surrounding an aqueous center. Water soluble substances can be trapped in the center of the liposome, and lipid-soluble substances can be incorporated into the bilayer.

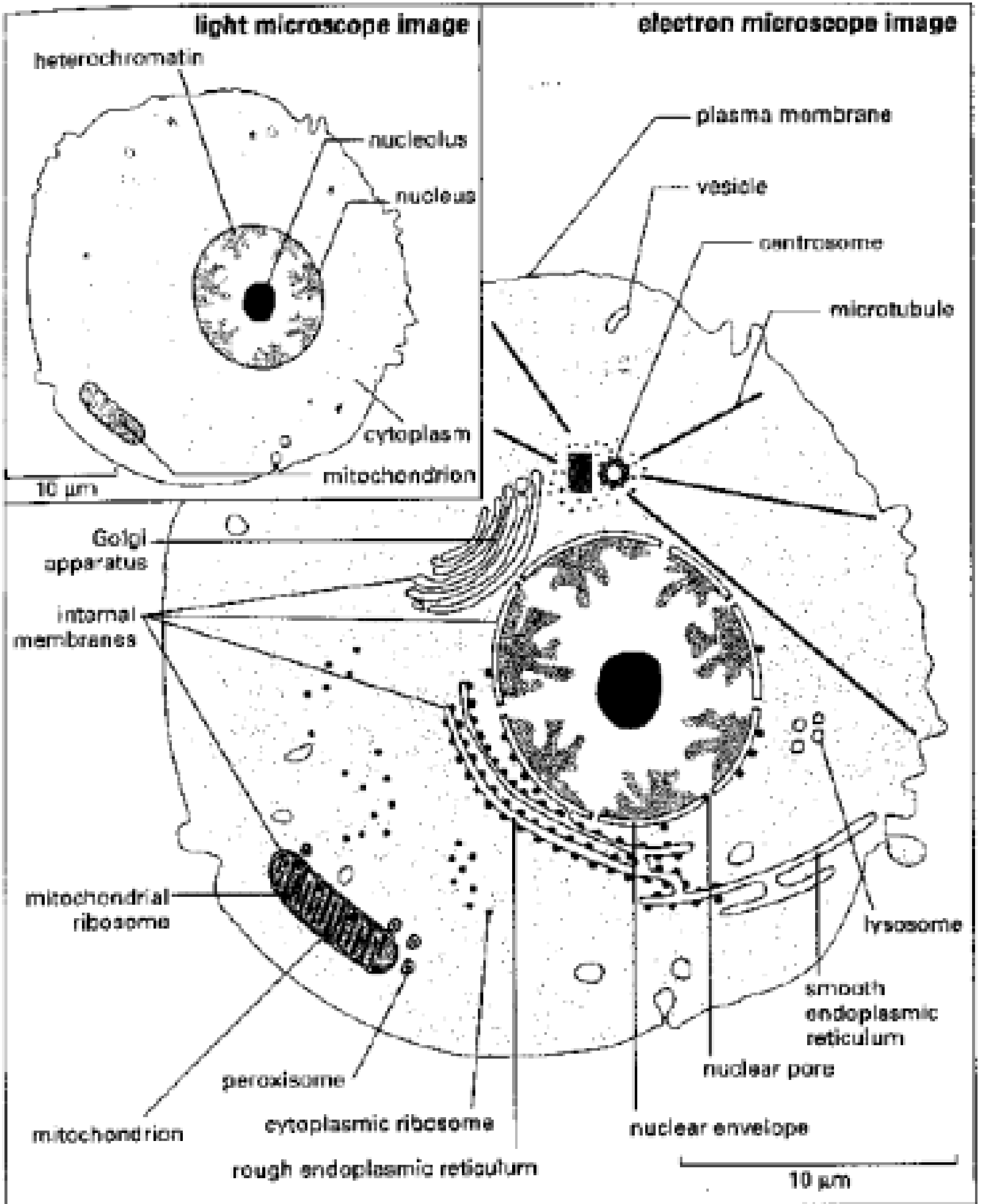
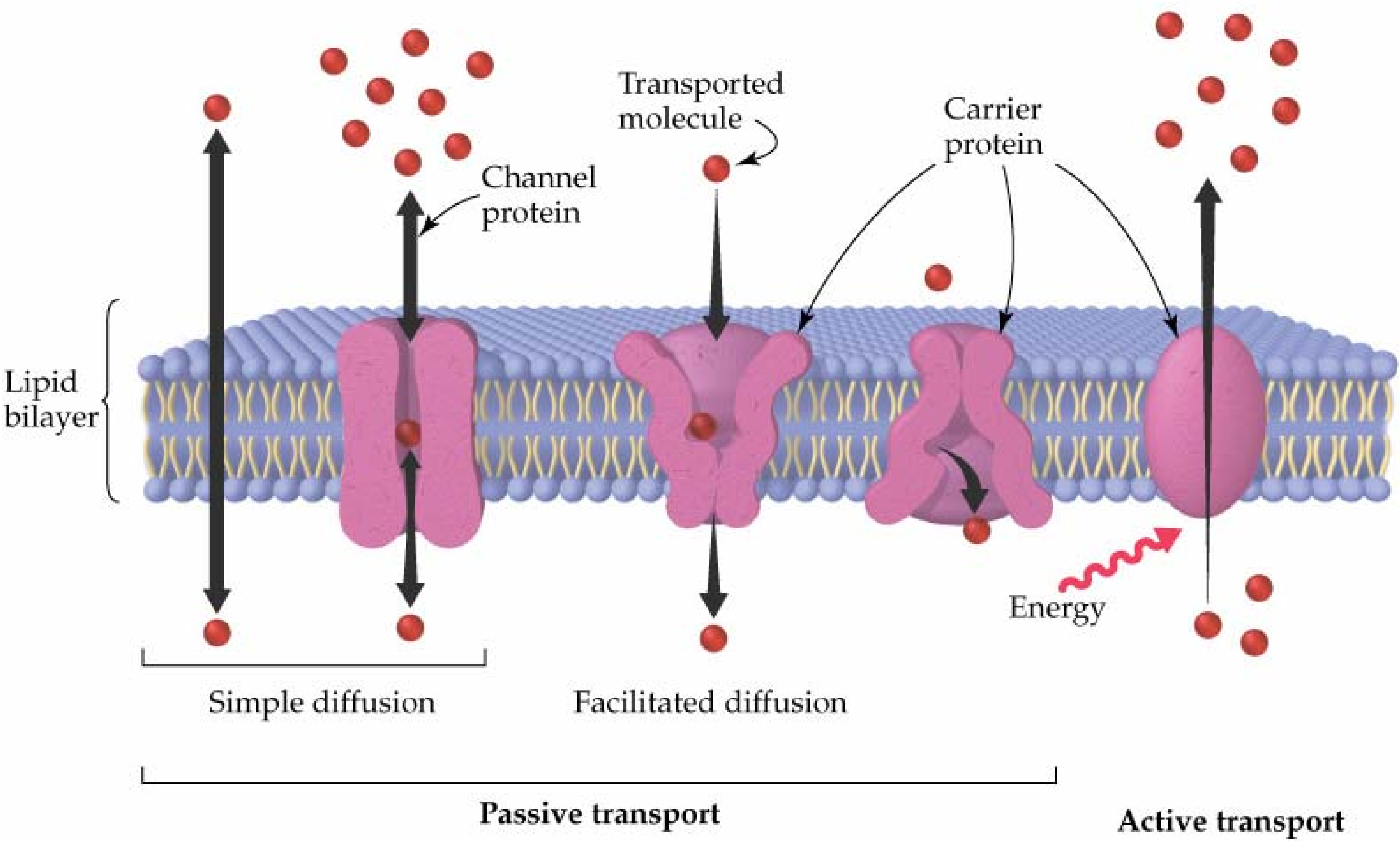


Figure 1.2. Cell structure as seen through the light and transmission electron microscopes.

24.8 Transport Across Cell Membranes

The cell membranes allow the passage of molecules and ions into and out of a cell by two modes; passive transportation and active transportation.

- *Passive transport* – substances move across the cell membrane freely by diffusion from regions of higher concentration to regions of lower concentration. Glucose is transported into many cells in this way.


Transported
molecule
Channel
protein
Carrier
protein
Lipid
bilayer
Energy
Simple diffusion
Facilitated diffusion
Passive transport
Active transport

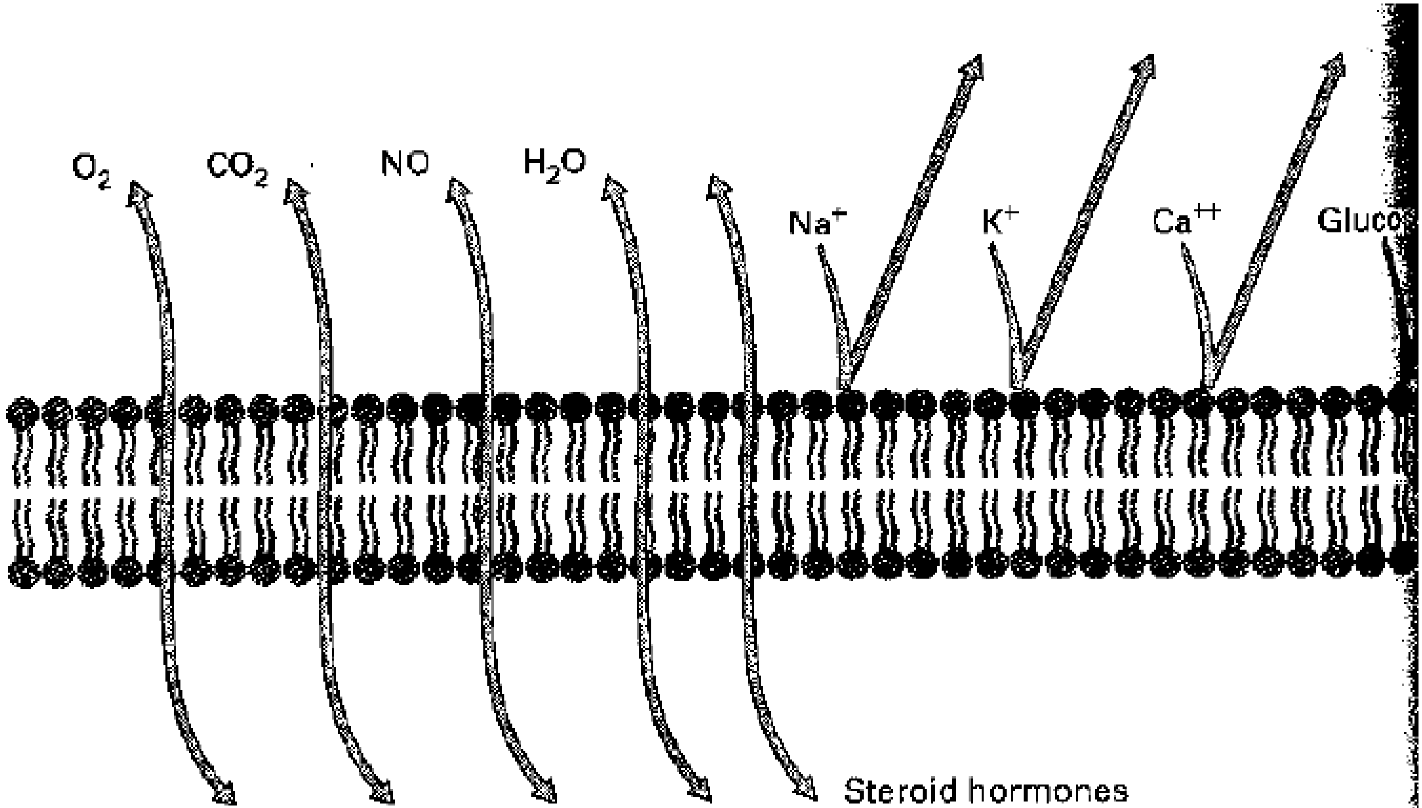


Figure 3.2. Small uncharged molecules can pass through membranes by simple diffusion, but ions can

- *Active transport* - substances move across the cell membrane only when energy is supplied because they must go in the reverse direction from regions of lower to regions of higher concentration. Only by this method, cells maintain lower Na^+ concentration within cells and higher Na^+ concentration in extracellular fluids, with the opposite concentration ratio for K^+.

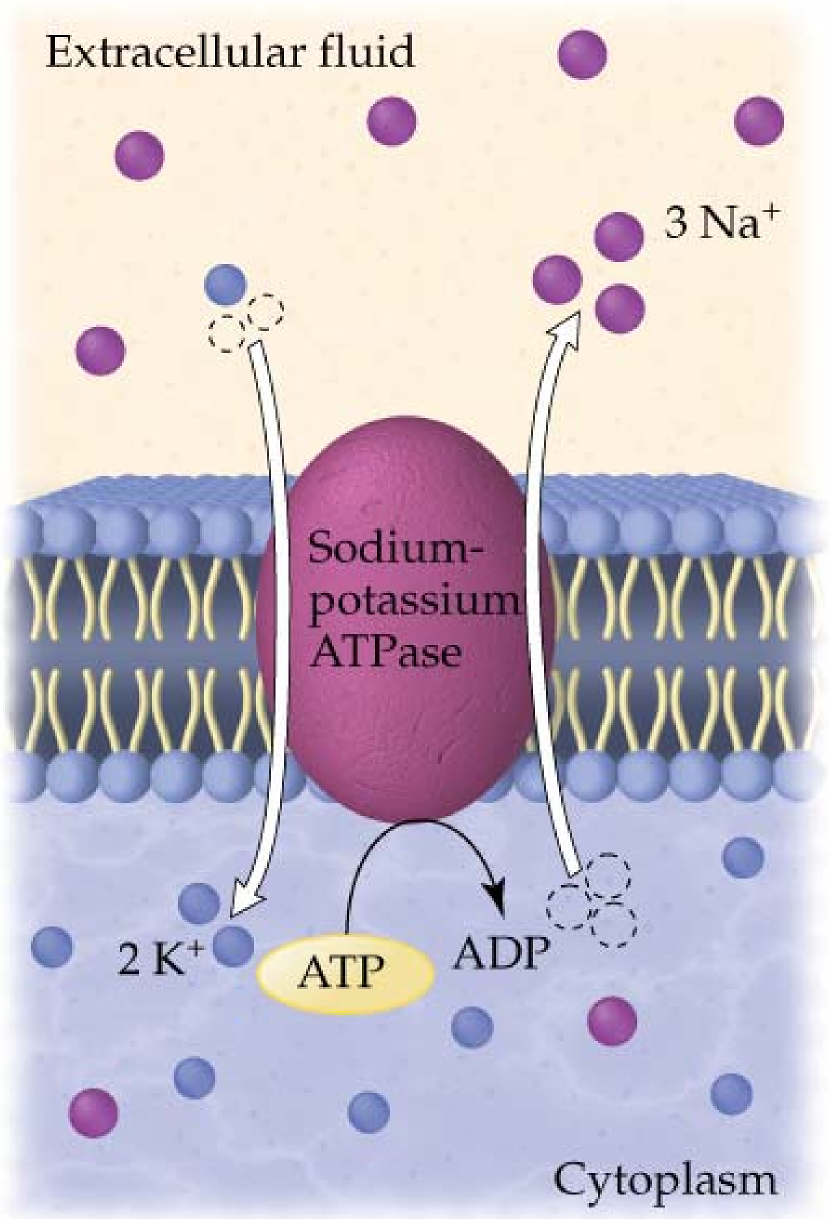


Fig 24.9 An example of active transport

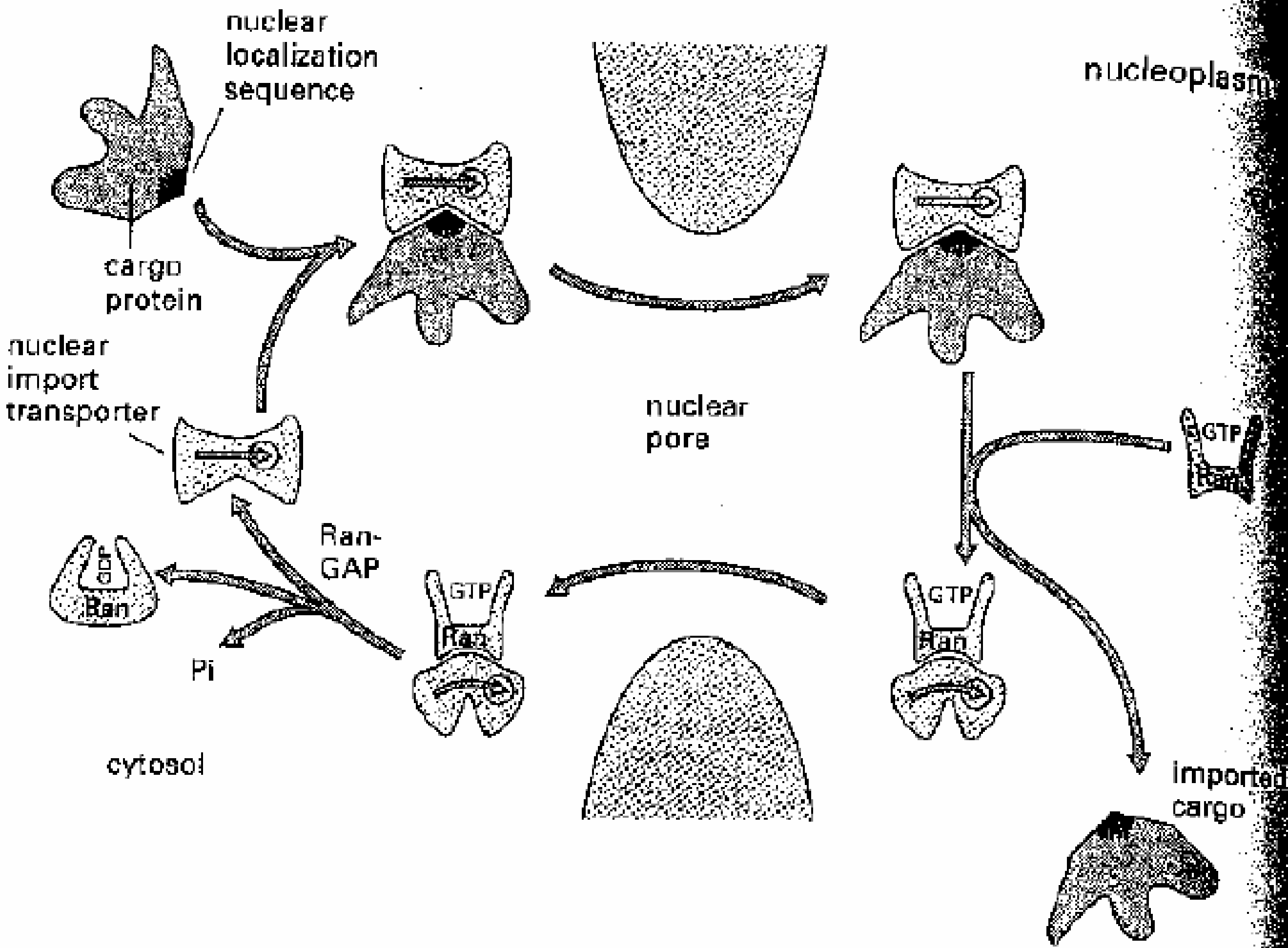


Figure 10.5. Nuclear import. Pi represents an inorganic phosphate ion.

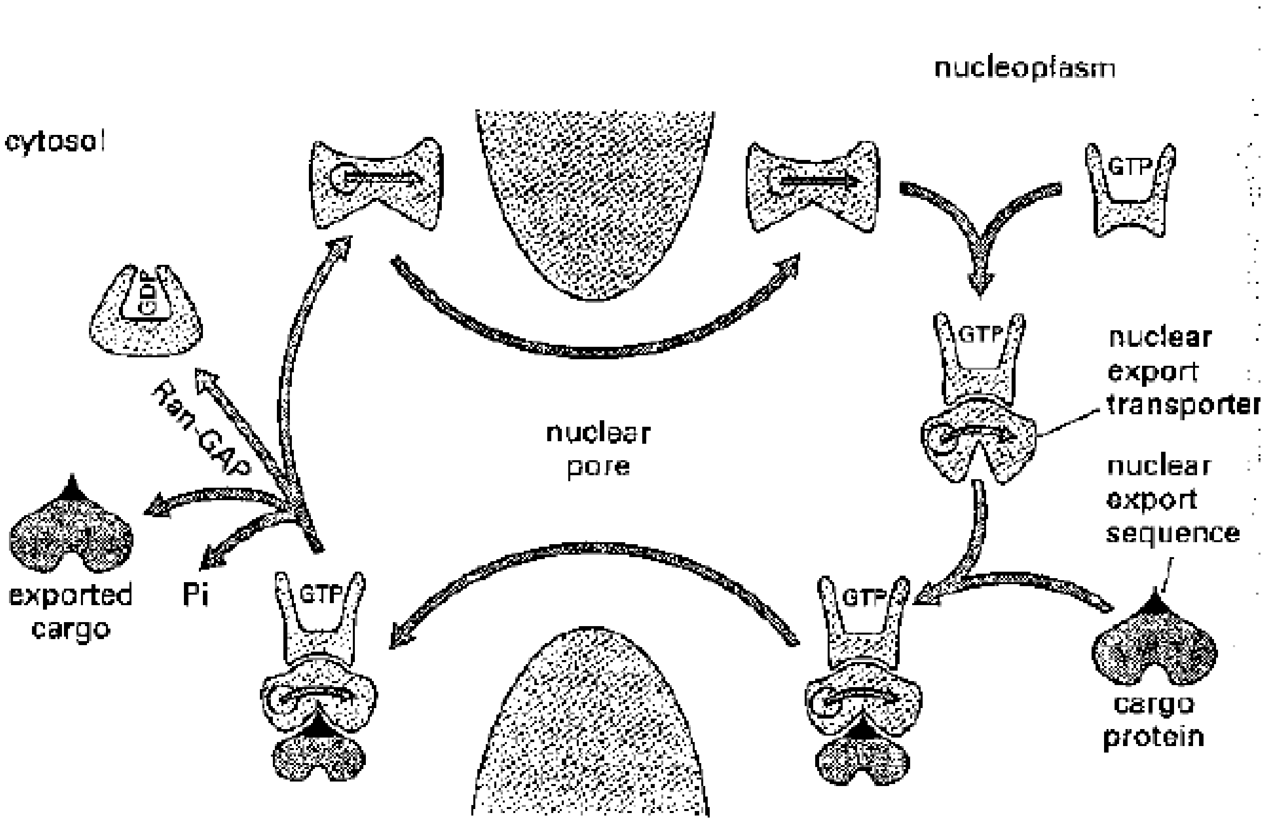


Figure 10.6. Nuclear export. Pi represents an inorganic phosphate ion.

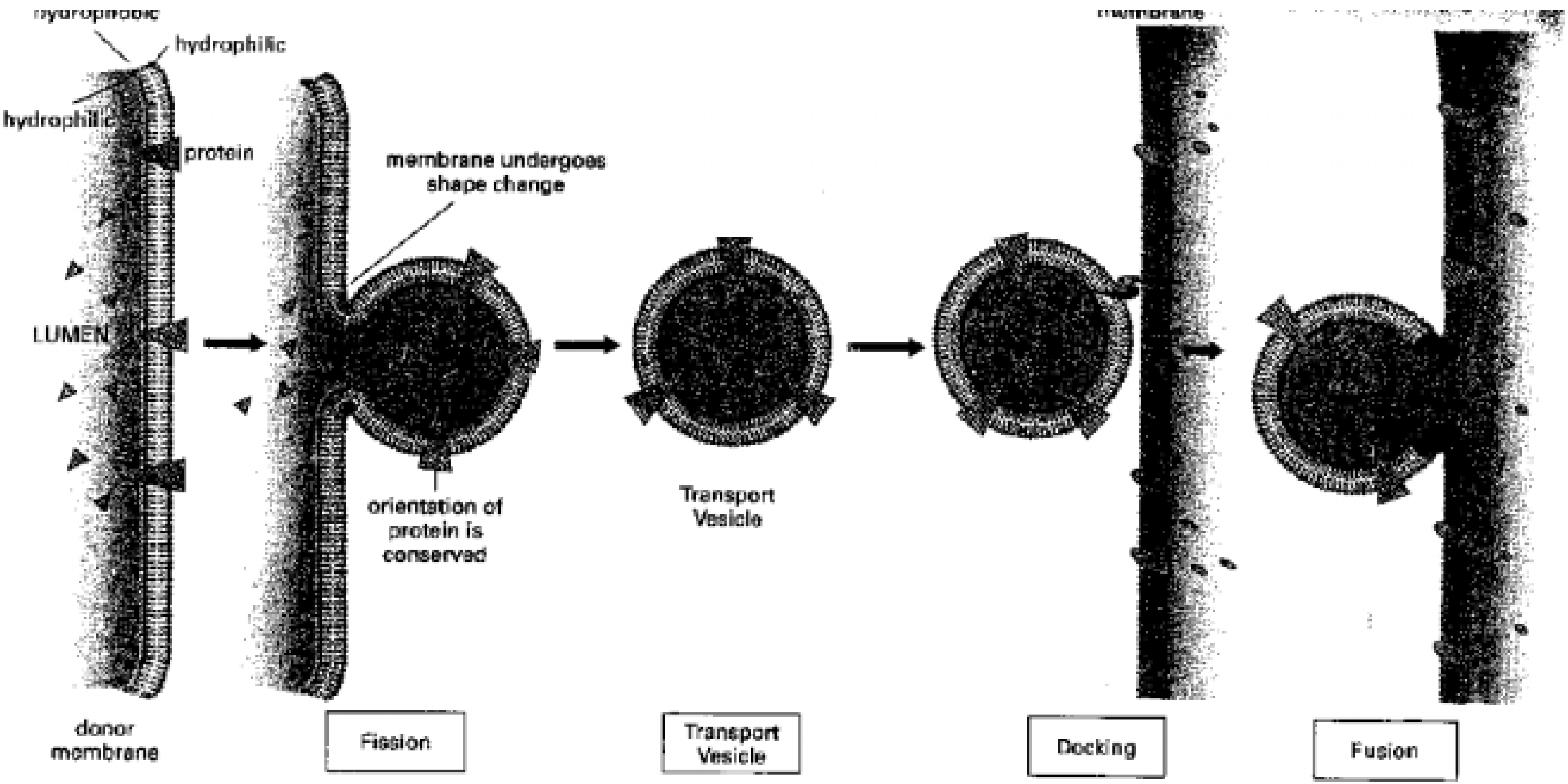


Figure 10.9. Fission and fusion.

Properties of cell membranes:

- Cell membranes are composed of a fluid like phospholipid bilayer.
- The bilayer incorporates cholesterol, proteins, and glycolipids.
- Small nonpolar molecules cross by diffusion through the lipid bilayer.

- Small ions and polar molecules diffuse through the aqueous media in protein pores.
- Glucose and certain other substances cross with the aid of proteins without energy input.
- Na^+, K^+, and other substances that maintain concentration gradients inside and outside the cell cross with expenditure of energy and the aid of proteins.

25.2 Lipoproteins for Lipid Transport

- Lipids enter metabolism from three different sources: (1) the diet, (2) storage in adipose tissue, and (3) synthesis in the liver.
- Whatever their source these lipids must eventually be transported in blood, an aqueous media.
- To become water soluble, fatty acid release from adipose tissue associate with albumin. All other lipids are carried by lipoproteins.

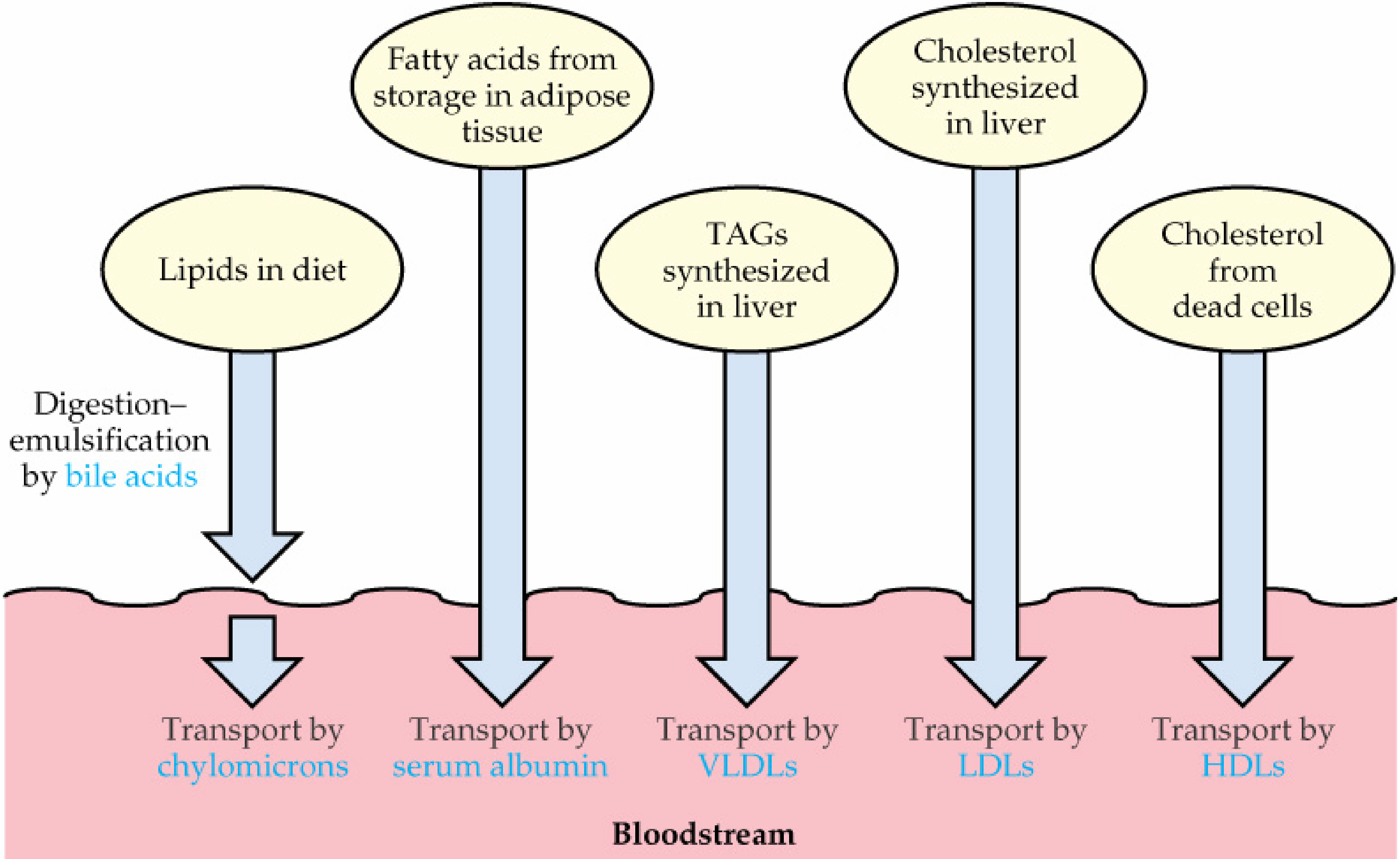


Fig 25.5 Transport of lipids