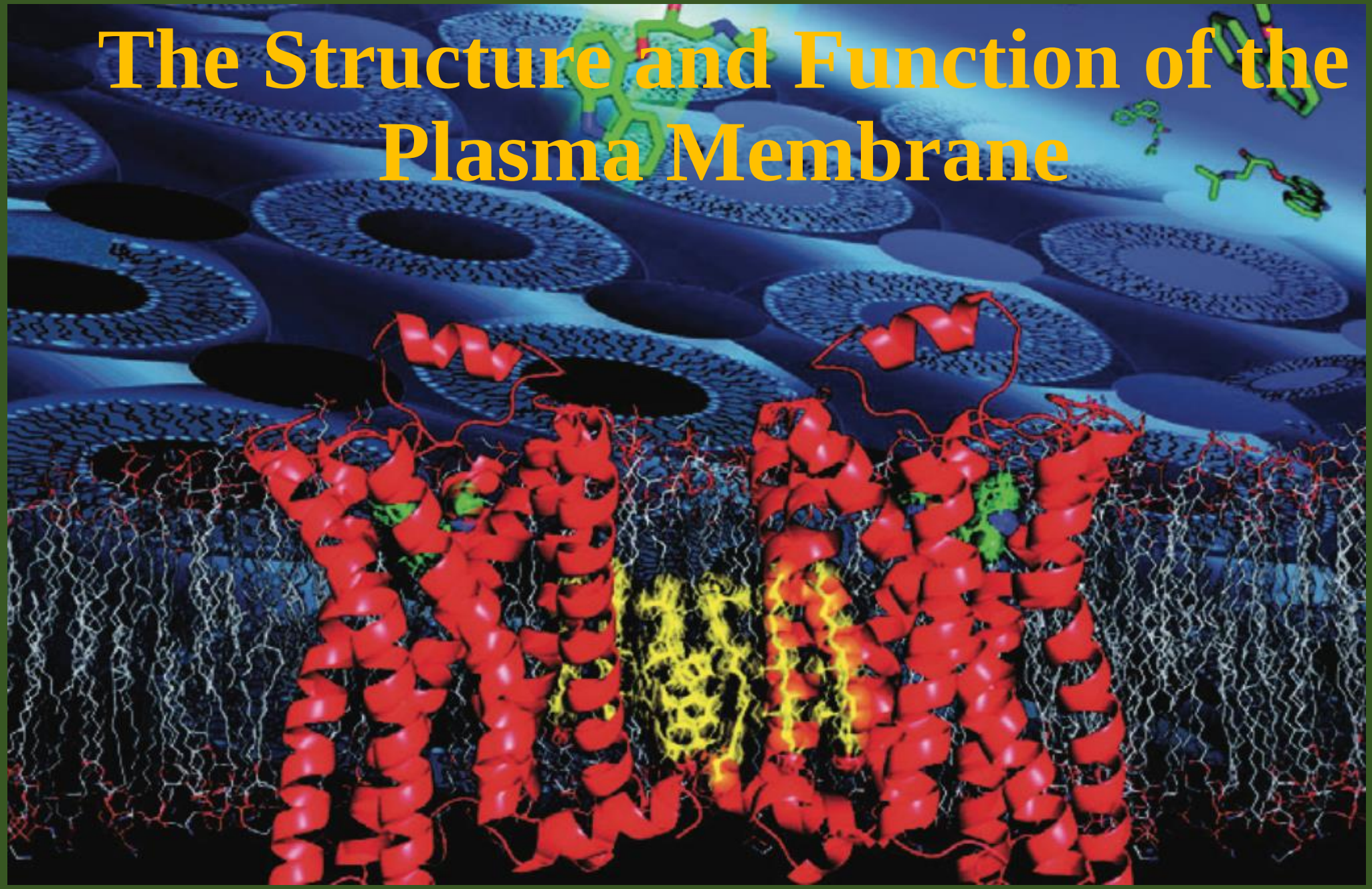
The Structure and Function of the Plasma Membrane



What is plasma membrane?

- Outermost layer (of animal cells)
- Thickness is 5-8 nm
- Selectively permeable
- Serve as outer boundary
- Allows some substances to cross more easily than others
- Made of Phospholipids, proteins & carbohydrate-conjugated molecules
- Separate and protect cell from external environment
- Provide connecting system between cell & its environment
- Also called cell membrane

Definition of plasma membrane

An outermost envelope surrounding the cell that separates and protects the cell from the external environment and provides a connecting system between the cell and its environment is called plasma membrane

Membrane Structure and Function

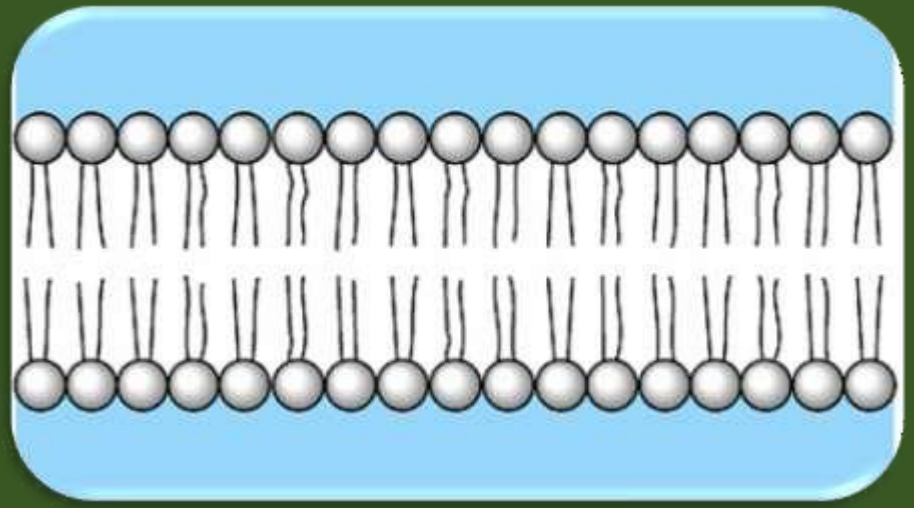
Membrane Structure:

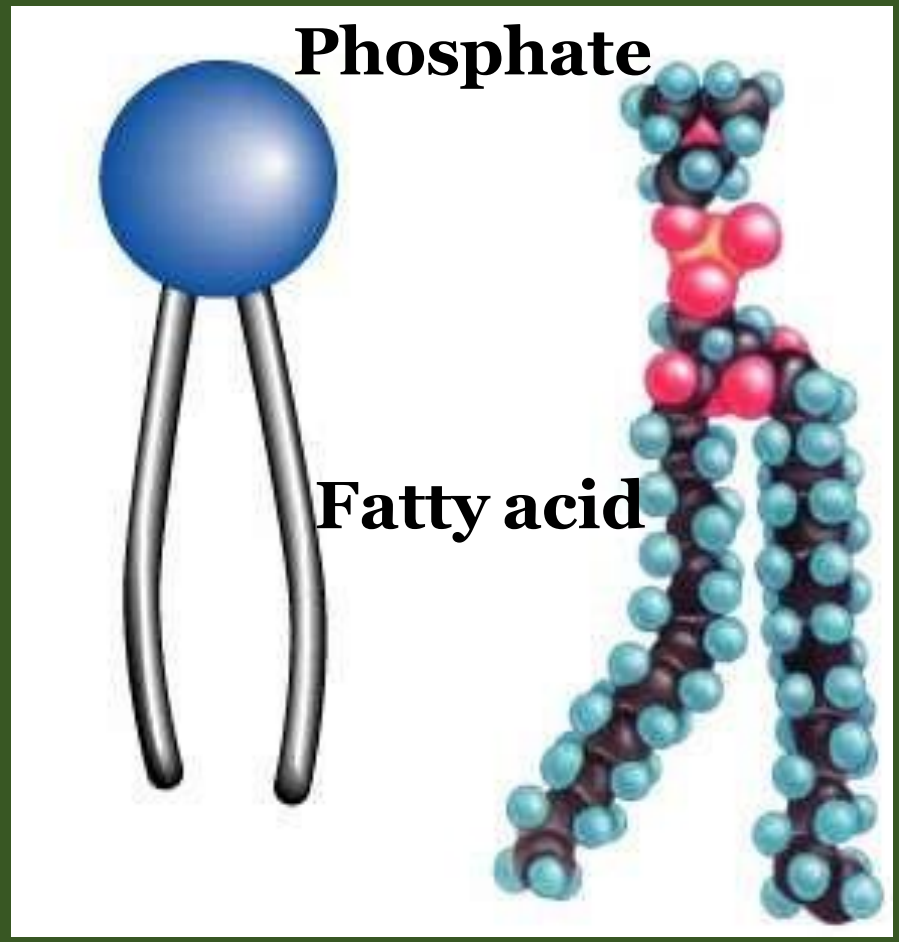
- Membrane models have evolved over the years to fit new data
- A membrane is a Fluid-Mosaic of lipids, proteins, and carbohydrates

- The plasma membrane is composed of two layers layers of phospholipids back-to-back.
- Phospholipids are lipids with a phosphate attached to them.

Phospholipids

- Fatty acid tails
  - hydrophobic
- Phosphate group head
  - hydrophilic
- Arranged as a bilayer





Phospholipids, glycolipids, cholesterol are amphipathic lipids containing

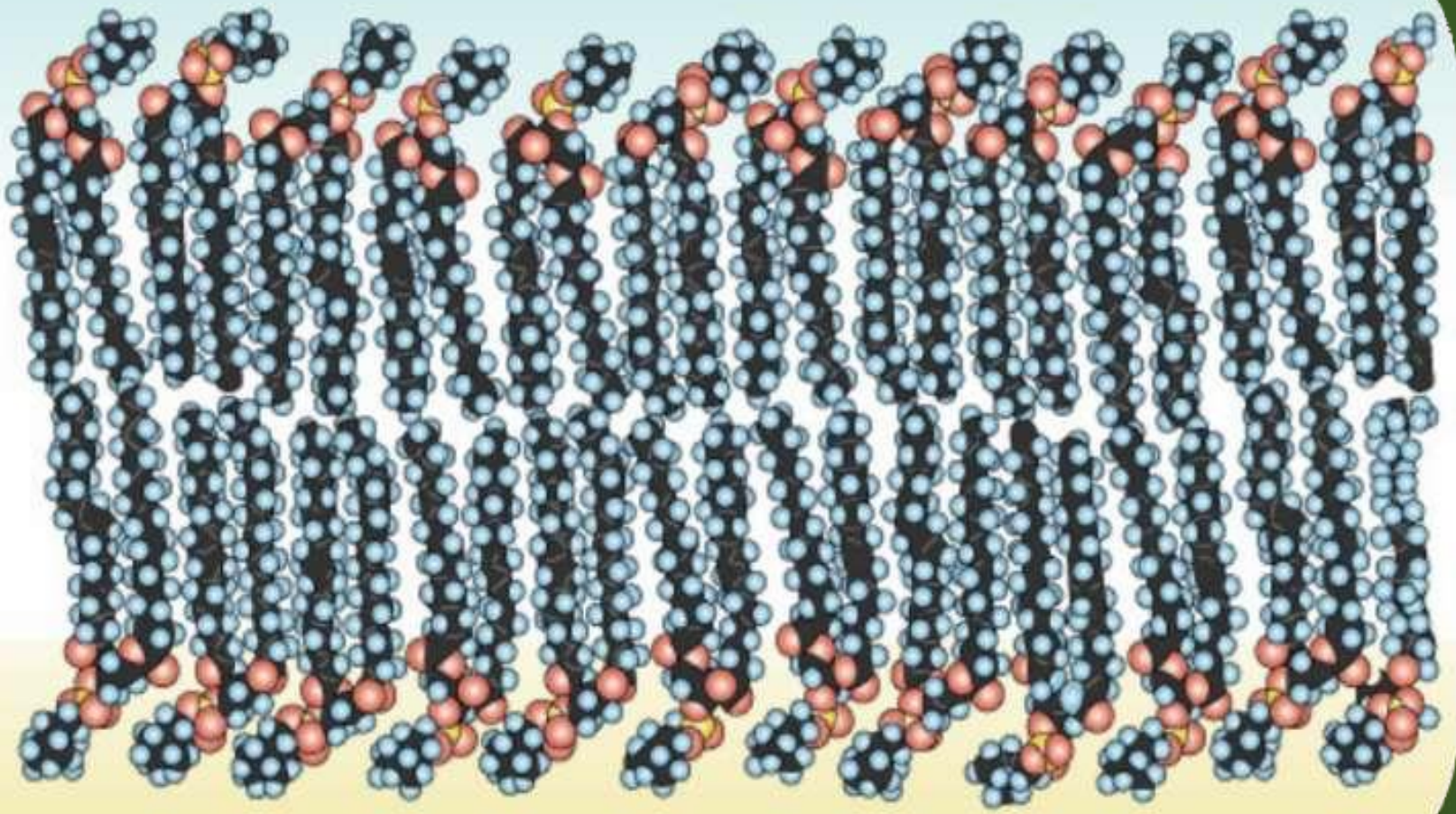
hydrophobic and hydrophillic ends

Phospholipid bilayer

polar hydrophilic heads

nonpolar hydrophobic tails

polar hydrophilic heads

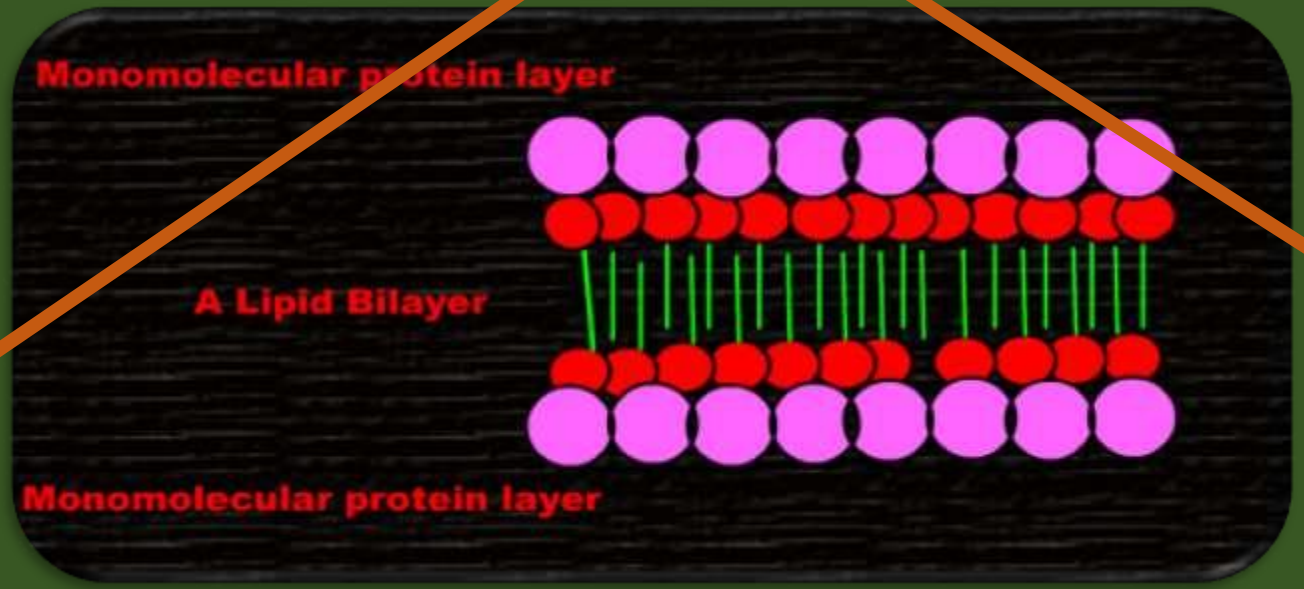


Membrane-different models

- Gorter and Grendel model (1925)-Lipid bilayer model
- Danielli-Dawson model (1935)-Sandwich model
- Singer-Nicolson model (1972)-Fluid-mosaic model

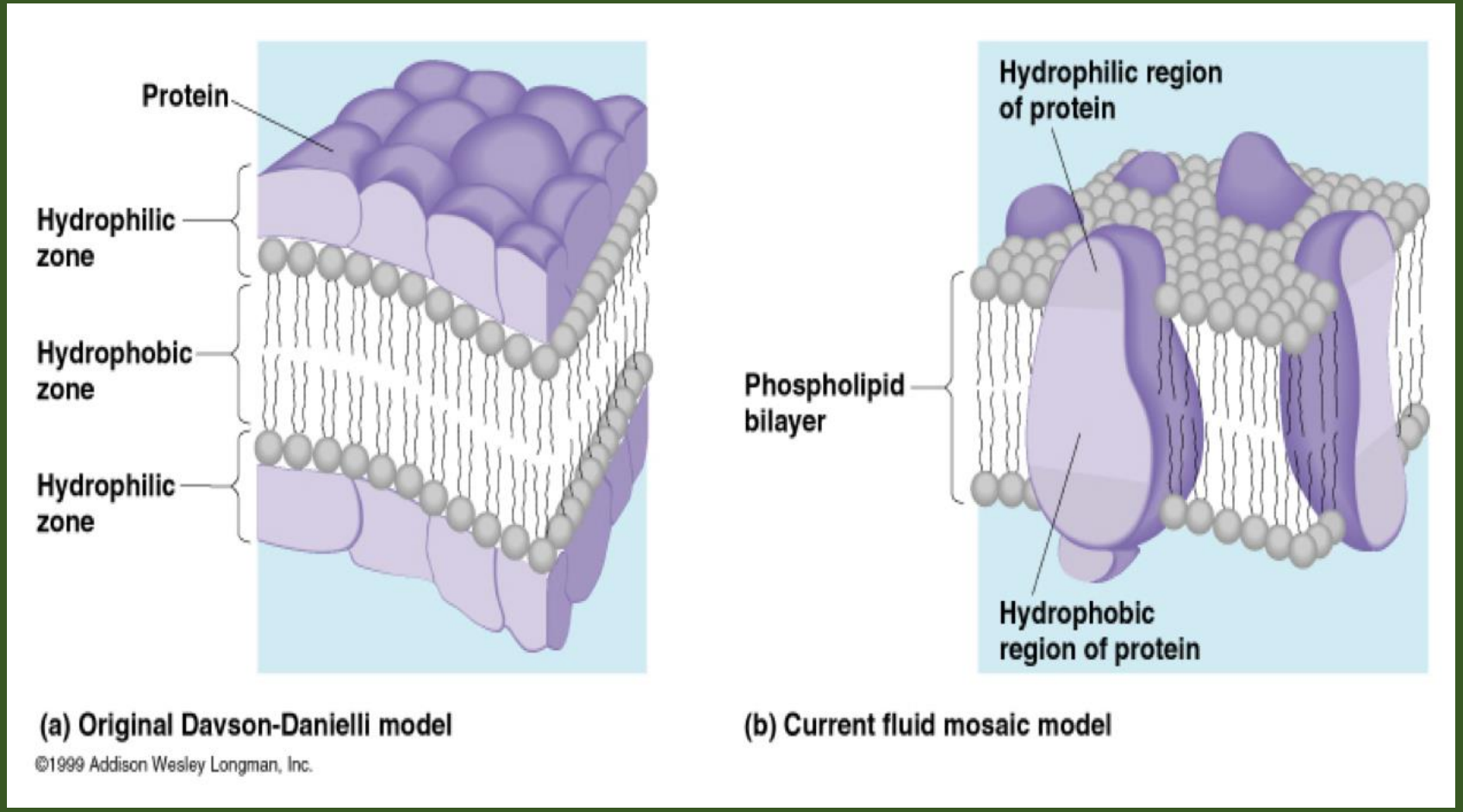
Sandwitch model
OR
Danielli- Davson Model

Proposed by Davson and Danielle in 1935
"Cell membrane is lipid bilayer sandwitched
B/w two monomolecular protein layers"



Fluid mosaic model

In 1972, S.J. Singer & G. Nicolson proposed Fluid mosaic model.



What is Fluid-mosaic model?

"Cell membrane is lipid bilayer in which proteins are partially embeded like floating iceburgs in sea"

The **fluid-mosaic model** describes the plasma membrane as a flexible boundary of a cell. The phospholipids move within the membrane.

Lipid molecules are present in a fluid state capable of rotating and moving.

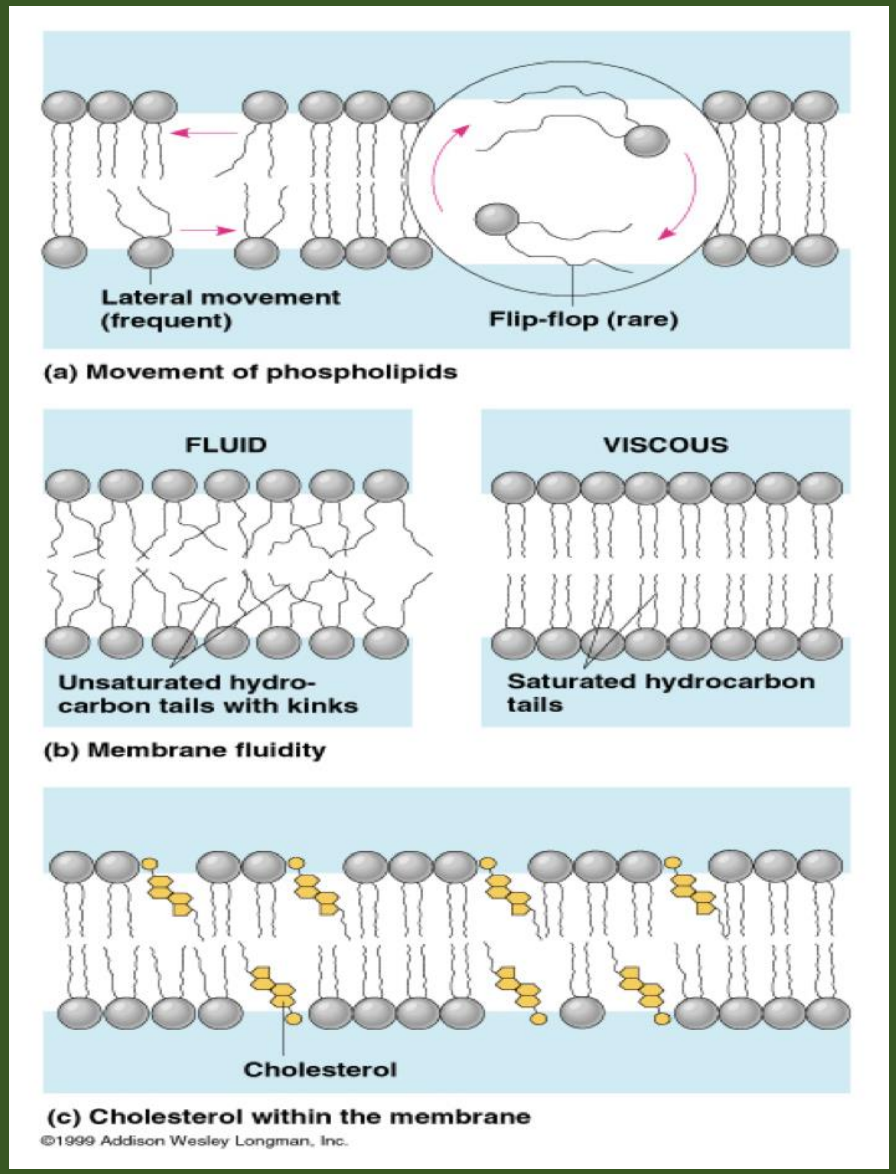
The proteins occur as a "mosaic" of discontinuous particles that penetrate deeply into and even through the lipid sheet.

Globular proteins are irregularly embedded in the lipid bilayer.

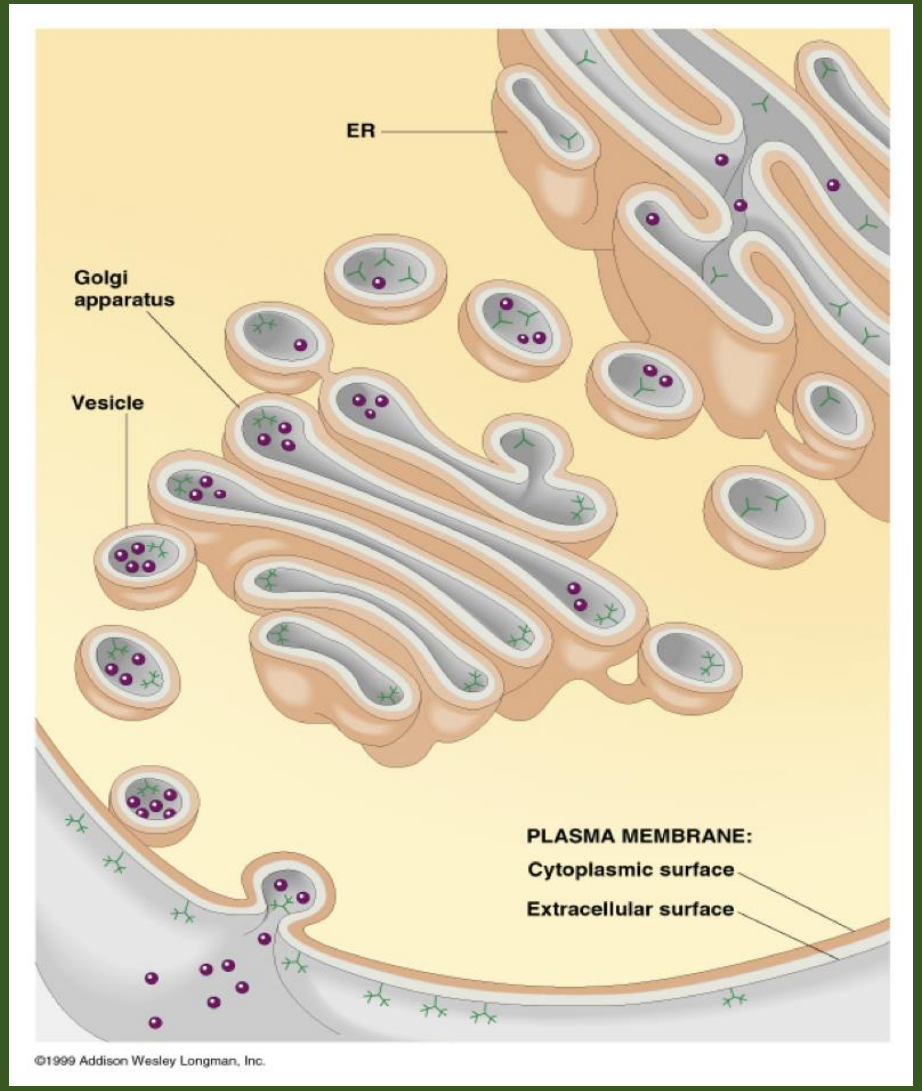
General Membrane Characteristics

- Held together by hydrophobic interactions
- Most lipids/proteins can drift laterally
- Molecules rarely flip transversely
- Phospholipids move faster than proteins
- Some proteins are connected to the cytoskeleton, can’t move far
- Unsaturated hydrocarbon tails on lipids increase fluidity
- Cholesterol decreases fluidity at warmer temps, more fluid at colder temps. (plant survival adaptation)

The Fluidity of Membranes



Sidedness of the Plasma Membrane



Membrane Carbohydrates

- Allow Cell to Cell Recognition: The ability of a cell to recognize if other cells are alike or different from itself. Has Immunity significance. This cell-cell recognition is the basis for:
- sorting an embryo's cells into tissues/organs
- rejection of foreign cells by immune system.

Role of Carbohydrates

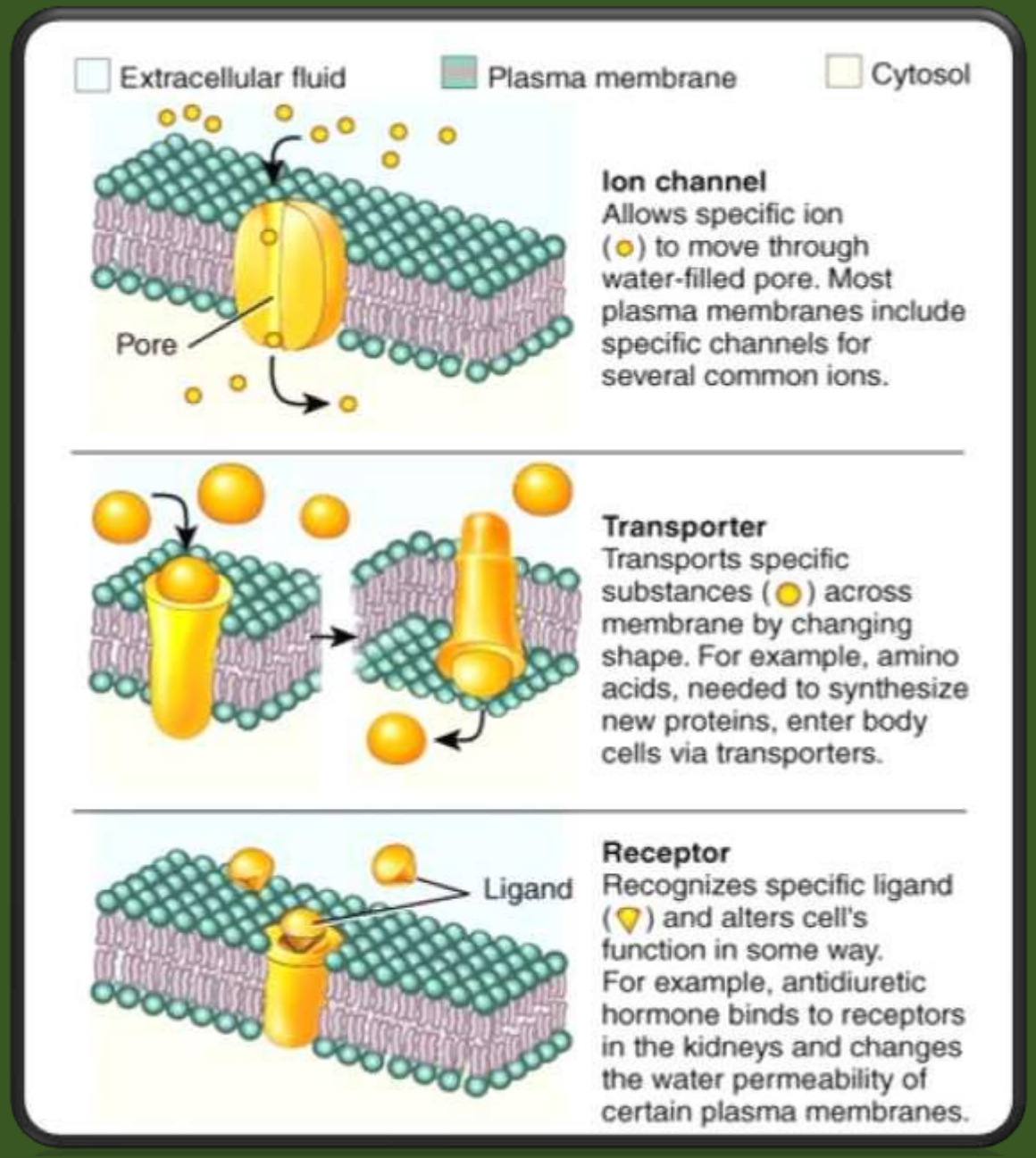
- Act as markers on cell's surface for recognition purposes
- Usually branched oligosaccharides (<15 monomers)
- Some are covalently bonded to lipids (glycolipids)
- MOST are covalently bonded to proteins (glycoproteins)
- Vary between species, individuals of same sp., and between cells in same organism

Plasma Membrane :

Membrane Proteins

Transmembrane Proteins

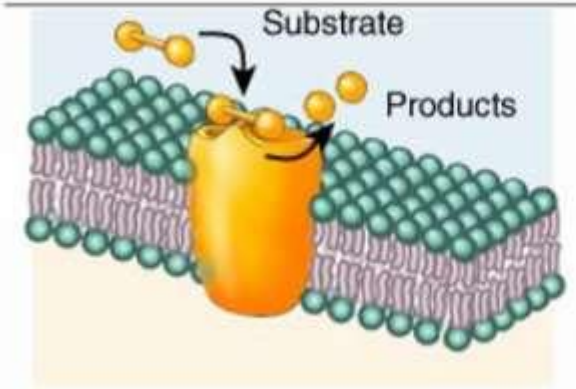
Functional classification



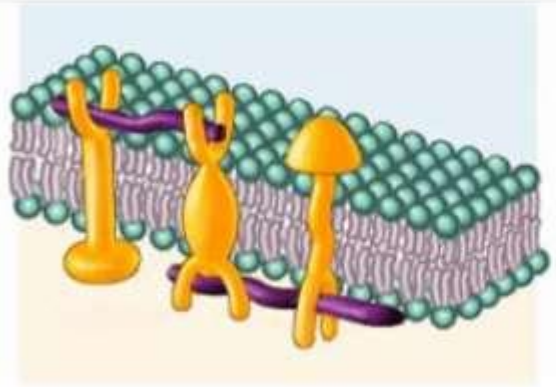
Plasma Membrane : Membrane Proteins

Functional classification

Transmembrane Proteins



Enzyme
Catalyzes reaction inside or outside cell (depending on which direction the active site faces). For example, lactase protruding from epithelial cells lining your small intestine splits the disaccharide lactose in the milk you drink.

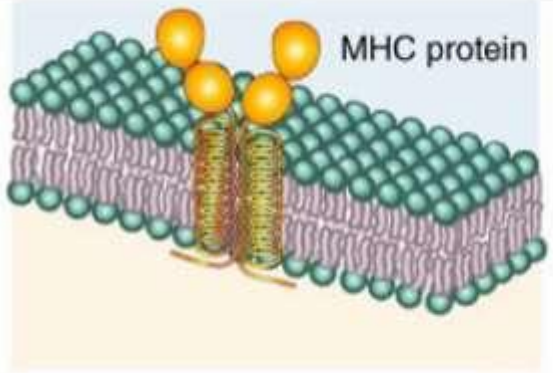


Linker
Anchors filaments inside and outside to the plasma membrane, providing structural stability and shape for the cell. May also participate in movement of the cell or link two cells together.

Plasma Membrane : Membrane Proteins

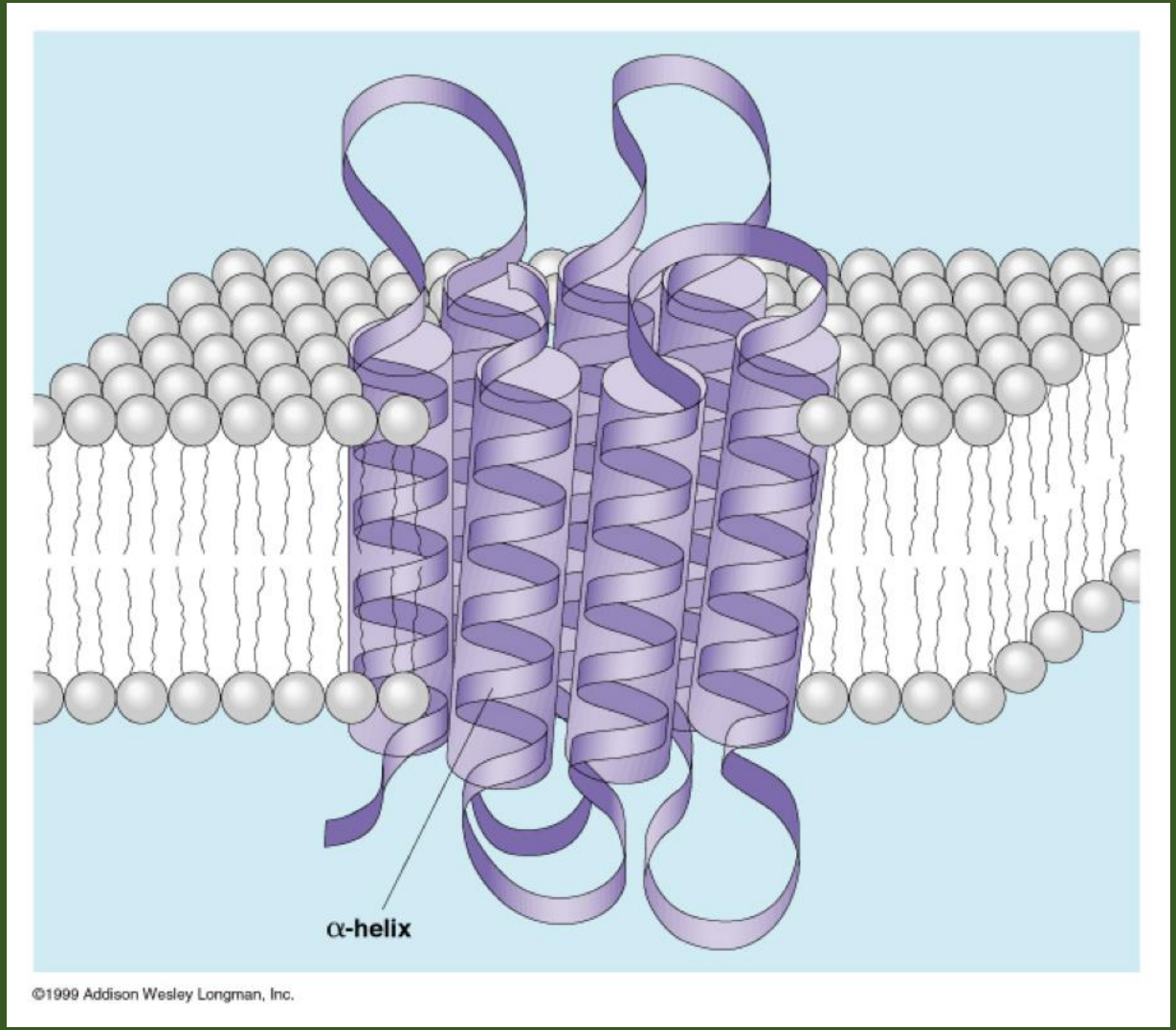
Functional classification

Peripheral Proteins (only one side of the membrane)



Cell Identity Marker
Distinguishes your cells from anyone else's (unless you are an identical twin). An important class of such markers are the major histocompatability (MHC) proteins.

The Structure of a Transport Protein



Chemical composition

- Composed of Lipids, Proteins and Carbohydrates.
- Actual components differs from tissue to tissue.

- Lipids of cell membrane are….

-Phospholipids
-Glycolipids
-Sterol
-Cholesterol

Four major phospholipids found in mammalian plasma membrane. There are many "minor" phospholipids exists, too.

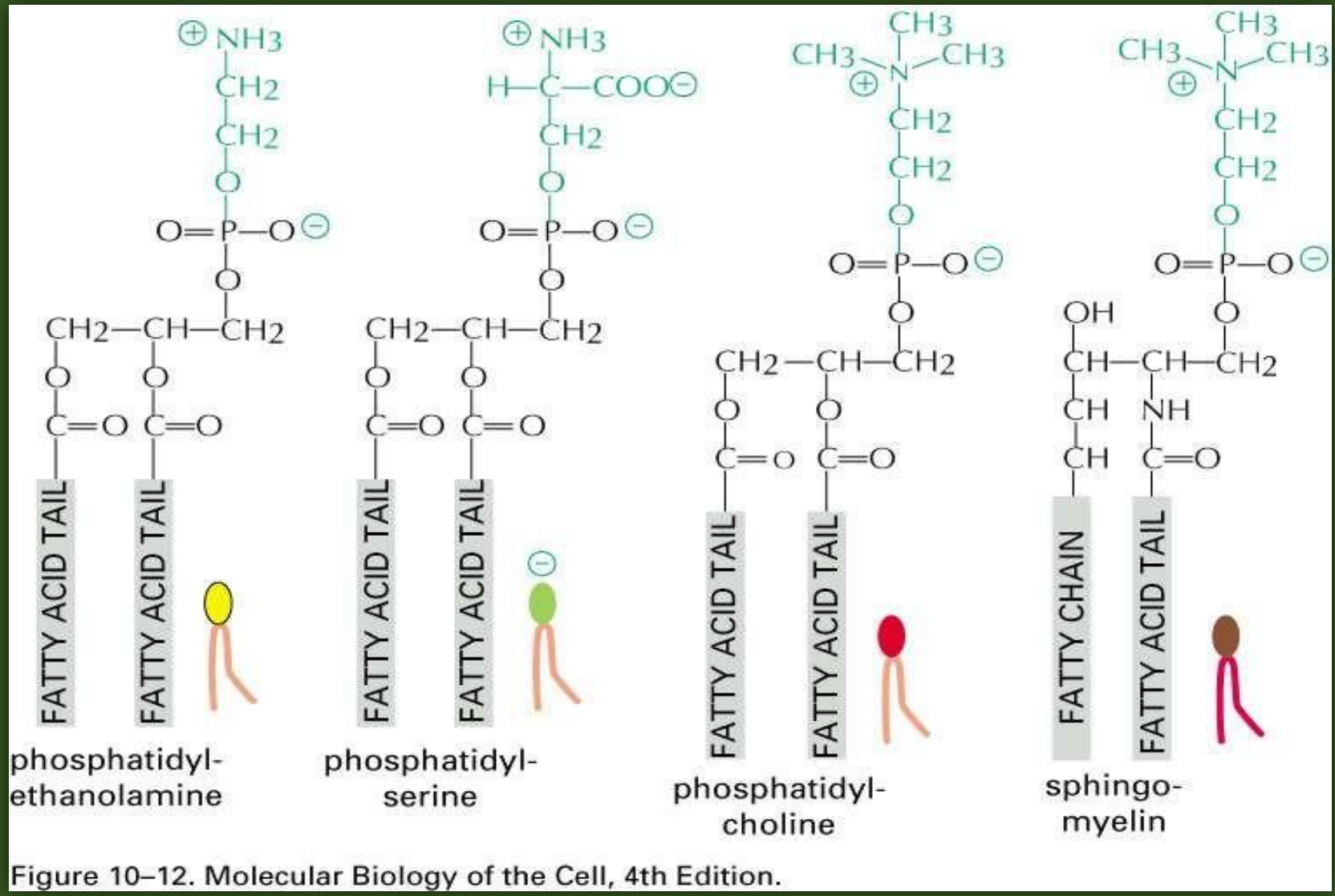


Figure 10–12. Molecular Biology of the Cell, 4th Edition.

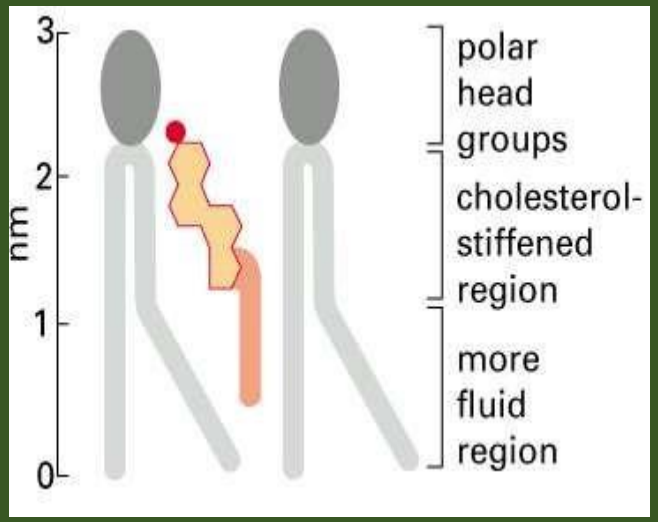
Cholesterol

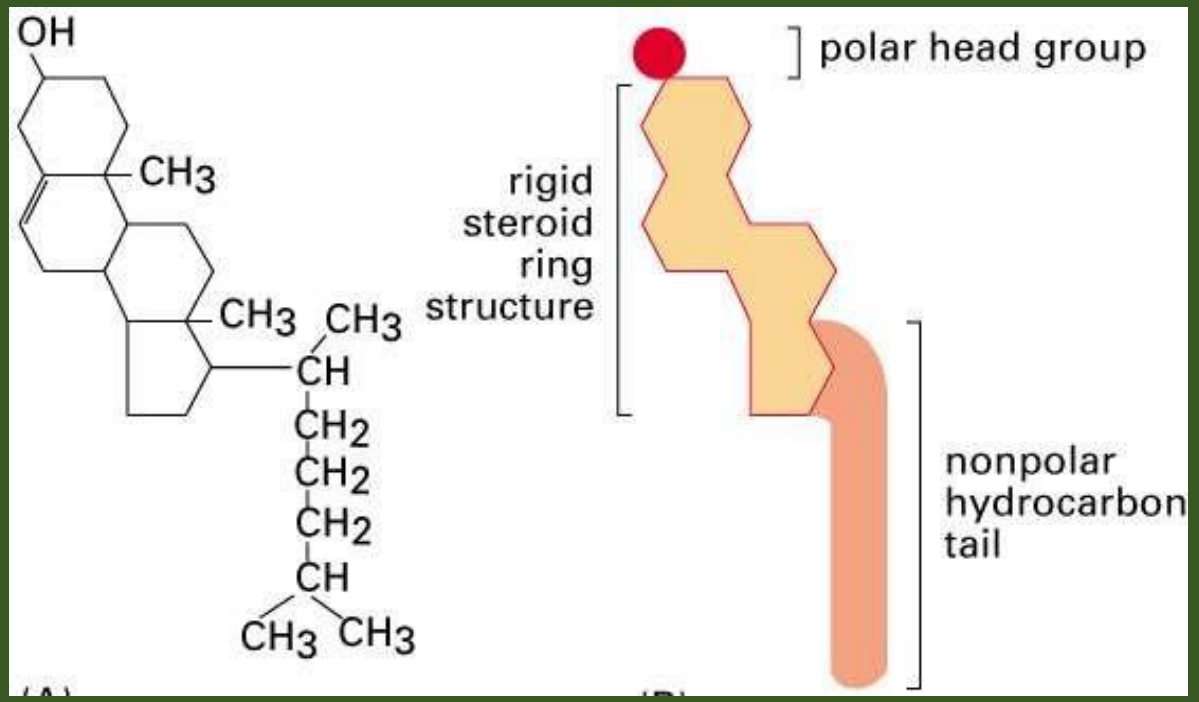
Unique to plasma membrane
Stabilizes membrane

Table 10–1 Approximate Lipid Compositions of Different Cell Membranes

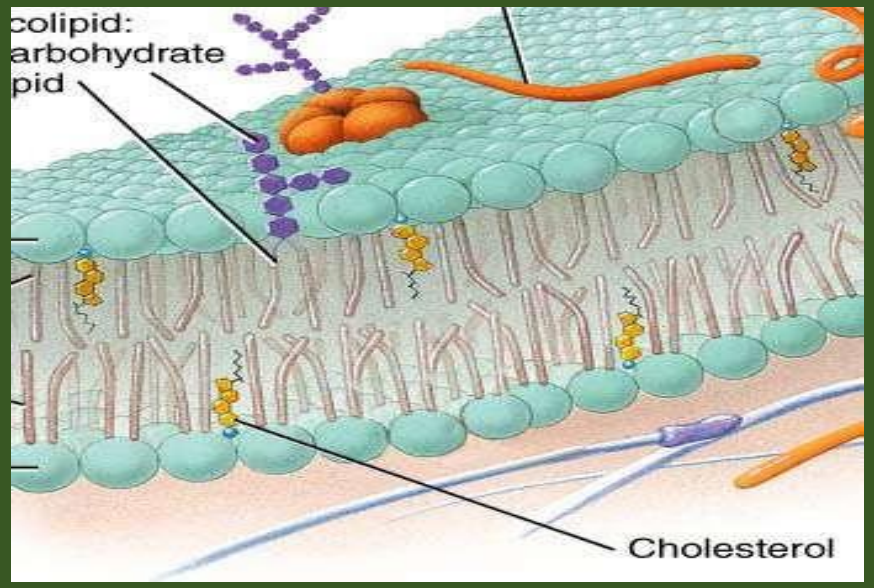
Lipid	Percentage of Total Lipid by Weight					
	Liver Plasma Membrane	Erythrocyte Plasma Membrane	Myelin	Mitochondrion (inner and outer membranes)	Endoplasmic Reticulum	*E. coli*
Cholesterol	17	23	22	3	6	0
Phosphatidyl-ethanolamine	7	18	15	35	17	70
Phosphatidylserine	4	7	9	2	5	trace
Phosphatidyl-choline	24	17	10	39	40	0
Sphingomyelin	19	18	8	0	5	0
Glycolipids	7	3	28	trace	trace	0
Others	22	13	8	21	27	30

Cholesterol





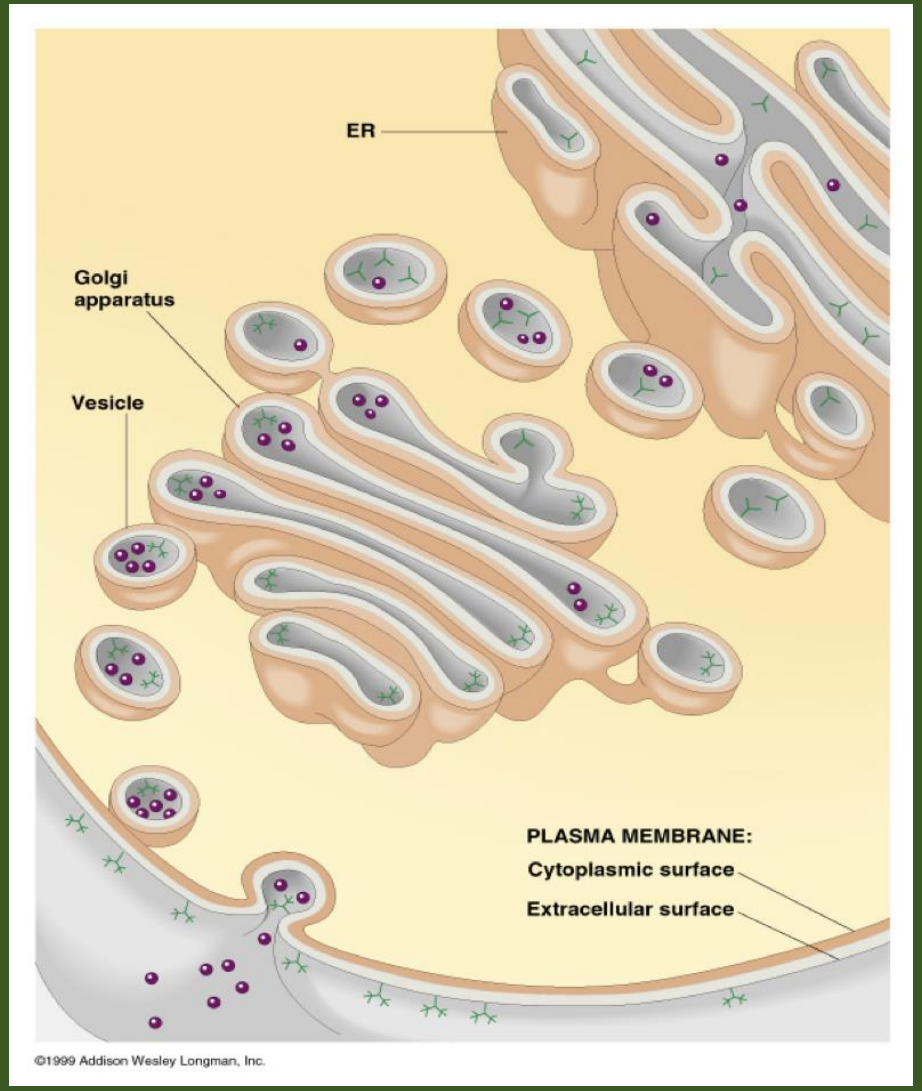
Cholesterol Unique to plasma membrane
Stabilize membrane



Membranes are Bifacial

- 2 lipid layers (leaf-let) may differ in composition
- Membrane proteins have distinct directional orientation
- Inside of vesicles, ER, Golgi is the same as the outside of the membrane

Sidedness of the Plasma Membrane



Membrane proteins

Membrane proteins are categorized into two groups:

1- Extrinsic (peripheral) membrane proteins

2- Intrinsic (integral) membrane proteins

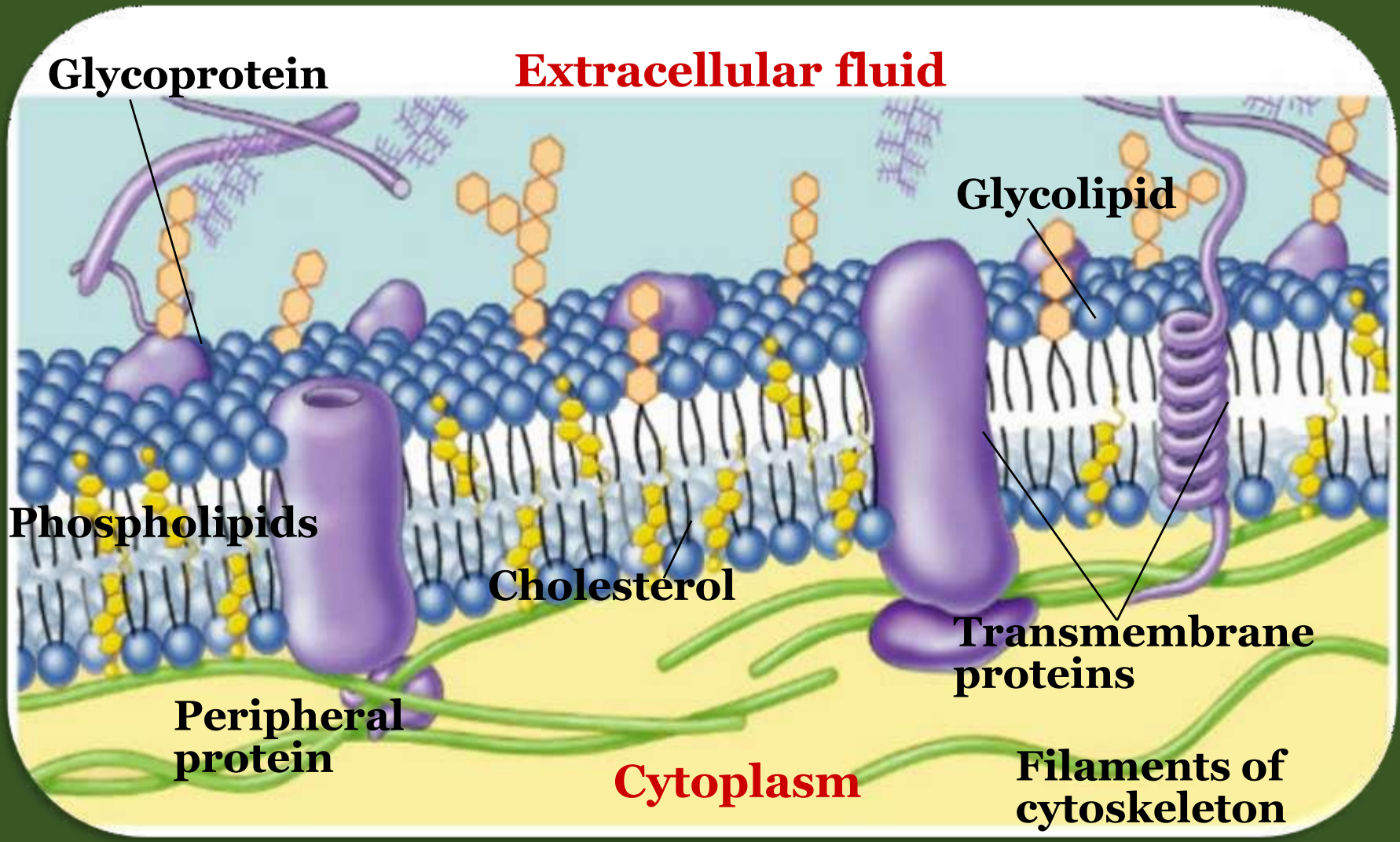
Extrinsic membrane protein

- Proteins loosely associated with membrane surface
- Located entirely outside of the lipid bilayer
- Either on the extracellular or cytoplasmic surface
- Also called Peripheral membrane proteins:
- Example:
  - Cytochrome C of Mitochondria
  - Cell surface identity marker (antigens)

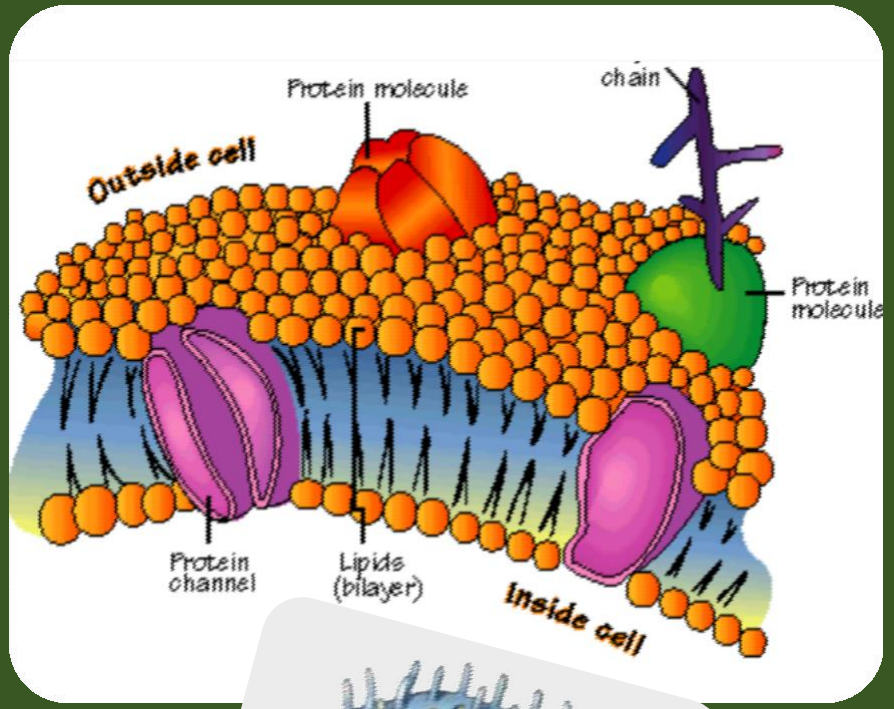
Intrinsic membrane proteins

- Directly incorporated within the lipid bilayer
- Tightly bound to lipid bilayer
- Provides a channel for the water-soluble substances
- Also called Integral membrane proteins
- Example:
- Transmembrane protein
- Transport proteins

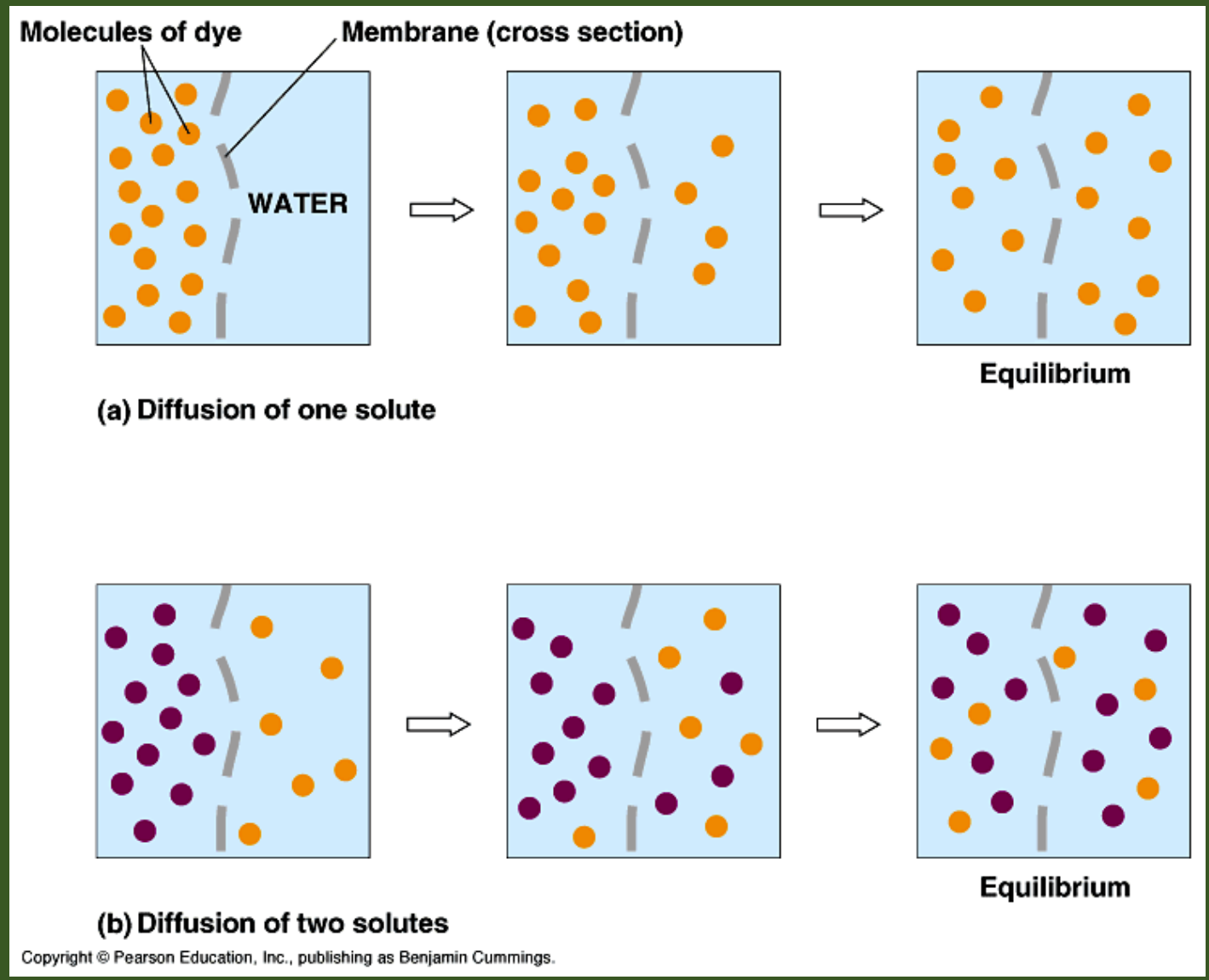
Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer



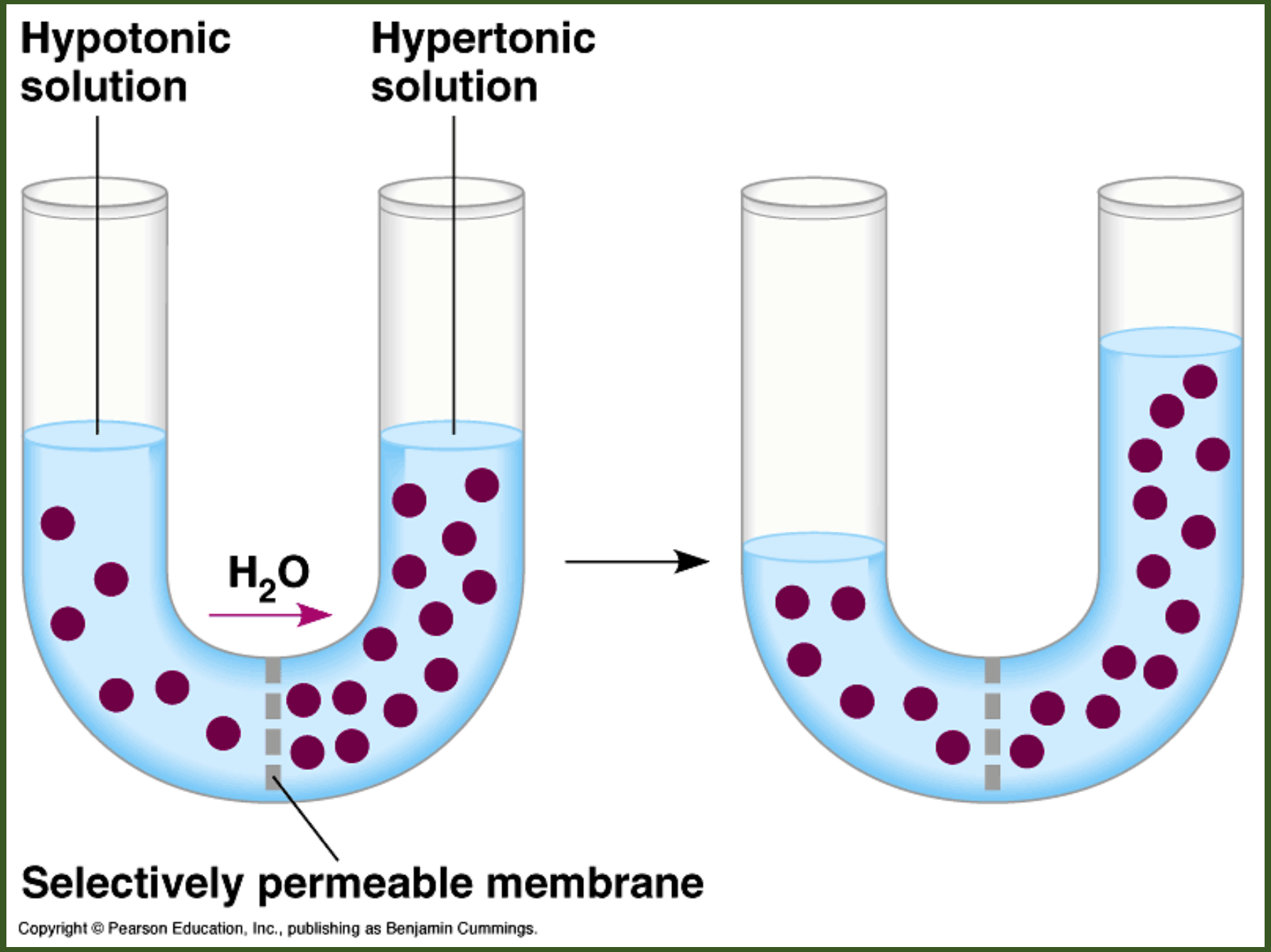
Movement across the Cell Membrane



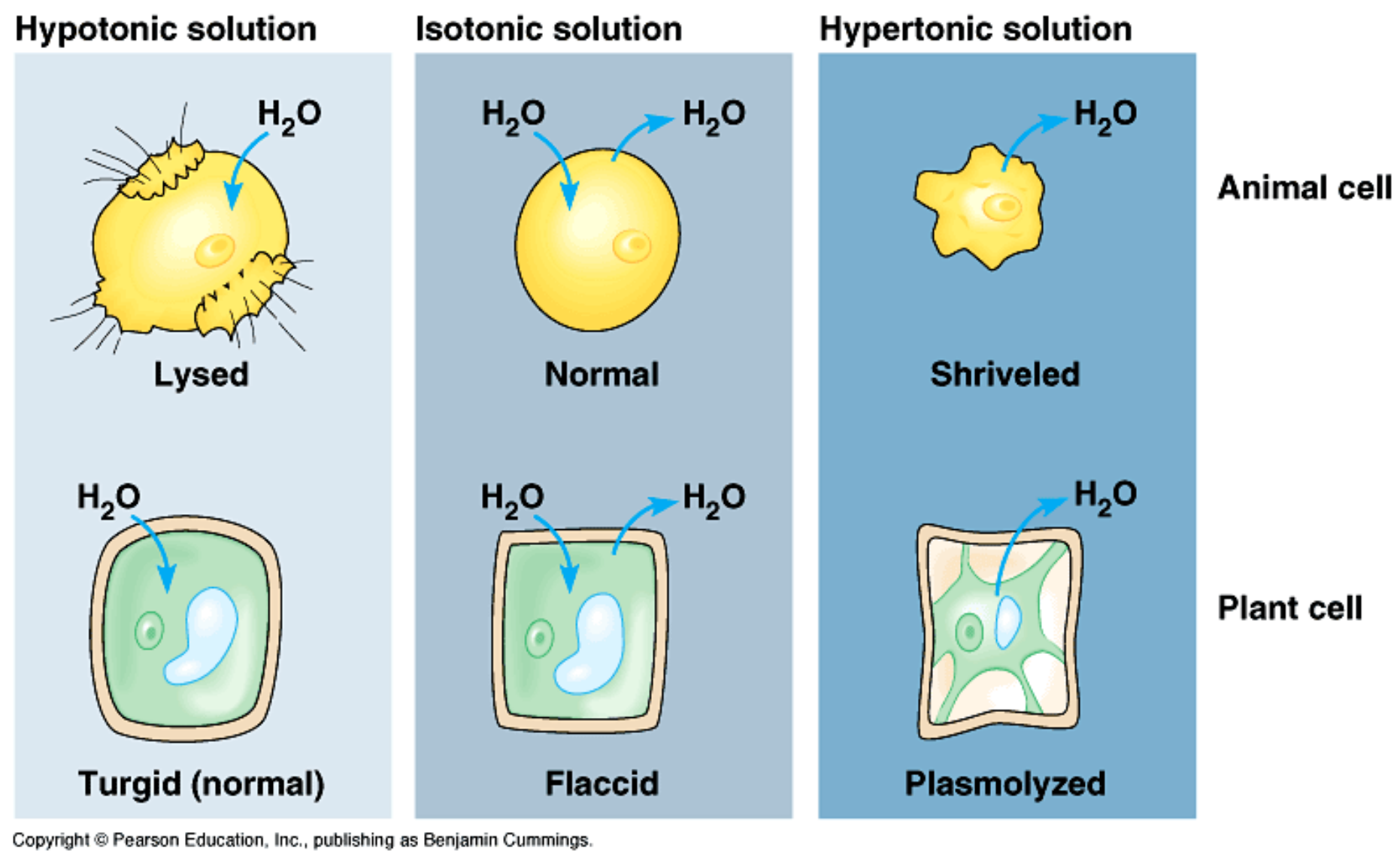
The diffusion of solutes across membranes



Osmosis



The water balance of living cells



Traffic Across Membranes

- Selective permeability depends on solubility characteristics of the lipid bilayer, and presence of specific integral proteins

Membrane Structure and Function

Traffic Across Membranes

a. Molecular organization of membrane=selective permeability

b. Passive Transport=Diffusion across a membrane

c. Osmosis=passive transport of water

d. Balancing water uptake/loss=cell survival

e. Specific proteins facilitate transport of selected solutes

f. Active transport=pumping solutes against gradient

g. Some ion pumps generate voltage across membranes

h. Co-transport: A membrane protein couples the transport of one solute to another

i. Exocytosis/Endocytosis transport large molecules

Mosaicism

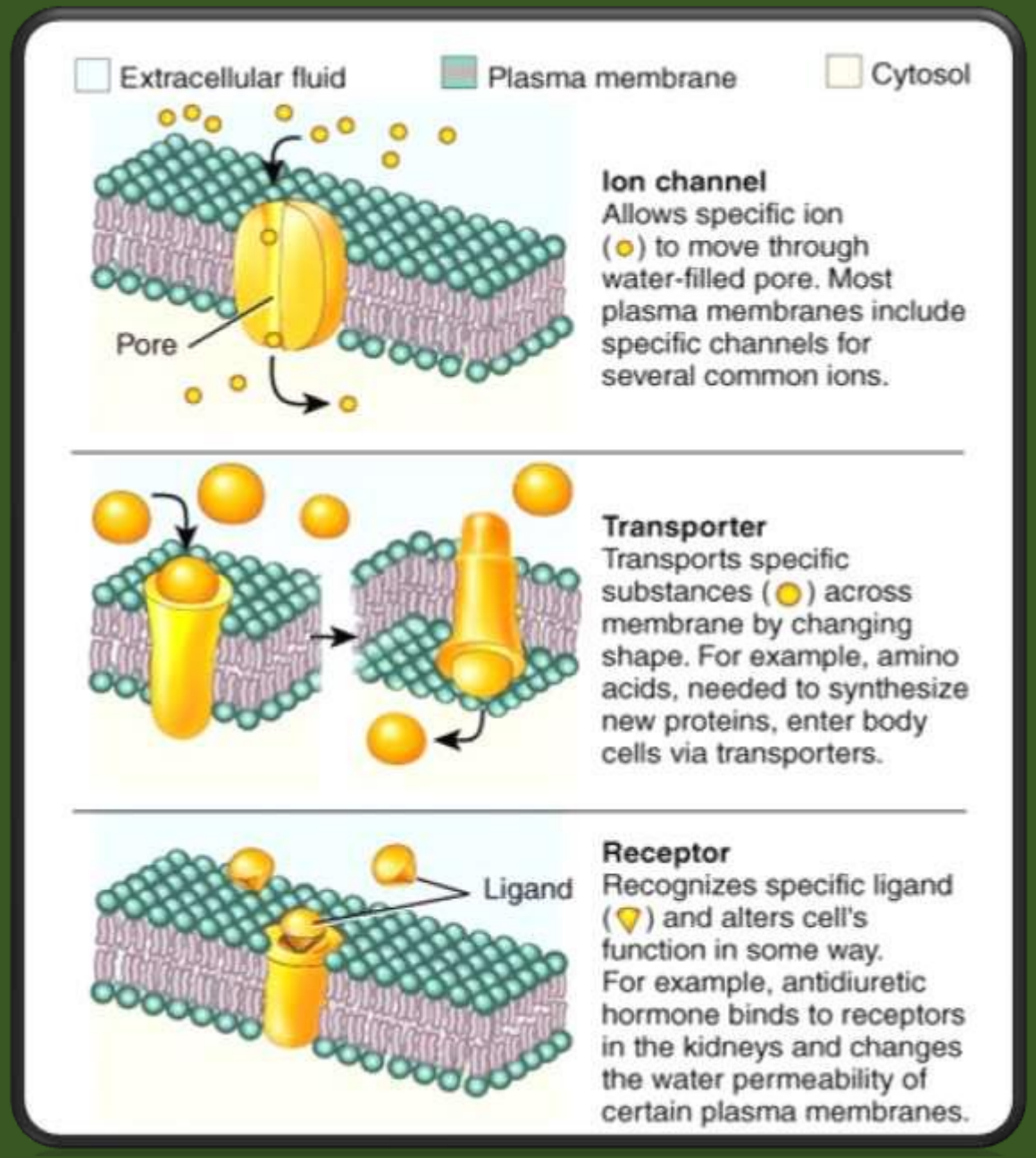
- Membranes are mosaics of floating proteins in a lipid bilayer. 2 ways:
  - Integral Proteins: transmembrane, have both hydropohilic and hydrophobic parts
  - Peripheral Proteins: Attached to membrane's surface by:
    - Attachment to integral proteins or ECM fibers (outside)
    - Attachment to filaments of cytoskeleton (inside)

Plasma Membrane :

Membrane Proteins

Transmembrane Proteins

Functional classification



Traffic Across Membranes

- Selective permeability depends on solubility characteristics of the lipid bilayer, and presence of specific integral proteins

Permeability of the Lipid Bilayer

- NONPOLAR Molecules
- Dissolve in membranes, cross with ease
- Smaller ones will cross faster

POLAR Molecules

•Small, polar, uncharged molecules can slip through

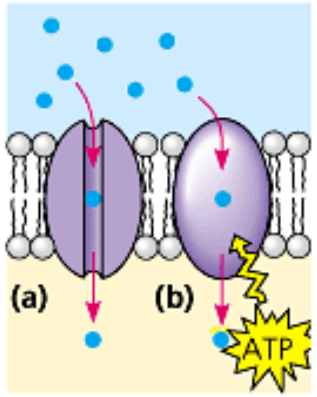
•Larger, polar, uncharged will not get through easily (glucose)

•All ions have trouble getting through hydrophobic layer

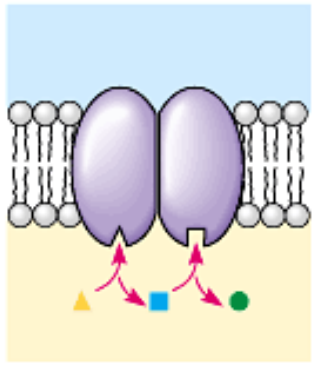
Transport Proteins

- Hydrophilic Substances like ions and moderately sized polar molecules can avoid going through the hydrophobic core of the membrane by going through transport proteins: Integral membrane proteins that transport specific ions or molecules across the membrane. They may provide a hydrophilic tunnel or may bind to, and physically carry a substance across. These are very specific.

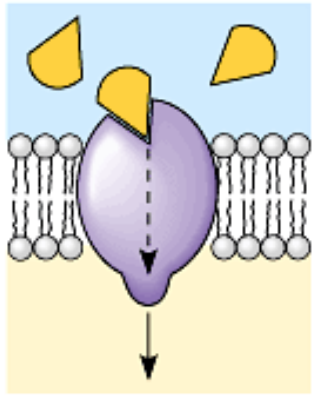
Some functions of membrane proteins



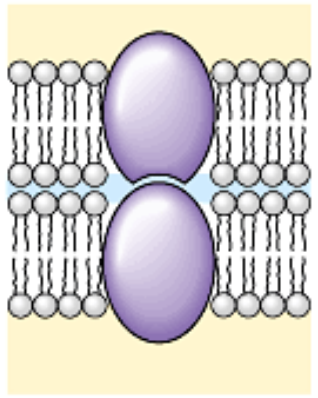
Transport



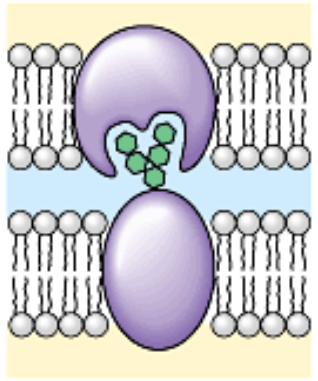
Enzymatic activity



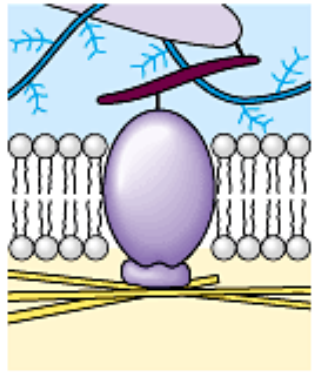
Signal transduction



Intercellular joining



Cell-cell recognition



Attachment to the cytoskeleton and extracellular matrix (ECM)

A few important membrane-related functions

- Passive transport: Concentration Gradient, Net directional movement, diffusion
- Osmosis: Hypertonic, hypotonic, isotonic, osmotic concentration, osmotic pressure
- Water balance in organisms without cell walls: Live in isotonic environment, osmoregulation
- Water balance in cells with walls: Turgidity, plasmolysis

Proteins Facilitate Passive Transport

- Facilitated Diffusion: specific transport proteins help solutes diffuse across membrane
  - Is passive transport (down conc. Gradient)
  - Helps many polar molecules/ions get through the lipid bilayer
  - SPECIFIC-Have binding site like active site
  - Can be saturated with solute: rate limited
  - Can be due to conformational changes
  - Can be gated channels

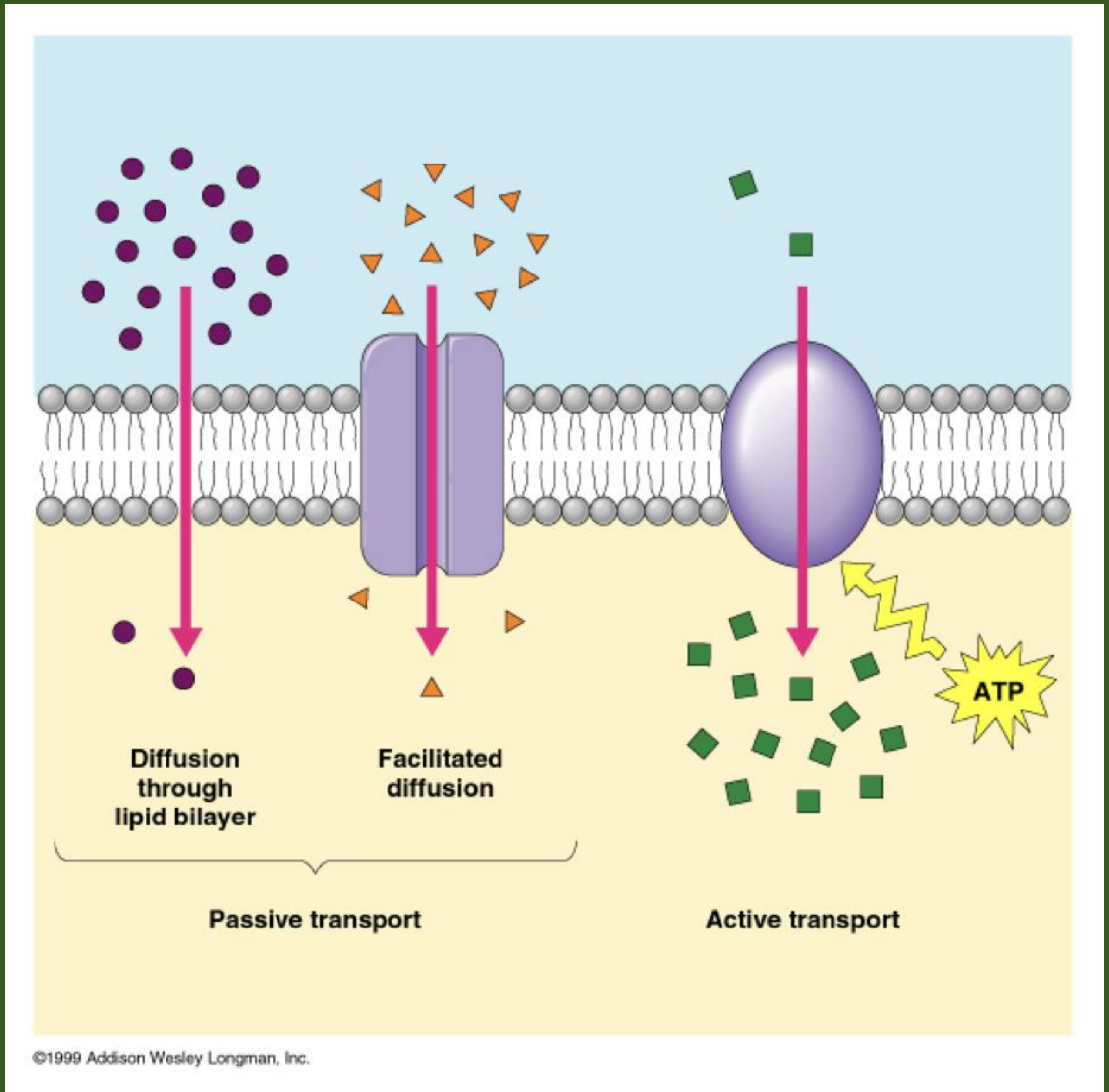
Active transport

- Endergonic process by which a transport protein pumps a molecule across a membrane AGAINST its concentration gradient.
- These maintain concentration gradients across membranes
- Use ATP as energy source.
- Ex. Sodium-Potassium Pump

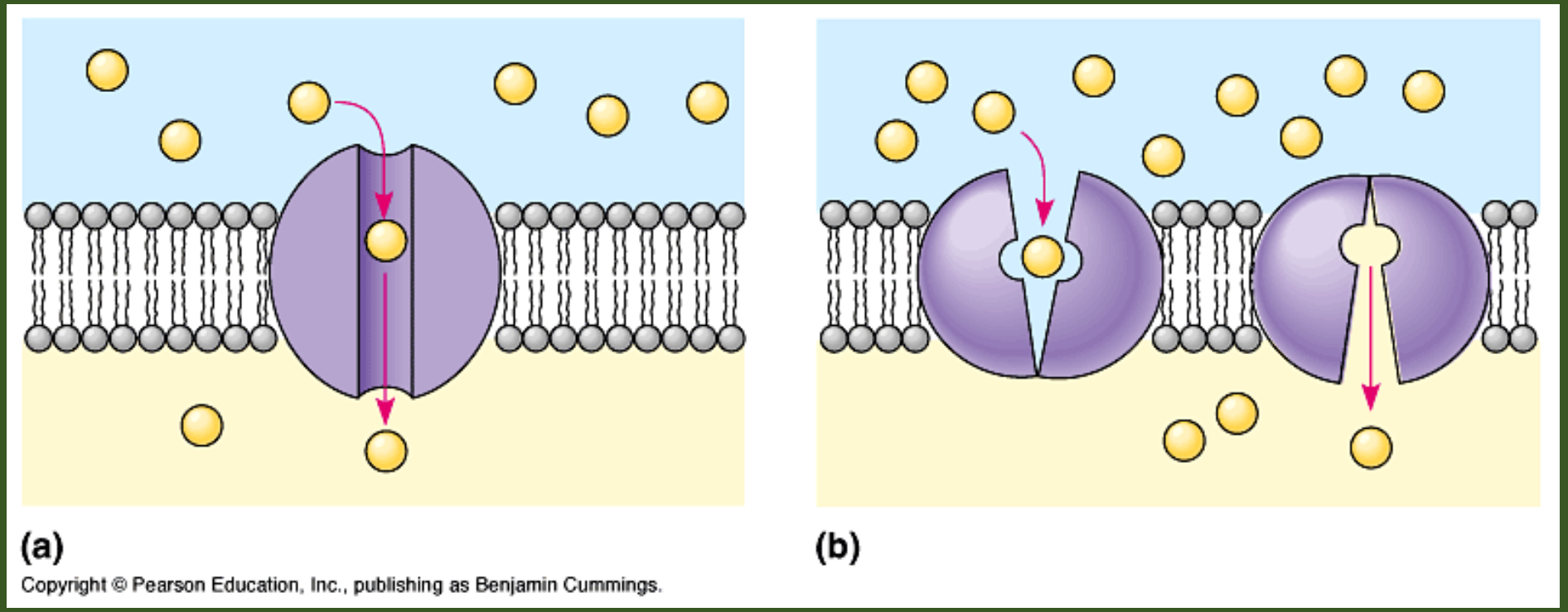
Passive Transport of Ions Depends On:

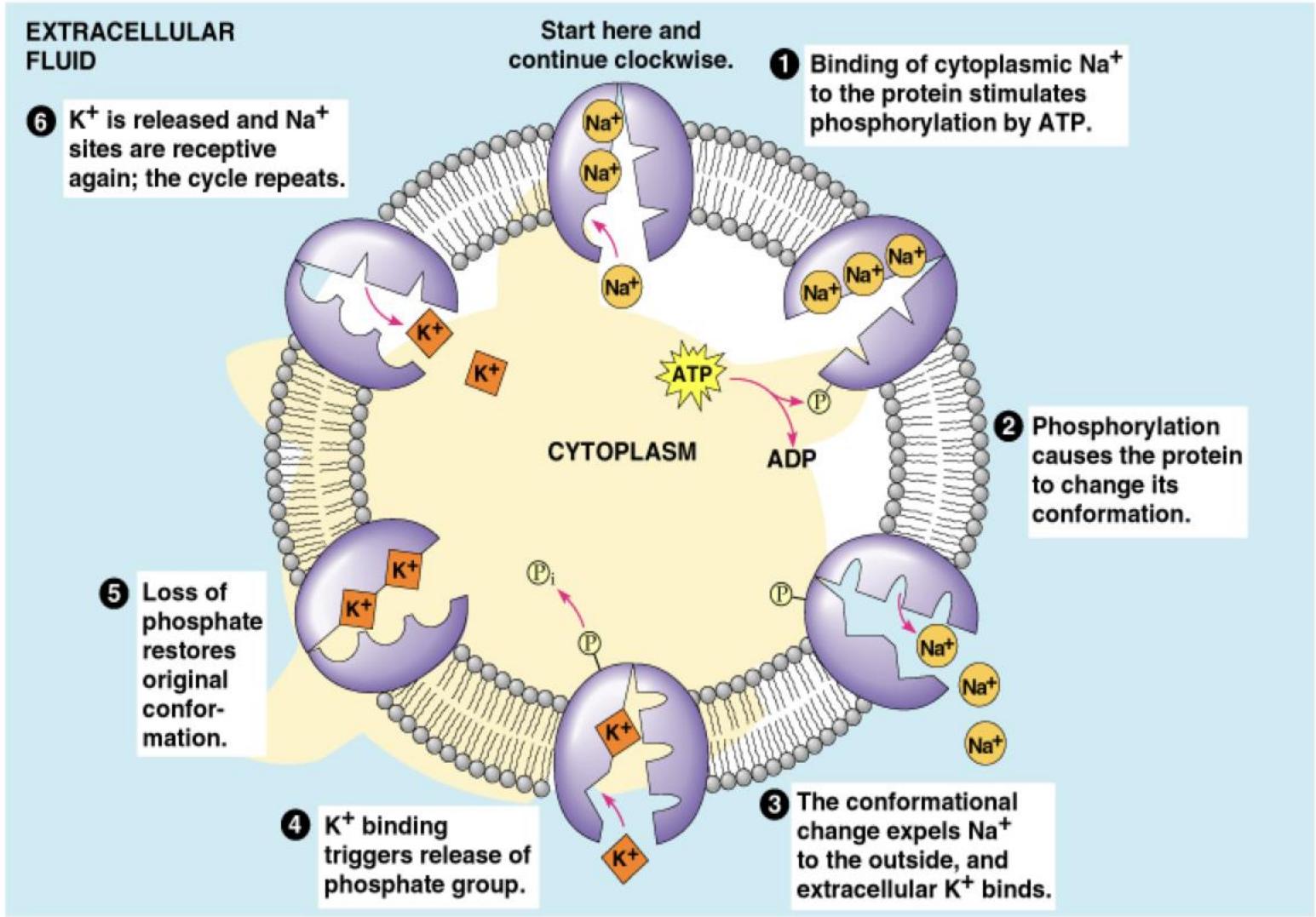
- Concentration gradient of the Ion
- Effect of the membrane potential of the ion
- The Electrochemical Gradient is the diffusion gradient created from the combined effects of both of the above

Passive/Active Transport



Two models for facilitated diffusion/transport





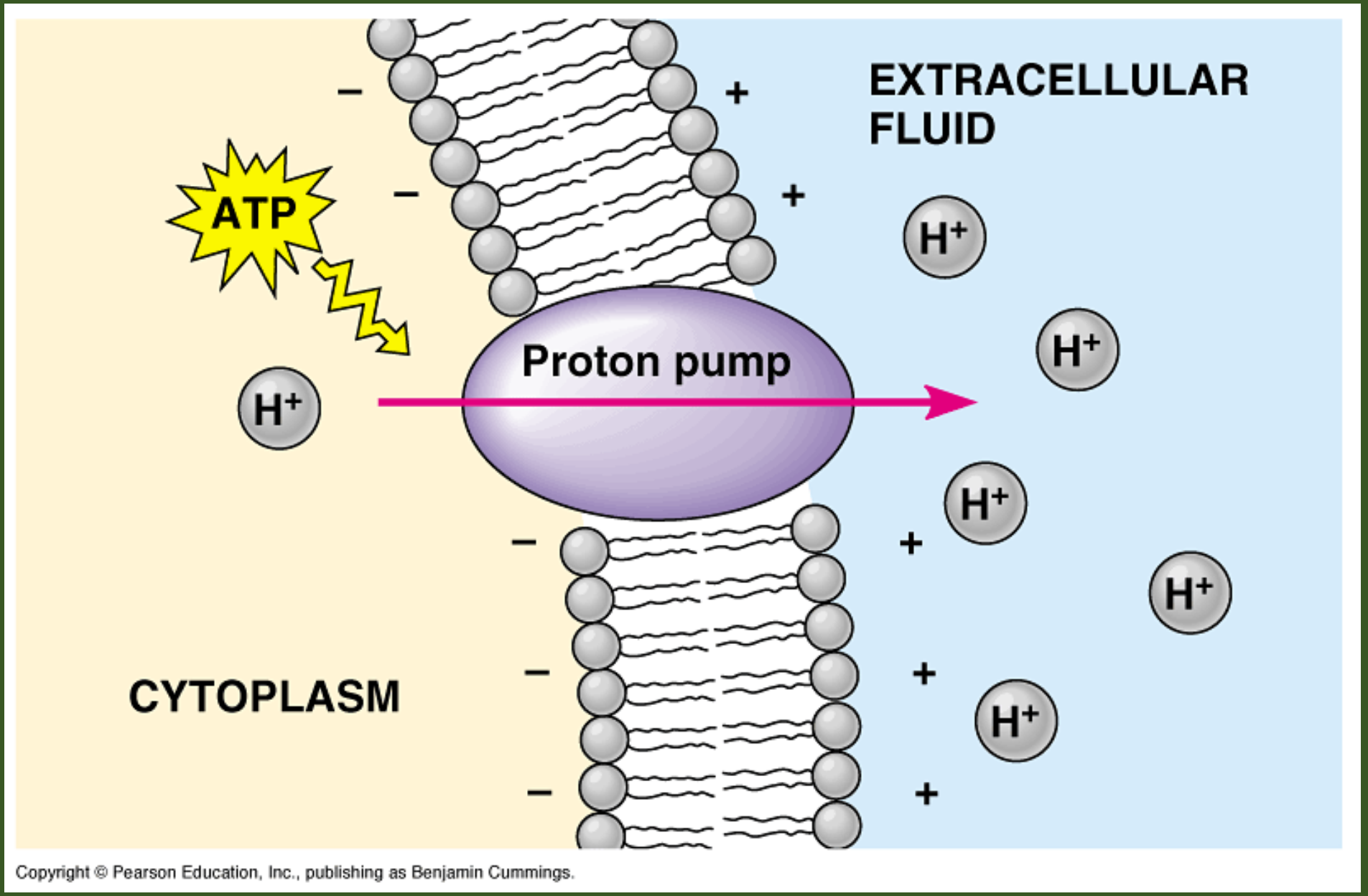
Membrane potential

- Voltage across membranes happens when anions/cations are unequally distributed across cell membranes
- Potential ranges from -50 to -200 mv
- Negative sign indicates the inside of the cell is – charged.
- Affects traffic of charged subs. across membrane, favours diffusion of anions out, cations in.

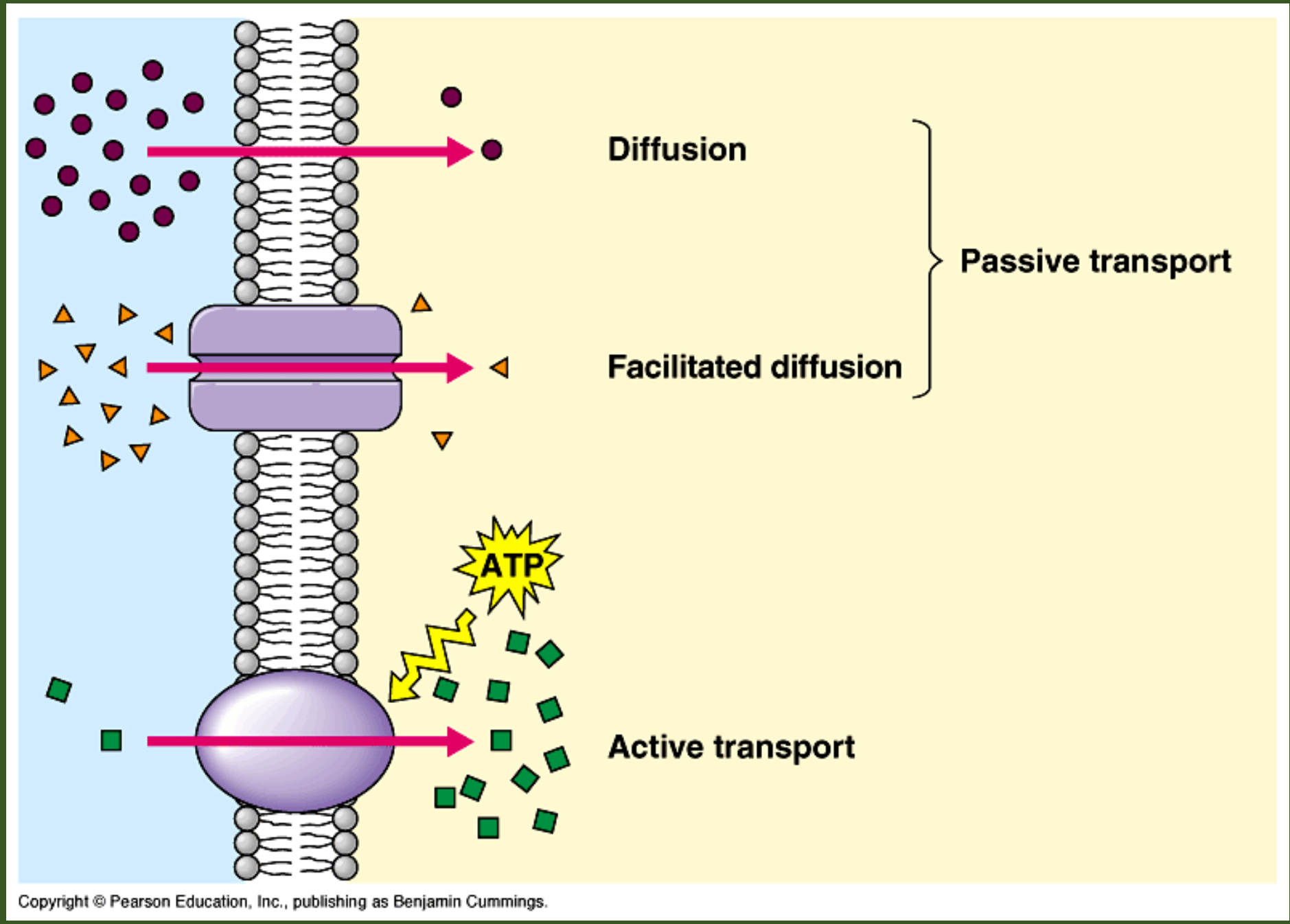
Factors Contributing to Membrane Potential:

- Negatively charged proteins in the cells interior
- Plasma membrane's selective permeability to various ions
- The Sodium-Potassium Pump is an ELECTROGENIC PUMP: a transport protein which generates voltage across a membrane. Na+/K+ ATPase is the major one in animals, a Proton pump is the major one in Plants, bacteria, fungi (also Mitochondria, Chloroplasts use it to make ATP)

An electrogenic pump

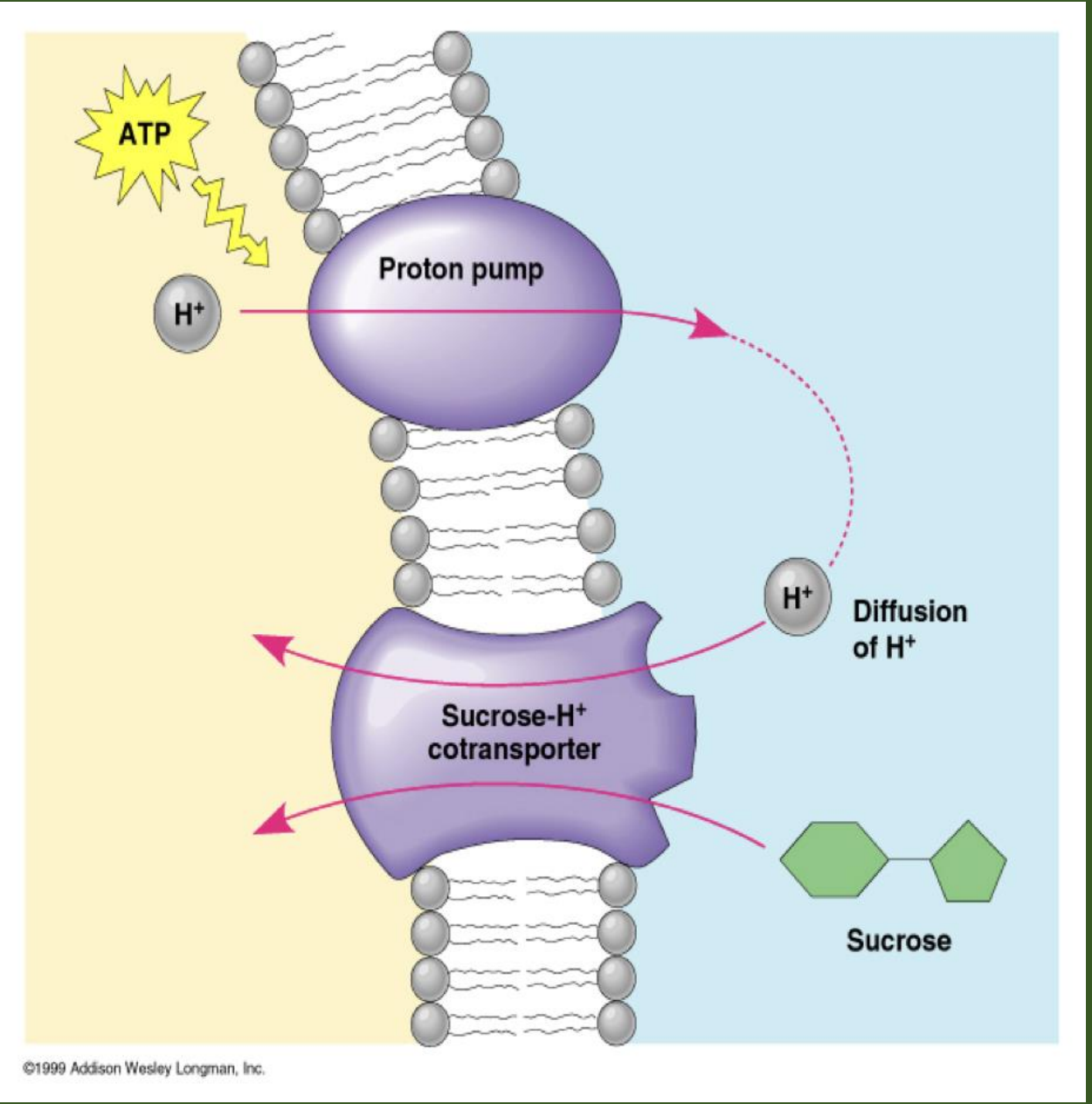


Review: passive and active transport compared



Cotransport

- A process where a single ATP-powered pump actively transports one solute, and indirectly drives the transport of other solutes against their concentration gradients



Exocytosis/Endocytosis

Exocytosis

- Exportation of macromolecules by the fusion of vesicles w/membrane
- Vesicle comes from ER or Golgi
- Used by secretory cells to export products

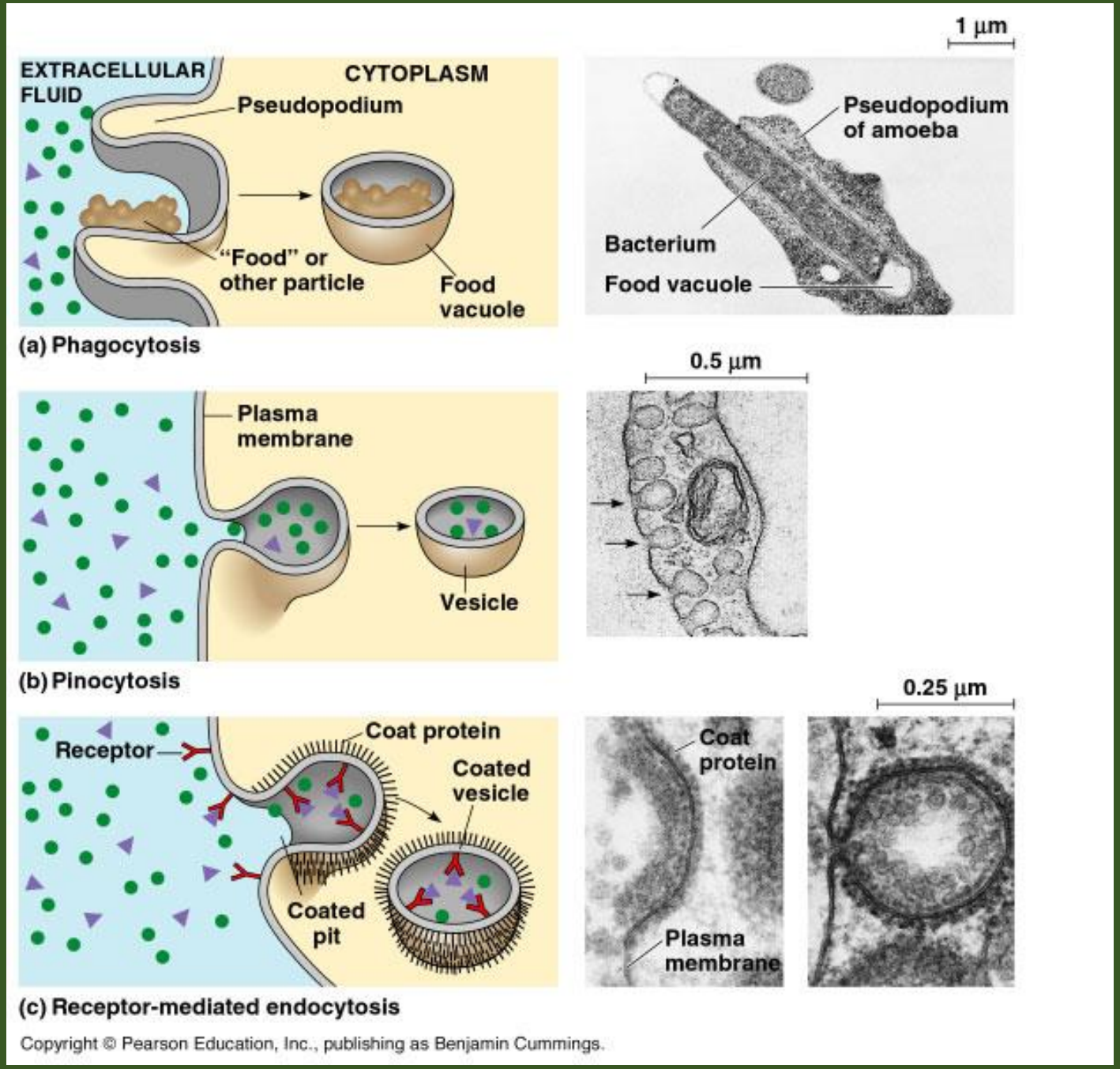
Endocytosis

- Importation of macromolecules into a cell by forming vesicles from membrane
- Used by cells to incorporate extracellular substances

Endocytosis

- Phagocytosis: “Cell eating” solid particles involved. Cell engulfs them with pseudopods. The vessicle then fuses w/ a food vacuole
- Pinocytosis: “Cell drinking” fluid droplets involved
- Receptor-Mediated endocytosis: stay tuned..

The three types of endocytosis in animal cells



Receptor-Mediated Endocytosis

- Importation of specific macromolecules into the cell by the inward budding of vessicles formed from COATED PITS
- A layer of CLATHRIN , a fibrous protein, lines and reinforces the coated pit, probably causing it to deepen the pit to form a vessicle
- This is specific, and is ligand/receptor triggered
- Ex. Cholesterol and LDL’s