

MEMBRANE STRUCTURE AND FUNCTION

Membrane Structure

Chapter 7

Objectives

- Be able to describe the structure of a membrane
- Be familiar with the structure and function of the lipid, protein, and carbohydrate components of a membrane
- Be familiar with the formation of a membrane

What is a membrane?

- Membranes are the borders between different regions of a cell.
- Where membranes exist, differing cell environments can be maintained.
- The plasma membrane borders the entire cell separating the internal environment from the external environment

Membrane Structure

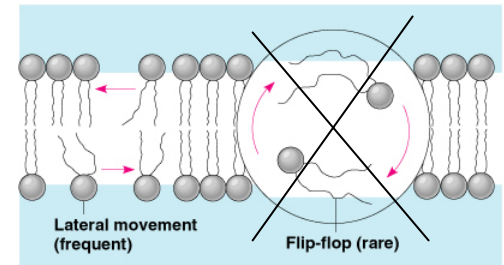
- Lipids and proteins are the chief ingredients of membrane
 - Phospholipid is amphipathic, both a hydrophobic and a hydrophilic region
 - Membrane proteins are also amphipathic
- Phospholipid is arranged as a bilayer
 - Hydrophilic heads exposed, hydrophobic tails protected
- Proteins are embedded in the phospholipid bilayer

Membrane Structure

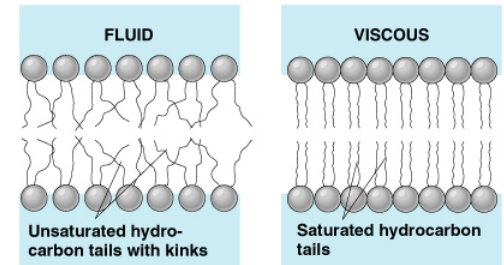
- Not all membranes are identical
 - Membranes with different functions differ in their chemical composition and structure
- Fluid Mosaic Model best describes our current understanding of membrane structure
 - a mosaic of proteins bobbing in a fluid bilayer of phospholipids

Fluidity

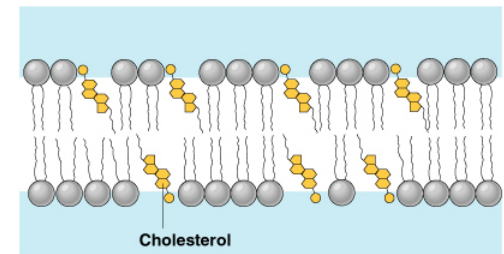
- Membranes are maintained by hydrophobic interactions of the phospholipids resulting in the alignment of the polar phosphate regions toward the aqueous environment and the nonpolar regions' hydrocarbon chains toward each other.
- Membranes are in motion with fast drifting lipids and slower drifting proteins



(a) Movement of phospholipids



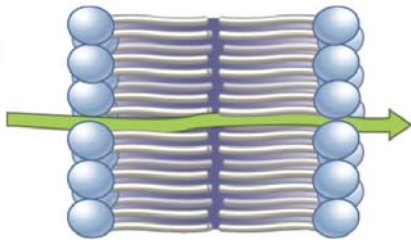
(b) Membrane fluidity



(c) Cholesterol within the membrane

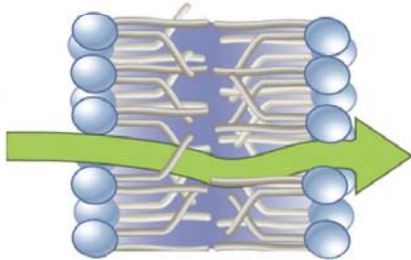
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Lipid bilayer with **no** unsaturated fatty acids



Lower permeability

Lipid bilayer with **many** unsaturated fatty acids



Higher permeability

Figure 6-11 Biological Science, 2/e

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- Membrane fluidity may be influenced by presence/absence of unsaturated FA chains and Cholesterol
- Fluidity of membranes is important for proper function

Question: Does adding cholesterol to a membrane affect its permeability?

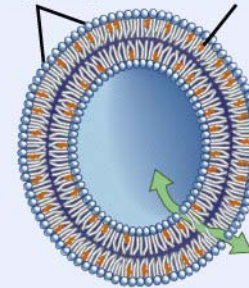
Hypothesis: Cholesterol reduces permeability because it fills spaces in phospholipid bilayers.

Null hypothesis: Cholesterol has no effect on permeability.

Experimental setup:

Liposome

Phospholipids Cholesterol



1. Create liposomes with no cholesterol, 20% cholesterol, and 50% cholesterol.

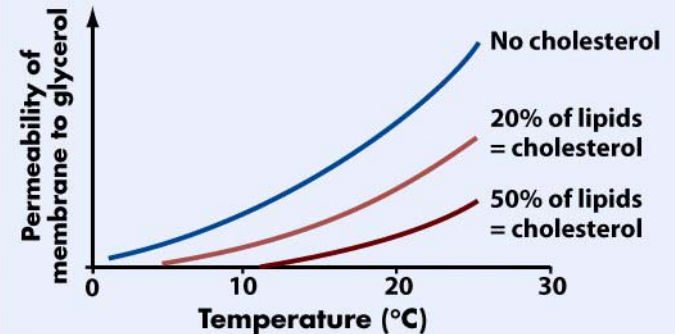
2. Record how quickly glycerol moves across each type of membrane at different temperatures.

Glycerol

Prediction: Liposomes with higher cholesterol levels will have reduced permeability.

Prediction of null hypothesis: All liposomes will have the same permeability.

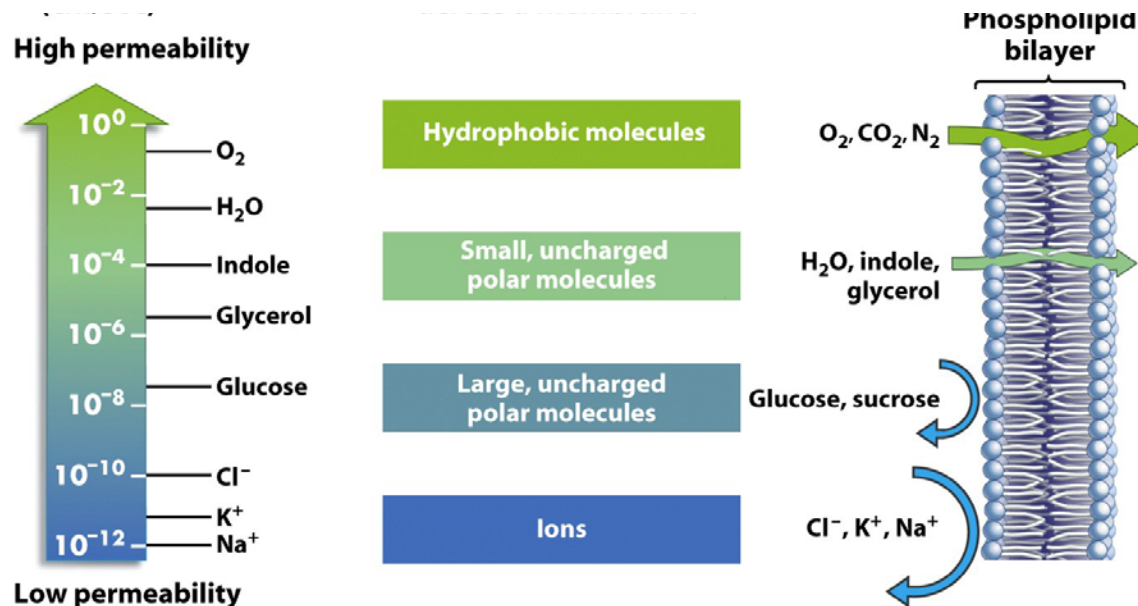
Results:



Conclusion: Adding cholesterol to membranes decreases their permeability to glycerol. The permeability of all membranes analyzed in this experiment increases with increasing temperature.

Fluidity Influences Permeability

- Permeability deals with the movement of materials across a membrane
- The hydrophobic portion of the lipid bilayer is selectively permeable; allowing only certain substances to cross

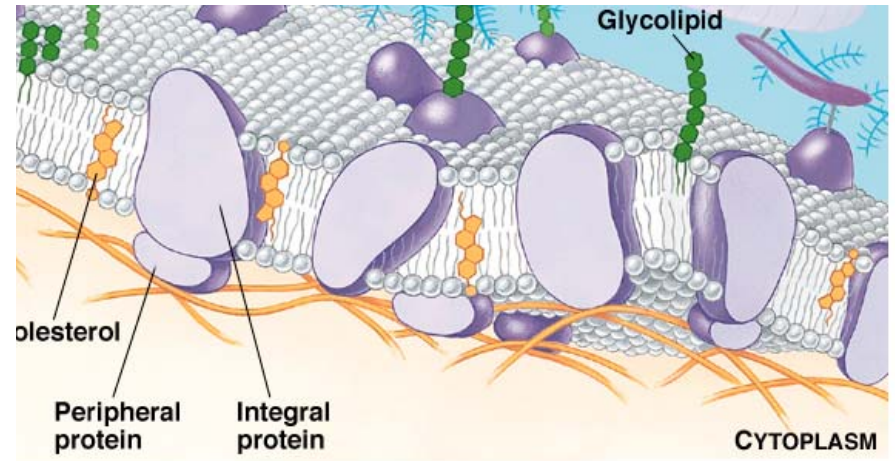


How are fluidity and permeability connected?

- Space must be present for molecules to cross the bilayer.
- “Available” space between phospholipid molecules allows for movement within a layer as well as the movement of molecules across the layer
 - Large polar molecules cannot fit between the lipid spaces
 - Charged molecules or atoms are chemically “repelled” by the hydrophobic component of the lipid

Mosaic

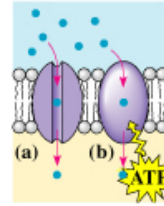
- Combination of proteins makes membrane unique
- Membrane proteins may be fluid or anchored



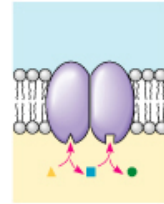
- Proteins may penetrate the bilayer fully (integral) or reside on the surfaces of membranes (peripheral)
- Integral proteins typically have hydrophobic regions that span the bilayer as a result of nonpolar amino acids arranged as helices
- Anchored proteins strengthen membranes

Protein function

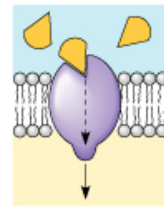
- Plasma membrane proteins serve diverse functions including:
 - Transport
 - Enzymatic activity
 - Signal transduction
 - Intercellular joining
 - Cell-cell recognition
 - Attachment to the cytoskeleton and extracellular matrix



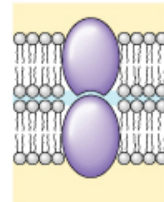
Transport (a) A protein that spans the membrane may provide a hydrophilic channel across the membrane that is selective for a particular solute. (b) Some transport proteins hydrolyze ATP as an energy source to actively pump substances across the membrane.



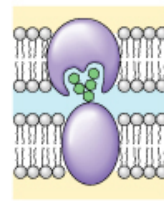
Enzymatic activity A protein built into the membrane may be an enzyme with its active site exposed to substances in the adjacent solution. In some cases, several enzymes in a membrane are ordered as a team that carries out sequential steps of a metabolic pathway.



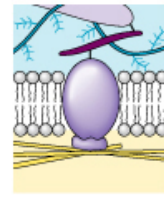
Signal transduction A membrane protein may have a binding site with a specific shape that fits the shape of a chemical messenger, such as a hormone. The external messenger (signal) may cause a conformational change in the protein that relays the message to the inside of the cell.



Intercellular joining Membrane proteins of adjacent cells may be hooked together in various kinds of junctions (see Figure 7.30).



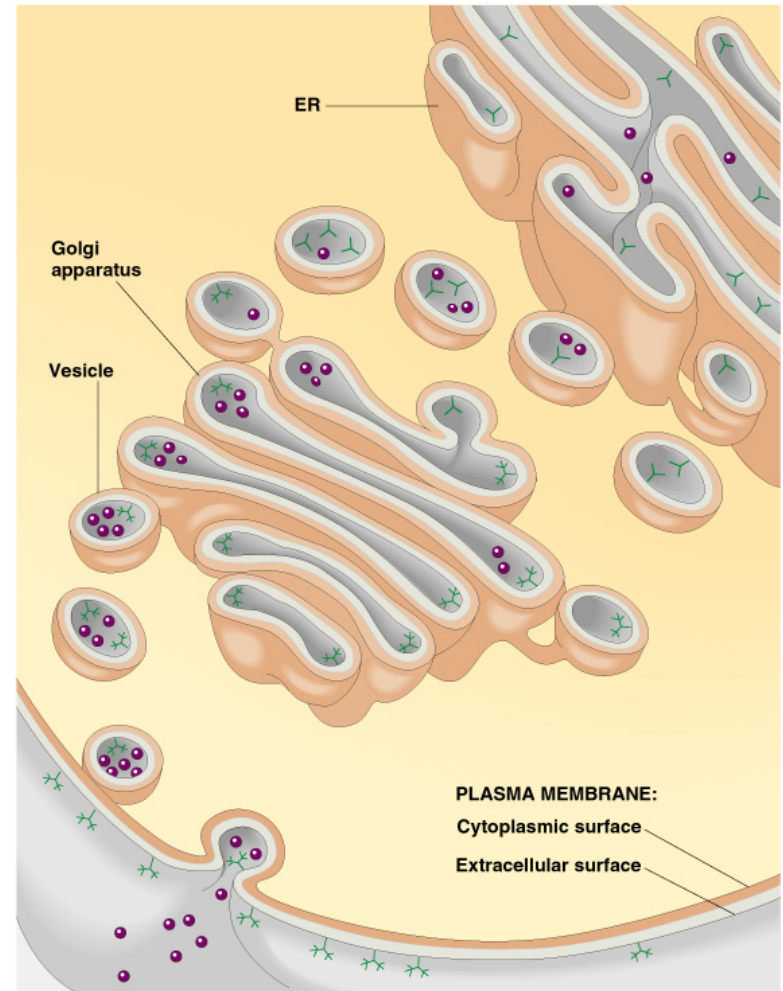
Cell-cell recognition Some glycoproteins (proteins with short chains of sugars) serve as identification tags that are specifically recognized by other cells.



Attachment to the cytoskeleton and extracellular matrix (ECM) Microfilaments or other elements of the cytoskeleton may be bonded to membrane proteins, a function that helps maintain cell shape and fixes the location of certain membrane proteins. Proteins that adhere to the ECM can coordinate extracellular and intracellular changes.

Carbohydrates diversify membranes

- Membrane carbohydrates are only found on the outside (external) face of membranes
- Attach to lipids or protein (glycolipid/ glycoprotein)
- Enable cells to distinguish/ recognize one another



Traffic Across Membranes

- Passive Transport is diffusion across a membrane
- Osmosis is the passive transport of water
- Cell survival depends on balancing water uptake and loss
- Facilitated Diffusion
- Active Transport is the pumping of solutes against their gradients
- Sodium-Potassium pump
- Cotransport
- Exocytosis, Endocytosis, and Pinocytosis