Chapter 7

Membrane Structure and Function

PowerPoint Lectures for
***Biology*, Seventh Edition**
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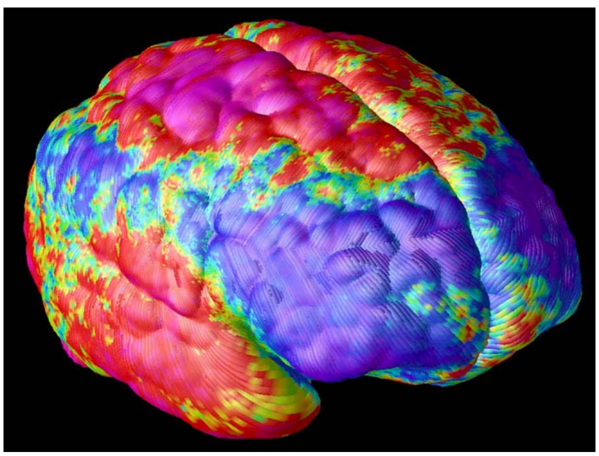
Cell membrane research: brain disorders

- Schizophrenia
- Autism



Selectively permeable fluid mosaic

- Connection - atherosclerosis

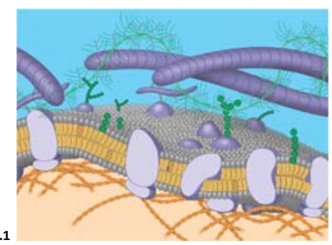
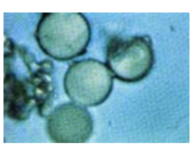


Figure 7.1

Early life - protobionts



Dialysis membranes

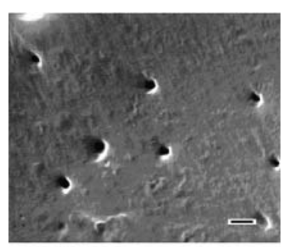


Figure 1. Scanning electron micrograph of the membrane surface showing pores (the mark at the lower right is one micron.

Fluid mosaic

- Amphipathic (hydrophobic/-philic regions)

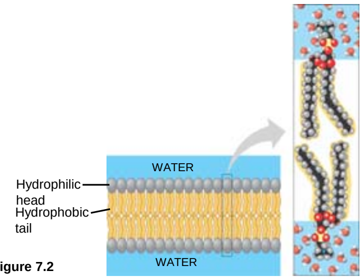


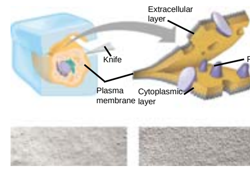
Figure 7.2

Freeze-fracture studies

Supported the fluid mosaic model of membrane structure

APPLICATION A cell membrane can be split into its two layers, revealing the ultrastructure of the membrane's interior.

TECHNIQUE A cell is frozen and fractured with a knife. The fracture plane often follows the hydrophobic interior of a membrane, splitting the phospholipid bilayer into two separated layers. The membrane proteins go wholly with one of the layers.

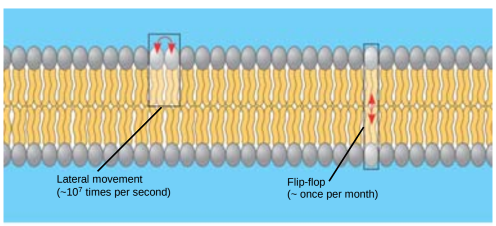


RESULTS These SEMs show membrane proteins (the "bumps") in the two layers, demonstrating that proteins are embedded in the phospholipid bilayer.

Figure 7.4 Extracellular layer Cytoplasmic layer

The Fluidity of Membranes

- Phospholipids can move within the bilayer



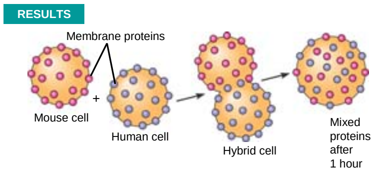
(a) Movement of phospholipids

Figure 7.5 A

- Proteins can drift within the bilayer

EXPERIMENT Researchers labeled the plasma mambrane proteins of a mouse cell and a human cell with two different markers and fused the cells. Using a microscope, they observed the markers on the hybrid cell.

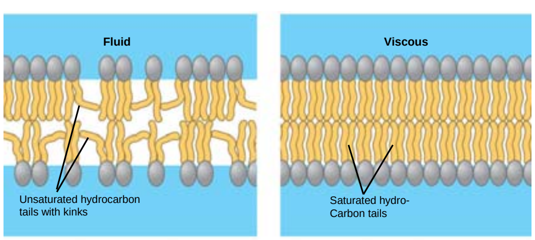
RESULTS



CONCLUSION The mixing of the mouse and human membrane proteins indicates that at least some membrane proteins move sideways within the plane of the plasma membrane.

Figure 7.6

- Hydrocarbon tails affects fluidity



(b) Membrane fluidity

Figure 7.5 B

- The steroid cholesterol
  - Has different effects on membrane fluidity at different temperatures

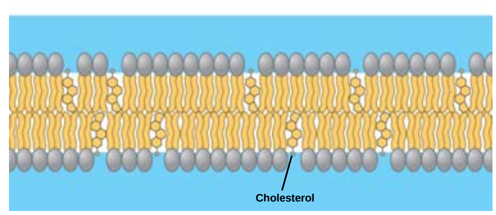


Figure 7.5 (c) Cholesterol within the animal cell membrane

Integral & peripheral proteins

Integral penetrate the hydrophobic core of the lipid bilayer, often transmembrane proteins, spanning membrane

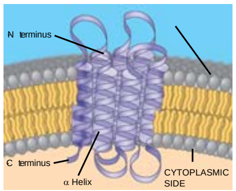


Figure 7.8

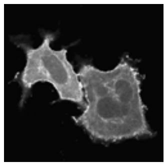


Figure 1. HeLa cells expressing a lipid-binding protein that is recruited to the plasma membrane on binding a specific phospholipid at the cytosolic face of the membrane bilayer. Note that plasma membrane ruffles in both cells are clearly defined by the localisation of this protein.

- An overview of six major functions of membrane proteins

(a) **Transport. (left)** A protein that spans the membrane may provide a hydrophilic channel across the membrane that is selective for a particular solute. **(right)** Other transport proteins shuttle a substance from one side to the other by changing shape. Some of these proteins hydrolyze ATP as an energy ssource to actively pump substances across the membrane.

(b) **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 organized as a team that carries out sequential steps of a metabolic pathway.

(c) **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 (receptor) that relays the message to the inside of the cell.

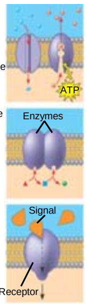


Figure 7.9

(d) **Cell-cell recognition.** Some glyco-proteins serve as identification tags that are specifically recognized by other cells.

(e) **Intercellular joining.** Membrane proteins of adjacent cells may hook together in various kinds of junctions, such as gap junctions or tight junctions (see Figure 6.31).

(f) **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 stabilizes the location of certain membrane proteins. Proteins that adhere to the ECM can coordinate extracellular and intracellular changes (see Figure 6.29).

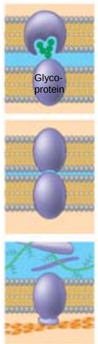


Figure 7.9

Carbohydrates in Cell-Cell Recognition

- Cell-cell recognition
  - Is a cell's ability to distinguish one type of neighboring cell from another
- Membrane carbohydrates
  - Interact with the surface molecules of other cells, facilitating cell-cell recognition

Synthesis and Sidedness of Membranes

- Membranes have distinct inside and outside faces
- This affects the movement of proteins synthesized in the endomembrane system

- Membrane proteins and lipids
  - Are synthesized in the ER and Golgi apparatus

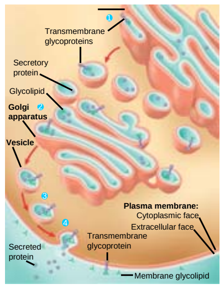


Figure 7.10

The Permeability of the Lipid Bilayer

- Hydrophobic molecules
  - Are lipid soluble and can pass through the membrane rapidly
- Polar molecules
  - Do not cross the membrane rapidly

Transport Proteins

- Transport proteins
  - Allow passage of hydrophilic substances across the membrane

Passive transport

- Diffusion
  - Is the tendency for molecules of any substance to spread out evenly into the available space

(a) Diffusion of one solute. The membrane has pores large enough for molecules of dye to pass through. Random movement of dye molecules will cause some to pass through the pores; this will happen more often on the side with more molecules. The dye diffuses from where it is more concentrated to where it is less concentrated (called diffusing down a concentration gradient). This leads to a dynamic equilibrium: The solute molecules continue to cross the membrane, but at equal rates in both directions.

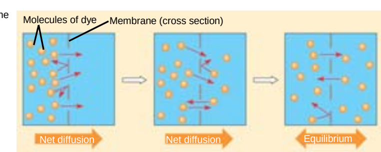


Figure 7.11 A

- Substances diffuse down their concentration gradient, the difference in concentration of a substance from one area to another

(b) Diffusion of two solutes. Solutions of two different dyes are separated by a membrane that is permeable to both. Each dye diffuses down its own concentration gradient. There will be a net diffusion of the purple dye toward the left, even though the *total* solute concentration was initially greater on the left side.

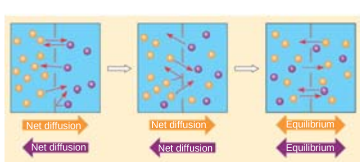


Figure 7.11 B

Effects of Osmosis on Water Balance

- Osmosis
  - Is the movement of water across a semipermeable membrane

- Is affected by the concentration gradient of dissolved substances

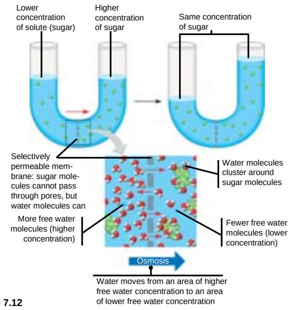


Figure 7.12

Water Balance of Cells Without Walls

- Tonicity
  - Is the ability of a solution to cause a cell to gain or lose water
  - Has a great impact on cells without walls

- If a solution is isotonic
  - The concentration of solutes is the same as it is inside the cell
  - There will be no net movement of water

- If a solution is hypertonic
  - The concentration of solutes is greater than it is inside the cell
  - The cell will lose water

- If a solution is hypotonic
  - The concentration of solutes is less than it is inside the cell
  - The cell will gain water

- Water balance in cells without walls

(a) Animal cell. An animal cell fares best in an isotonic environment unless it has special adaptations to offset the osmotic uptake or loss of water.

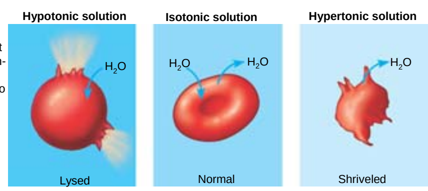


Figure 7.13

- Animals and other organisms without rigid cell walls living in hypertonic or hypotonic environments
  - Must have special adaptations for osmoregulation

(a) Animal cell. An animal cell fares best in an isotonic environment unless it has special adaptations to offset the osmotic uptake or loss of water.

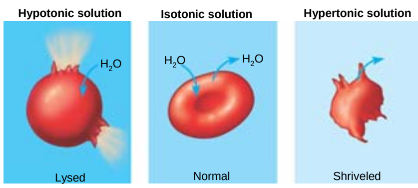


Figure 7.13

Water Balance of Cells with Walls

- Cell walls
  - Help maintain water balance

- If a plant cell is turgid
  - It is in a hypotonic environment
  - It is very firm, a healthy state in most plants

- If a plant cell is flaccid
  - It is in an isotonic or hypertonic environment

- Water balance in cells with walls

(b) Plant cell. Plant cells are turgid (firm) and generally healthiest in a hypotonic environment, where the uptake of water is eventually balanced by the elastic wall pushing back on the cell.

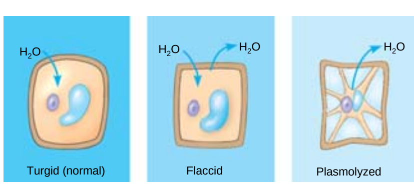
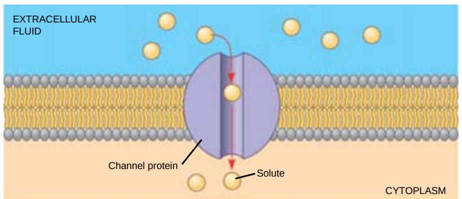


Figure 7.13

Facilitated Diffusion: Passive Transport Aided by Proteins

- In facilitated diffusion
  - Transport proteins speed the movement of molecules across the plasma membrane

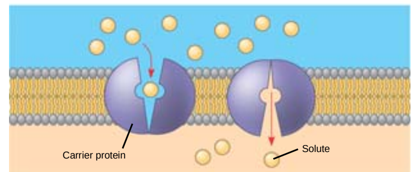
- Channel proteins
  - Provide corridors that allow a specific molecule or ion to cross the membrane



(a) A channel protein (purple) has a channel through which water molecules or a specific solute can pass.

Figure 7.15

- Carrier proteins
  - Undergo a subtle change in shape that translocates the solute-binding site across the membrane



(b) A carrier protein alternates between two conformations, moving a solute across the membrane as the shape of the protein changes. The protein can transport the solute in either direction, with the net movement being down the concentration gradient of the solute.

Figure 7.15

Active transport

- Active transport
  - Moves substances against their concentration gradient
  - Requires energy, usually in the form of ATP

- The sodium-potassium pump
  - Is one type of active transport system

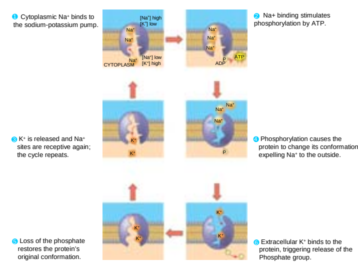


Figure 7.16

- Review: Passive and active transport compared

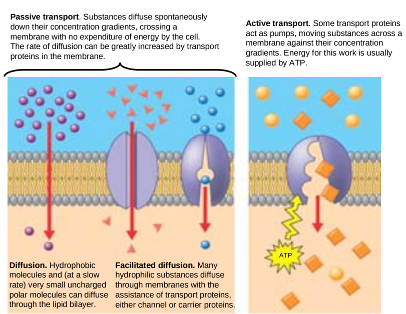


Figure 7.17

Maintenance of Membrane Potential by Ion Pumps

- Membrane potential
  - Is the voltage difference across a membrane

- An electrochemical gradient
  - Is caused by the concentration electrical gradient of ions across a membrane

- An electrogenic pump
  - Is a transport protein that generates the voltage across a membrane

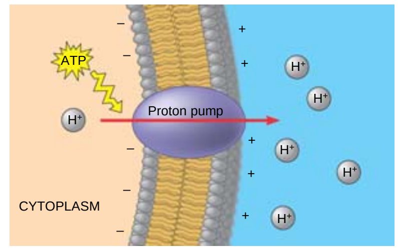


Figure 7.18

Cotransport: Coupled Transport by a Membrane Protein

- Cotransport
  - Occurs when active transport of a specific solute indirectly drives the active transport of another solute

- Cotransport: active transport driven by a concentration gradient

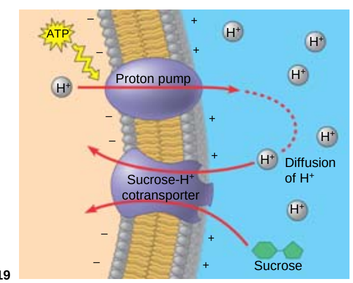


Figure 7.19

Exocytosis and endocytosis

- Large proteins
  - Cross the membrane by different mechanisms
- In exocytosis
  - Transport vesicles migrate to the plasma membrane, fuse with it, and release their contents
- In endocytosis
  - The cell takes in macromolecules by forming new vesicles from the plasma membrane

- Three types of endocytosis

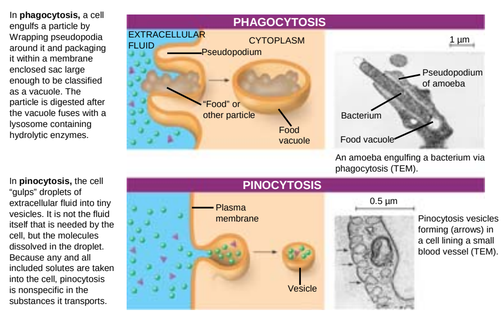
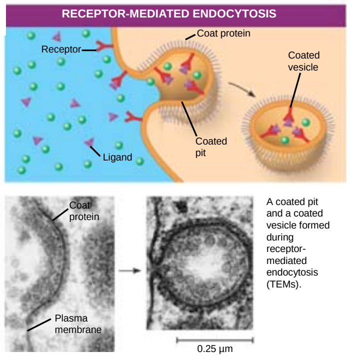


Figure 7.20

Receptor-mediated endocytosis enables the cell to acquire bulk quantities of specific substances, even though those substances may not be very concentrated in the extracellular fluid. Embedded in the membrane are proteins with specific receptor sites exposed to the extracellular fluid. The receptor proteins are usually already clustered in regions of the membrane called coated pits, which are lined on their cytoplasmic side by a fuzzy layer of coat proteins. Extracellular substances (ligands) bind to these receptors. When binding occurs, the coated pit forms a vesicle containing the ligand molecules. Notice that there are relatively more bound molecules (purple) inside the vesicle, other molecules (green) are also present. After this ingested material is liberated from the vesicle, the receptors are recycled to the plasma membrane by the same vesicle.



A coated pit and a coated vesicle formed during receptor-mediated endocytosis (TEMs).