Membrane Structure
and Function

The plasma membrane

- the boundary that separates the living cell from its nonliving surroundings
- The plasma membrane exhibits selective permeability
  - It allows some substances to cross it more easily than others
Cellular membranes

- Lipids
  - Phospholipids
    - Are the most abundant lipid in the plasma membrane
    - Are amphipathic, containing both hydrophobic and hydrophilic regions

- Proteins

Membrane Models

- Scientists studying the plasma membrane
  - Reasoned that it must be a phospholipid bilayer
The Davson-Danielli sandwich model of membrane structure
- Stated that the membrane was made up of a phospholipid bilayer sandwiched between two protein layers
- Was supported by electron microscope pictures of membranes

In 1972, Singer and Nicolson
- Fluid mosaic model
- Proposed that membrane proteins are dispersed and individually inserted into the phospholipid bilayer
Freeze-fracture studies of the plasma membrane

- Supported the fluid mosaic model of membrane structure

The Fluidity of Membranes

- Phospholipids in the plasma membrane
  - Can move within the bilayer
Proteins in the plasma membrane
- Can drift within the bilayer

- Membrane proteins
  - Mouse cell
  - Human cell
  - Hybrid cell
  - Mixed proteins after 1 hour

The type of hydrocarbon tails in phospholipids
- Fluid
  - Unsaturated hydrocarbon tails with kinks
- Viscous
  - Saturated hydrocarbon tails

(b) Membrane fluidity
The steroid cholesterol

- Has different effects on membrane fluidity at different temperatures

![Image of cholesterol in membrane](image)

(c) Cholesterol within the animal cell membrane

Membrane Proteins and Their Functions

- A membrane
  - Is a collage of different proteins embedded in the fluid matrix of the lipid bilayer
- Integral proteins
- Peripheral proteins
Integral proteins

- Penetrate the hydrophobic core of the lipid bilayer
- Are often transmembrane proteins, completely spanning the membrane

Peripheral proteins

- Are appendages loosely bound to the surface of the membrane
An overview of six major functions of membrane proteins

(a) **Transport.**

(b) **Enzymatic activity.**

(c) **Signal transduction.**

(d) **Cell-cell recognition.**

(e) **Intercellular joining.**

(f) **Attachment to the cytoskeleton and extracellular matrix (ECM).**
The Role of 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

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
- No energy investment
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.
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

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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.

![Turgid (normal) Flaccid Plasmolyzed](image)

**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.
Carrier proteins

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

![Diagram of carrier protein](image)

(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.

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

1. Cytoplasmic Na+ binds to the sodium-potassium pump.
2. Na+ binding stimulates phosphorylation by ATP.
3. K+ is released and Na+ sites are receptive again; the cycle repeats.
4. Phosphorylation causes the protein to change its conformation, expelling Na+ to the outside.
5. Extracellular K+ binds to the protein, triggering release of the Phosphate group.
6. Loss of the phosphate restores the protein’s original conformation.

Passive and active transport compared

**Passive transport.** Substances diffuse spontaneously down their concentration gradients, crossing a membrane with no expenditure of energy by the cell. The rate of diffusion can be greatly increased by transport proteins in the membrane.

**Active transport.** Some transport proteins act as pumps, moving substances across a membrane against their concentration gradients. Energy for this work is usually supplied by ATP.

**Diffusion.** Hydrophobic molecules and (at a slow rate) very small uncharged polar molecules can diffuse through the lipid bilayer.

**Facilitated diffusion.** Many hydrophilic substances diffuse through membranes with the assistance of transport proteins, either channel or carrier proteins.
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
Cotransport

- Coupled Transport by a Membrane Protein
- Occurs when active transport of a specific solute indirectly drives the active transport of another solute

Cotransport: active transport driven by a concentration gradient
Bulk transport across the plasma membrane

- Large proteins
  - Cross the membrane by different mechanisms
- Exocytosis
- Endocytosis

Exocytosis

- In exocytosis
  - Transport vesicles migrate to the plasma membrane, fuse with it, and release their contents
Endocytosis

- In endocytosis
  - The cell takes in macromolecules by forming new vesicles from the plasma membrane

Three types of endocytosis

PHAGOCYTOSIS

- Extracellular fluid
- Pseudopodium
- Food vacuole

An amoeba engulfing a bacterium via phagocytosis (TEM).

PINOCYTOSIS

- Plasma membrane
- Vesicle

Pinocytosis vesicles forming (arrows) in a cell lining a small blood vessel (TEM).
A coated pit and a coated vesicle formed during receptor-mediated endocytosis (TEMs).