Cell Membranes
Overview: Life at the Edge

This thin barrier, 8 nm thick, controls traffic into and out of the cell.
Like all biological membranes, the plasma membrane is **selectively permeable**

Concept 7.1 Cellular membranes are fluid mosaics of lipids and proteins

The main macromolecules in membranes are lipids and proteins, **but carbohydrates are also important**.
Phospholipids and most other membrane constituents are **amphipathic molecules**.
The arrangement of phospholipids and proteins in membranes is described by the **fluid mosaic model**.
The molecules in the bilayer are arranged such that the hydrophobic fatty acid tails are sheltered from water while the hydrophilic phosphate groups interact with water.
Membranes with different functions differ in chemical composition and structure.
Membrane proteins are amphipathic, with hydrophobic and hydrophilic regions.
A specialized preparation technique, freeze-fracture, splits a membrane along the middle of the phospholipid bilayer.

Membranes are fluid.

Membrane molecules are **held in place by relatively weak hydrophobic interactions**.
Most of the lipids and some proteins **drift laterally in the plane of the membrane, but rarely flip-flop**
Other proteins never move and are anchored to the cytoskeleton.
Membrane fluidity is also influenced by its components. **Membranes rich in unsaturated fatty acids are more fluid**

Membranes are mosaics of structure and function.

A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer.
Proteins determine most of the membrane's specific functions.
The plasma membrane and the membranes of the various organelles each have **unique collections** of proteins.
There are two major populations of membrane proteins: Peripheral proteins and integral proteins
- Where integral proteins are in contact with the aqueous environment, they have hydrophilic regions.

The proteins of the plasma membrane have six major functions:

(1) Transport of specific solutes into or out of cells, (2) Enzymatic activity, (3) Signal transduction, (4) Cell-cell recognition, (5) Intercellular joining of adjacent cells with gap or tight junctions, and (6) Attachment to the cytoskeleton and extracellular matrix, maintaining cell shape and stabilizing the location of membrane proteins.
Membrane carbohydrates are important for cell-cell recognition.
Membranes have distinct inside and outside faces. Asymmetrical orientation of proteins

Concept 7.2 Membrane structure results in selective permeability

A **steady traffic** of small molecules and ions moves across the plasma membrane in both directions.
However, substances do not move across the barrier indiscriminately; **membranes are selectively permeable**.
Movement of a molecule through a membrane depends on the interaction of the molecule with the hydrophobic core of the membrane.
Hydrophobic molecules, such as hydrocarbons, CO_2, and O_2, can dissolve in the lipid bilayer and cross easily.
Proteins assist and regulate the transport of ions and polar molecules.
Specific ions and polar molecules can cross the lipid bilayer by passing through **transport proteins** that **span** the membrane.
Some transport proteins, called **channel proteins**, have a **hydrophilic channel** that certain molecules or ions can use as a **tunnel through the membrane**: Example: Water and aquaporins.
Other transport proteins, called **carrier proteins**, bind to molecules and change shape to shuttle them across the membrane. Each transport protein is **specific** as to the substances that it will translocate.

Concept 7.3 Passive transport is diffusion of a substance across a membrane with no energy investment

Diffusion is the tendency of molecules of any substance to spread out in the available space.
Each substance **diffuses down** its own concentration gradient, independent of the concentration gradients of other substances.
The diffusion of a substance across a biological membrane **is passive transport** because it requires **no energy**.
The solution **with the higher concentration of solutes is hypertonic** relative to the other solution.
The solution with the **lower concentration of solutes is hypotonic relative** to the other solution.
Cell survival depends on balancing water uptake and loss.
An animal cell immersed in an **isotonic** environment experiences no net movement of water.
Organisms without rigid walls have osmotic problems in either a hypertonic or hypotonic

Specific proteins **facilitate passive transport** of water and selected solutes.
Passive movement of molecules down their concentration **gradient via** transport proteins is facilitated diffusion.

Concept 7.4 Active transport uses energy to move solutes against their gradients

Some transport proteins can move solutes across membranes **against** their concentration gradient.
This active transport **requires** the cell to expend **metabolic energy (ATP)**.
Active transport is performed by specific proteins embedded in the membranes.
The sodium-potassium pump actively maintains the gradient of sodium ions (Na+) and potassium ions (K+) across the plasma membrane of animal cells.
Some ion pumps **generate voltage** across membranes.
All cells maintain a voltage across their plasma membranes. The membrane potential acts like a **battery**.
Two combined forces, the **electrochemical gradient**, drive the diffusion of ions across a membrane.
An ion does not simply diffuse down its concentration gradient but diffuses down its electrochemical gradient.
Special transport proteins, **electrogenic pumps**, generate the voltage gradient across a membrane.
The sodium-potassium pump is the **major electrogenic pump of animal cells**.
In plants, bacteria, and fungi, **a proton pump is the major electrogenic pump**: Proton pumps in the cristae of mitochondria and the thylakoids of chloroplasts **concentrate** H+ behind membranes.
These electrogenic pumps **store energy** that can be accessed for cellular work.
In **cotransport**, a membrane protein couples the **transport of two solutes**.

Concept 7.5 Bulk transport across the plasma membrane occurs by exocytosis and endocytosis

Small molecules and water enter or leave the cell through the lipid bilayer or by transport proteins.
Large molecules, such as polysaccharides and proteins, cross the membrane via vesicles.
Many secretory cells use **exocytosis** to export their products.
During **endocytosis**, a cell brings in macromolecules and particulate matter by forming new vesicles from the plasma membrane.
Endocytosis is a reversal of exocytosis, although different proteins are involved in the two processes.
There are three types of endocytosis: **phagocytosis** ("cellular eating"), **pinocytosis** ("cellular drinking"), and **receptor-mediated endocytosis**.
In phagocytosis, the cell **engulfs** a particle by extending **pseudopodia** around it and packaging it in a large vacuole.
The contents of the vacuole are digested when the vacuole fuses with a lysosome.
In pinocytosis, a cell creates a vesicle around a droplet of extracellular fluid. All included solutes are taken into the cell in this nonspecific process.
Receptor-mediated endocytosis **allows greater specificity**, transporting only certain substances.