Phospholipids are the most abundant lipid in the plasma membrane. Phospholipids are amphipathic molecules, containing hydrophobic and hydrophilic regions. The fluid mosaic model states that a membrane is a fluid structure with a “mosaic” of various proteins embedded in it.

Fluidity of Membranes
Phospholipids in the plasma membrane can move within the bilayer. Most of the lipids, and some proteins, drift laterally. Rarely does a molecule flip-flop transversely across the membrane.

As temperatures cool, membranes switch from a fluid state to a solid state. The temperature at which a membrane solidifies depends on the types of lipids. Membranes rich in unsaturated fatty acids are more fluid than those rich in saturated fatty acids. Membranes must be fluid to work properly; they are usually about as fluid as salad oil.

The steroid cholesterol has different effects on membrane fluidity at different temperatures. At warm temperatures (such as 37°C), cholesterol restrains movement of phospholipids. At cool temperatures, it maintains fluidity by preventing tight packing.

Evolution of membrane lipid composition
Variations in lipid composition of cell membranes of many species appear to be adaptations to specific environmental conditions. Ability to change the lipid compositions in response to temperature changes has evolved in organisms that live where temperatures vary.

Functions of membrane proteins
A membrane is a collage of different proteins, often grouped together, embedded in the fluid matrix of the lipid bilayer. Proteins determine most of the membrane’s specific functions. Peripheral proteins are bound to the surface of the membrane. Integral proteins penetrate the hydrophobic core. Integral proteins that span the membrane are called transmembrane proteins. The hydrophobic regions of an integral protein consist of one or more stretches of nonpolar amino acids, often coiled into alpha helices.

Six major functions of membrane proteins:
Transport
Enzymatic activity
Signal transduction
Cell-cell recognition
Intercellular joining
Attachment to the cytoskeleton and extracellular matrix (ECM)

Cell – Cell recognition
Cells recognize each other by binding to surface molecules, often containing carbohydrates, on the extracellular surface of the plasma membrane. Membrane carbohydrates may be covalently bonded to lipids (forming glycolipids) or more commonly to proteins (forming glycoproteins). Carbohydrates on the external side of the plasma membrane vary among species, individuals, and even cell types in an individual.

Synthesis & Sidedness
Membranes have distinct inside and outside faces. The asymmetrical distribution of proteins, lipids, and associated carbohydrates in the plasma membrane is determined when the membrane is built by the ER and Golgi apparatus.

Selective Permeability
A cell must exchange materials with its surroundings, a process controlled by the plasma membrane. Plasma membranes are selectively permeable, regulating the cell’s molecular traffic. Hydrophobic (nonpolar) molecules, such as hydrocarbons, can dissolve in the lipid bilayer and pass through the membrane rapidly. Polar molecules, such as sugars, do not cross the membrane easily.

Transport Membranes
Transport proteins allow passage of hydrophilic substances across the membrane. Some transport proteins, called channel proteins, have a hydrophilic channel that certain molecules or ions can use as a tunnel. Channel proteins called aquaporins facilitate the passage of water. Other transport proteins, called carrier proteins, bind to molecules and change shape to shuttle them across the membrane. A transport protein is specific for the substance it moves.

Diffusion
Diffusion is the tendency for molecules to spread out evenly into the available space. Although each molecule moves randomly, diffusion of a population of molecules may be directional. At dynamic equilibrium, as many molecules cross the membrane in one direction as in the other.
Substances diffuse down their concentration gradient, the region along which the density of a chemical substance increases or decreases. No work must be done to move substances down the concentration gradient. The diffusion of a substance across a biological membrane is passive transport because no energy is expended by the cell to make it happen.

Osmosis
Osmosis is the diffusion of water across a selectively permeable membrane. Water diffuses across a membrane from the region of lower solute concentration to the region of higher solute concentration until the solute concentration is equal on both sides.

Water Balance of Cells without walls
Tonicity is the ability of a surrounding solution to cause a cell to gain or lose water. Isotonic solution: Solute concentration is the same as that inside the cell; no net water movement across the plasma membrane. Hypertonic solution: Solute concentration is greater than that inside the cell; cell loses water. Hypotonic solution: Solute concentration is less than that inside the cell; cell gains water.

Hypertonic or hypotonic environments create osmotic problems for organisms. Osmoregulation, the control of solute concentrations and water balance, is a necessary adaptation for life in such environments. The protist Paramecium, which is hypertonic to its pond water environment, has a contractile vacuole that acts as a pump.

Water Balance of Cells with walls
Cell walls help maintain water balance. A plant cell in a hypotonic solution swells until the wall opposes uptake; the cell is now turgid (firm). If a plant cell and its surroundings are isotonic, there is no net movement of water into the cell; the cell becomes flaccid (limp), and the plant may wilt. In a hypertonic environment, plant cells lose water; eventually, the membrane pulls away from the wall, a usually lethal effect called plasmolysis.

Facilitative Diffusion: Passive Transport aided by Proteins
In facilitated diffusion, transport proteins speed the passive movement of molecules across the plasma membrane. Channel proteins provide corridors that allow a specific molecule or ion to cross the membrane. Channel proteins include: Aquaporins, for facilitated diffusion of water. Ion channels that open or close in response to a stimulus (gated channels).
Carrier proteins undergo a subtle change in shape that translocates the solute-binding site across the membrane. Some diseases are caused by malfunctions in specific transport systems, for example the kidney disease cystinuria.

Active Transport uses energy – against the gradient
Facilitated diffusion is still passive because the solute moves down its concentration gradient, and the transport requires no energy.
Some transport proteins, however, can move solutes against their concentration gradients.
Active transport moves substances against their concentration gradient.
Active transport requires energy, usually in the form of ATP.
Active transport is performed by specific proteins embedded in the membranes.

Active transport allows cells to maintain concentration gradients that differ from their surroundings.
The sodium-potassium pump is one type of active transport system.

Ion Pumps
Membrane potential is the voltage difference across a membrane.
Voltage is created by differences in the distribution of positive and negative ions across a membrane.
Two combined forces, collectively called the electrochemical gradient, drive the diffusion of ions across a membrane.
A chemical force (the ion’s concentration gradient)
An electrical force (the effect of the membrane potential on the ion’s movement)

An electrogenic pump is a transport protein that generates voltage across a membrane.
The sodium-potassium pump is the major electrogenic pump of animal cells.
The main electrogenic pump of plants, fungi, and bacteria is a proton pump.
Electrogenic pumps help store energy that can be used for cellular work.

Cotransport
Cotransport occurs when active transport of a solute indirectly drives transport of other solutes.
Plants commonly use the gradient of hydrogen ions generated by proton pumps to drive active transport of nutrients into the cell.
Bulk Transport: Endo & Exocytosis
Small molecules and water enter or leave the cell through the lipid bilayer or via transport proteins.
Large molecules, such as polysaccharides and proteins, cross the membrane in bulk via vesicles.
Bulk transport requires energy.
Exocytosis
In exocytosis, transport vesicles migrate to the membrane, fuse with it, and release their contents.
Many secretory cells use exocytosis to export their products.

Phagocytosis
In phagocytosis a cell engulfs a particle in a vacuole.
The vacuole fuses with a lysosome to digest the particle.

Pinocytosis
In pinocytosis, molecules are taken up when extracellular fluid is “gulped” into tiny vesicles.

In receptor-mediated endocytosis, binding of ligands to receptors triggers vesicle formation.
A ligand is any molecule that binds specifically to a receptor site of another molecule.