Introduction

- The plasma membrane separates the living cell from its nonliving surroundings.
- This thin barrier, 8 nm thick, controls traffic into and out of the cell.
- Like other membranes, the plasma membrane is **selectively permeable**, allowing some substances to cross more easily than others.
- The main macromolecules in membranes are lipids and proteins, but include some carbohydrates.
- The most abundant lipids are phospholipids.
- Phospholipids and most other membrane constituents are **amphipathic molecules**.
  - Amphipathic molecules have both hydrophobic regions and hydrophilic regions.
- The phospholipids and proteins in membranes create a unique physical environment, described by the **fluid mosaic model**.
  - A membrane is a fluid structure with proteins embedded or attached to a double layer of phospholipids.

Membrane modes have evolved to fit new data

- Models of membranes were developed long before membranes were first seen with electron microscopes in the 1950s.
  - In 1895, Charles Overton hypothesized that membranes are made of lipids because substances that dissolve in lipid enter cells faster than those that are insoluble.
  - Twenty years later, chemical analysis confirmed that membranes isolated from red blood cells are composed of lipids and proteins.
- Attempts to build artificial membranes provided insight into the structure of real membranes.
  - In 1917, Irving Langmuir discovered that phosphilipids dissolved in benzene would form a film on water when the benzene evaporated.
    - The hydrophilic heads were immersed in water.

- In 1925, E. Gorter and F. Grendel reasoned that cell membranes must be a phospholipid bilayer, two molecules thick.
- 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.

- Early images from electron microscopes seemed to support the Davson-Danielli model and until the 1960s, it was considered the dominant model.
- In 1972, S.J. Singer and G. Nicolson presented a revised model that proposed that the membrane proteins are dispersed and individually inserted into the phospholipid bilayer.
  - In this fluid mosaic model, the hydrophilic regions of proteins and phospholipids are in maximum contact
    with water and the hydrophobic regions are in a nonaqueous environment.

Membranes are fluid

- Membrane molecules are held in place by relatively weak hydrophobic interactions.
- Most of the lipids and some proteins can drift laterally in the plane of the membrane, but rarely flip-flop from one layer to the other.

- The lateral movements of phospholipids are rapid, about 2 microns per second.
- Many larger membrane proteins move more slowly but ***do drift.***
  - Some proteins move in very directed manner, perhaps guided/driven by the motor proteins attached to the cytoskeleton.
  - Other proteins never move, anchored by the cytoskeleton.

- Membrane fluidity is influenced by temperature and by its constituents.
- As temperatures cool, membranes switch from a fluid state to a solid state as the phospholipids are more closely packed.
- Membranes rich in unsaturated fatty acids are more fluid that those dominated by saturated fatty acids because the
  kinks in the unsaturated fatty acid tails prevent tight packing.

- The steroid cholesterol is wedged between phospholipid molecules in the plasma membrane of animals cells.
- At warm temperatures, it restrains the movement of phospholipids and reduces fluidity.
- At cool temperatures, it maintains fluidity by preventing tight packing.

- To work properly with active enzymes and appropriate permeability, membranes must be fluid, about as fluid as salad oil.
- Cells can alter the lipid composition of membranes to compensate for changes in fluidity caused by changing temperatures.

- For example, cold-adapted organisms, such as winter wheat, increase the percentage of unsaturated phospholipids in the autumn.
- This allows these organisms to prevent their membranes from solidifying during winter.

Membranes are mosaics of structure and function

- A membrane is a collage of different proteins embedded in the fluid matrix of the lipid bilayer.

  - **Integral proteins** penetrate the hydrophobic core of the lipid bilayer, often completely spanning the membrane (a *transmembrane* protein).
    - Where they contact the core, they have hydrophobic regions with nonpolar amino acids, often coiled into alpha helices ***(what level of structure forms these???).***
    - Where they are in contact with the aqueous environment, they have hydrophilic regions of amino acids.

- One role of membrane proteins is to reinforce the shape of a cell and provide a strong framework.
  - On the cytoplasmic side, some membrane proteins connect to the cytoskeleton.
  - On the exterior side, some membrane proteins attach to the fibers of the extracellular matrix.
- Membranes have distinctive inside and outside faces.
- The two layers may differ in lipid composition Each protein has directional orientation in the membrane
- The outer surface of the membrane also has carbohydrates.
- This asymmetrical orientation of the membrane begins during synthesis of new membrane in the endoplasmic reticulum.

- The proteins in the plasma membrane may provide a variety of major cell functions.

Membrane carbohydrates are important for cell-cell recognition

- The membrane plays the key role in cell-cell recognition.
  - Cell-cell recognition is the ability of a cell to distinguish one type of neighboring cell from another.
  - This attribute is important in cell sorting and organization as tissues and organs in development.

  - It is also the basis for rejection of foreign cells by the immune system.
  - Cells recognize other cells by keying on surface molecules, often carbohydrates, on the plasma membrane.
- Membrane carbohydrates are usually branched oligosaccharides with fewer than 15 sugar units.
- They may be covalently bonded either to lipids, forming glycolipids, or, more commonly, to proteins, forming glycoproteins.
- The oligosaccharides on the external side of the plasma membrane vary from species to species, individual to individual, and even from cell type to cell type within the same individual.
  - This variation marks each cell type as distinct.
  - The four human blood groups (A, B, AB, and O) differ in the external carbohydrates on red blood cells.