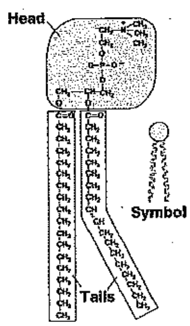
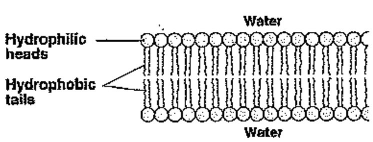
Membranes *and Movement*

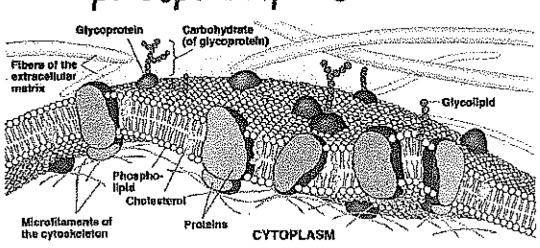
1. Membranes organize the chemical activities within the cell.

2. Membrane phospholipids form a bilayer.



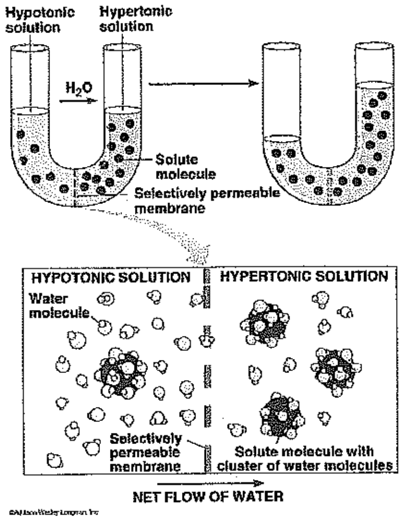


3. The membrane is a fluid mosaic of proteins and phospholipids.

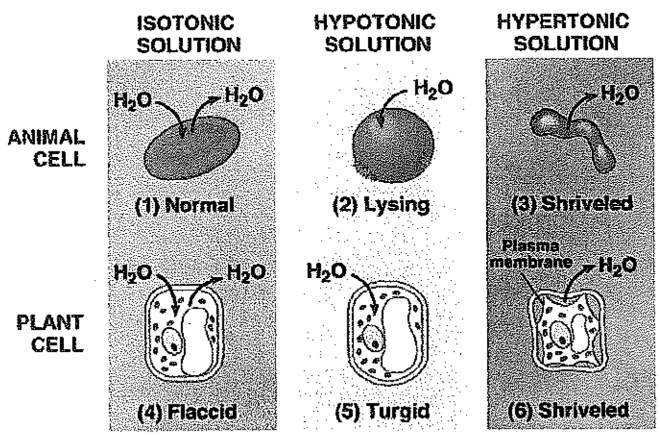


4. Passive Transport is diffusion across a membrane.

5. *Osmosis is passive transport of water.*



6. *Water balance is crucial for all living organisms.*



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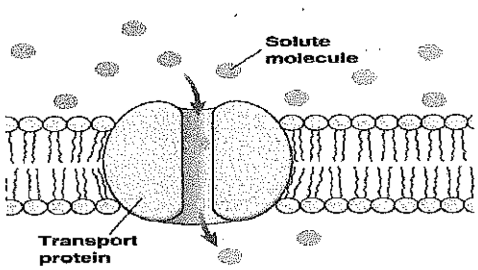
7. *Specific proteins facilitate movement across a membrane.*



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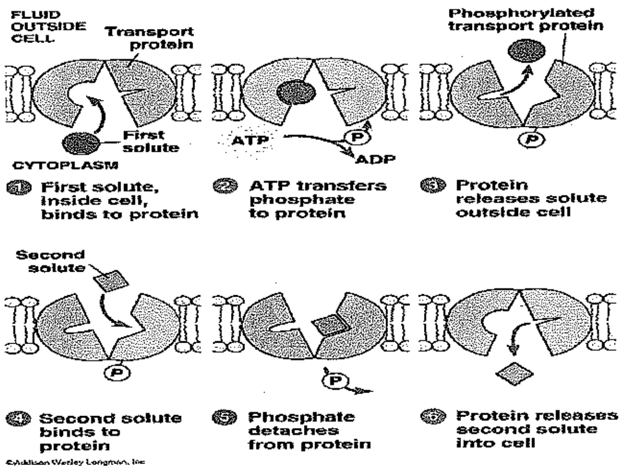
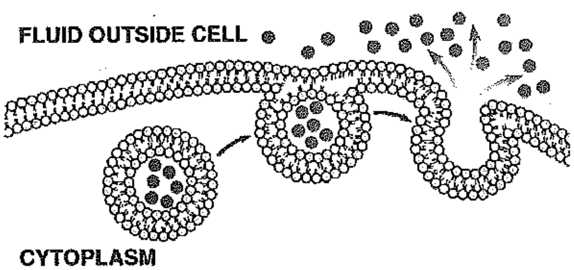
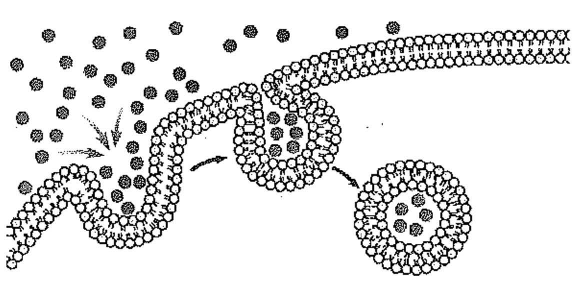
8. Cells use energy for active transport.



9. Exo and endocytosis move big molecule across a membrane.





5.4 Cell Transport

The plasma membrane regulates the passage of molecules into and out of the cell. This function is crucial because the life of the cell depends on maintenance of its normal composition. The plasma membrane can carry out this function because it is differentially permeable, meaning that certain substances can freely pass through the membrane while others are transported across. Basically, substances enter a cell in one of three ways: passive transport, active transport, and bulk transport. Although there are different types of passive transport, in all cases substances move from a higher to a lower concentration, and no energy is required. Active transport moves substances against a concentration gradient and requires energy. Bulk transport requires energy, but movement of the large substances involved is independent of concentration gradients.

Passive Transport: No Energy Required

Actually, no membrane is required for simple diffusion. During **simple diffusion,** molecules move down their concentration gradient until equilibrium is achieved and they are distributed equally. Simple diffusion occurs because molecules are in motion, but it is a *passive* form of transport because a cell does not need to expend energy for it to happen. Small, noncharged molecules, such as oxygen, carbon dioxide, glycerol, alcohol, and water, are able to slip between the phospholipid molecules making up the plasma membrane. Therefore, these molecules can diffuse across the membrane.

Figure 5.11 demonstrates simple diffusion. Water is present on two sides of a membrane, and dye is added to one side. The dye particles move in various directions, but the net movement is toward the opposite side of the membrane. Eventually, the dye is dispersed, with no net movement of dye in either direction. A **solution** contains both a solute and a solvent. In this case, the dye is called the **solute,** and the water is called the **solvent.** Solutes are usually solids, and solvents are usually liquids.

Dissolved gases can diffuse through the phospholipid bilayer, and indeed this is the mechanism by which oxygen enters cells and carbon dioxide exits them. Also, oxygen enters blood from the air sacs of the lungs, and carbon dioxide moves in the opposite direction by diffusion.

Ions and polar molecules, such as glucose and amino acids, are often assisted across the plasma membrane by transport proteins. This process is called **facilitated diffusion.** Even those proteins that simply provide a channel for passage are usually specific to the solute. In these cases, the transport proteins most likely undergo a change in shape as the solute enters the cell.

Osmosis

Diffusion of water across a differentially permeable membrane is called **osmosis.** To illustrate osmosis, a tube containing a 5% salt solution and covered at one end by a membrane is placed in a beaker that contains water only (Fig. 5.12*a*). The beaker has a higher concentration of water molecules than the tube does because the tube also contains a solute. Water can cross the membrane, but the solute cannot. Therefore, there will be a net movement of water across the membrane from the beaker to the inside of the tube. Theoretically, the solution inside the tube will rise until there is an equal concentration of water on both sides of the membrane (Fig. 5.12*b,c*). What would happen if the beaker contained a 2% salt solution? Water would still diffuse into the tube, because the tube at 5% salt would still contain a lower concentration of water molecules than the beaker at 2%.

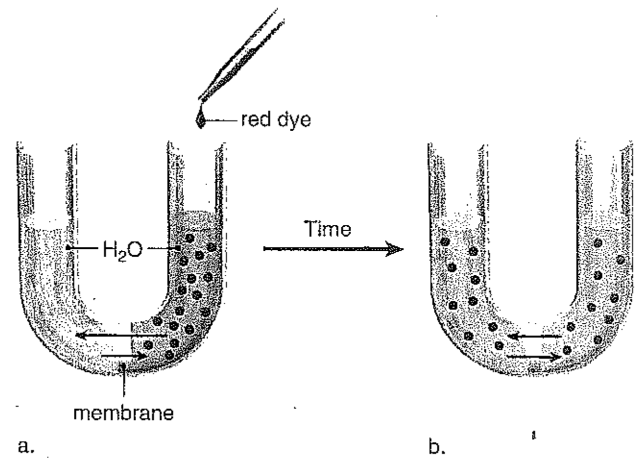


Figure 5.11 **Simple diffusion demonstration.**

Simple diffusion is spontaneous, and no energy is required to bring it about. **a.** Red dye is added to water separated by a membrane. The dye molecules can pass through the membrane. The dye molecules move randomly about, but over time the net movement of dye is toward the region of lower concentration. **b.** Eventually, the dye molecules are equally distributed throughout the container and there is no net movement of dye in either direction.

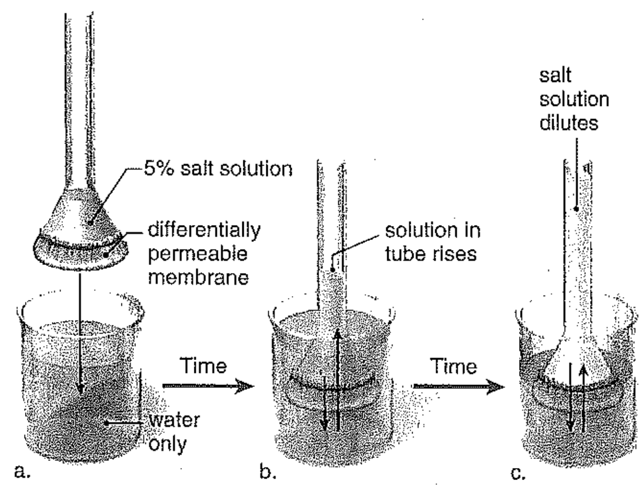


Figure 5.12 **Osmosis demonstration.**

a. A tube covered at the broad end by a differentially permeable membrane contains a 5% salt solution, and the beaker contains only water. The salt ions are unable to pass through freely, but the water molecules can pass through the membrane. **b.** Therefore, there is a net movement of water toward the inside of the tube, where the percentage of water molecules is lower than the outside. **c.** The level of the solution rises in the tube because of the incoming water.

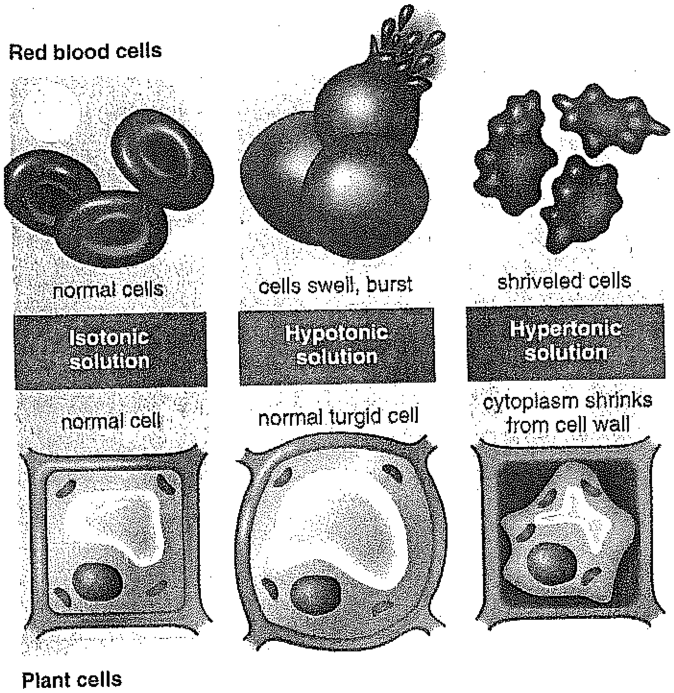


Figure 5.13 Osmosis in animal and plant cells.

In an isotonic solution, cells neither gain nor lose water. In a hypotonic solution, cells gain water. Red blood cells swell to bursting, and plant cells become turgid. In a hypertonic solution, cells lose water. Red blood cells shrivel, and plant cell cytoplasm shrinks away from the cell wall.

The Effect of Osmosis on Cells

Osmosis can affect the size and shape of cells, as shown in Figure 5.13. In the laboratory, cells are normally placed in **isotonic solutions** (*iso*, same as) in which the cell neither gains nor loses water—that is, the concentration of water is the same on both sides of the membrane. In medical settings, a 0.9% solution of the salt sodium chloride (NaCl) is known to be isotonic to red blood cells; therefore, intravenous solutions usually have this concentration.

Cells placed in a **hypotonic solution** (*hypo*, less than) gain water. Outside the cell, the concentration of solute is less, and the concentration of water is greater, than inside the cell. Animal cells placed in a hypotonic solution expand and sometimes burst. The term *lysis* refers to disrupted cells; *hemolysis*, then, is disrupted red blood cells.

When a plant cell is placed in a hypotonic solution, the large central vacuole gains water, and the plasma membrane pushes against the rigid cell wall as the plant cell becomes *turgid*. The plant cell does not burst because the cell wall does not give way. Turgor pressure in plant cells is extremely important in maintaining their erect position.

Cells placed in a **hypertonic solution** (*hyper*, more than) lose water. Outside the cell, the concentration of solute is more, and the concentration of water is less, than inside the cell. Animal cells placed in a hypertonic solution shrink. For example, meats are sometimes preserved by being salted. Bacteria are killed not by the salt, but by the lack of water in the meat.

When a plant cell is placed in a hypertonic solution, the plasma membrane pulls away from the cell wall as the large central vacuole loses water. This is an example of **plasmolysis,** shrinking of the cytoplasm due to osmosis. The dead plants you may see along a roadside could have died due to exposure to a hypertonic solution during the winter, when salt was used on the road.

Check Your Progress

1. **Compare and contrast simple diffusion with facilitated diffusion.**
2. **Describe the relationship between a solute, a solvent, and a solution.**

Answers: 1. Both types of diffusion move molecules from high to low concentration. Simple diffusion does not require a membrane or transport proteins, while facilitated diffusion does. 2. A solution is composed of a solute dissolved in a solvent.

Active Transport: Energy Required

During **active transport,** molecules or ions move through the plasma membrane, accumulating on one side of the cell (Fig. 5.14). For example, iodine collects in the cells of the thyroid gland; glucose is completely absorbed from the digestive tract by the cells lining the digestive tract; and sodium can be almost completely withdrawn from urine by cells lining the kidney tubules. In these instances, molecules have moved against their concentration gradients, a situation that requires both a transport protein and ATP. Therefore, cells involved in active transport, such as kidney cells, have a large number of mitochondria near their plasma membranes to generate the ATP.

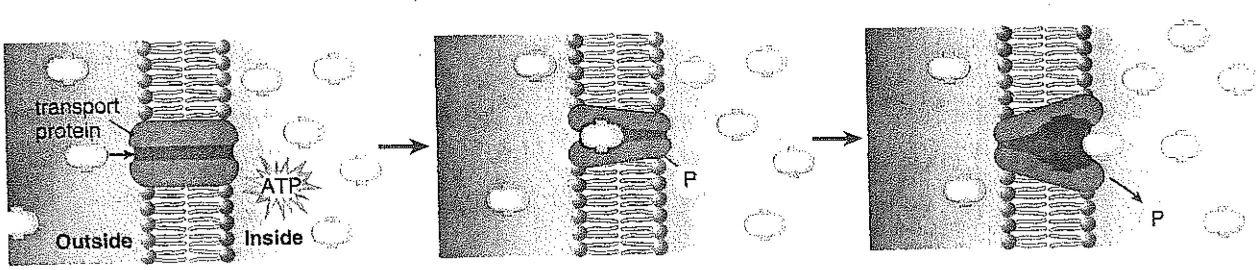


Figure 5.14 Active transport.

During active transport, a transport protein uses energy to move a solute across the plasma membrane toward a higher concentration. Note that the transport protein changes shape during the process.

The passage of salt (NaCl) across a plasma membrane is of primary importance in cells because the salt causes water to move to that side of the plasma membrane. First, sodium ions are actively transported across a membrane, and then chloride ions simply diffuse through channels that allow their passage. Chloride ion channels malfunction in persons with cystic fibrosis, leading to the symptoms of this inherited disorder. Proteins engaged in active transport are often called *pumps.* The **sodium-potassium pump,** vitally important to nerve conduction, undergoes a change in shape that allows it to combine alternately with sodium ions and potassium ions.

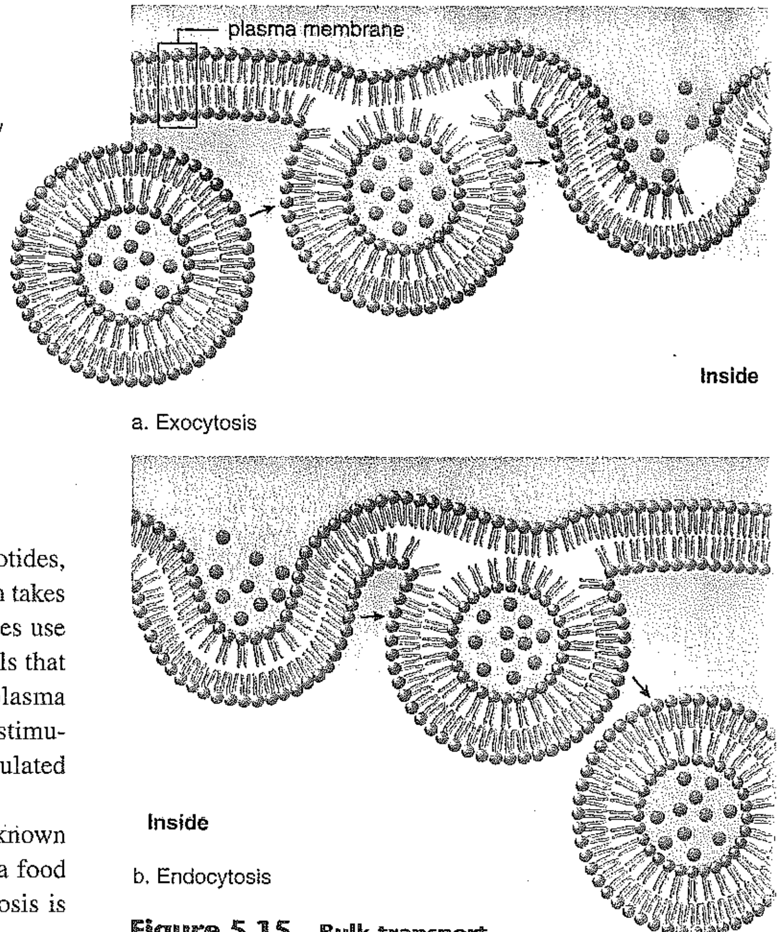


Figure 5.15 **Bulk transport.**

During exocytosis (**a**) and endocytosis (**b**), vesicle formatic transports substances out of or into a cell, respectively.

Bulk Transport

Macromolecules, such as polypeptides, polysaccharides, or polynucleotides, are too large to be moved by transport proteins. Instead, vesicle formation takes them into or out of a cell. For example, digestive enzymes and hormones use molecules transported out of the cell by **exocytosis** (Fig. 5.15*a*). In cells that synthesize these products, secretory vesicles accumulate near the plasma membrane. These vesicles release their contents only when the cell is stimulated by a signal received at the plasma membrane, a process called regulated secretion.

When cells take in substances by vesicle formation, the process is known as **endocytosis** (Fig. 5.15*b*). If the material taken in is large, such as a food particle or another cell, the process is called **phagocytosis.** Phagocytosis is common in unicellular organisms, such as amoebas. It also occurs in humans. Certain types of human white blood cells are amoeboid—that is, they are mobile like an amoeba, and are able to engulf debris such as worn-out red blood cells or bacteria. When an endocytic vesicle fuses with a lysosome, digestion occurs. In Chapter 26, we will see that this process is a necessary and preliminary step toward the development of immunity to bacterial diseases.

Pinocytosis occurs when vesicles form around a liquid or around very small particles. White blood cells, cells that line the kidney tubules and the intestinal wall, and plant root cells all use pinocytosis to ingest substances.

During **receptor-mediated endocytosis,** receptors for particular substances are found at one location in the plasma membrane. This location is called a coated pit because there is a layer of protein on its intracellular side (Fig. 5.16). Receptor-mediated endocytosis is selective and much more efficient than ordinary pinocytosis. It is involved when substances move from maternal blood into fetal blood at the placenta, for example.

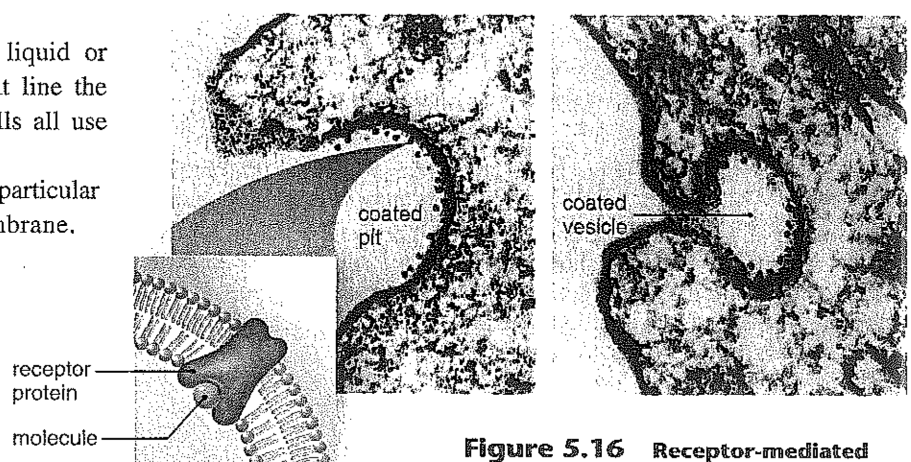


Figure 5.16 **Receptor-mediated endocytosis.**

During receptor-mediated endocytosis, molecules first bind to specific receptor proteins that are in a coated pit. The vesicle that forms contains the molecules and their receptors.

Check Your Progress

Compare and contrast exocytosis and endocytosis.

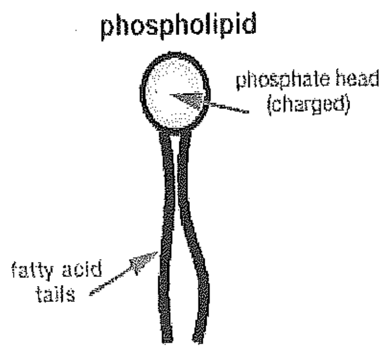
Answer: Both use vesicles to transport materials across the plasma membrane. Molecules are transported out by exocytosis and in by endocytosis.

Biology Lecture Notes

Membranes: Basic Structure

>> Key Concepts:

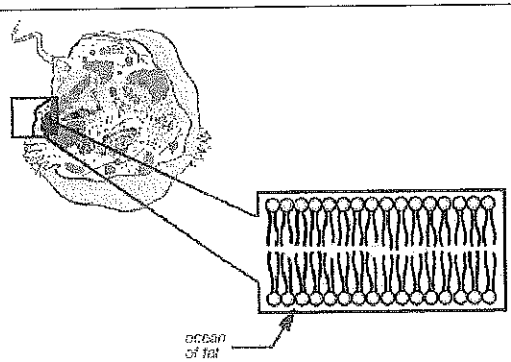
- The structure of plasma membranes allows cellular compartmentalization and **selective permeability** to various substances.
- The **fluid mosaic model** is a model of membrane structure. According to the model, membranes are composed of a double layer of **phospholipids** in which proteins are embedded. The layer is somewhat fluid, allowing the movement of proteins within it.
- The plasma membrane separates the eukaryotic cell's contents from the outside. The **cytoplasm** is defined as all the cell's contents from the plasma membrane to the nucleus. The **cytosol** is the liquid of the cytoplasm



This illustration depicts the major components of the **fluid mosaic model**, a model that describes the dynamic—yet constant—properties of the plasma membrane.

The main structural molecule of the cell membrane is the **phospholipid**, a lipid consisting of glycerol bonded to two fatty acid "tails" and a phosphate-charged "head."

Because the fatty acid tails are saturated with hydrogen, they are nonpolar (**hydrophobic**). The charged head is polar (**hydrophilic**).



The term **phospholipid bilayer** refers to the arrangement of phospholipids in the cell membrane. The phospholipids form a double layer; the hydrophilic heads face outwards and the hydrophobic tails form the center of the layer.

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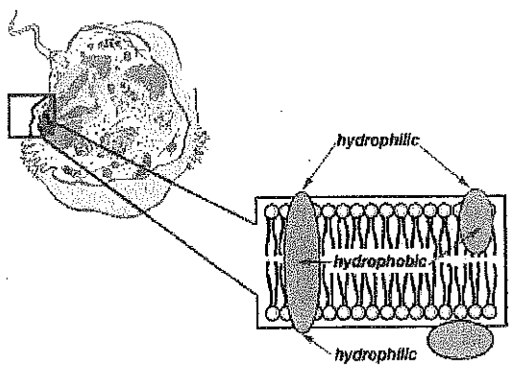
Biology Lecture Notes



Proteins are also embedded in the bilayer. Because the proteins are charged, they are **hydrophilic**. The proteins occur throughout the bilayer complex.

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