Membrane structure and function:

A plasma membrane enclose every cell :

1- Unicellular organism.
2- Multicellular organism.

- It is the edge of life; the boundary that separates the living cell from its nonliving surrounding (8 nm thick).
- Biological membranes are **selectively Permeable**

EVOLUTION OF MEMBRANE MODELES:

A- **The Davson- Danieli** model 1935 was a sandwiched –a phospholipids bilayer between two protein layers. With later modifications, this model was widely accepted until 1970.

- Not all the membranes look alike in EM, they have different functions, differ in chemical composition and structure.
- **In 1972 , S. Singer and G. Nicolson** proposed that membrane proteins are dispersed and individually inserted into the phospholipids bilayer ,so the membrane is a mosaic of protein molecules bobbing in a fluid bilayer of phospholipids: hence the term fluid mosaic model
- **Fluid** ----- not static, not solid sheets of molecules, molecules exchanging places with neighbors.
- **Mosaics of structure and function—The** P M and the M of the various organelles have their unique collections of proteins ex. 50 kinds of proteins found in P M of R. Blood.
- Part of membrane is fluid phospholipids - bilayers in which protein molecules are either partially or wholly embedded. The mosaic distribution (an irregular pattern) of proteins is supported by E.M. of freeze-fractured membrane.
- In a membrane, the hydrophilic heads of the **phospholipids** molecules face the **intracellular** and **extra cellular** fluids. The hydrophobic tails face each other in the membrane interior.

Phospholipids is an amphipathic molecule(has both a hydrophilic region & hydrophobic):

- The other types of lipids in P.m**.*Glycolipids** the hydrophilic head is a variety of sugars joined to form a straight or branch chain

- And ***Cholesterol** reduces the permeability of the membrane to most biological molecules; helps to keep the membrane fluid by hindering close packing of pho. Lipids.

- The fluidity of a phospholipids bilayer has the consistency of olive oil. Phospholipid moves along the plan the membrane quite rapidly, proteins are much larger than lipids.

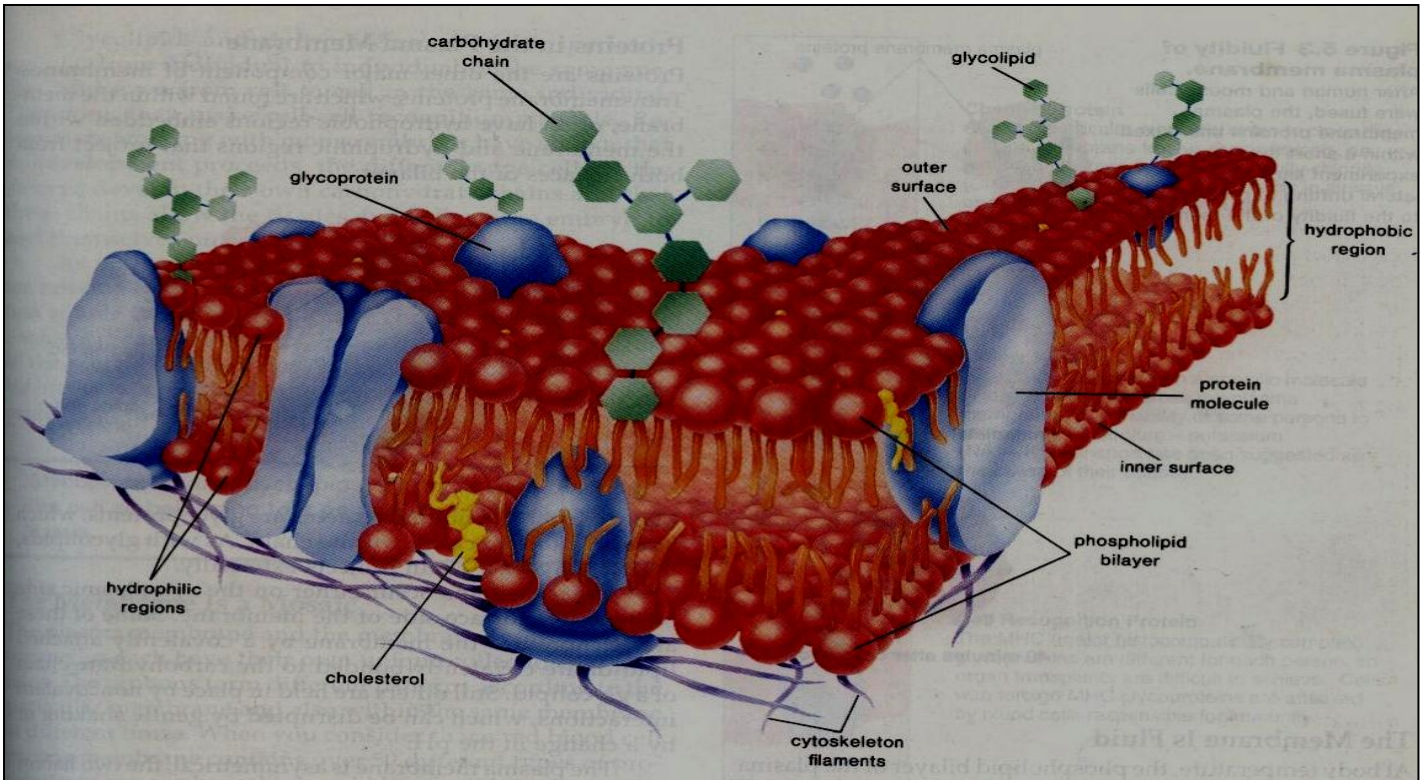
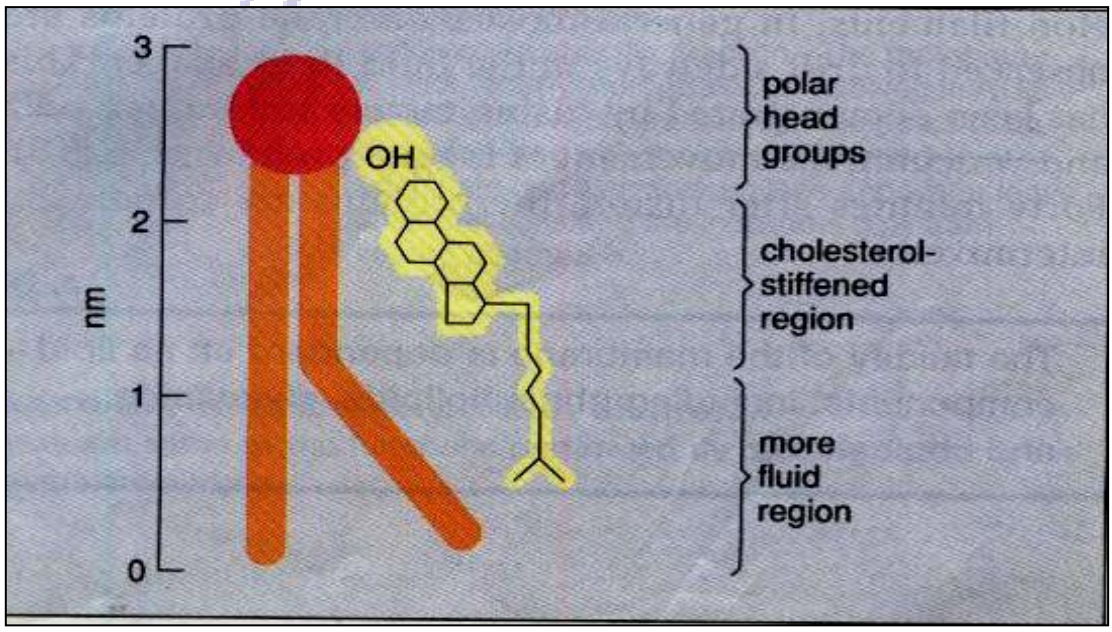


Figure 5.2 Fluid-mosaic model of an animal cell plasma membrane.
The plasma membrane is composed of a phospholipid bilayer with embedded proteins. The hydrophilic heads of the phospholipids are at the surfaces of the membrane, and the hydrophobic tails make up the interior of the membrane. Note the asymmetry of the membrane; for example, carbohydrate chains project externally and cytoskeleton filaments attach to proteins on the cytoplasmic side of the plasma membrane.



Proteins:

- **Transmembrane proteins** have hydrophilic region embedded within the have hydrophilic region embedded within the membrane and hydrophilic regions that project from both surfaces of the bilayer:
- Many P.M. proteins are glycoproteins (have an attached carbohydrate chains).
- Other proteins, on the cytoplasmic side or the other surface side of the membrane *__Peripheral membrane proteins__.
- The plasma membrane is **asymmetrical;** the two halves are not identical.
- The carbohydrate chains of the **glycolipids** and **glycoproteins** form a carbohydrate coat that envelops the outer surface of the plasma membrane.
- The carbohydrate chains of the **glycolipids** and **glycoproteins** serve as **the "fingerprints**" of the cells .The glycolipids and glycoproteins vary from species to species , from individual to other of the same species and from cell to cell in the same individual .
- **They make cell-cell recognition possible (the ability of a cell to determine if other cells it encounters are alike or different from itself). Transplanted tissues are often rejected by the body**. This because the immune system is able to recognize that tissue as foreign tissues. cells don't have the same glycolipids and glycoprotein , so they are involved in marking the cells as belonging to a particular individual and tissue.
- **Thus, the entire outside surface of the cell has a loose carbohydrate coat called the Glycocalyx .**

The important functions of carbohydrate moieties :

1- **Many of them have a negative electrical charge that repels other negative objects .**
2- **The glycoclyx of some cells attaches to the glycoclyx of the other cells, thus attaching cells to one other**
3- **Many of carbohydrates act as receptor substances for binding hormones ex. Insulin;**
4- **Some carbohydrate moieties enter into immune reactions .**

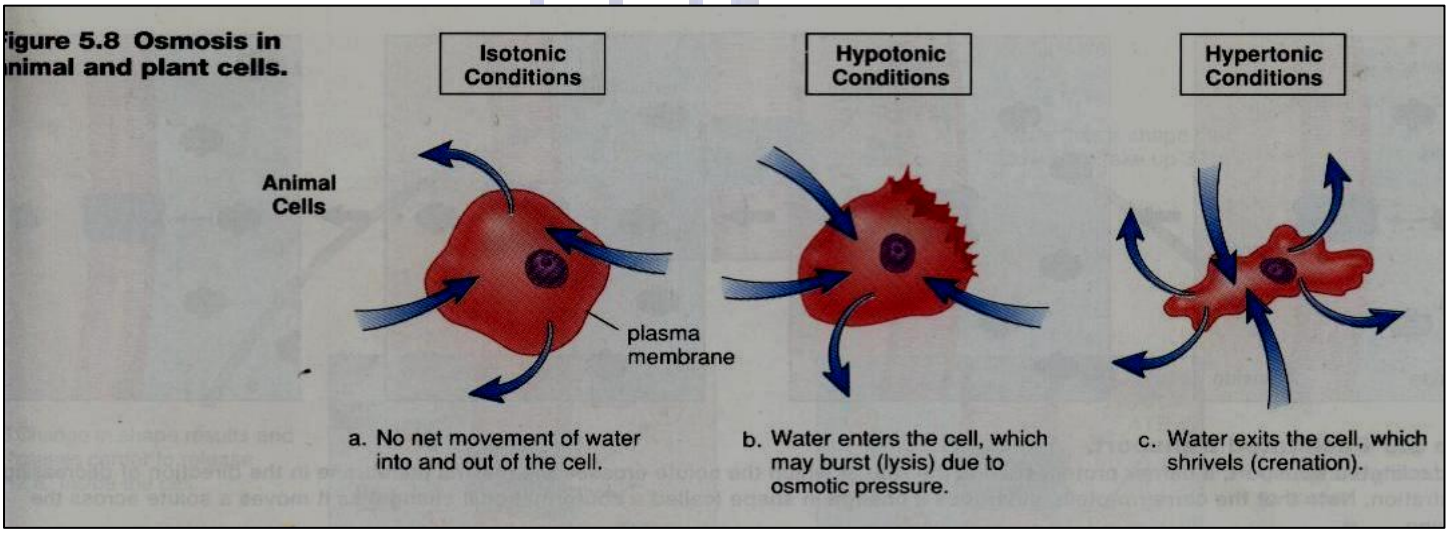
Table 3.2 Functions of the Glycocalyx

- ***Protection***: Cushions the plasma membrane and protects it from physical and chemical injury.

- ***Immunity to Infection***: Enables the immune system to recognize and selectively attack foreign organisms
- ***Defense Against Cancer*** :Changes in the glycocalyx of cancerous cells enable the immune system to recognize and destroy them
- ***Transplant Compatibility***: Forms the basis for compatibility of blood transfusions, tissue grafts, and organ transplants
- ***Cell Adhesion*** :Binds cells together so that tissues do not fall apart
- ***Fertilization***: Enables sperm to recognize and bind to eggs
- ***Embryonic Development***: Guides embryonic cells to their destinations in the body.

How molecules cross the plasma membrane:

- Plasma membrane is **Semi permeable** (allow some molecule to pass through it) some molecules (lipid- soluble compound, water and gases) diffuses across the membrane from the area of higher concentration to the area of lower concentration. No ATP requires.
- The diffusion of water across differentially permeable membrane is called **Osmosis.**
- **Osmosis** occurs in living organism. ex. Water is absorbed from the human large intestine , is retained by the kidneys , and is taken up by blood.
- **Tonicity:** the strength of a solution in relationship to Osmosis**.**



- Other molecules are transported across the membrane by carrier **proteins Facilitated transport,** a carrier proteins assists the movement of a molecule down its concentration gradient .No energy is required.
- **Active transport** **,** a carrier proteins acts as a pump that causes a substance to move against its concentration gradient .The Na^+-- K^+ pump carries $3Na^+$ to the outside of the cell and K to the inside of the cell. Energy in the form of ATP molecules is required for active transport to occur

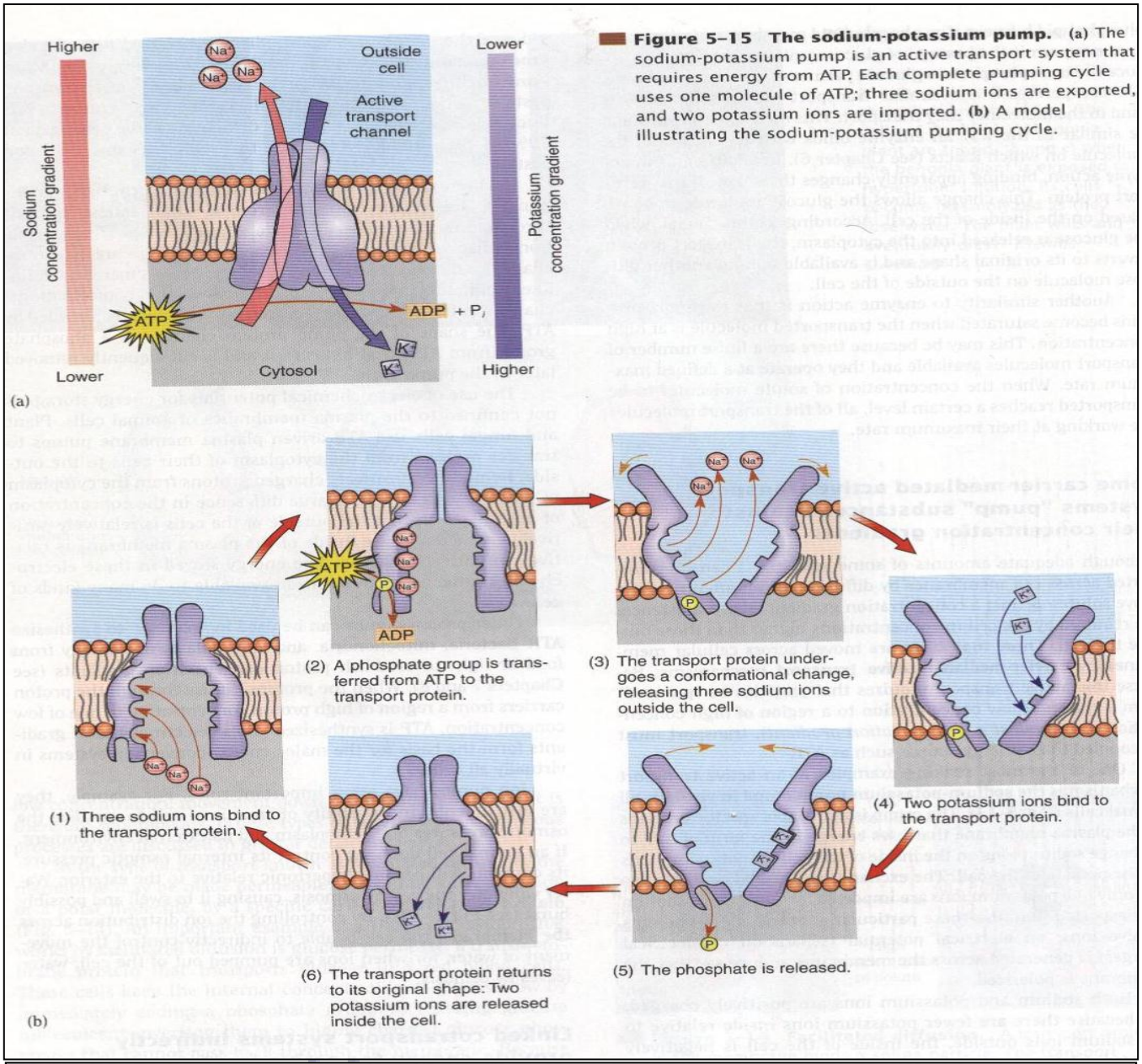
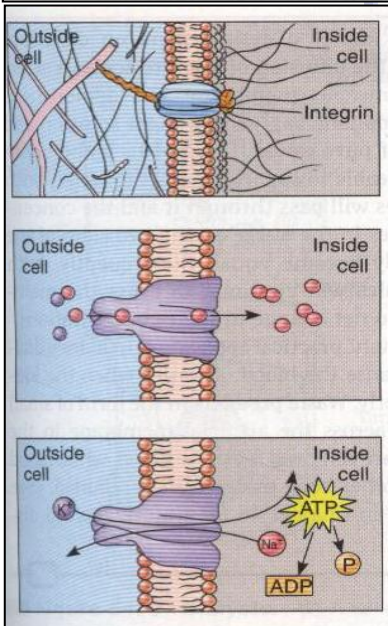


Figure 5–15 The sodium-potassium pump. (a) The sodium-potassium pump is an active transport system that requires energy from ATP. Each complete pumping cycle uses one molecule of ATP; three sodium ions are exported, and two potassium ions are imported. (b) A model illustrating the sodium-potassium pumping cycle.

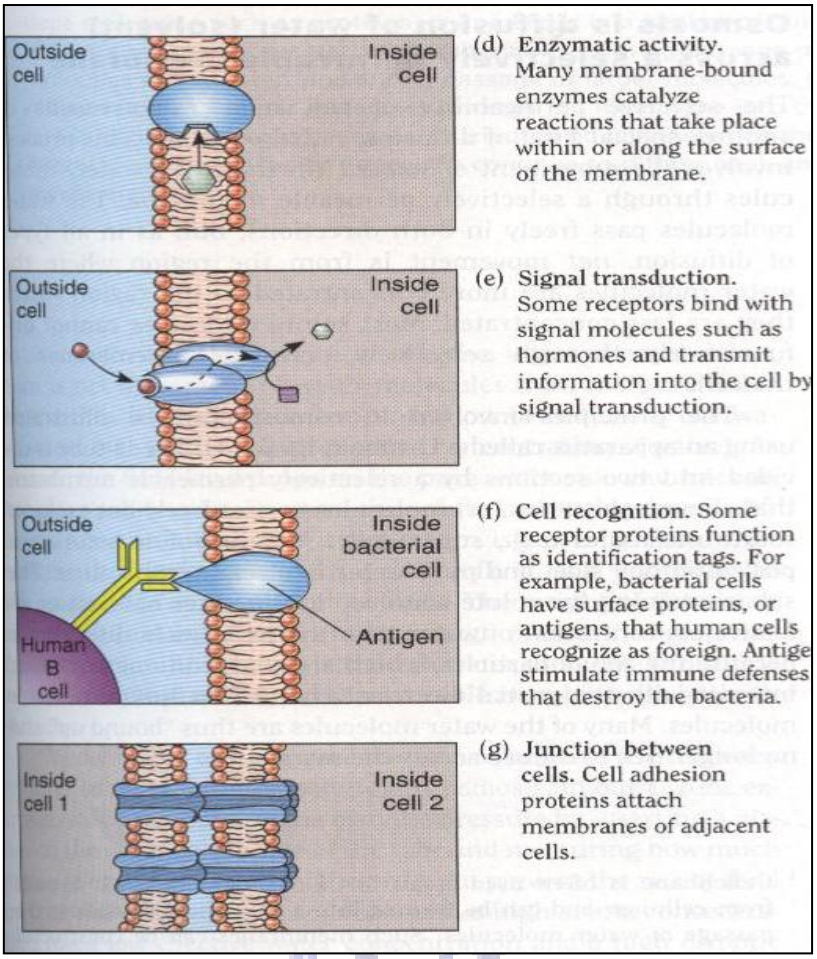


(a) Anchoring cell. Some membrane proteins, for example, integrins, anchor the cell to the extracellular matrix; they also connect to microfilaments within the cell.

(b) Passive transport. Certain proteins form channels that allow selective passage of ions or molecules.

(c) Active transport. Some transport proteins pump solutes across the membrane, a process that requires a direct input of energy.

Figure 5–9 Functions of membrane proteins. Membrane proteins function (a) in anchoring the cell, (b) in passive transport, (c) in active transport, (d) as enzymes, (e) to transmit information into the cell by signal transduction, (f) in cell recognition, and (g) in forming junctions between cells.



(d) **Enzymatic activity.** Many membrane-bound enzymes catalyze reactions that take place within or along the surface of the membrane.

(e) **Signal transduction.** Some receptors bind with signal molecules such as hormones and transmit information into the cell by signal transduction.

(f) **Cell recognition.** Some receptor proteins function as identification tags. For example, bacterial cells have surface proteins, or antigens, that human cells recognize as foreign. Antige stimulate immune defenses that destroy the bacteria.

(g) **Junction between cells.** Cell adhesion proteins attach membranes of adjacent cells.

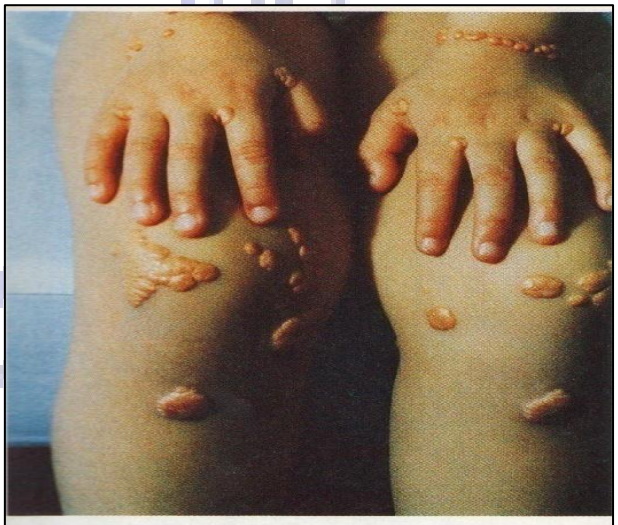
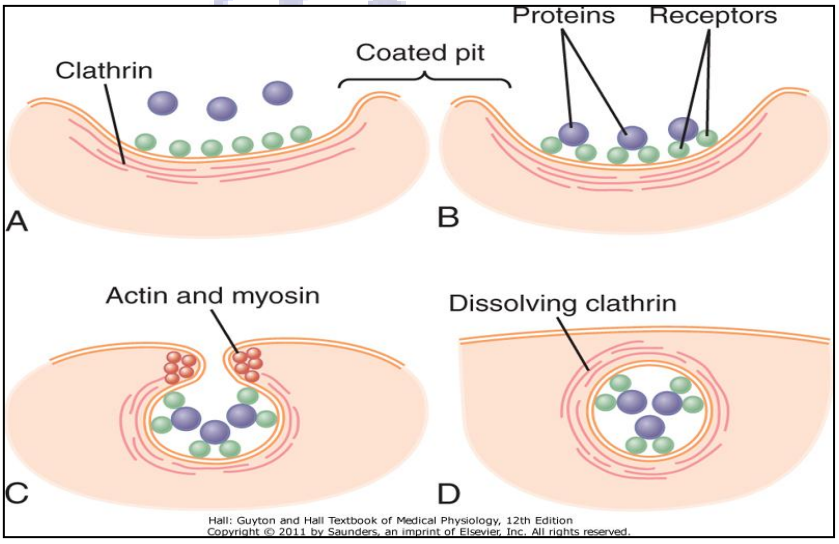


Figure 8.25
An inherited membrane disorder. The yellow deposits of cholesterol and other lipids beneath the skin of this young girl are due to familial hypercholesterolemia (FH), an inherited defect of the plasma membranes of cells. Cholesterol travels in the blood mainly in particles called LDLs (for low-density lipoproteins), each containing about 1500 cholesterol molecules. An LDL also has a large protein molecule that fits a receptor on the membranes of cells. By receptor-mediated endocytosis, cells incorporate LDLs within coated vesicles, and then metabolize the cholesterol or use it in membrane synthesis. A person who has FH lacks LDL receptors or has defective receptors on their membranes, and thus the cholesterol-containing particles accumulate in the blood. This not only results in the cholesterol pockets beneath the skin but, worse, causes early cardiovascular disease by depositing cholesterol on the walls of blood vessels. In this case, a malfunctioning membrane threatens life.

Functional Systems of the Cell:

- What about the transport of molecules such as Polysaccharides or Polynucleotide?
- They can enter and exit a membrane by Exocytosis and Endocytosis.
- Endocytosis:
  A- phagocytosis
  B- Pinocytosis
  C- Receptor – mediated endocytosis
- Pinocytosis is the only means by which most large macromolecules, such as most protein molecules, can enter cells. In fact, the rate at which pinocytotic vesicles form is usually enhanced when such macromolecules attach to the cell membrane Figure 2-11 demonstrates the successive steps of pinocytosis, showing three molecules of protein attaching to the membrane. These molecules usually attach to specialized protein *receptors* on the surface of the membrane that are specific for the type of protein that is to be absorbed. The receptors generally are concentrated in small pits on the outer surface of the cell membrane, called *coated pits.* On the inside of the cell membrane beneath these pits is to be absorbed. On the inside of the cell membrane beneath these pits is a latticework of fibrillar protein called*clathrin,* as well as other proteins, perhaps including contractile filaments of *actin* and *myosin*



- The protein molecules have bound with the receptors, the surface properties of the local membrane change in such a way that the entire pit invaginates inward and the fibrillar proteins surrounding the invaginating pit cause its borders to close over the attached proteins, as well as over a small amount of extracellular fluid. Immediately thereafter, the invaginated portion of the membrane breaks away from the surface of the cell, forming a *pinocytotic vesicle* inside the cytoplasm of the cell.

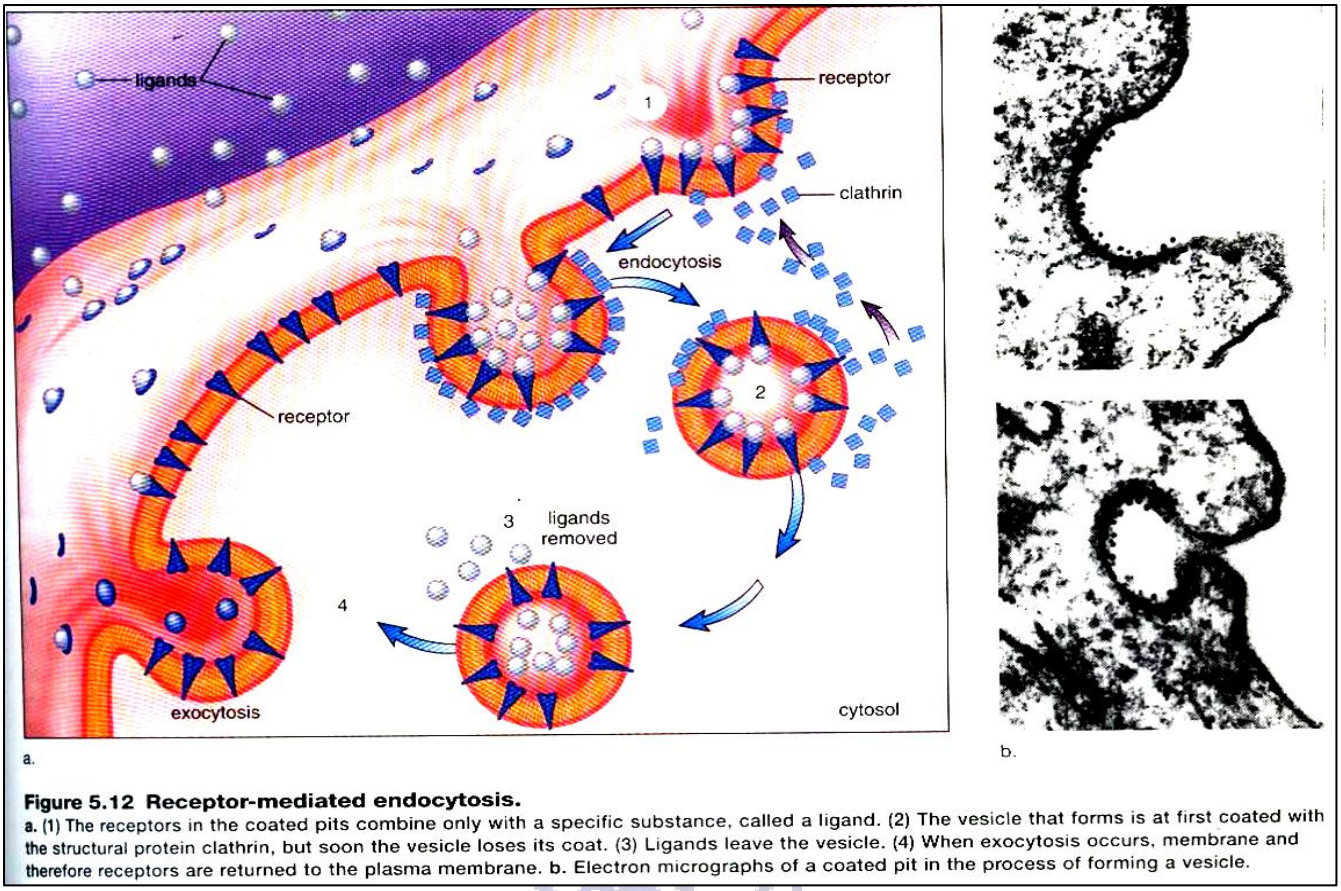


Figure 5.12 Receptor-mediated endocytosis.
a. (1) The receptors in the coated pits combine only with a specific substance, called a ligand. (2) The vesicle that forms is at first coated with the structural protein clathrin, but soon the vesicle loses its coat. (3) Ligands leave the vesicle. (4) When exocytosis occurs, membrane and therefore receptors are returned to the plasma membrane. b. Electron micrographs of a coated pit in the process of forming a vesicle.

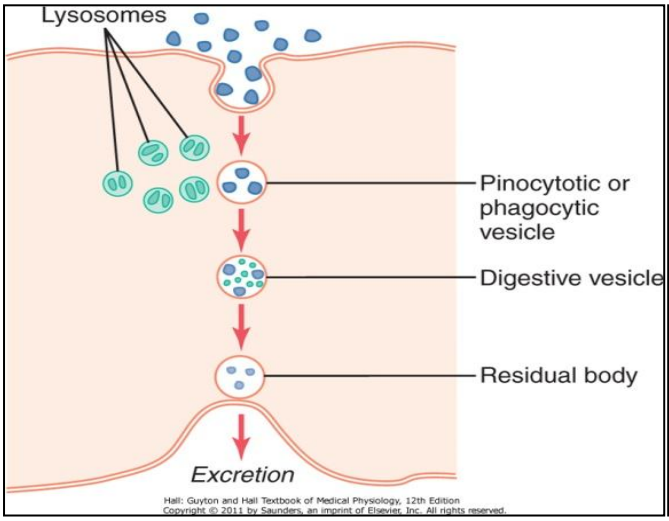
Phagocytosis:

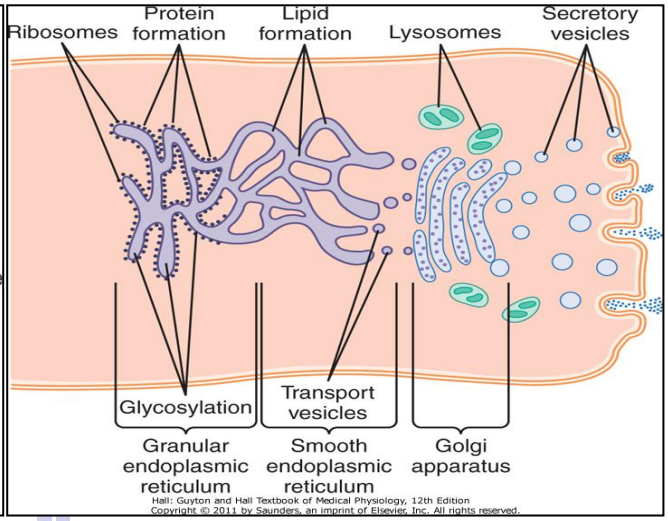
- Phagocytosis occurs in much the same way as pinocytosis, except that it involves large particles rather than molecules. Only certain cells have the capability of phagocytosis, most notably the tissue macrophages and some of the white blood cells.
- Phagocytosis is initiated when a particle such as a bacterium, a dead cell, or tissue debris binds with receptors on the surface of the phagocyte. In the case of bacteria, each bacterium is usually already attached to a specific antibody, and it is the antibody that attaches to the phagocyte receptors,. This intermediation of antibodies is called opsonization.

Phagocytosis occurs in the following steps:

- The cell membrane receptors attach to the surface ligands of the particle.
- The edges of the membrane around the points of attachment evaginate outward within a fraction of a second to surround the entire particle; then, progressively more and more membrane receptors attach to the particle ligands. All this occurs suddenly in a zipper-like manner to form a closed ***phagocytic vesicle.***
- Actin and other contractile fibrils in the cytoplasm surround the phagocytic vesicle and contract around its outer edge, pushing the vesicle to the interior.

- The contractile proteins then pinch the stem of the vesicle so completely that the vesicle separates from the cell membrane, leaving the vesicle in the cell interior in the same way that pinocytotic vesicles are formed.



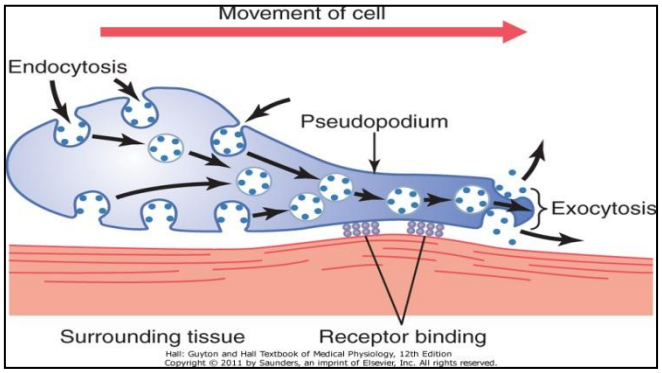


Locomotion of Cells:

- THE most important type of movement that occurs in the body is that of the muscle cells in skeletal, cardiac, and smooth muscle, which constitute almost 50 percent of the entire body mass. Two other types of movement-***ameboidlocomotion*** and ***ciliary*** *movement*-occur in other cells.

Ameboid Movement

- Typically, ameboid locomotion begins with protrusion of **a *pseudopodium*** from one end of the cell. The pseudopodium project far out, away from the cell body, and partially secures itself in a new tissue area. Then the remainder of the cell is pulled toward the pseudopodium. Figure 2-16 demonstrates this process, showing an elongated cell, the right-hand end of which is a protruding pseudopodium. The membrane of this end of the cell is continually moving forward, and the membrane at the left-hand end of the cell is continually following along as the cell moves.

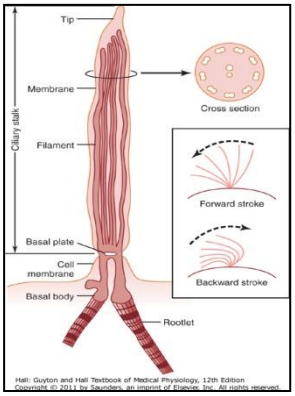


Types of Cells That Exhibit Ameboid Locomotion:

- The most common cells are the ***white blood*** *cells* when they move out of the blood into the tissues to form *tissue macrophages.* Other types of cells, ***fibroblasts*** move into a damaged area to help repair the damage and even the germinal cells of the skin,, move toward a cut area to repair the opening. Finally, cell locomotion is especially important in development of the embryo and fetus after fertilization of an ovum. For instance, ***embryonic cells*** often must migrate long distances from their sites of origin to new areas during development of special structures.

Cilia and Ciliary Movements

- A second type of cellular motion, *ciliary movement,* is a whiplike movement of cilia on the surfaces of cells. This occurs in only two places in the human body: on the surfaces of the respiratory airways and on the inside surfaces of the uterine tubes (fallopian tubes) of the reproductive tract. In the nasal cavity and lower respiratory airways, the whiplike motion of cilia causes a layer of mucus to move at a rate of about 1 cm/min toward the pharynx, in this way continually clearing these passageways of mucus and particles that have become trapped in the mucus. In the uterine tubes, the cilia cause slow movement of fluid from the ostium of the uterine tube toward the uterus cavity; this movement of fluid transports the ovum from the ovary to the uterus.
- The cilium moves forward with a sudden, rapid whiplike stroke 10 to 20 times per second, bending sharply where it projects from the surface of the cell. Then it moves backward slowly to its initial position. The rapid forward-thrusting, whiplike movement pushes the fluid lying adjacent to the cell in the direction that the cilium moves; the slow, dragging movement in the backward direction has almost no effect on fluid movement. As a result, the fluid is continually propelled in the direction of the fast-forward stroke. Because most ciliated cells have large numbers of cilia on their surfaces and because all the cilia are oriented in the same direction, this is an effective means for moving fluids from one part of the surface to another.



ANIMAL CELLS HAVE AN EXTRACELLULLAR MATRIX:

- Is a meshwork of insoluble proteins with carbohydrate chains (glycoprotiens).
- The Ex. Matrix fills the spaces between animal cells & supports them.
- The Ex. Matrix influences **the development, migration, shape**, **& function of the cells** .Collagen & Elastin fibers are the structural component of extra cellular matrix.
- **Fibroectins & laminins** are two adhesive proteins that play a dynamic role in influencing the behavior of the cells. They form "highways" that direct the migration of cell during development. **Laminins** were found to be necessary for the production of the milk by the mammary gland cell.
- **Proteoglycan are glycoproteins** that are composed of **carbohydrate chains containing amino sugars** .Pro. Provide a packing gel that joins the various proteins in the matrix.

Animal cells have Junction:

Three types of junctions are seen between animal cells.

1) Adhesion junctions (desmosom)

Desmosomes spot weld adjacent animal cells together .It found in heart , stomach & bladder .

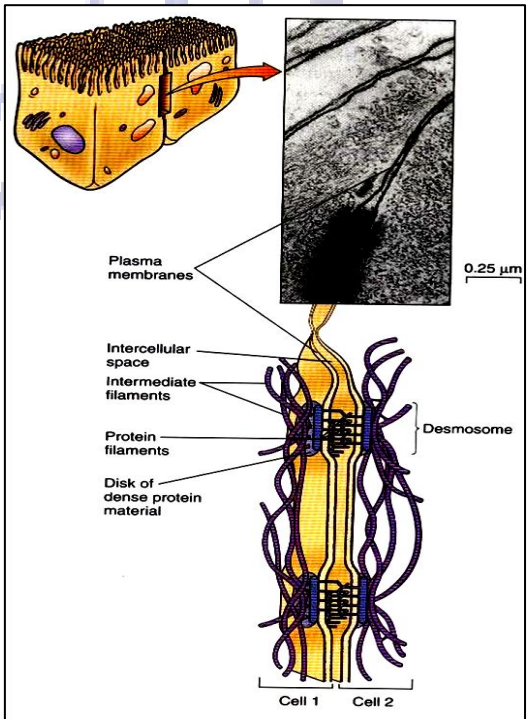


Figure 5–22 Desmosomes. The dense structure in the TEM is a desmosome. Each desmosome consists of a pair of button-like disks associated with the plasma membranes of adjacent cells, plus the intercellular protein filaments that connect them. Intermediate filaments in the cells are attached to the disks and are connected to other desmosomes. *(D.W. Fawcett)*

2) Tight Junction

- Seal membranes of adjacent animal cells together, preventing substances from moving through the spaces between the cells; in the intestine the digestive juices stay out of the body, and the kidneys the urine stay within the kidney tubules.

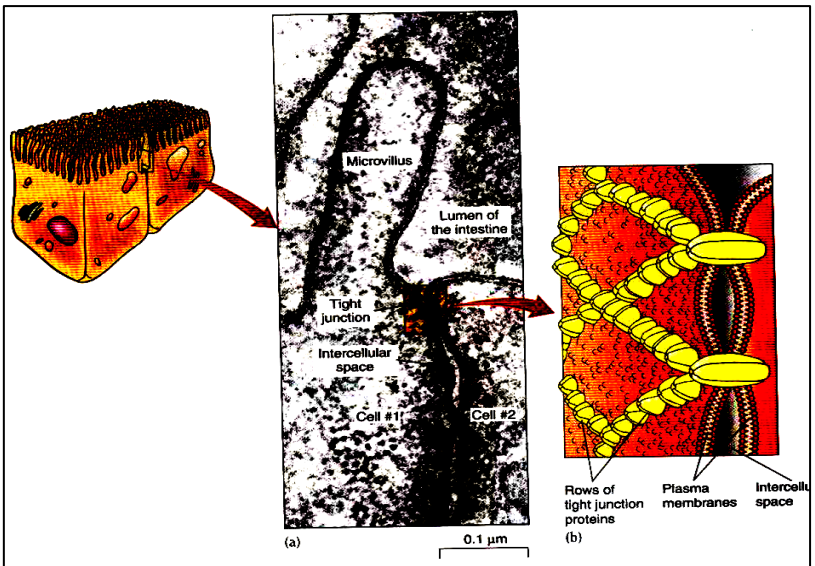


Figure 5–23 Tight junctions. These junctions prevent passage of materials through spaces between cells. Tight junctions occur at the points of contact between two cells and extend completely around the cells. **(a)** This TEM shows points of fusion between the plasma membranes of adjacent cells lining the intestine. One tight junction is marked by the box. **(b)** The diagram shows that a tight junction is formed by linkages between rows of proteins of adjacent cells. These proteins are tightly packed in rows that seal off the intercellular space. *(a, G.E. Palade)*

3) Gap junctions

- Are proteins complexes form channels in membranes, allowing communication between cytoplasm of adjacent animal cells by channel is lined by six plasma membrane proteins; in heart muscle & smooth muscle, because they permit a flow of ions that is required for the cells to contract.

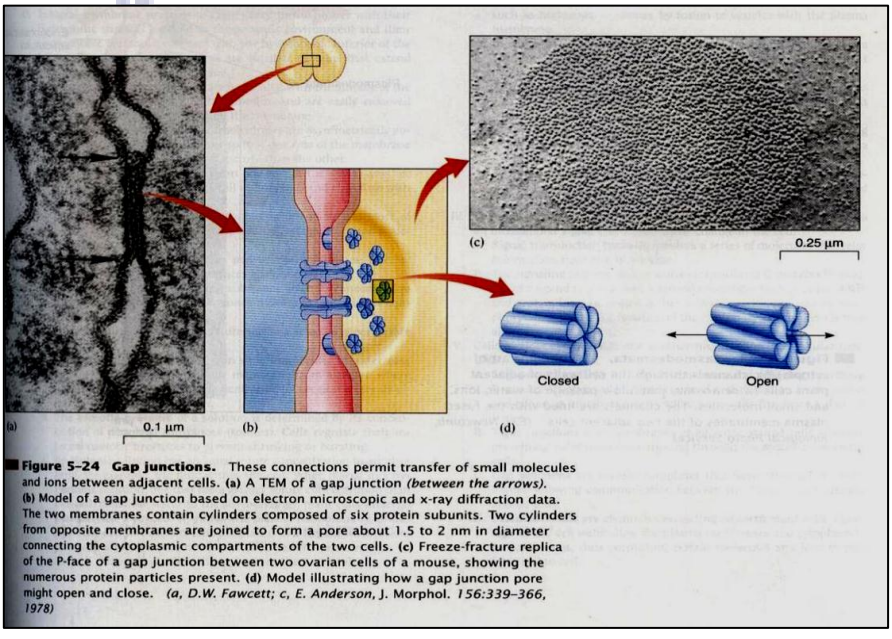


Figure 5–24 Gap junctions. These connections permit transfer of small molecules and ions between adjacent cells. **(a)** A TEM of a gap junction *(between the arrows)*. **(b)** Model of a gap junction based on electron microscopic and x-ray diffraction data. The two membranes contain cylinders composed of six protein subunits. Two cylinders from opposite membranes are joined to form a pore about 1.5 to 2 nm in diameter connecting the cytoplasmic compartments of the two cells. **(c)** Freeze-fracture replica of the P-face of a gap junction between two ovarian cells of a mouse, showing the numerous protein particles present. **(d)** Model illustrating how a gap junction pore might open and close. *(a, D.W. Fawcett; c, E. Anderson,* J. Morphol. *156:339–366, 1978)*