



# Pengantar Ilmu Faal, Struktur Biologis Tubuh Manusia dan Sel

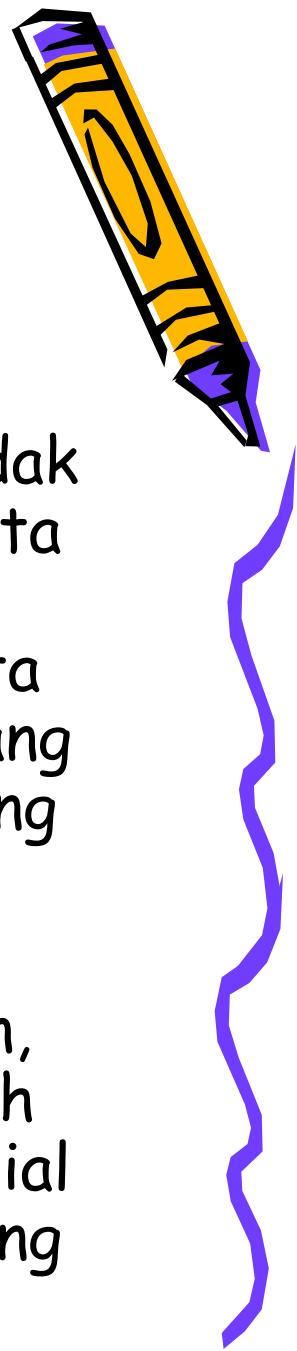
By Ikbal Gentar Alam, dr

# Pendahuluan



- Apa itu fisiologi?
- Tujuan : Utk menjelaskan faktor2 fisika dan kimiawi yg berperan dlm asal usul, pertumbuhan dan perkembangan dari kehidupan.
- Terbagi menjadi fisiologi virus, fisiologi bakteri, fisiologi sel, fisiologi tanaman, fisiologi manusia, dan lain lain.





- Pada fisiologi manusia, terfokus pada karakterkhusus dan mekanisme tubuh manusia serta yang menjadikannya sebagai sesuatu yg hidup.
- Fakta yang ada bahwa kita bisa tetap hidup tidak selalu dalam kontrol kita. Rasa lapar membuat kita mencari makanan dan rasa takut membuat kita mencari perlindungan. Rasa dingin membuat kita mencari kehangatan. Berbagai dorongan lain yang menyebabkan kita berkelompok dan berkembang biak.
- Manusiawi itu sesungguhnya sesuatu yang otomatis, dan kenyataan bahwa kita merasakan, mempunyai perasaan danberpengetahuan adalah bagian dari otomatisasi kehidupan.; these special attributes allow us to exist under widely varying conditions.



# Sel sebagai unit kehidupan dalam tubuh



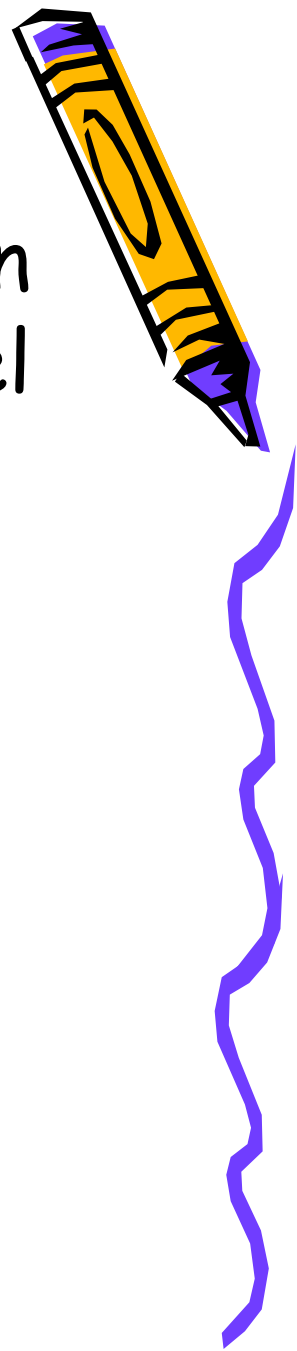
- Unit dasar kehidupan pada tubuh adalah sel dan setiap organ terdiri dari banyak sel yang berbeda yg pertahankan oleh struktur pendukung interseluler.
- Sel darah merah, 25 juta sel pada manusia.
- Ada sekitar 75 juta sel lain pada seluruh tubuh, yang artinya sekitar 100 juta sel pada manusia.

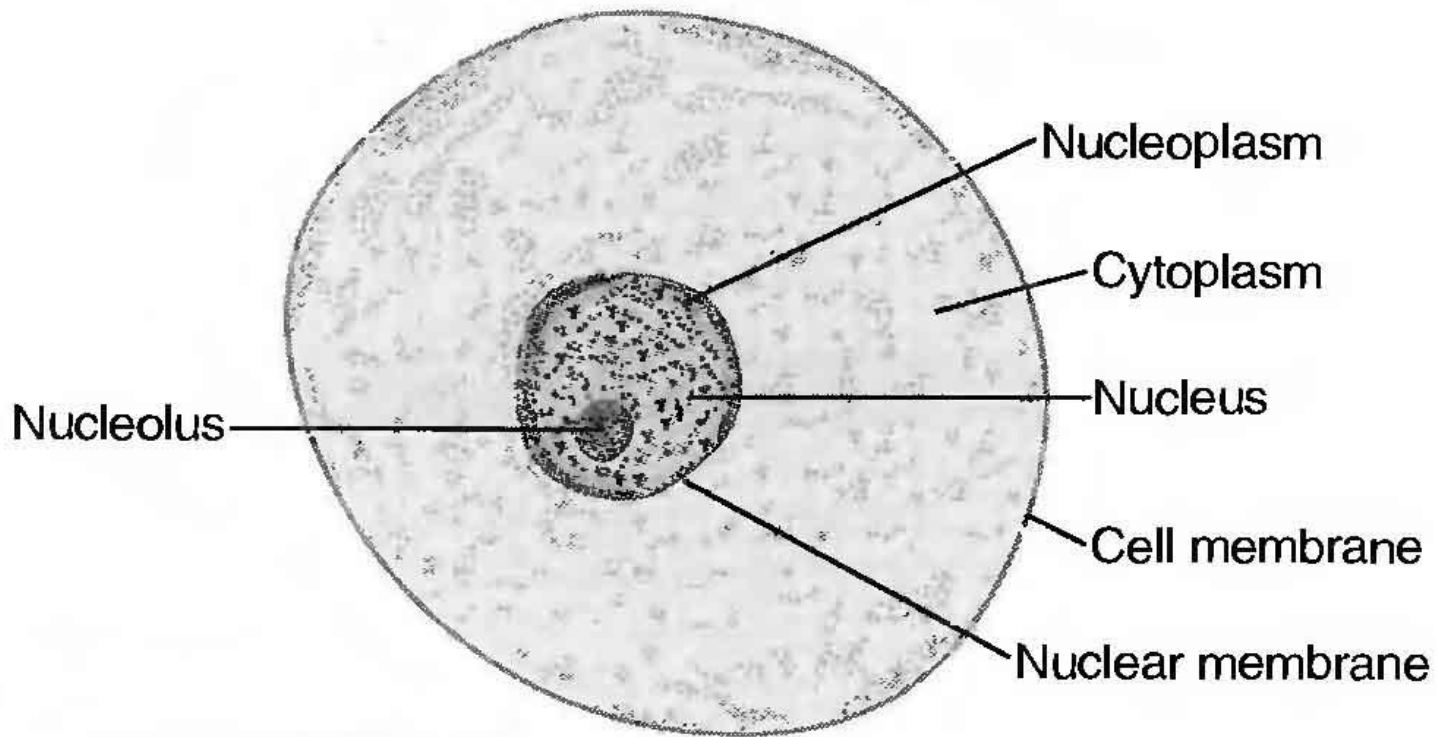


- Oksigen bersama dengan produk akhir karbohidrat, lemak atau protein akan memberikan tenaga/energi yang diperlukan untuk berfungsinya sel.
- Semua sel juga memberikan produk akhir dari reaksi kimia sel tsb ke cairan sekitarnya.



- Hampir semua sel mempunyai kemampuan untuk bereproduksi dan ketika sebagian sel hancur maka sel yang tersisa akan berusaha membentuk sel baru sampai sama dengan keadaan semula.





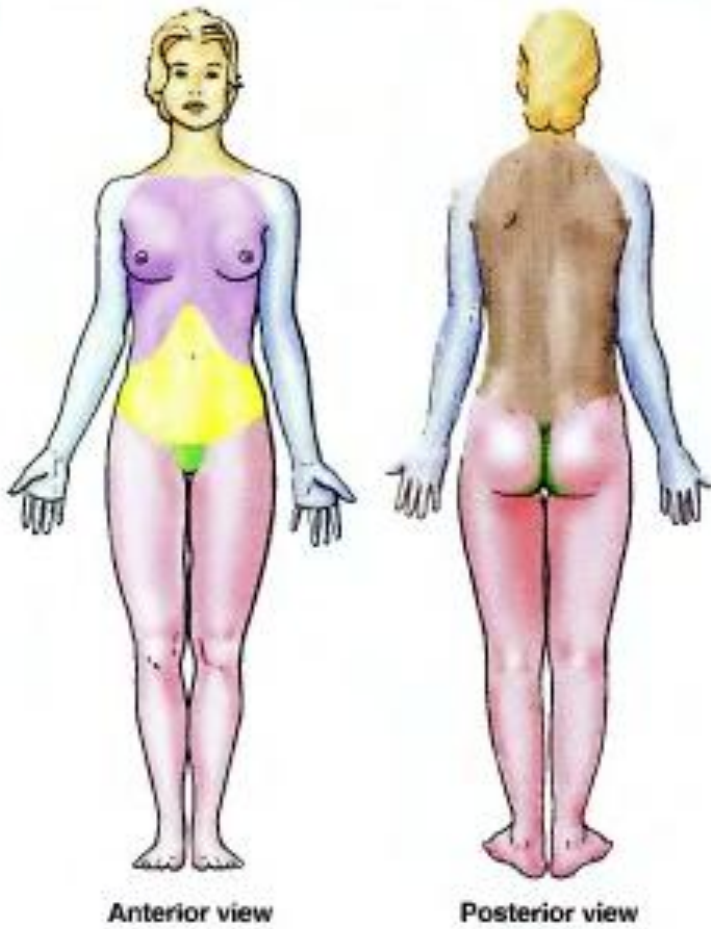
**FIGURE 2 - 1**

Structure of the cell as seen with the light microscope.

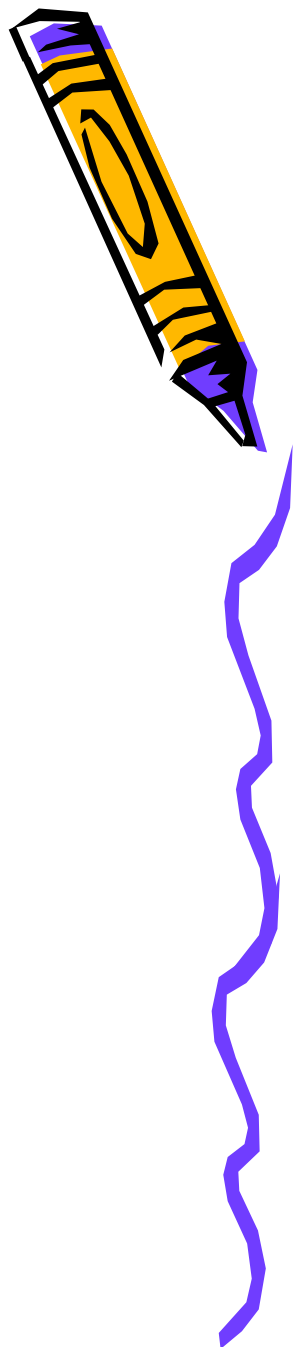


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Key			
 Head/neck	 Thorax	 Abdomen	 Lower limb
 Upper limb	 Back	 Pelvis/perineum	 limb

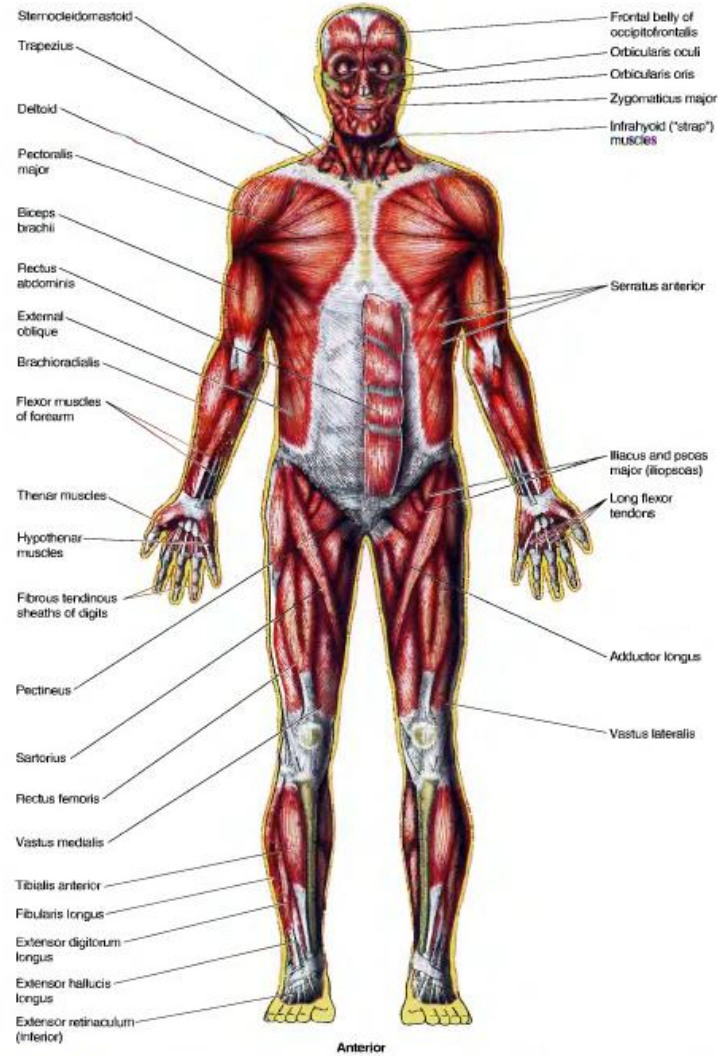


**Figure 1.1. Regions of the body.** All descriptions are expressed in relation to the anatomical position illustrated here.

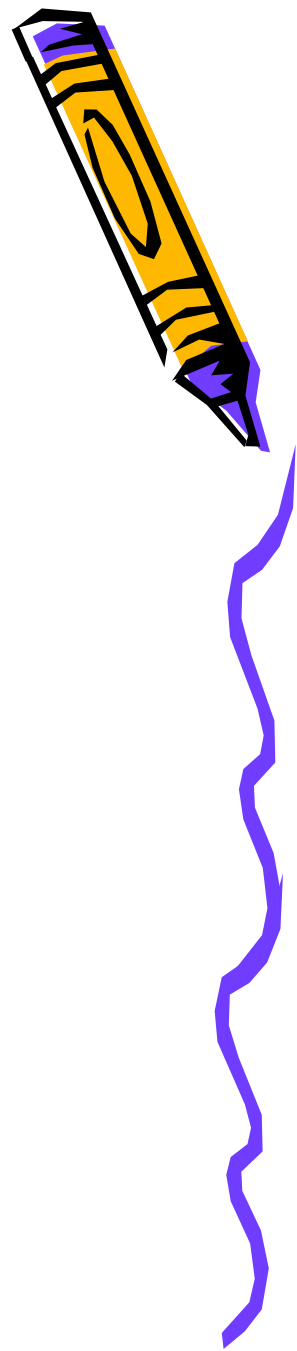




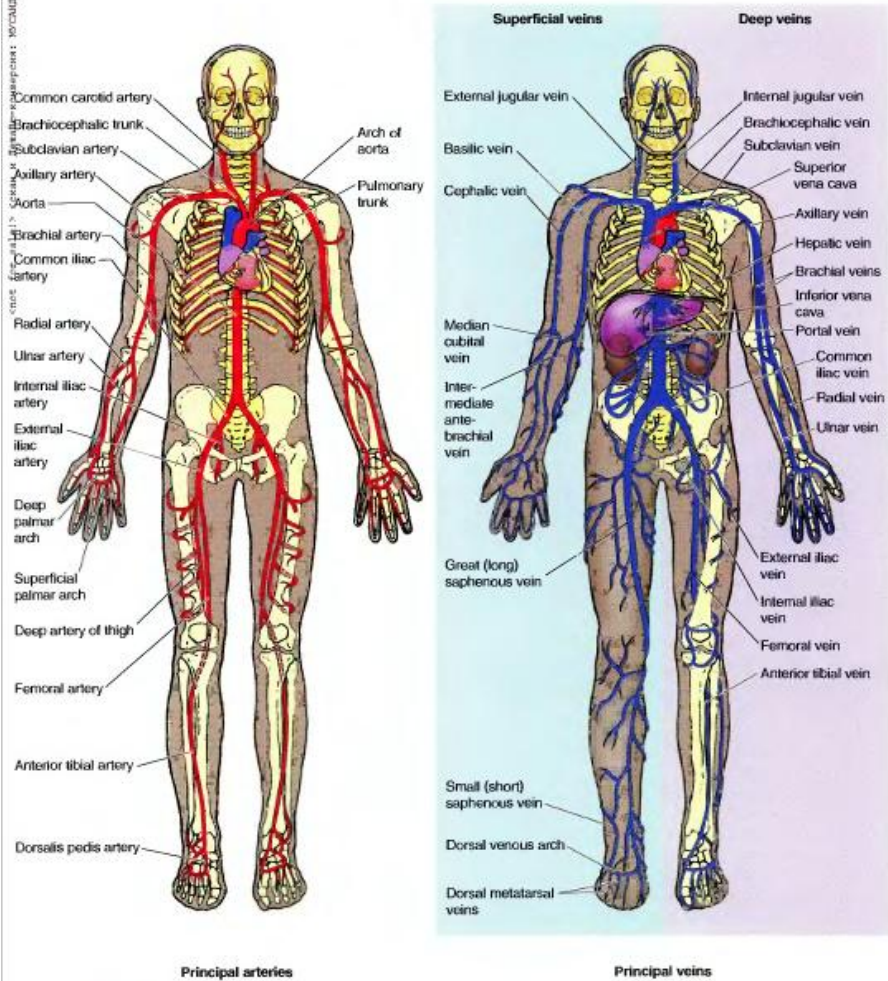
См. для анатомии: «Словарь анатомии» ВОСМАН, стр. 1183, 1184.



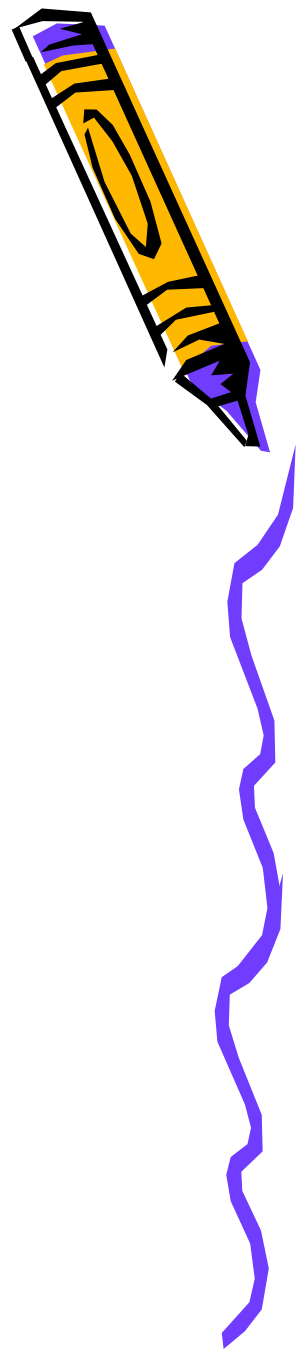
**Figure 1.15. Skeletal muscles.** Most of these muscles produce movements of the skeleton; however, some muscles move other parts (e.g., the eyes, mouth, and scalp). The *orbicularis oris* encircles the mouth and plays an important role in articulation and chewing. The tongue has no bones or joints beyond the hyoid bone, which serves as its base, yet it is mobile.



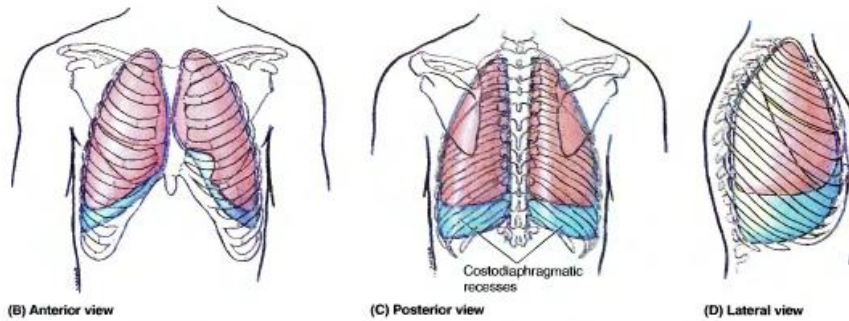
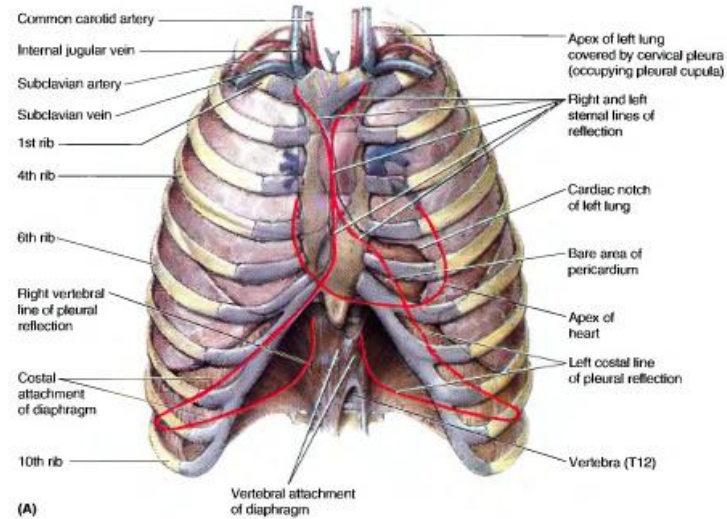
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**Figure 1.18. Cardiovascular system.** The heart and blood vessels are designed to distribute blood throughout the body. Most arteries carry oxygenated blood away from the heart and most veins carry deoxygenated blood to the heart; however, the pulmonary arteries arising from the pulmonary trunk carry deoxygenated blood to the lungs, and the pulmonary veins carry oxygenated blood from the lungs to the heart.



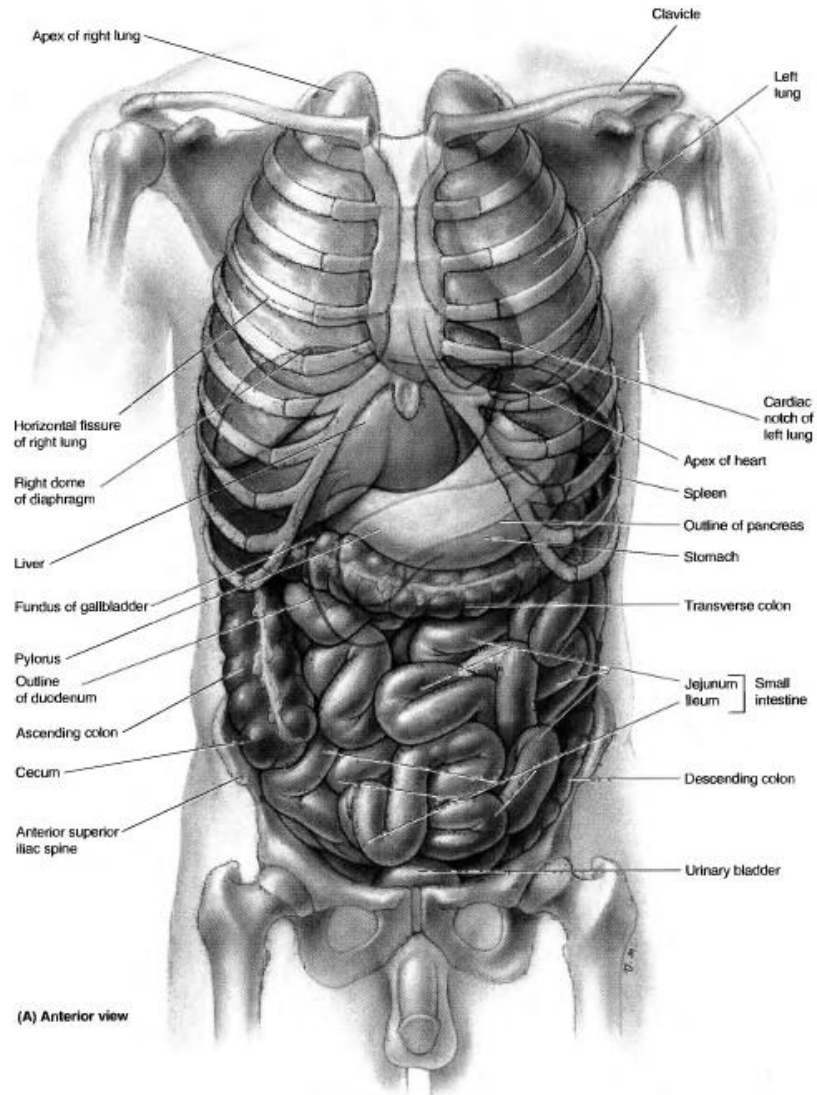
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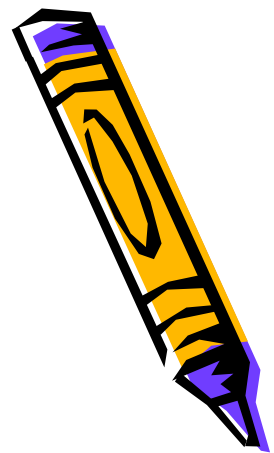
**Figure 1.26. Contents of the thorax and outline of the pleura and lungs.** A. Observe the apices of the lungs and cervical pleura extending into the neck. Note the cardiac notch in the left lung. Observe that the parietal pleura also deviates away from the median plane toward the left side in the region of the lung's cardiac notch, leaving a "bare area" where the pericardial sac is accessible for needle puncture without traversing the lung or pleural cavity. In B-D, observe the outline of the parietal pleura and lungs during quiet respiration and note the costodiaphragmatic recesses not occupied by lung. This is where pleural exudate accumulates when the body is erect. In A and D, follow the outlines of the oblique and horizontal fissures in the right lung, noting especially how the horizontal fissure parallels the 4th rib.



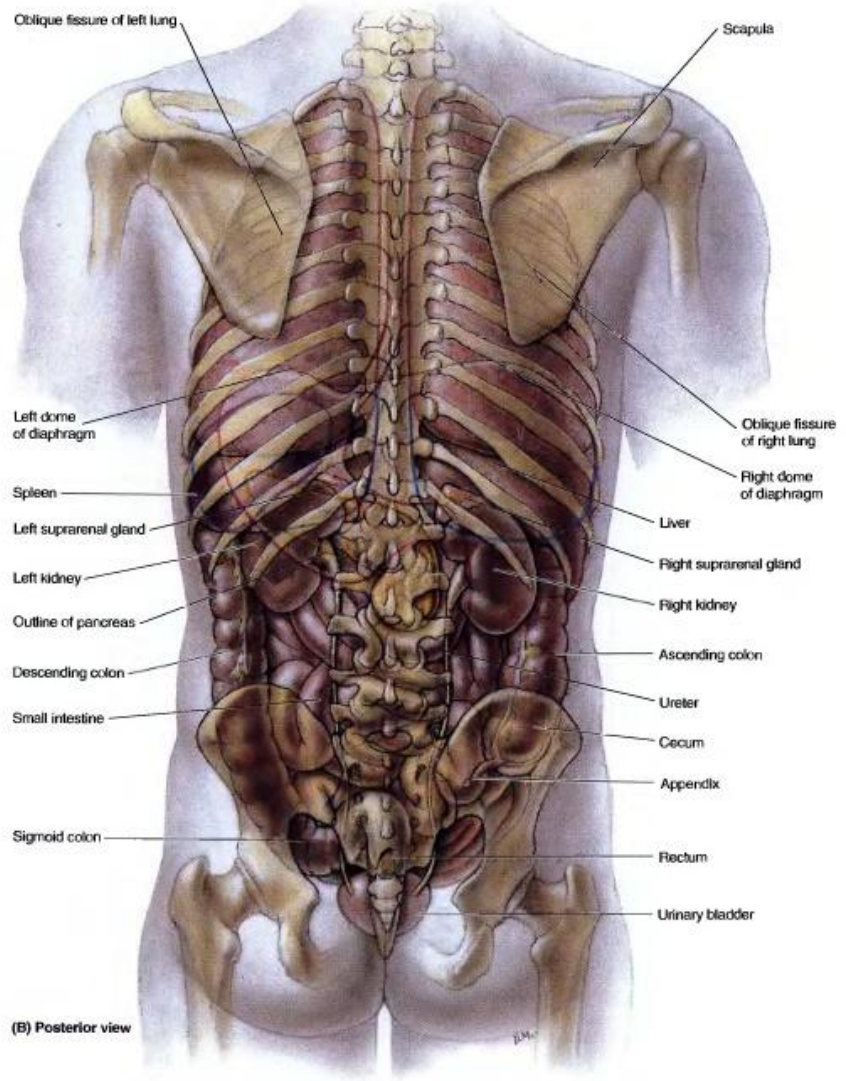
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**Figure 2.26. Overview of thoracic and abdominal viscera. A-B.** Observe that some abdominal organs extend superiorly into the thoracic cage (rib cage) and are protected by it. Observe also that a large part of the small intestine is in the pelvis and that the right kidney is lower than the left kidney; this results from the mass of the liver on the right side.



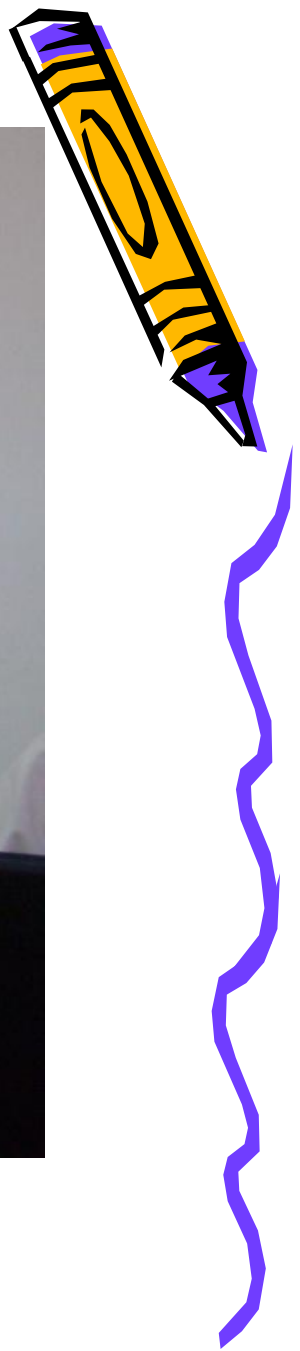
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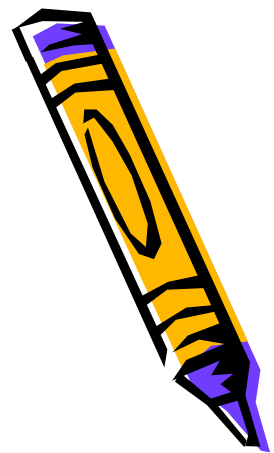
(B) Posterior view

**Figure 2.26.** (Continued) Observe that the appendix projects posteriorly and inferomedially toward the pelvic brim; consequently, it is visible only in the posterior view.



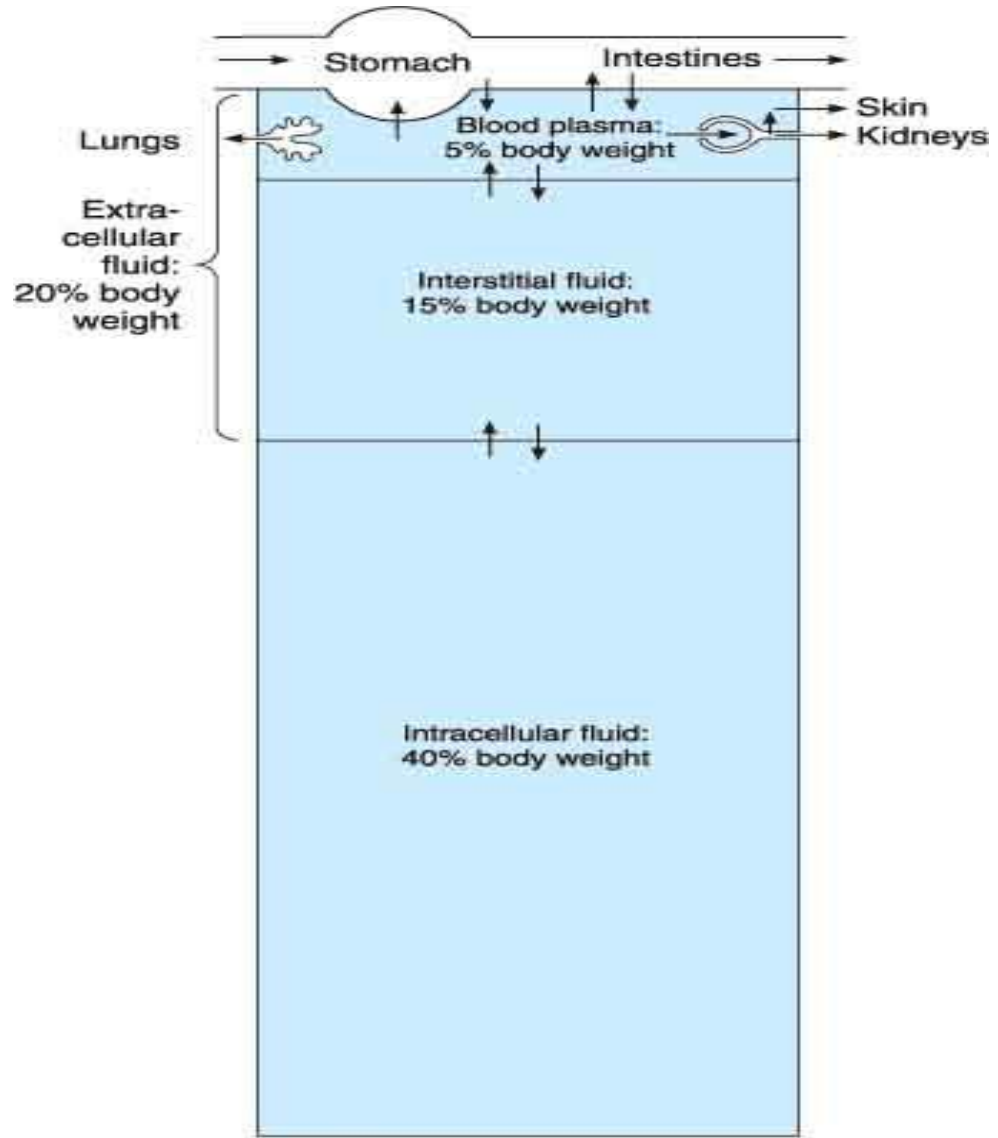


# EXTRACELLULAR FLUID - THE INTERNAL ENVIRONMENT

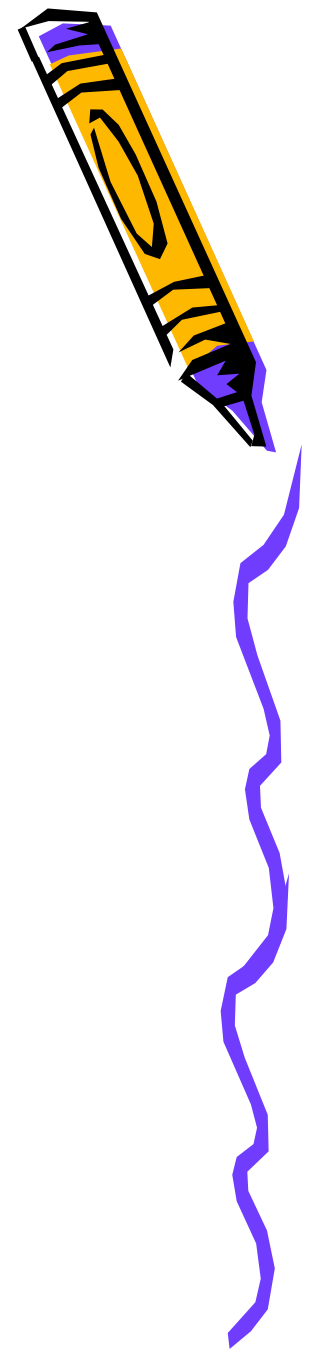


- About 60 per cent of the adult human body is fluid.
- About two third is intracellular fluid,
- one third is in the spaces outside the cells and is called extracellular fluid.
- This extracellular fluid is in constant motion throughout the body. It is transported rapidly in the circulating blood and then mixed between the blood and the tissue fluids by diffusion through the capillary walls.





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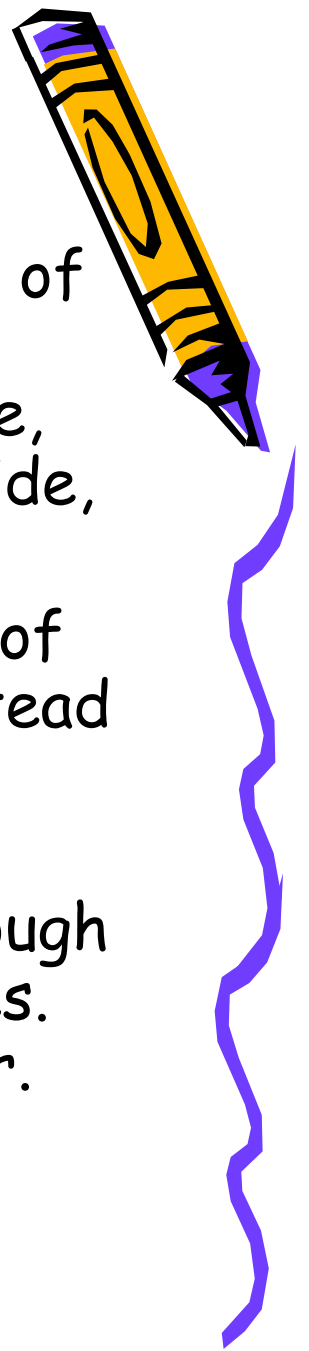






- All cells live in essentially the same environment, the extracellular fluid, the extracellular fluid is called the **internal environment of the body**, or **the milieu interieur**, a term introduced more than 100 years ago by the great 19th-century French physiologist Claude Bernard.
- Cells are capable of living, growing, and performing their special functions so long as the proper concentrations of are available in this internal environment.





- **Differences Between Extracellular and Intracellular Fluids.**
- The extracellular fluid contains large amounts of sodium, chloride, and bicarbonate ions plus nutrients for the cells, such as oxygen, glucose, fatty acids, and amino acids. Also carbon dioxide, other cellular waste products.
- The intracellular fluid contains large amounts of potassium, magnesium, and phosphate ions instead of the sodium and chloride ions found in the extracellular fluid.
- Special mechanisms for transporting ions through the cell membranes maintain these differences. These transport processes are discussed later.



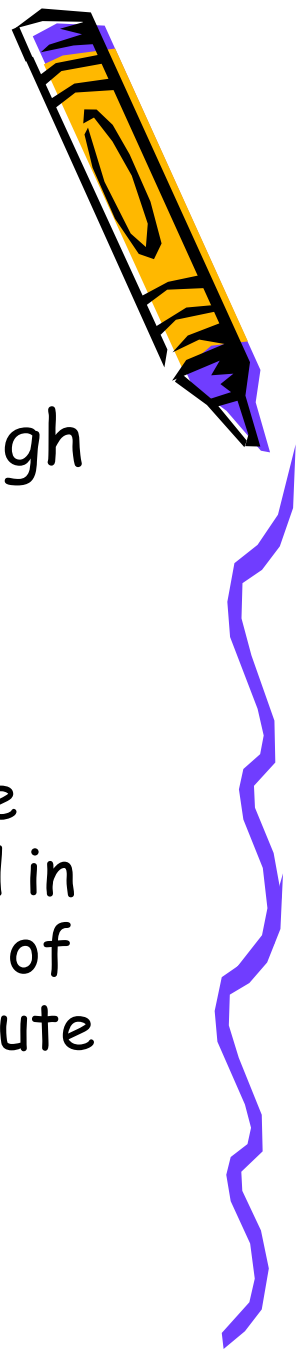


# "HOMEOSTATIC" MECHANISMS OF THE MAJOR FUNCTIONAL SYSTEMS

- *Maintenance of static or constant conditions in the internal environment.*
- Essentially all of the organs and tissues of the body perform functions to maintain constant conditions.
- The lungs provide oxygen to the extracellular fluid to continually replenish the oxygen that is being used by the cells.
- The kidneys maintain constant ion concentrations, and the gastrointestinal system provides nutrients.

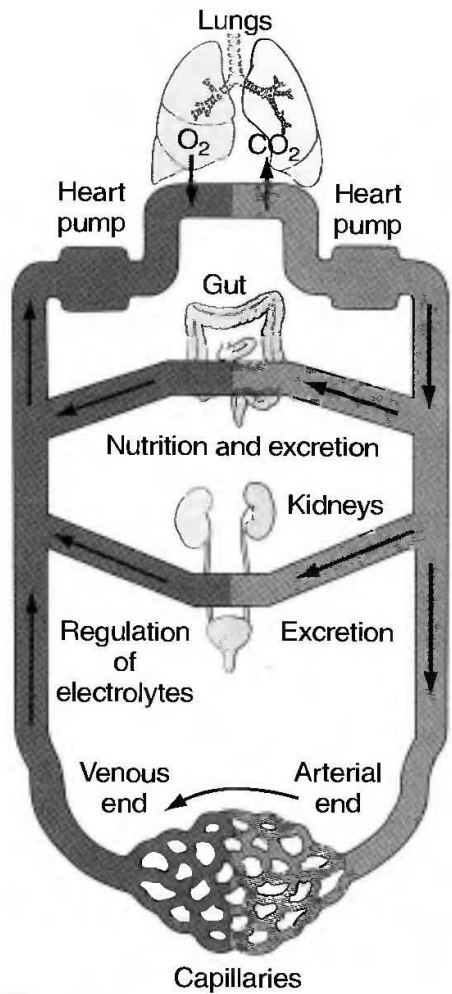


# Extra cellular Fluid Transport System-The Circulatory System



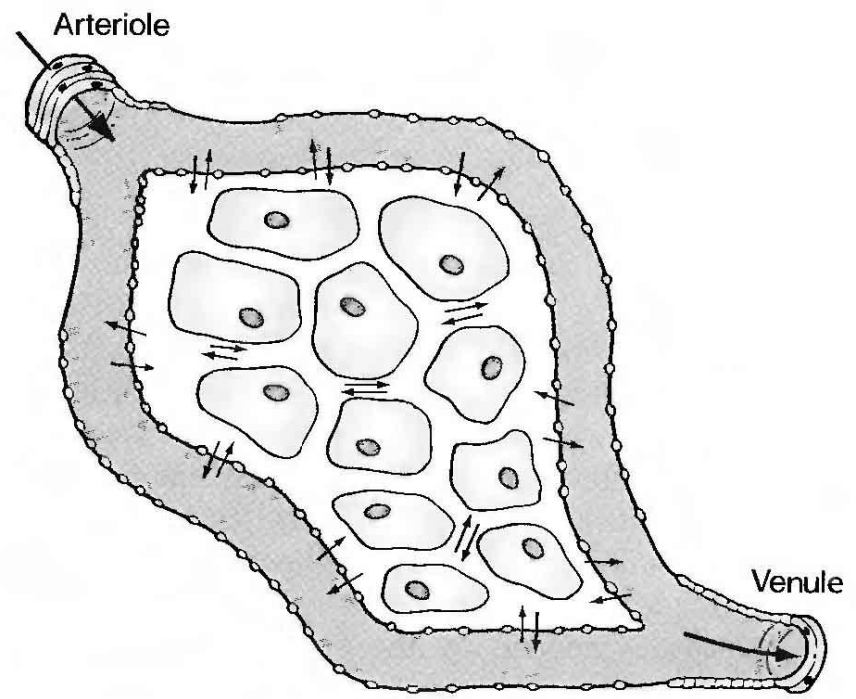
- Extracellular fluid is transported through all parts of the body in two stages.
  - The first stage entails movement of blood through the body in the blood vessels.
  - The second, movement of fluid between the blood capillaries and the cells. All the blood in the circulation traverses the entire circuit of the circulation an average of once each minute when the body is at rest and as many as six times each minute when a person becomes extremely active.





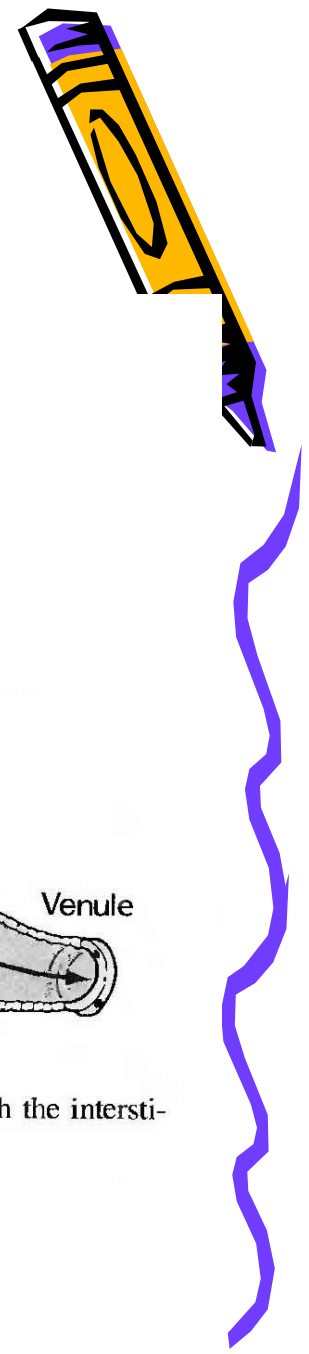
**FIGURE 1-1**

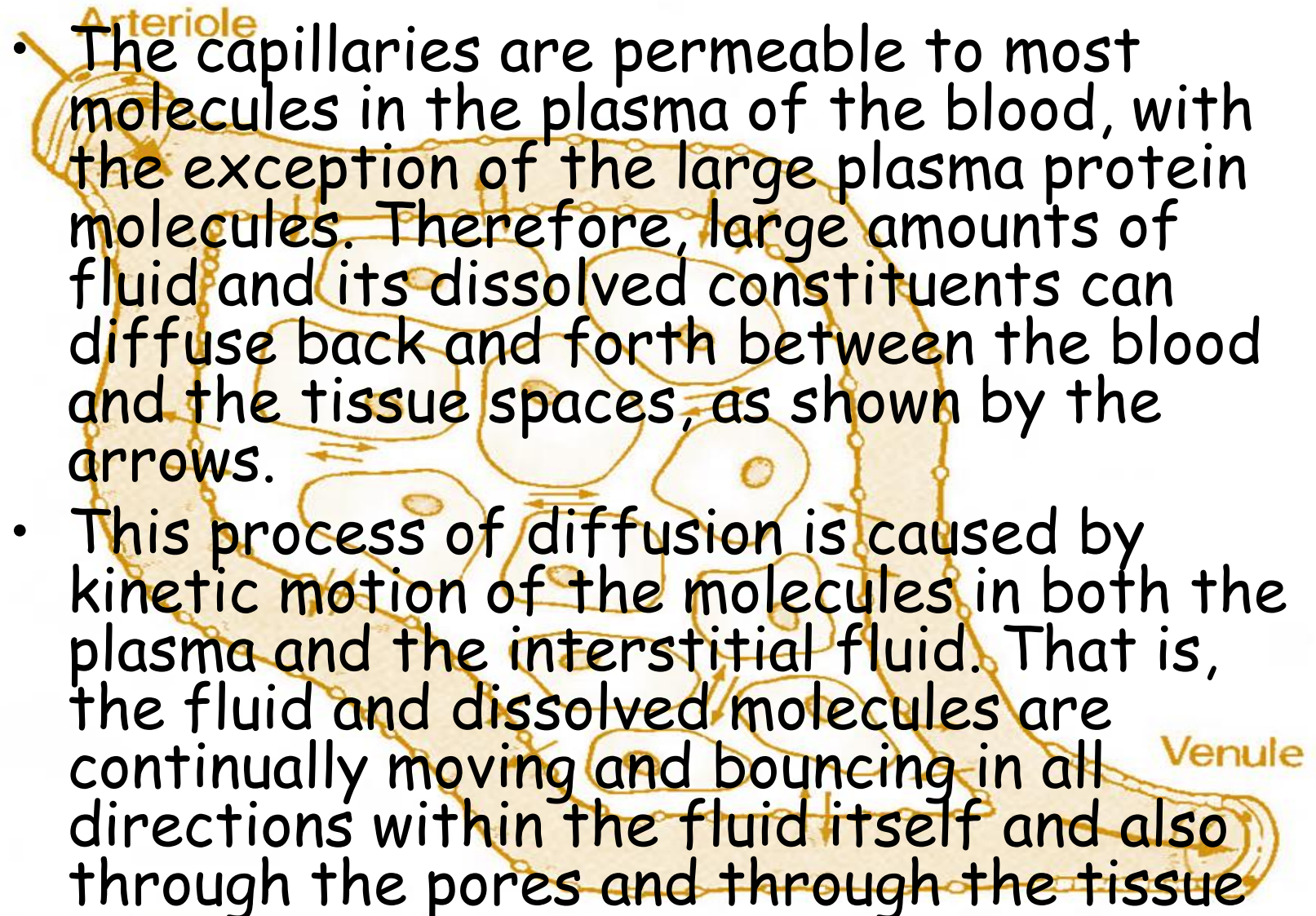
General organization of the circulatory system.



**FIGURE 1-2**

Diffusion of fluids through the capillary walls and through the interstitial spaces.

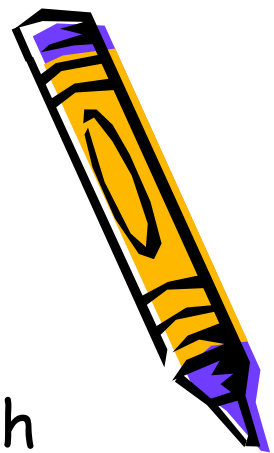


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- A diagram illustrating the process of diffusion between a blood vessel and tissue spaces. The vessel is shown as a network of capillaries, with an 'Arteriole' labeled at the top left and a 'Venule' labeled at the bottom right. Small arrows indicate the movement of fluid and dissolved molecules from the blood into the tissue spaces and vice versa. The background is a light tan color with faint outlines of cells and capillaries.
- The capillaries are permeable to most molecules in the plasma of the blood, with the exception of the large plasma protein molecules. Therefore, large amounts of fluid and its dissolved constituents can diffuse back and forth between the blood and the tissue spaces, as shown by the arrows.
  - This process of diffusion is caused by kinetic motion of the molecules in both the plasma and the interstitial fluid. That is, the fluid and dissolved molecules are continually moving and bouncing in all directions within the fluid itself and also through the pores and through the tissue

**FIG. 1 - 2**

Diffusion of fluids through the capillary walls and through the interstitial spaces.

# Origin of Nutrients in the Extracellular Fluid



- Respiratory System. Figure 1-1 shows that each time the blood passes through the body, it also flows through the lungs. The blood picks up oxygen in the alveoli, thus acquiring the oxygen needed by the cells.
- The membrane between the alveoli and the lumen of the pulmonary capillaries is only 0.4 to 2.0 micrometers thick, and oxygen diffuses by molecular motion through the pores of this membrane into the blood in the same manner that water and ions diffuse through walls of the tissue capillaries.

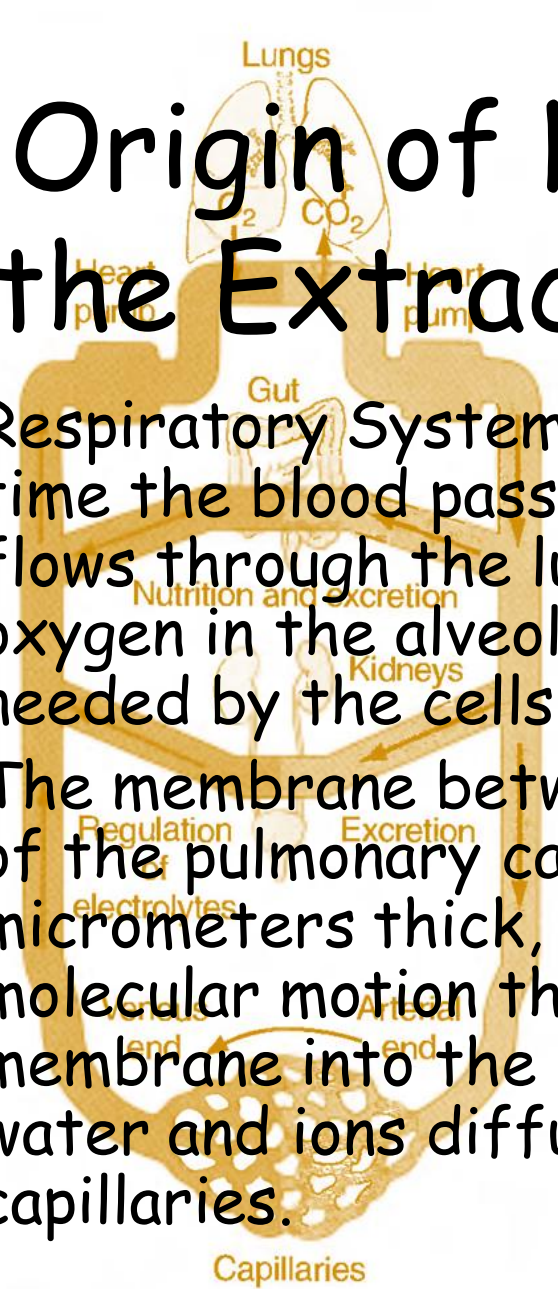


FIGURE 1-1

General organization of the circulatory system.



- Gastrointestinal Tract.
- A large portion of the blood pumped by the heart also passes through the walls of the gastrointestinal tract.
- Here different dissolved nutrients, including carbohydrates, fatty acids, and amino acids, are absorbed from the ingested food into the extracellular fluid of the blood.

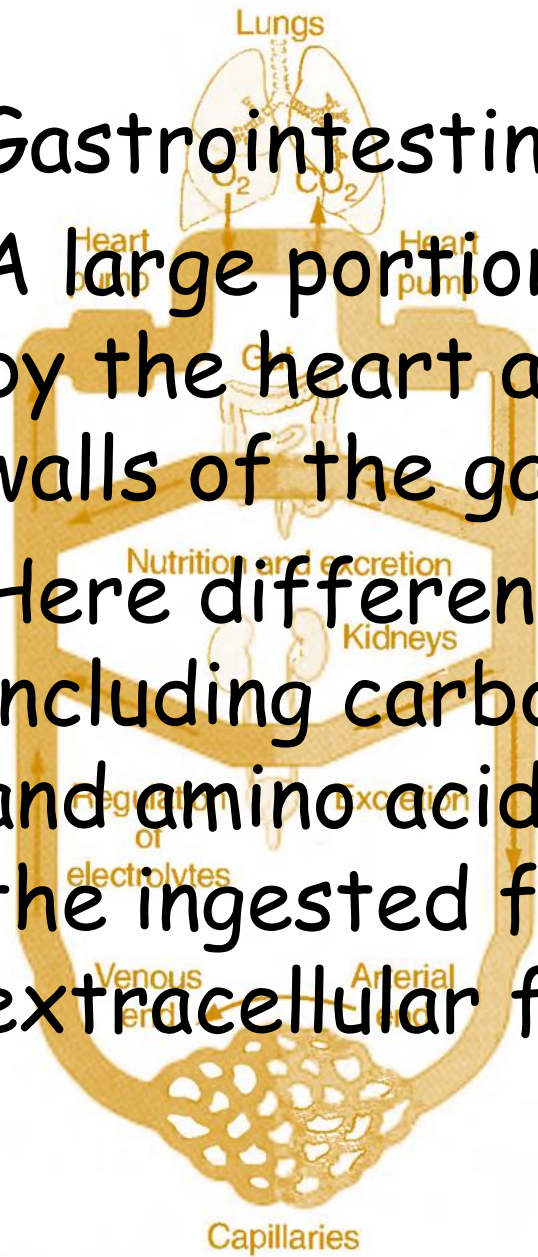


FIGURE 1-1

General organization of the circulatory system.



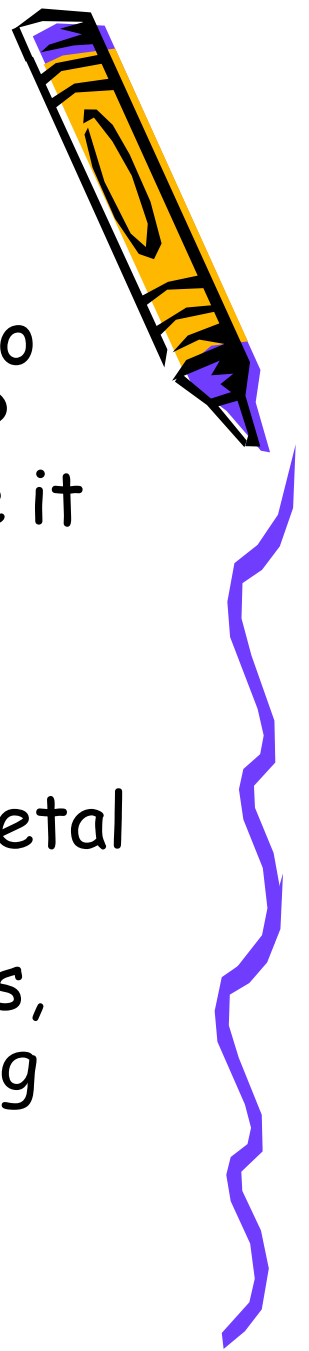


- Liver and Other Organs That Perform Primarily Metabolic Functions.
- Not all substances absorbed from the gastrointestinal tract can be used in their absorbed form by the cells. The liver changes the chemical compositions of many of these substances to more useable forms, and other tissues of the body (fat cells, gastrointestinal mucosa, kidneys, and endocrine glands) help to modify the absorbed substances or store them until they are needed.



FIGURE 1-1

General organization of the circulatory system.



- Musculoskeletal System.
- Sometimes the question is asked, How does the musculoskeletal system fit into the homeostatic functions of the body? The answer is obvious and simple: Were it not for this system, the body could not move to the appropriate place at the appropriate time to obtain the foods required for nutrition. The musculoskeletal system also provides motility for protection against adverse surroundings, without which the entire body, and along with it all the homeostatic mechanisms, could be destroyed instantaneously.



# Removal of Metabolic End Products



- Removal of Carbon Dioxide by the Lungs.
- At the same time that blood picks up oxygen in the lungs, carbon dioxide is released from the blood into the alveoli, and the respiratory movement of air into and out of the alveoli carries the carbon dioxide to the atmosphere. Carbon dioxide is the most abundant of all the end products of metabolism.

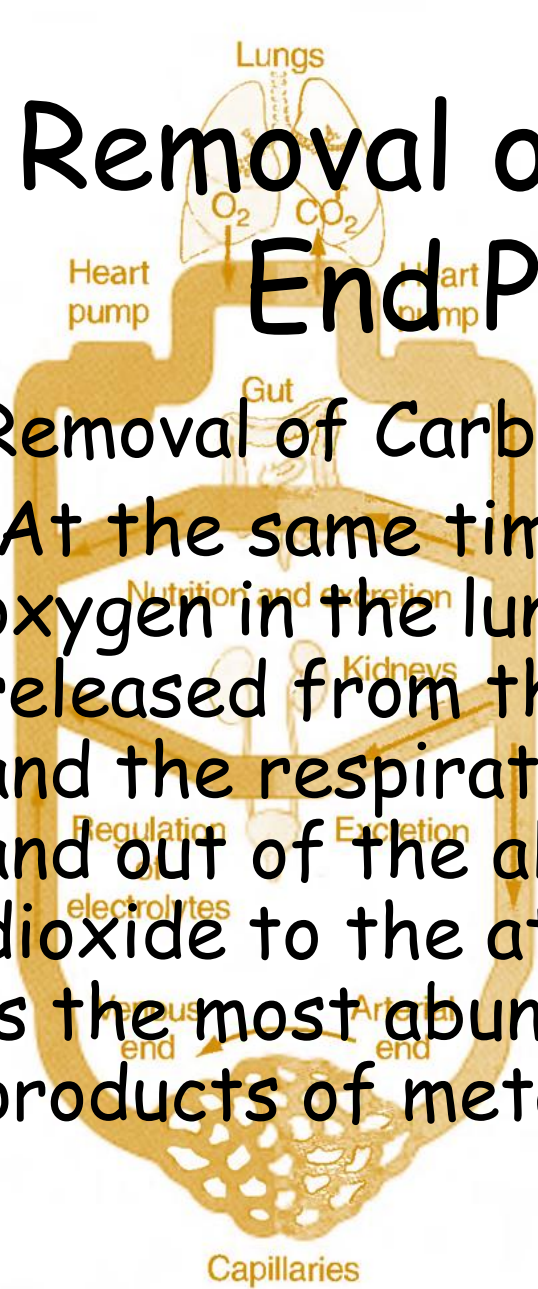


FIGURE 1-1

General organization of the circulatory system.



- Kidneys.
- Passage of the blood through the kidneys removes from the plasma many substances include especially different end products of cellular metabolism such as urea and uric acid; excesses of ions and water from the food that might have accumulated in the extracellular fluid and pass on through the renal tubules into the urine..
- The kidneys perform their function by first filtering large quantities of plasma through the glomeruli into the tubules and then reabsorbing into the blood those substances needed by the body, such as glucose, amino acids, appropriate amounts of water, and many of the ions.

FIGURE 1-1

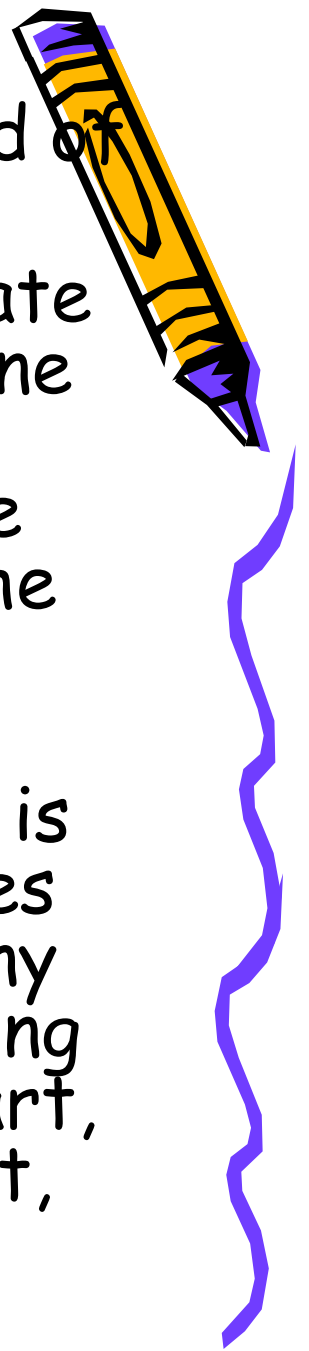
General organization of the circulatory system.

# Regulation of Body Functions



- Nervous System.
- The nervous system is composed of three major parts:
  - the sensory input portion,
  - the central nervous system (or integrative portion).
  - the motor output portion.
- Sensory receptors detect the state of the body or the state of the surroundings. For instance, receptors present everywhere in the skin apprise one every time an object touches the skin at any point. The eyes are sensory organs that give one a visual image of the surrounding area. The ears also are sensory organs.



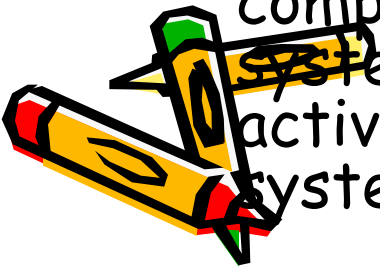


- The central nervous system is composed of the brain and spinal cord.
- The brain can store information, generate thoughts, create ambition, and determine reactions that the body performs in response to the sensations. Appropriate signals are then transmitted through the motor output portion of the nervous system to carry out one's desires.
- A large segment of the nervous system is called the autonomic system. It operates at a subconscious level and controls many functions of the internal organs, including the level of pumping activity by the heart, movements of the gastrointestinal tract, and glandular secretion.





- Hormonal System of Regulation.
- Located in the body are eight major endocrine glands that secrete chemical substances called hormones.
- Hormones are transported in the extracellular fluid to all parts of the body to help regulate cellular function. For instance, thyroid hormone increases the rates of most chemical reactions in all cells.
- Thyroid hormone helps to set the tempo of bodily activity. Insulin controls glucose metabolism; adrenocortical hormones control sodium ion, potassium ion, and protein metabolism; and parathyroid hormone controls bone calcium and phosphate.
- The hormones are a system of regulation that complements the nervous system. The nervous system regulates mainly muscular and secretory activities of the body, whereas the hormonal system regulates mainly metabolic functions.



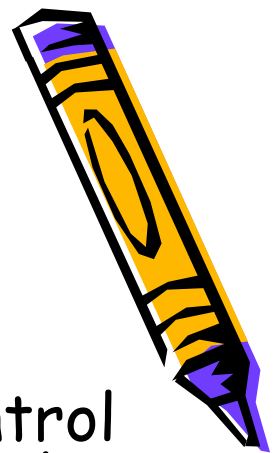
# Reproduction

- Sometimes reproduction is not considered a homeostatic function. However, help to maintain static conditions by generating new beings to take the place of those that are dying. This perhaps sounds like a permissive usage of the term homeostasis, but it does illustrate that, in the final analysis, essentially all body structures are organized such that they help maintain the automaticity and continuity of life.





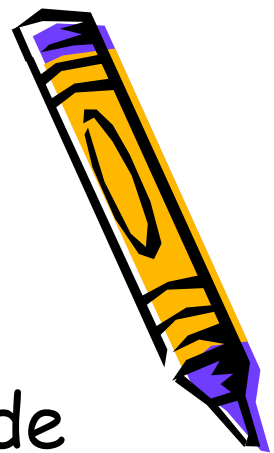
# CONTROL SYSTEMS OF THE BODY



- The human body has literally thousands of control systems in it. The most intricate of these are the genetic control systems that operate in all cells to control intracellular function as well as all extracellular functions.
- Many other control systems operate within the organs to control functions of the individual parts of the organs; others operate throughout the entire body to control the interrelations between the organs.
- For instance, the respiratory system, operating in association with the nervous system, regulates the concentration of carbon dioxide in the extracellular fluid.

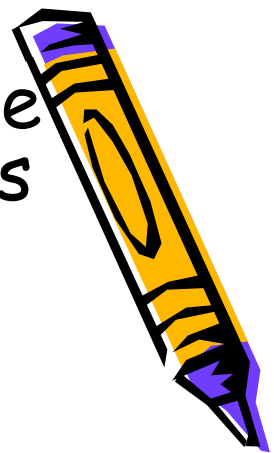


# Examples of Control Mechanisms



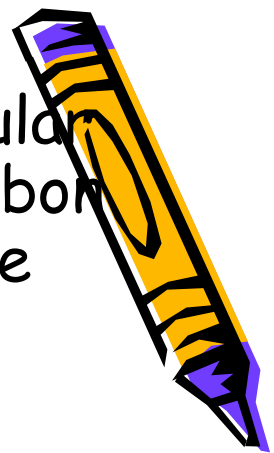
- Regulation of Oxygen and Carbon Dioxide Concentrations in the Extracellular Fluid. Because oxygen is one of the major substances required for chemical reactions in the cells, it is fortunate that the body has a special control mechanism to maintain an almost exact and constant oxygen concentration in the extracellular fluid.
- This mechanism depends principally on the chemical characteristics of hemoglobin, which is present in all red blood cells.





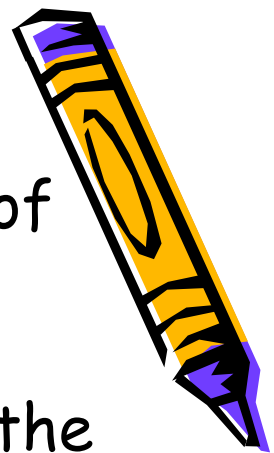
- Hemoglobin combines with oxygen as the blood passes through the lungs. Then, as the blood passes through the tissue capillaries.
- hemoglobin, because of its own strong chemical affinity for oxygen, does not release the oxygen into the tissue fluid if too much oxygen is already there. however, sufficient oxygen is released to re-establish adequate tissue oxygen concentration. Thus, the regulation of oxygen concentration in the tissues is vested principally in the chemical characteristics of hemoglobin itself.
- This regulation is called the oxygen buffering function of hemoglobin.





- Carbon dioxide concentration in the extracellular fluid is regulated in quite a different way. Carbon dioxide is a major end product of the oxidative reactions in cells.
- If all the carbon dioxide formed in the cells should continue to accumulate in the tissue fluids, the mass action of the carbon dioxide itself would soon halt all the energy-giving reactions of the cells.
- Fortunately, a higher than normal carbon dioxide concentration in the blood excites the respiratory center, causing a person to breathe rapidly and deeply. This increases the expiration of carbon dioxide and, therefore, its removal from the blood and the extracellular fluid. This process continues until the concentration returns to normal.





- Regulation of Arterial Blood Pressure.
- Several systems contribute to the regulation of arterial blood pressure.
- The baroreceptor system, is a simple and excellent example of a control mechanism. In the walls of the bifurcation region of the carotid arteries in the neck and also in the arch of the aorta in the thorax are many nerve receptors called baroreceptors.
- This stimulated by stretch of the arterial wall. When the arterial pressure rises too high, the baroreceptors send barrages of impulses to the medulla of the brain. Here the impulses inhibit the vasomotor center, which in turn decreases the number of impulses transmitted through the sympathetic nervous system to the heart and blood vessels.





- Lack of these impulses causes diminished pumping activity by the heart and also dilation of the peripheral blood vessels, allowing increased ease of blood flow through the vessels.
- Both of these effects lower the arterial pressure back toward normal.
- A decrease in arterial pressure relaxes the stretch receptors, allowing the vasomotor center to become more active than usual, thereby causing the arterial pressure to rise back toward normal.



# Normal Ranges of Important Extracellular Fluid Constituents and Physical Characteristics



**TABLE 1-1**

Some Important Constituents and Physical Characteristics of the Extracellular Fluid, the Normal Range of Control, and the Approximate Nonlethal Limits for Short Periods

	Normal Value	Normal Range	Approximate Nonlethal Limits	Units
Oxygen	40	35-45	10-1000	mm Hg
Carbon dioxide	40	35-45	5-80	mm Hg
Sodium ion	142	138-146	115-175	mmol/L
Potassium ion	4.2	3.8-5.0	1.5-9.0	mmol/L
Calcium ion	1.2	1.0-1.4	0.5-2.0	mmol/L
Chloride ion	108	103-112	70-130	mmol/L
Bicarbonate ion	28	24-32	8-45	mmol/L
Glucose	85	75-95	20-1500	mg/dl
Body temperature	98.4 (37.0)	98-98.8 (37.0)	65-110 (18.3-43.3)	°F (°C)
Acid-base	7.4	7.3-7.5	6.9-8.0	pH

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# Characteristics of Control Systems



- The aforementioned examples of homeostatic control mechanisms are only a few of the many hundreds to thousands in the body, all of which have certain characteristics in common.

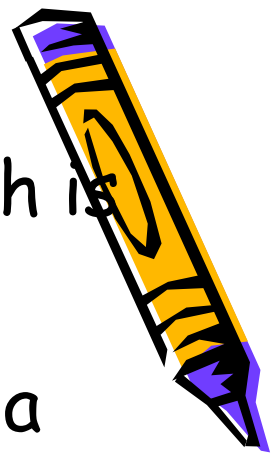






- Most control systems of the body act by negative feedback, which can best be explained by reviewing some of the homeostatic control systems mentioned previously.
- In the regulation of carbon dioxide concentration, a high concentration of carbon dioxide in the extracellular fluid increases pulmonary ventilation. This in turn decreases the extracellular fluid carbon dioxide concentration because the lungs then excrete greater amounts of carbon dioxide from the body.





- In other words, the high concentration causes a decreased concentration, which is negative to the initiating stimulus. Conversely, if the carbon dioxide concentration falls too low, this causes a feedback increase in the concentration. This response also is negative to the initiating stimulus.
- In the arterial pressure-regulating mechanisms, a high pressure causes a series of reactions that promote a lowered pressure, or a low pressure causes a series of reactions that promote an elevated pressure. In both instances, these effects are negative with respect to the initiating stimulus.





- "Gain" of a Control System.
- The degree of effectiveness with which a control system maintains constant conditions is determined by the gain of the negative feedback.
- For instance, let us assume that a large volume of blood is transfused into a person whose baroreceptor pressure control system is not functioning, and the arterial pressure rises from the normal level of 100 mm Hg up to 175 mm Hg.





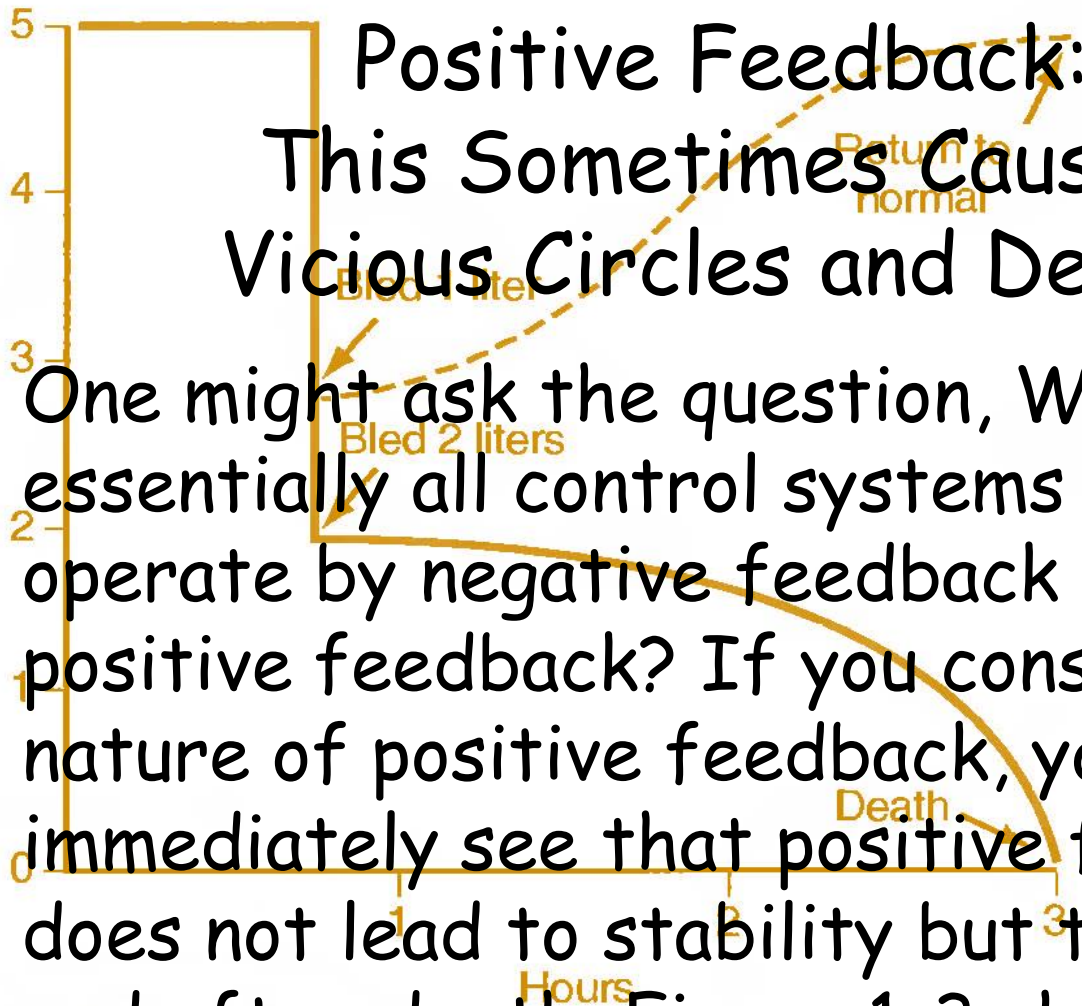
- Then, let us assume that the same volume of blood is injected into the same person when the baroreceptor system is functioning, and this time the pressure increases only 25 mm Hg.
- There remains an increase in pressure of + 25 mm Hg, called the "error," which means that the control system is not 100 per cent effective in preventing change.





# Positive Feedback: This Sometimes Causes Vicious Circles and Death

Pumping effectiveness of heart  
(Liters pumped per minute)



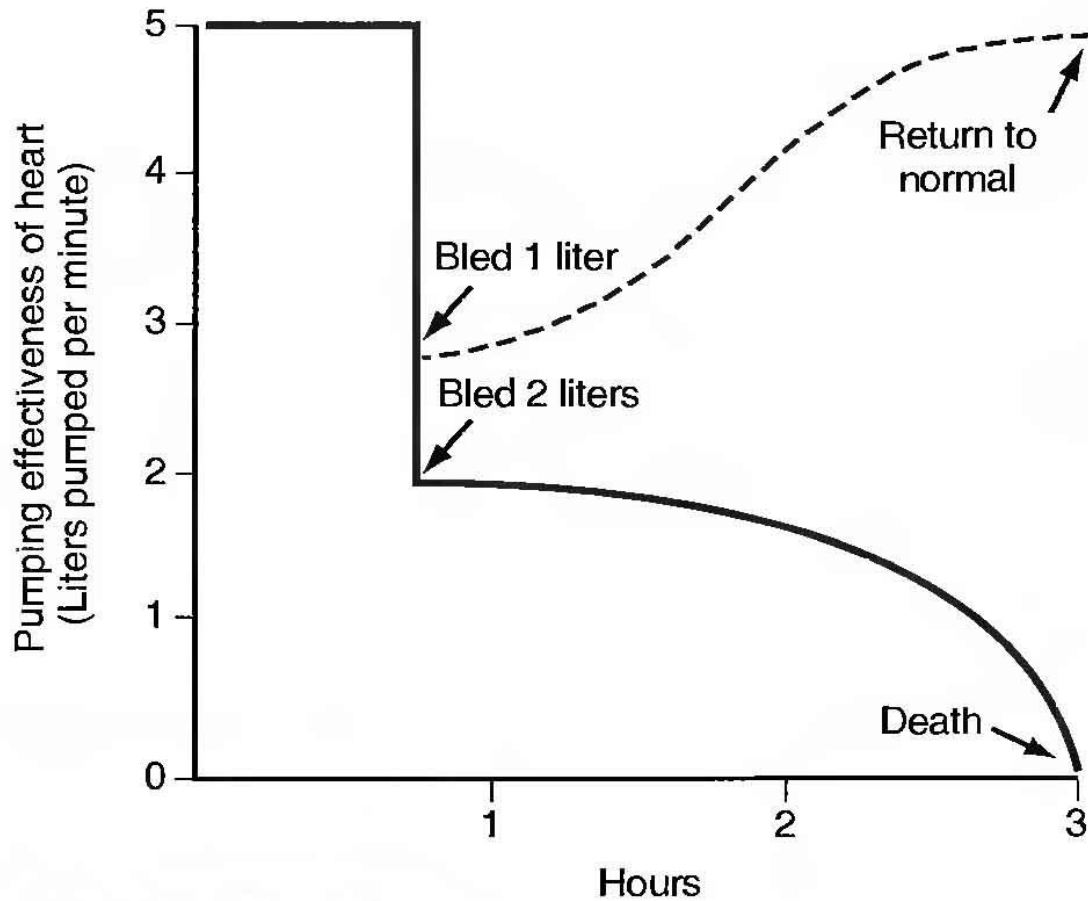
• One might ask the question, Why do essentially all control systems of the body operate by negative feedback rather than positive feedback? If you consider the nature of positive feedback, you will immediately see that positive feedback does not lead to stability but to instability and often death. Figure 1-3 shows an

**FIGURE 1-3**

Recovery of heart pumping caused by negative feedback after loss of blood is removed from the circulation. Death caused by positive feedback when 2 liters of blood are removed.

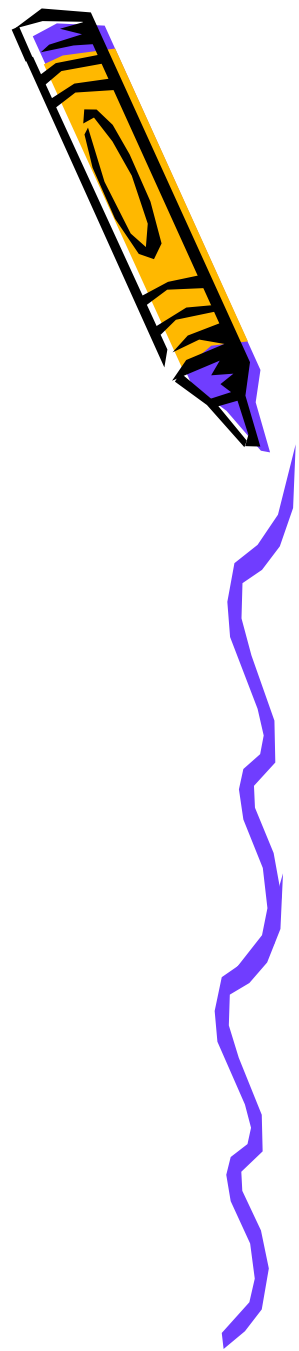
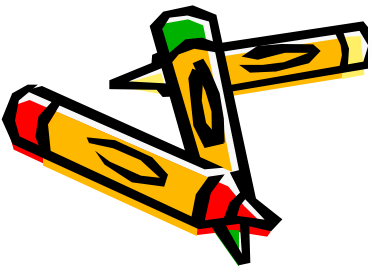
example in which death can ensue from positive feedback. This figure depicts the





**FIGURE 1 - 3**

Recovery of heart pumping caused by *negative feedback* after 1 liter of blood is removed from the circulation. Death caused by *positive feedback* when 2 liters of blood are removed.



Pumping effectiveness of heart  
(Liters pumped per minute)

• pumping effectiveness of the heart, showing that the heart of a healthy human being pumps about 5 liters of blood per minute. If the person is suddenly bled 2 liters, the amount of blood in the body is decreased to such a low level that not enough is available for the heart to pump effectively.

• This results in weakening of the heart, further diminished pumping, further decrease in coronary blood flow, and still more weakness of the heart; the cycle repeats itself again and again until death occurs. Note that each cycle in the feedback results in further weakening of the heart. In other words, the initiating stimulus causes more of the same, which is positive feedback.

**FIGURE**

Recovery of heart pumping caused by *negative feedback* after 1 liter of blood is removed from the circulation. Death caused by *positive feedback* when 2 liters of blood are removed.



Pumping effectiveness of heart  
(Liters pumped per minute)

- Positive feedback is better known as a vicious circle, but a mild degree of positive feedback can be overcome by the negative feedback control mechanisms of the body, and a vicious circle fails to develop.
- If the person in the aforementioned example were bled only 1 liter instead of 2 liters, the normal negative feedback mechanisms for controlling cardiac output and arterial pressure would overbalance the positive feedback and the person would recover, as shown by the dashed

curve of Figure 1-3.

FIGURE 1-3

Recovery of heart pumping caused by negative feedback after 1 liter of blood is removed from the circulation. Death caused by positive feedback when 2 liters of blood are removed.





Pumping effectiveness of heart  
(Liters pumped per minute)

- Positive Feedback Can Sometimes Be Useful.
- In rare instances, the body has learned to use positive feedback to its advantage. Blood clotting is an example of a valuable use of positive feedback.
- This process continues until the hole in the vessel is plugged and bleeding no longer occurs.
- On occasion, this mechanism can itself get out of hand and cause the formation of unwanted clots. In fact, this is what initiates most acute heart attacks, which are caused by a clot beginning on an atherosclerotic plaque in a coronary artery and then growing until the artery is blocked.

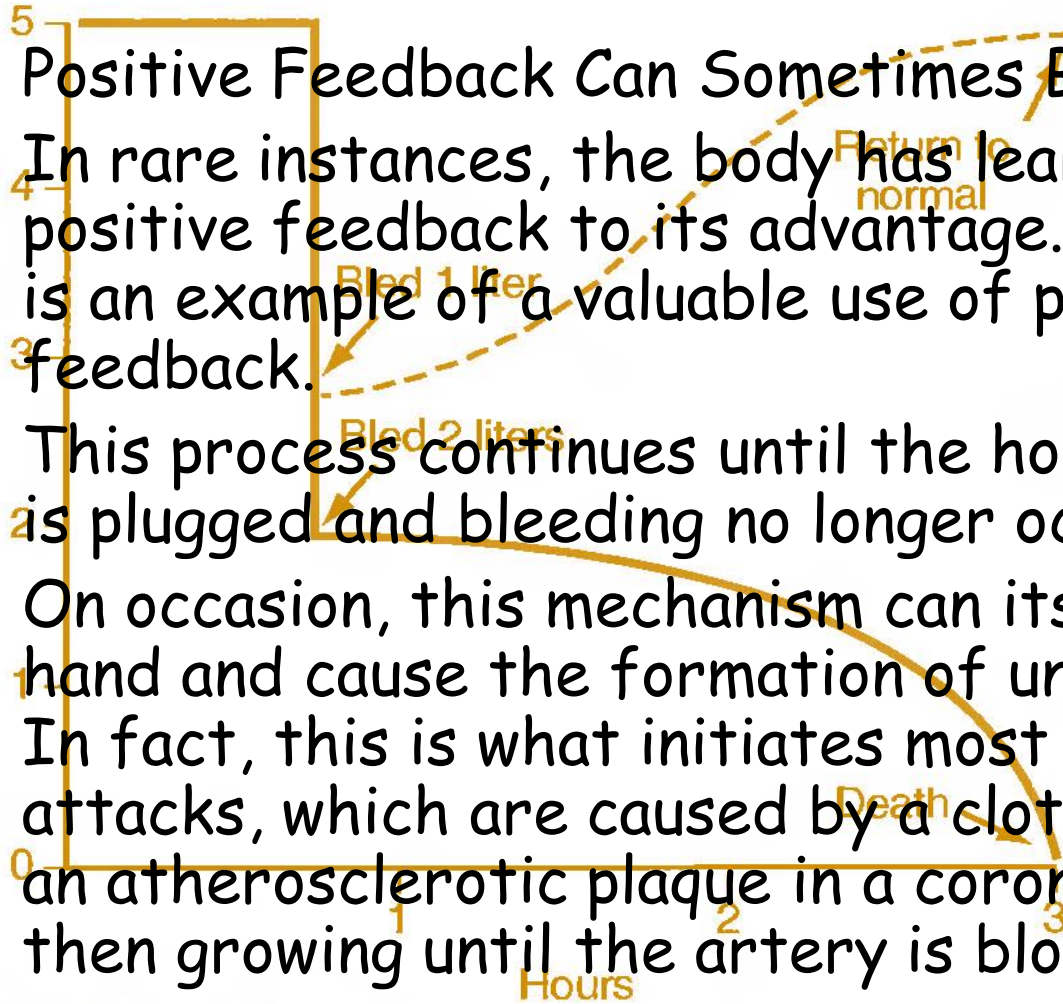


FIGURE 1-3

Recovery of heart pumping caused by *negative feedback* after 1 liter of blood is removed from the circulation. Death caused by positive feedback when 2 liters of blood are removed.





- Another important use of positive feedback is for the generation of nerve signals. That is, when the membrane of a nerve fiber is stimulated, this causes slight leakage of sodium ions through sodium channels in the nerve membrane to the fiber's interior.
- The sodium ions entering the fiber then change the membrane potential, which in turn causes more opening of channels, more change of potential, still more opening of channels, and so forth.
- Thus, from a slight beginning, there is an explosion of sodium leakage into the interior of the nerve fiber that creates the nerve action potential.





- We shall learn that in each case in which positive feedback is useful, the positive feedback itself is part of an overall negative feedback process.
- For example, in the case of blood clotting, the positive feedback clotting process is a negative feedback process for maintenance of normal blood volume. Also, the positive feedback that causes nerve signals allows the nerves to participate in literally thousands of negative feedback nervous control systems.

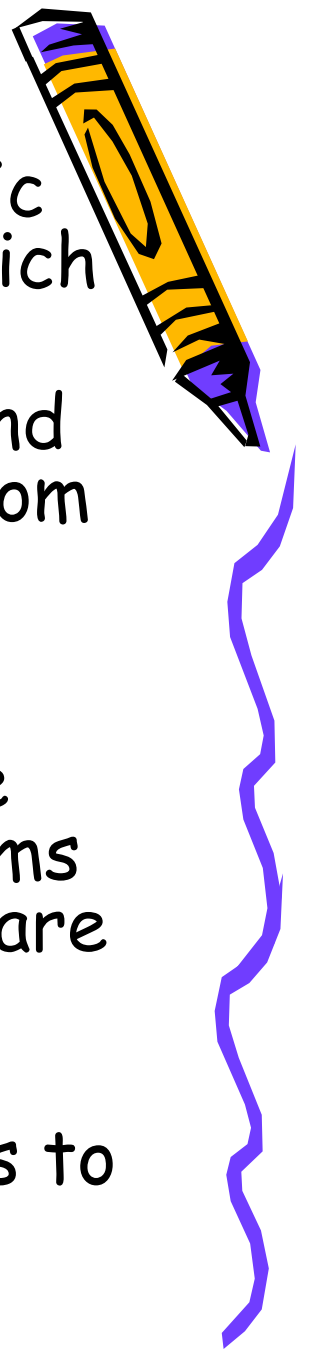


# AUTOMATICITY OF THE BODY



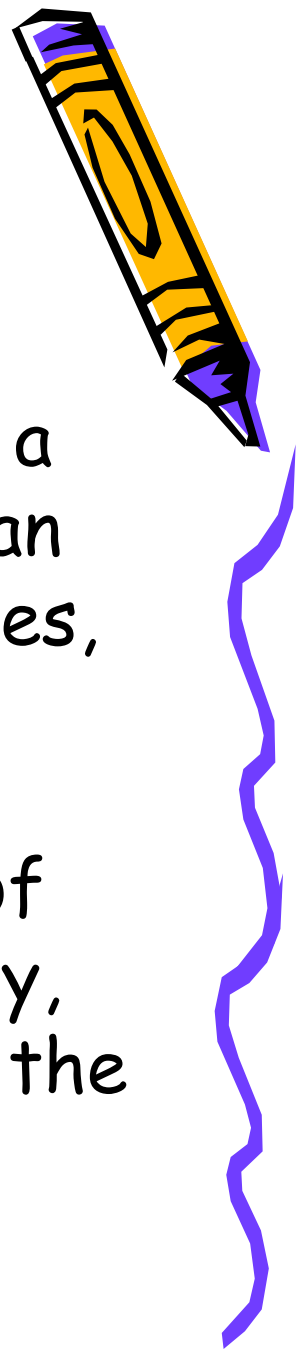
- The purpose of this chapter has been to point out, first, the overall organization of the body and, second, the means by which the different parts of the body operate in harmony.
- The body is actually a social order of about 100 trillion cells organized into different functional structures, some of which are called organs.





- Each functional structure provides its share in the maintenance of homeostatic conditions in the extracellular fluid, which is called the internal environment.
- The cells of the body continue to live and function properly. Each cell benefits from homeostasis, each cell contributes its share toward the maintenance of homeostasis. This reciprocal interplay provides continuous automaticity of the body until one or more functional systems lose their ability to contribute their share of function.
- When this happens, all the cells of the body suffer. Extreme dysfunction leads to death, whereas moderate dysfunction leads to sickness.



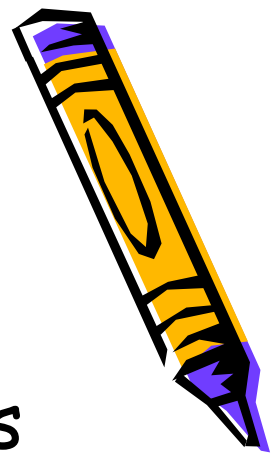


# The Cell and Its Function

- Each of the 100 trillion or more cells in a human being is a living structure that can survive indefinitely and, in most instances, can even reproduce itself provided its surrounding fluids contain appropriate nutrients. To understand the function of organs and other structures of the body, it is essential that we first understand the basic organization of the cell and the function of its component parts.

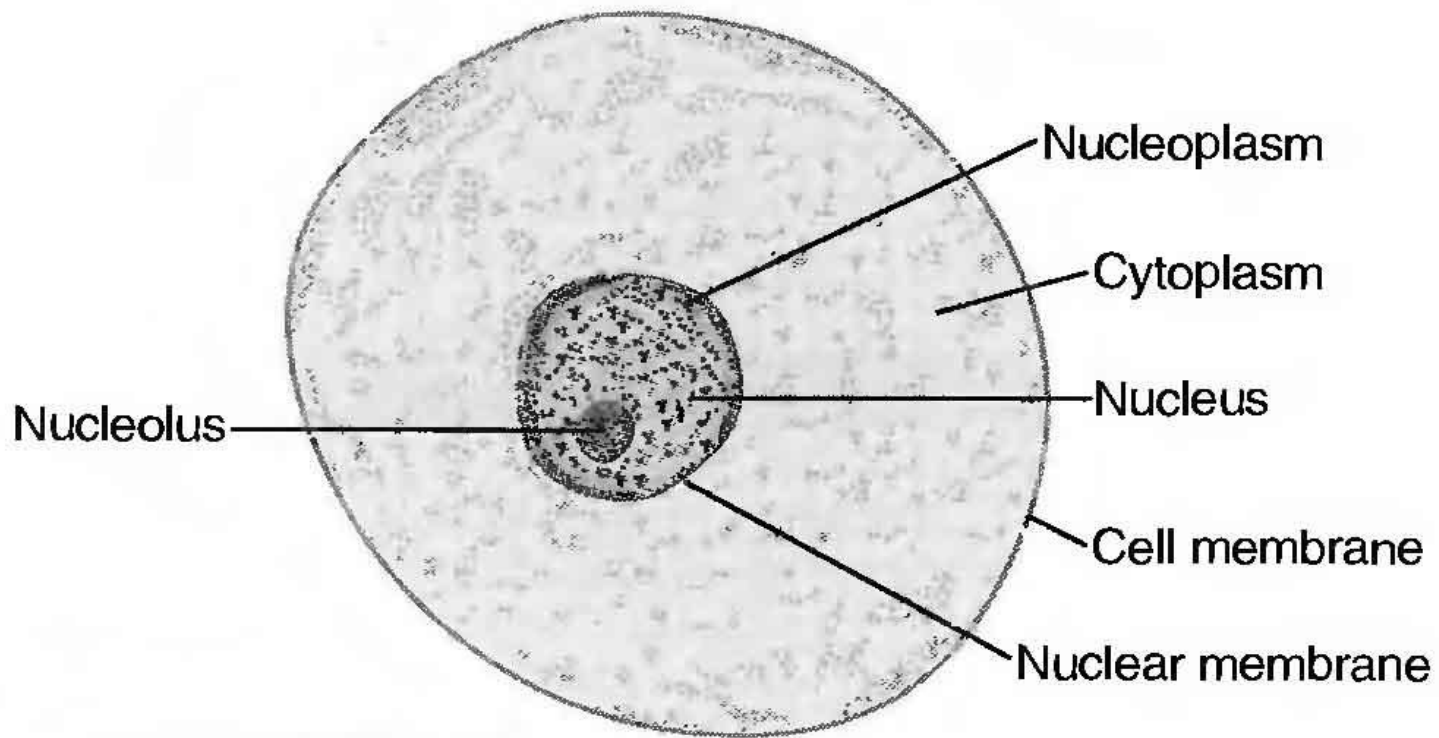


# ORGANIZATION OF THE CELL



- A typical cell, is shown in Figure 2-1. Its two major parts are the nucleus and the cytoplasm.
- The nucleus is separated from the cytoplasm by a nuclear membrane, and the cytoplasm is separated from the surrounding fluids by a cell membrane. The different substances that make up the cell are collectively called protoplasm.
- Protoplasm is composed mainly of five basic substances: water, electrolytes, proteins, lipids, and carbohydrates.



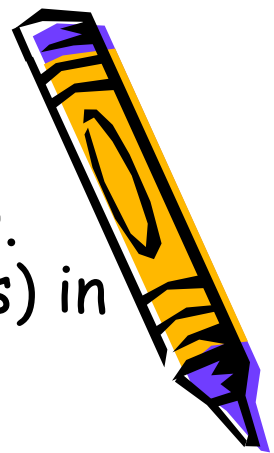


**FIGURE 2 - 1**

Structure of the cell as seen with the light microscope.



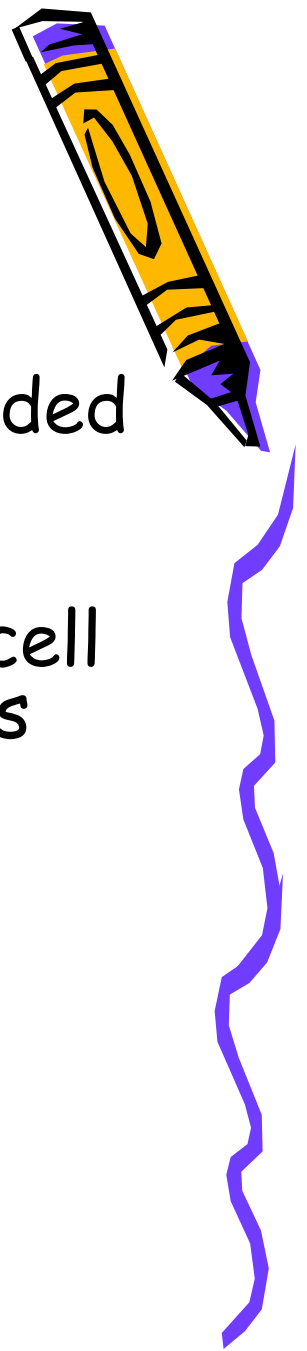




- Water.
- The principal fluid medium of the cell is water. which is present in most cells (except fat cells) in a concentration of 70 to 85 per cent.
- Ions.
- The most important ions in the cell are potassium, magnesium, phosphate, sulfate, bicarbonate, and small quantities of sodium, chloride, and calcium. The ions provide inorganic chemicals for cellular reactions. Also, they are necessary for operation of some of the cellular control mechanisms. For instance, ions acting at the cell membrane are required for transmission of electrochemical impulses in nerve and muscle fibers.

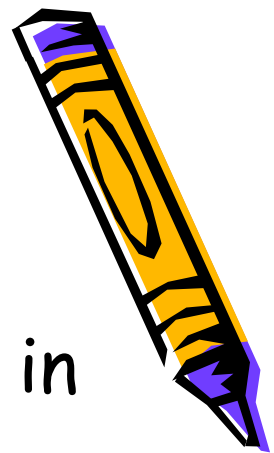


- Proteins.
- After water, the most abundant substances in most cells are proteins, which normally constitute 10 to 20 per cent of the cell mass. These can be divided into two types, structural proteins and globular proteins.
- Structural proteins are present in the cell mainly in the form of long thin filaments that themselves are polymers of many basic protein molecules. The most prominent use of such intracellular filaments is to provide the contractile mechanism of all muscles.



- The globular proteins are an entirely different type of protein, usually composed of individual protein molecules or, at most, combinations of a few molecules in a globular form rather than a fibrillar form. These proteins are mainly the enzymes of the cell and, in contrast to the fibrillar proteins, are often soluble in the cell fluid. Also, many of them are adherent to membranous structures inside the cell.





- Lipids.
- Lipids are several types of substances that are grouped together because of their common property of being soluble in fat solvents.
- The most important lipids in most cells are phospholipids and cholesterol which together constitute about 2 per cent of the total cell mass. The special importance of phospholipids and cholesterol is that they are mainly insoluble in water and, therefore, are used to form the cell membrane as well as intracellular membranous barriers that separate the different cell compartments.



- some cells contain large quantities of triglycerides, also called neutral fat. In the so-called fat cells, triglycerides often account for as much as 95 per cent of the cell mass. The fat stored in these cells represents the body's main storehouse of energy-giving nutrient that can later be dissolved and used for energy wherever in the body it is needed.

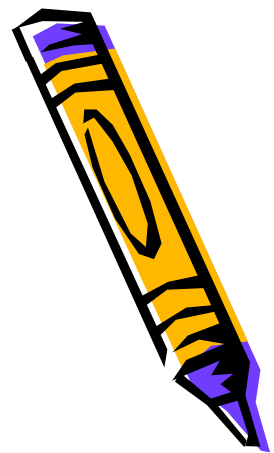




- Carbohydrates.
- Carbohydrates have little structural function in the cell except as parts of glycoprotein molecules, but they play a major role in nutrition of the cell. Most human cells do not maintain large stores of carbohydrates; the amount usually averages about 1 percent of their total mass but increases to as much as 3 percent in muscle cells and, occasionally, 6 percent in liver cells.

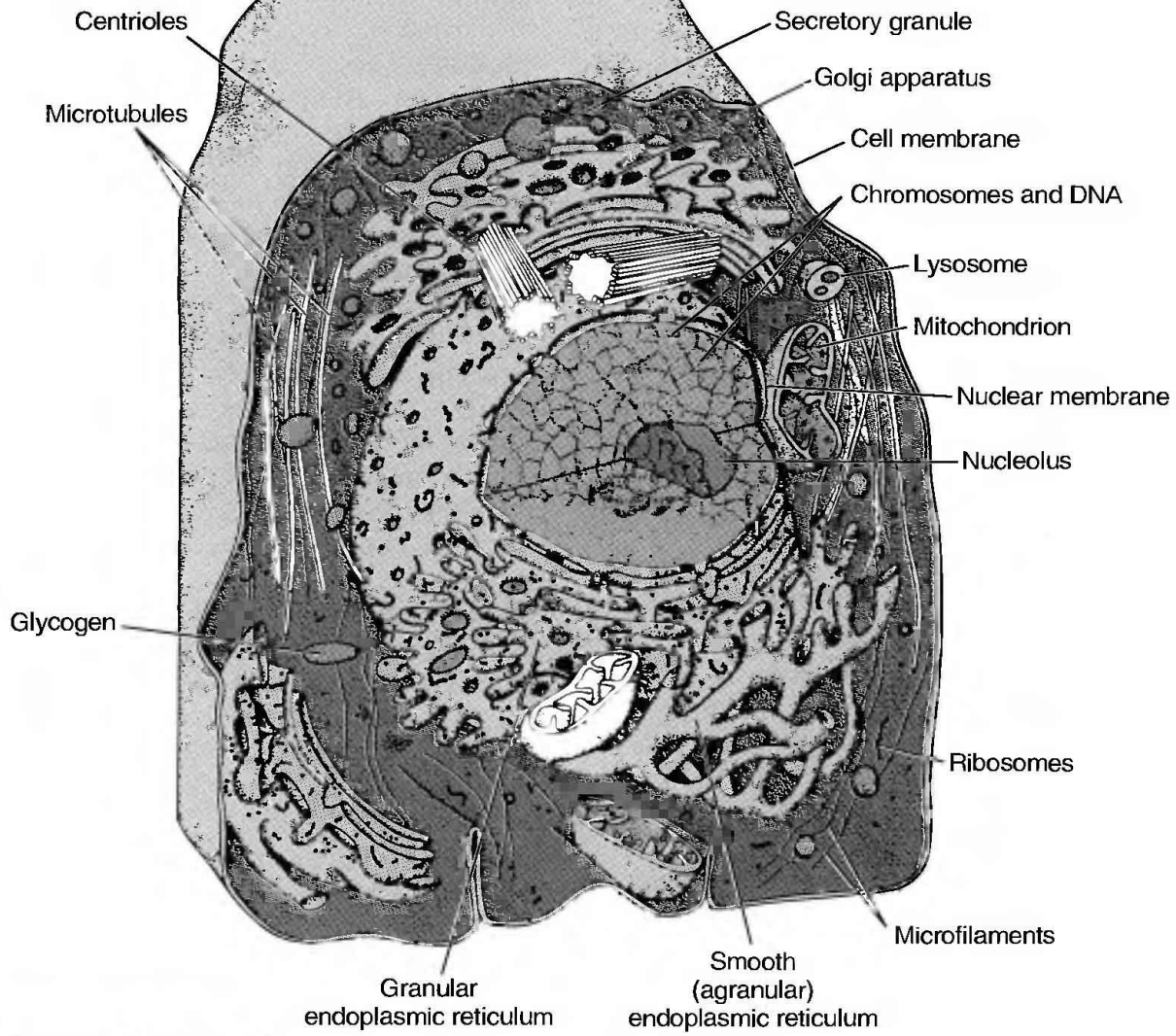


# PHYSICAL STRUCTURE OF THE CELL



- The cell is not merely a bag of fluid, enzymes, and chemicals; it also contains highly organized physical structures, many of which are called organelles. The physical nature of each structure is equally as important to the function of the cell as the cell's chemical constituents. For instance, without one of the organelles, the mitochondria, more than 95 percent of the cell's energy supply would cease immediately.



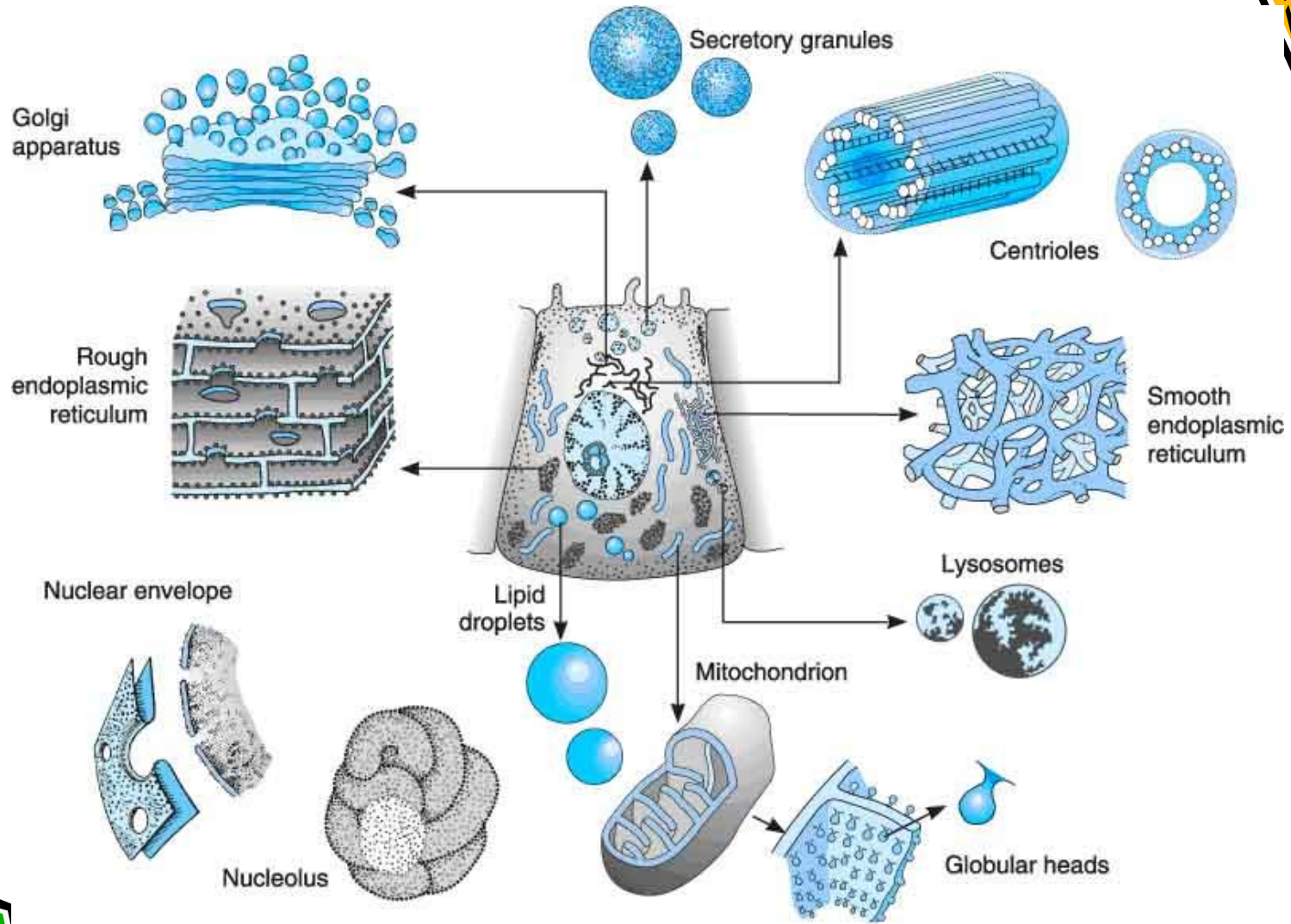


**FIGURE 2 - 2**

Reconstruction of a typical cell, showing the internal organelles in the cytoplasm and in the nucleus.

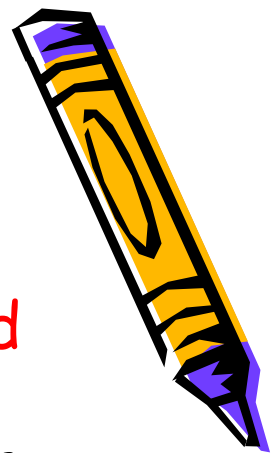






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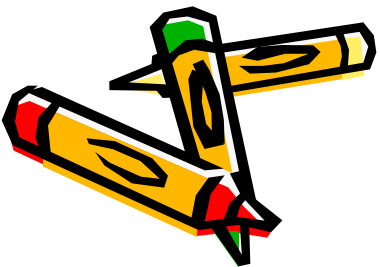


- Membranous Structures of the Cell

- Most organelles of the cell are covered by membranes composed primarily of **lipids and proteins**. These membranes include the cell membrane, nuclear membrane, membrane of the endoplasmic reticulum, and membranes of the mitochondria, lysosomes, and Golgi apparatus.
- **The lipids** of the membranes provide **a barrier** that prevents movement of water and water-soluble substances from one cell compartment to the other because the water is not soluble in the lipids.



- **Protein molecules** in the membrane often penetrate all the way through the membrane, providing **specialized pathways**, often called pores, for passage of specific substances through the membrane. Also, many other membrane proteins are enzymes that catalyze a multitude of different chemical reactions, which are the subjects of numerous discussions in this and subsequent chapters.

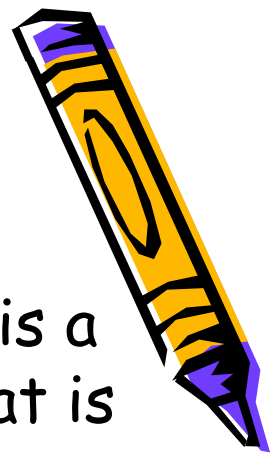




- Cell Membrane

- The cell membrane, which envelops the cell, is a thin, pliable, elastic structure only 7.5 to 10 nanometers thick. It is composed almost entirely of proteins and lipids. The approximate composition is proteins, 55 per cent; phospholipids, 25 per cent; cholesterol, 13 per cent; other lipids, 4 per cent; and carbohydrates, 3 per cent.

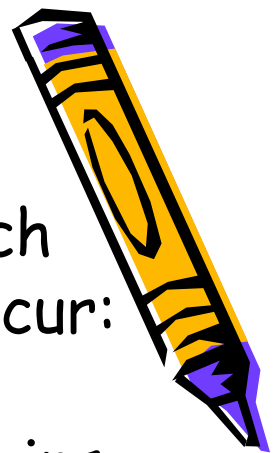




- Lipid Barrier of the Cell Membrane Prevents Water Penetration.

- Its basic structure is a lipid bilayer, which is a thin film of lipids only 2 molecules thick that is continuous over the entire cell surface. Interspersed in this lipid film are large globular protein molecules.
- The basic lipid bilayer is composed of phospholipid molecules. One end of each phospholipid molecule is soluble in water; that is, it is hydrophilic. The other end is soluble only in fats; that is, it is hydrophobic. It is the phosphate end of the phospholipid that is hydrophilic, and the fatty acid portion that is hydrophobic.

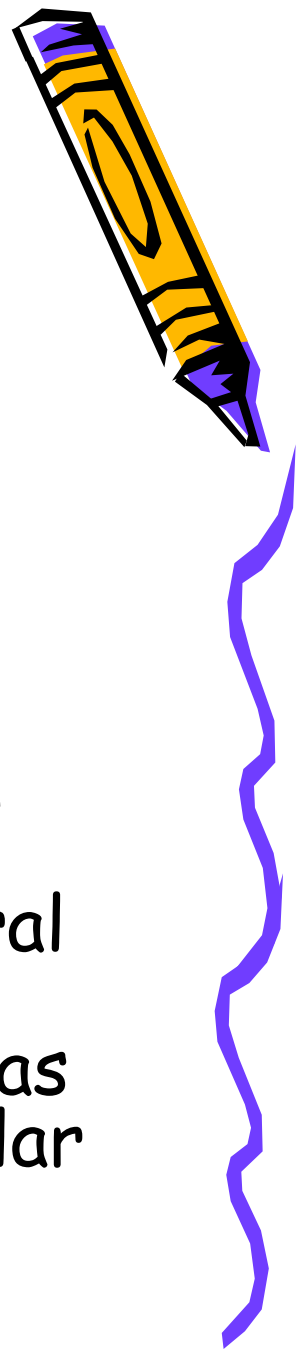




- Cell Membrane Proteins.

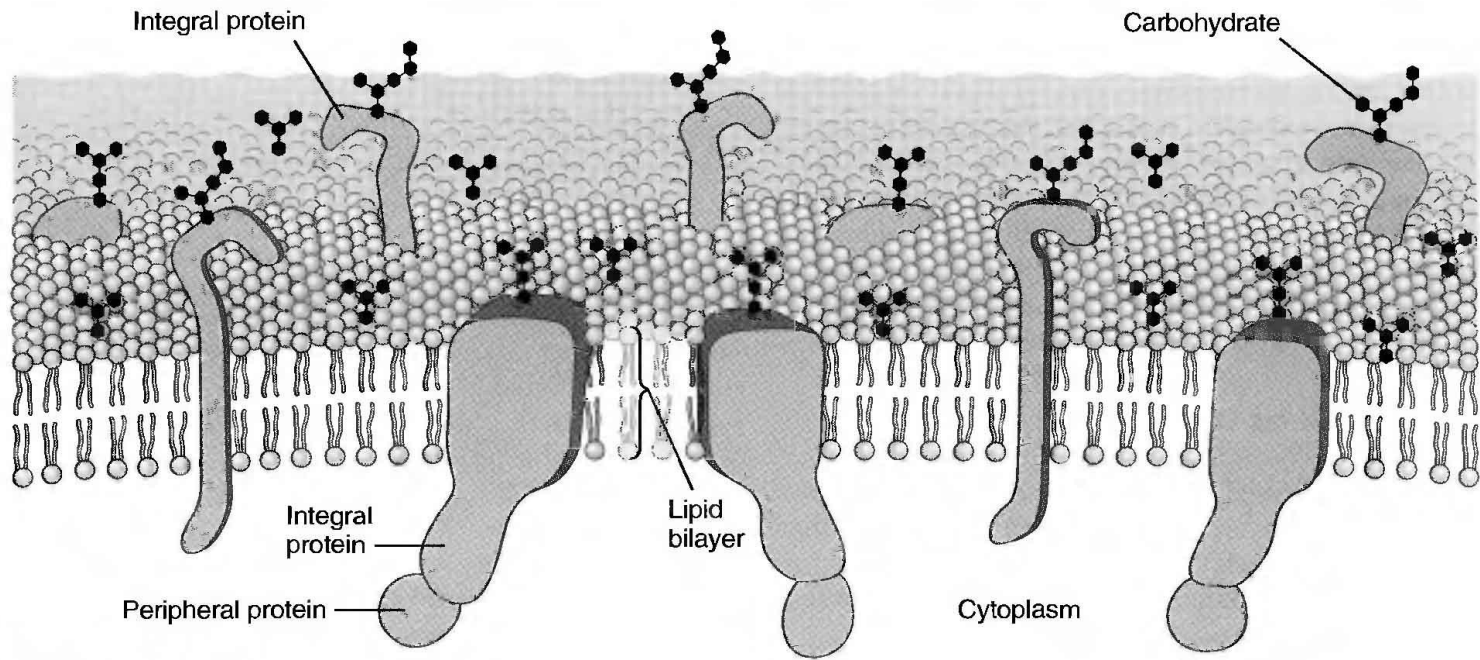
- These are membrane proteins, most of which are glycoproteins. Two types of proteins occur: integral proteins that protrude all the way through the membrane and peripheral proteins that are attached only to one surface of the membrane and do not penetrate.
- Many of the integral proteins provide structural channels (or pores) through which water molecules and water-soluble substances, especially ions, can diffuse between the extracellular and intracellular fluid. These protein channels also have selective properties that allow preferential diffusion of some substances more than others.





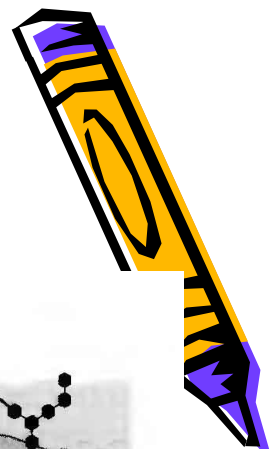
- Others of the integral proteins act as carrier proteins for transporting substances that otherwise could not penetrate the lipid bilayer. Sometimes these even transport substances in the direction opposite to their natural direction of diffusion, which is called "active transport." Still others act as enzymes.
- The peripheral proteins occur mainly on the inside of the membrane, and they often are attached to one of the integral proteins. These peripheral proteins function almost entirely as enzymes or as other types of controllers of intracellular function.





**FIGURE 2-3**

Structure of the cell membrane, showing that it is composed mainly of a lipid bilayer of phospholipid molecules, but with large numbers of protein molecules protruding through the layer. Also, carbohydrate moieties are attached to the protein molecules on the outside of the membrane and to additional protein molecules on the inside. (Redrawn from Lodish HF, Rothman JE: The assembly of cell membranes. *Sci Am* 240:48, 1979. ©1979 by Scientific American, Inc. All rights reserved.)







- Membrane Carbohydrates--The Cell "Glycocalyx."
- Membrane carbohydrates occur almost invariably in combination with proteins or lipids in the form of glycoproteins or glycolipids.
- Many other carbohydrate compounds, called proteoglycans, which are mainly carbohydrate substances bound to small protein cores, often are loosely attached to the outer surface of the cell as well.
- The entire outside surface of the cell often has a loose carbohydrate coat called the glycocalyx.

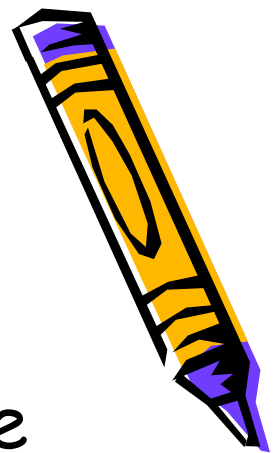




- The carbohydrate attached to the outer surface of the cell have several important functions:
- (1) Many of them are electrically negatively charged, which gives most cells an overall negative surface charge that repels other negative objects.
- (2) The glycocalyx of some cells attaches to the glycocalyx of other cells, thus attaching cells one to another.
- (3) Many of the carbohydrates act as receptor substances for binding hormones such as insulin, and when bound, this combination activates attached internal proteins that in turn activate a cascade of intracellular enzymes.
- (4) Some carbohydrate enter into immune reactions.



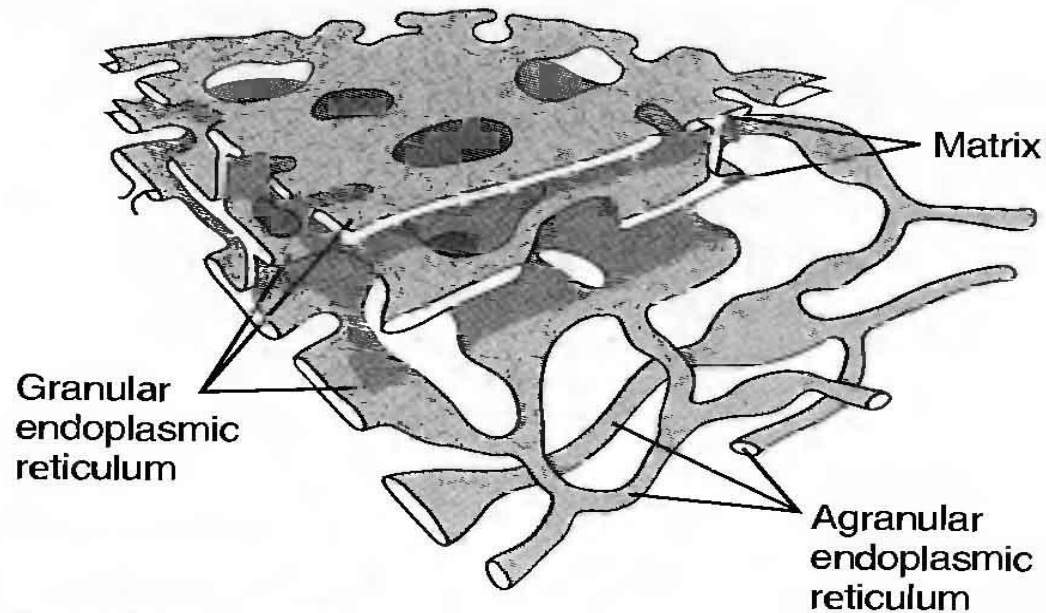
# Cytoplasm and Its Organelles



- The cytoplasm is filled with both minute and large dispersed particles and organelles. The clear fluid portion of the cytoplasm in which the particles are dispersed is called cytosol; this contains mainly dissolved proteins, electrolytes, and glucose.
- Dispersed in the cytoplasm are neutral fat globules, glycogen granules, ribosomes, secretory vesicles, and five especially important organelles: the endoplasmic reticulum, the Golgi apparatus, mitochondria, lysosomes, and peroxisomes.

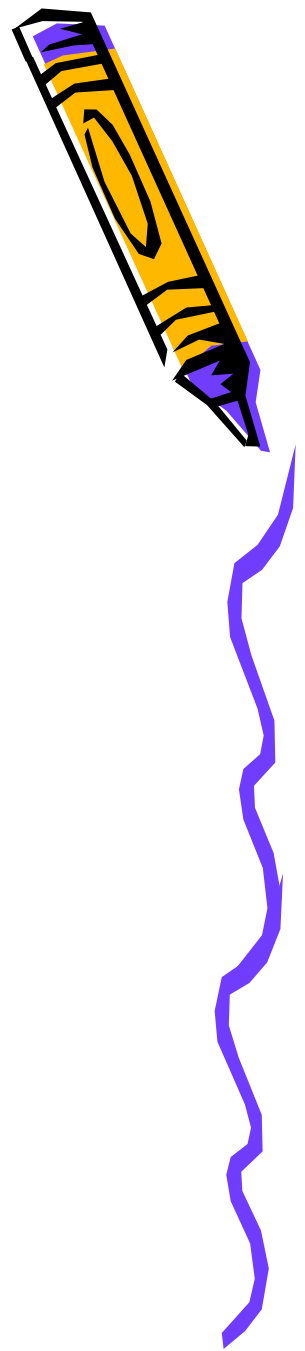
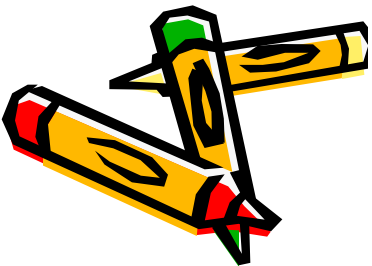


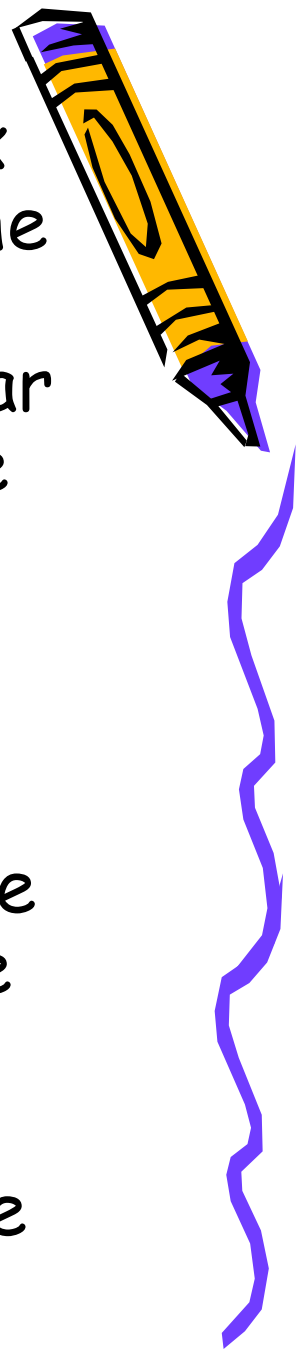
# Endoplasmic Reticulum



**FIGURE 2-4**

Structure of the endoplasmic reticulum. (Modified from DeRobertis EDP, Saez FA, DeRobertis EMF: Cell Biology. 6th ed. Philadelphia: WB Saunders Co, 1975.)





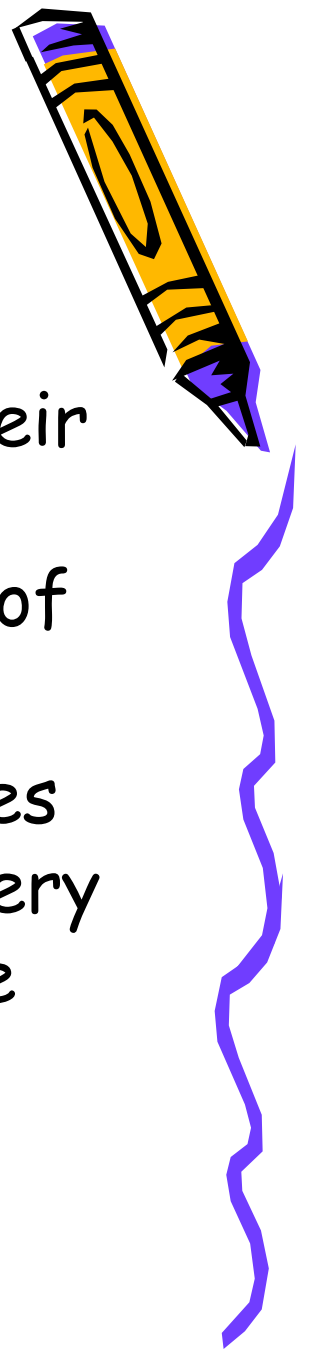
- The **endoplasmic reticulum** is a complex series of tubules in the cytoplasm of the cell. The inner limb of its membrane is continuous with a segment of the nuclear membrane, so in effect this part of the nuclear membrane is a cistern of the endoplasmic reticulum. The tubule walls are made up of membrane.
- In **rough, or granular, endoplasmic reticulum**, granules called **ribosomes** are attached to the cytoplasmic side of the membrane, whereas in **smooth, or agranular, endoplasmic reticulum**, the granules are absent. Free ribosomes are also found in the cytoplasm.





- The granular endoplasmic reticulum is concerned with protein synthesis and the initial folding of polypeptide chains with the formation of disulfide bonds.
- The agranular endoplasmic reticulum is the site of steroid synthesis in steroid-secreting cells and the site of detoxification processes in other cells.

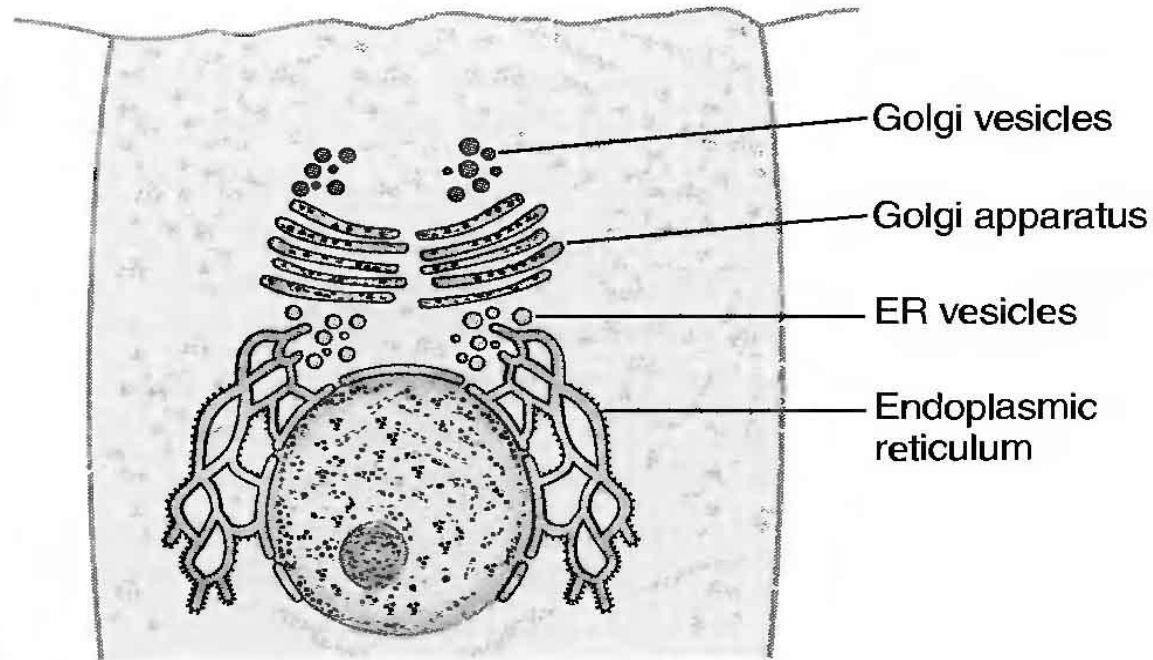




- a network of tubular and flat vesicular structures that is the endoplasmic reticulum. The tubules and vesicles interconnect with one another. Also, their walls are constructed of lipid bilayer membranes that contain large amounts of proteins.
- The space inside the tubules and vesicles is filled with endoplasmic matrix, a watery fluid medium that is different from the fluid in the cytosol outside the endoplasmic reticulum.

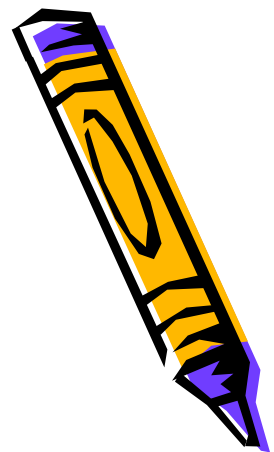


# Golgi Apparatus



**FIGURE 2 - 5**

A typical Golgi apparatus and its relationship to the endoplasmic reticulum (ER) and the nucleus.



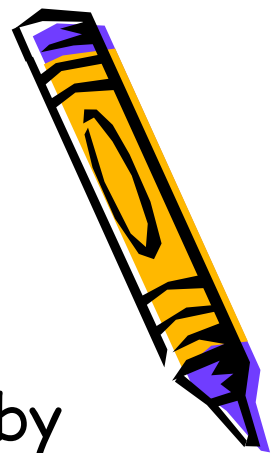




- The Golgi apparatus is closely related to the endoplasmic reticulum. It has membranes similar to those of the agranular endoplasmic reticulum. It usually is composed of four or more stacked layers of thin, flat enclosed vesicles lying near one side of the nucleus. This apparatus is prominent in secretory cells; in these cells, it is located on the side of the cell from which the secretory substances are extruded.
- The Golgi apparatus functions in association with the endoplasmic reticulum. small "transport vesicles," also called endoplasmic reticulum vesicles or simply ER vesicles, continually pinch off from the endoplasmic reticulum and shortly thereafter fuse with the Golgi apparatus. In this way, substances entrapped in the ER vesicles are transported from the endoplasmic reticulum to the Golgi apparatus. The transported substances are then processed in the Golgi apparatus to form lysosomes, secretory vesicles, or other cytoplasmic



# Lysosomes



- Lysosomes are vesicular organelles that form by breaking off from the Golgi apparatus and then dispersing throughout the cytoplasm.
- The lysosomes provide an intracellular digestive system that allows the cell to digest within itself (1) damaged cellular structures, (2) food particles that have been ingested by the cell, and (3) unwanted matter such as bacteria.
- The lysosome is quite different in different types of cells, but it usually is 250 to 750 nanometers in diameter. It is surrounded by a typical lipid bilayer membrane and is filled with large numbers of small granules 5 to 8 nanometers in diameter, which are protein aggregates of as many as 40 different hydrolase (digestive) enzymes.



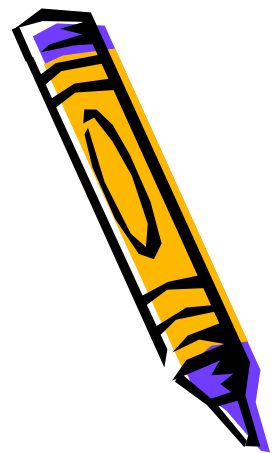
# Peroxisomes



- Peroxisomes are similar physically to lysosomes, but they are different in two important ways: First, they are believed to be formed by self-replication (or perhaps by budding off from the smooth endoplasmic reticulum) rather than by the Golgi apparatus. Second, they contain oxidases rather than hydrolases. Several of the oxidases are capable of combining oxygen with hydrogen ions from different intracellular chemicals to form hydrogen peroxide ( $H_2O_2$ ).
- The hydrogen peroxide in turn is itself a highly oxidizing substance, and this is used in association with catalase, another oxidase enzyme present in large quantities in peroxisomes, to oxidize many substances that might otherwise be poisonous to the cell. For instance, about half the alcohol a person drinks is detoxified by the peroxisomes of the liver cells in this manner

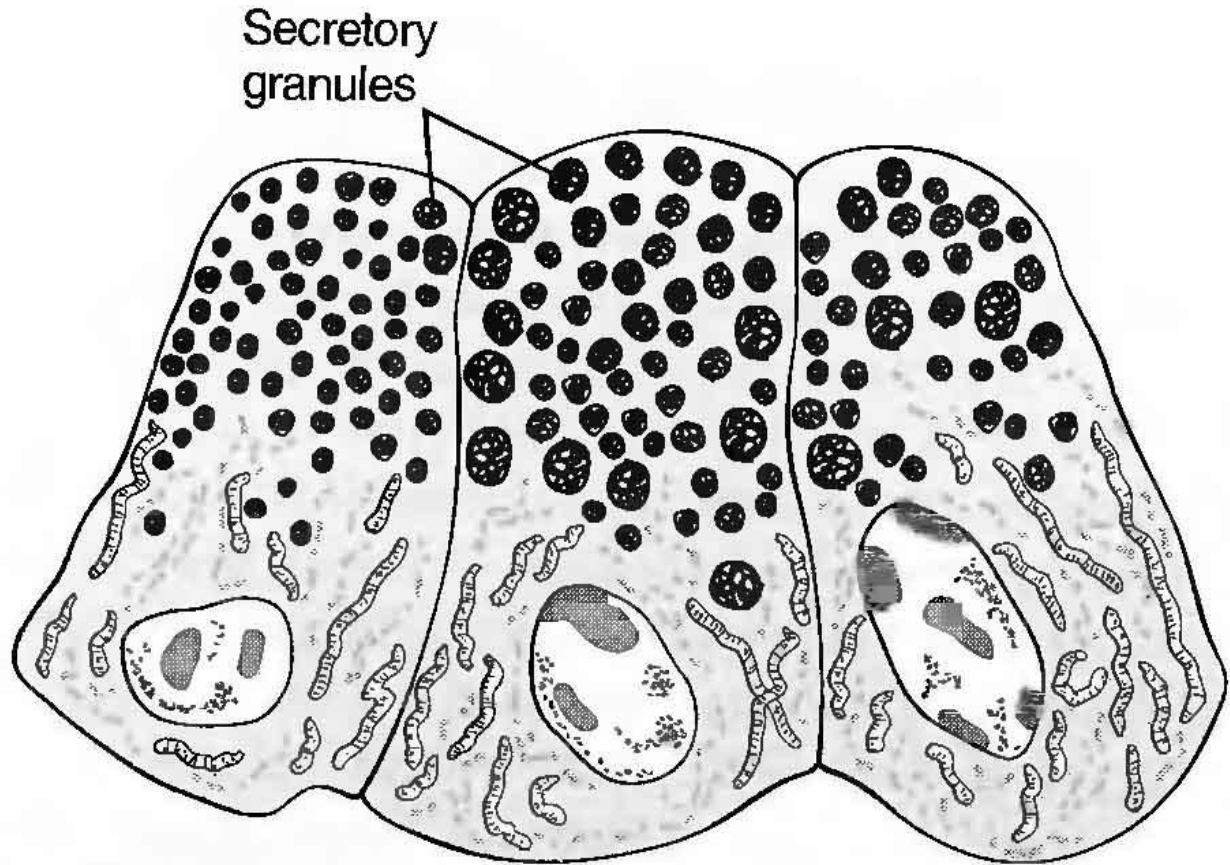


# Secretory Vesicles



- One of the important functions of many cells is secretion of special substances. Almost all such secretory substances are formed by the endoplasmic reticulum Golgi apparatus system and are then released from the Golgi apparatus into the cytoplasm in the form of storage vesicles called secretory vesicles or secretory granules.
- Figure 2-6 shows typical secretory vesicles inside pancreatic acinar cells; these vesicles store protein proenzymes (enzymes that are not yet activated). The proenzymes are secreted later through the outer cell membrane into the pancreatic duct and thence into the duodenum, where they become activated and perform digestive functions on the food in the intestinal tract.





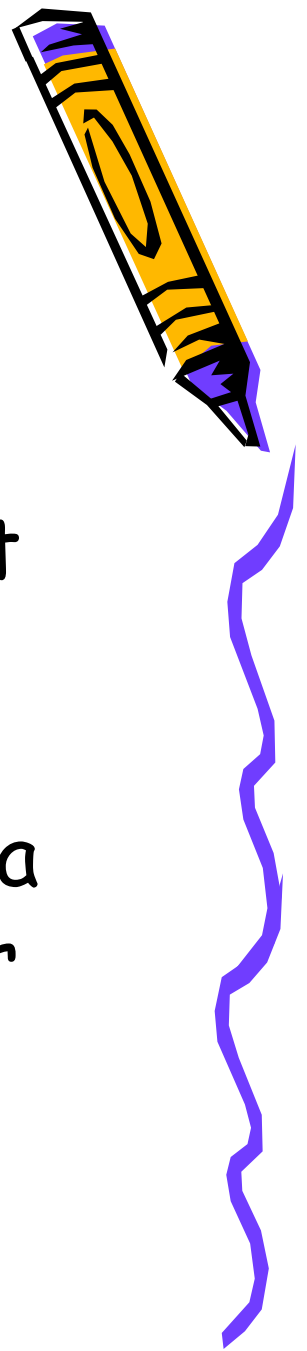
**FIGURE 2-6**

Secretory granules (secretory vesicles) in acinar cells of the pancreas.



# Mitochondria

- The mitochondria are called the "powerhouses" of the cell. Without them, the cells would be unable to extract significant amounts of energy from the nutrients, and as a consequence, essentially all cellular functions would cease.





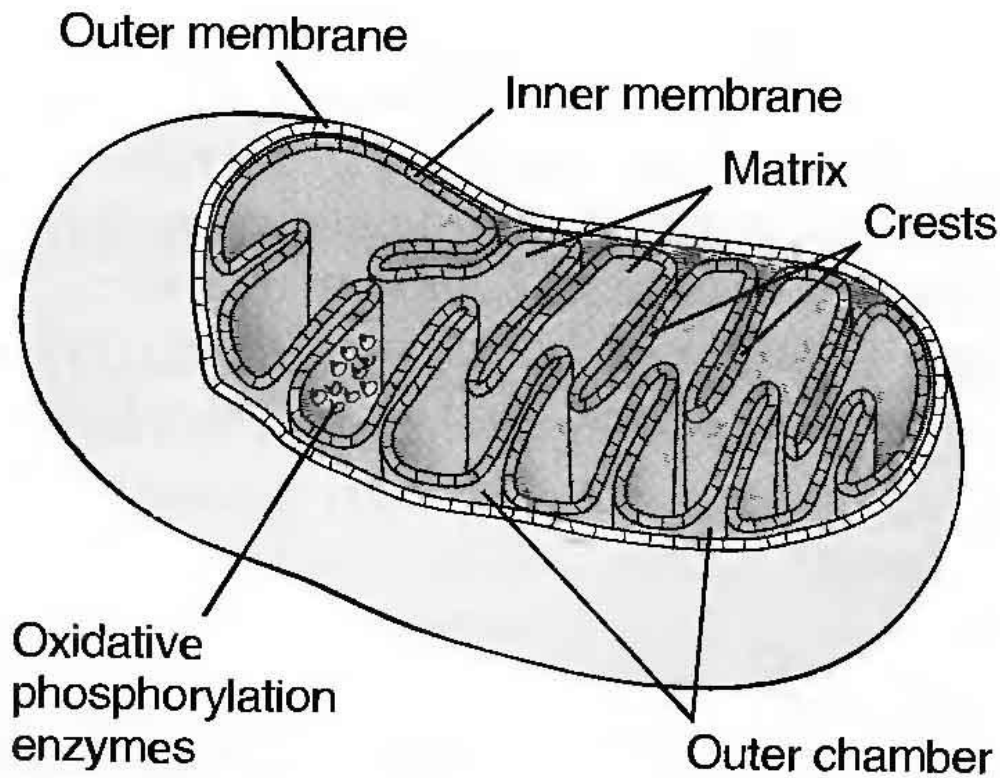
- The basic structure of the mitochondrion is composed mainly of two lipid bilayer-protein membranes: an outer membrane and an inner membrane. Many infoldings of the inner membrane form shelves onto which oxidative enzymes are attached. In addition, the inner cavity of the mitochondrion is filled with a matrix that contains large quantities of dissolved enzymes that are necessary for extracting energy from nutrients.
- These enzymes operate in association with the oxidative enzymes on the shelves to cause oxidation of the nutrients, thereby forming carbon dioxide and water and at the same time releasing energy. The liberated energy is used to synthesize a high-energy substance called adenosine triphosphate (ATP).
- The ATP is then transported out of the mitochondrion, and it diffuses throughout the cell to release its energy wherever it is needed for performing cellular functions.



- Mitochondria are self-replicative, which means that one mitochondrion can form a second one, a third one, and so on, whenever there is need in the cell for increased amounts of ATP. Indeed, the mitochondria contain deoxyribonucleic acid (DNA) similar to that found in the nucleus.







**FIGURE 2-7**

Structure of a mitochondrion. (Modified from DeRobertis EDP, Saez FA, DeRobertis EMF: Cell Biology. 6th ed. Philadelphia: WB Saunders Co, 1975.)



# Nucleus



- The nucleus is the control center of the cell. Briefly, the nucleus contains large quantities of DNA, which are the genes. The genes determine the characteristics of the cell's proteins, including the structural proteins as well as the enzymes of the cytoplasm that control cytoplasmic activities. They also control reproduction; the genes first reproduce themselves to give two identical sets of genes, and after this, the cell splits by a special process called mitosis to form two daughter cells, each of which receives one of the two sets of DNA genes.



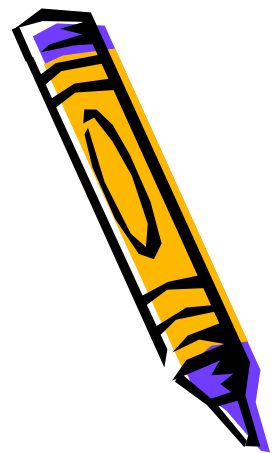
# Nuclear Membrane



- The nuclear membrane, also called the nuclear envelope, is actually two separate bilayer membranes, one inside the other. The outer membrane is continuous with the endoplasmic reticulum of the cell cytoplasm, and the space between the two nuclear membranes is also continuous with the space inside the endoplasmic reticulum. The nuclear membrane is penetrated by several thousand nuclear pores. Large complexes of protein molecules are attached at the edges of the pores so that the central area of each pore is only about 9 nanometers in diameter. Even this size is large enough to allow molecules up to 44,000 molecular weight to pass through with reasonable ease.



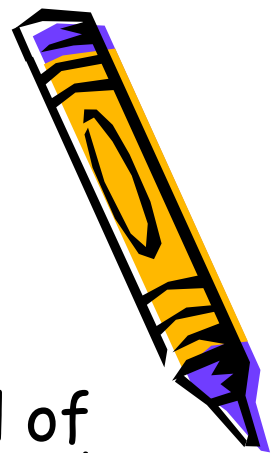
# Nucleoli and Formation of Ribosomes



- The nuclei of most cells contain one or more differently staining structures called nucleoli. The nucleolus, unlike most other organelles that we have discussed, does not have a limiting membrane. Instead, it is simply an accumulation of large amounts of RNA and proteins of the types found in ribosomes. The nucleolus becomes considerably enlarged when the cell is actively synthesizing proteins.

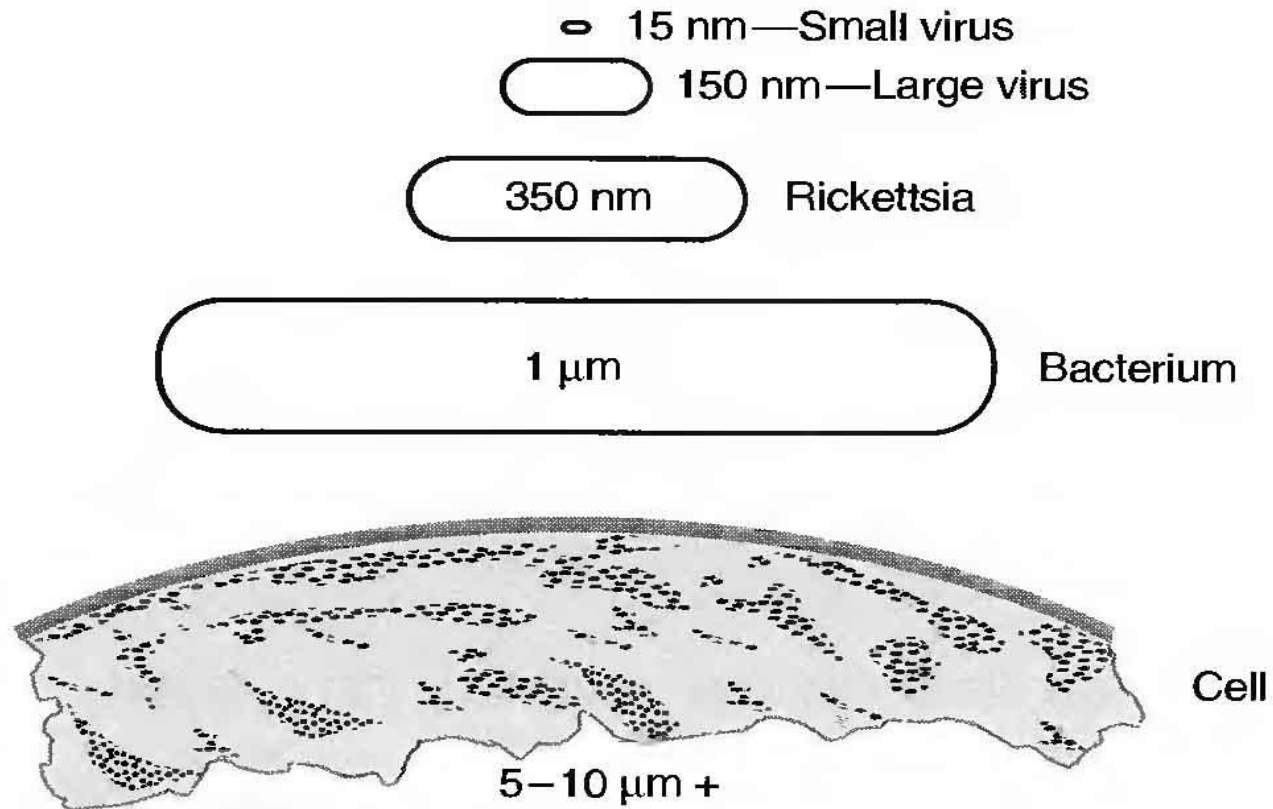


# COMPARISON OF THE ANIMAL CELL WITH PRECELLULAR FORMS OF LIFE



- Many of us think of the cell as the lowest level of life. However, the cell is a very, very complicated organism, which required many hundreds of million years to develop after the earliest form of life, an organism similar to the present-day virus, first appeared on earth. Figure 2-10 shows the relative sizes of (1) smallest known virus, (2) a large virus, (3) a rickettsia, (4) a bacterium, and (5) a nucleated cell, demonstrating that the cell has a diameter about 1000 times that of the smallest virus and, therefore, a volume about 1 billion times that of the smallest virus. Correspondingly, the functions and anatomic organization of the cell are also far more complex than those of the virus.



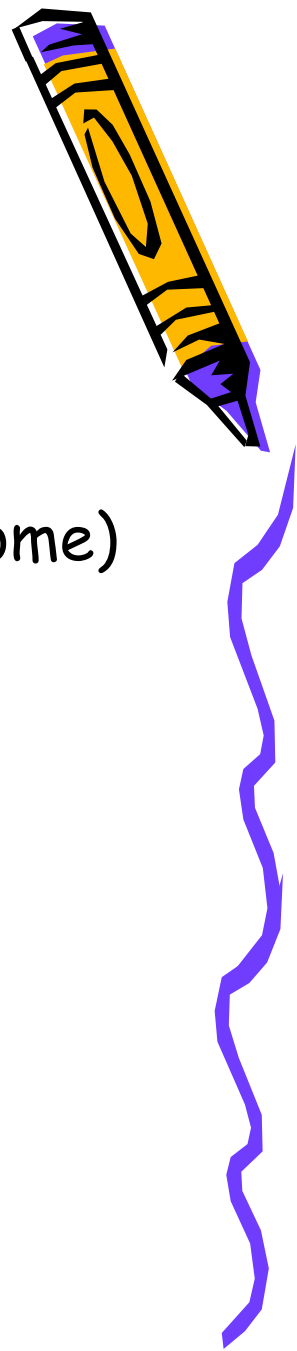


**FIGURE 2-10**

Comparison of sizes of precellular organisms with that of the average cell in the human body.

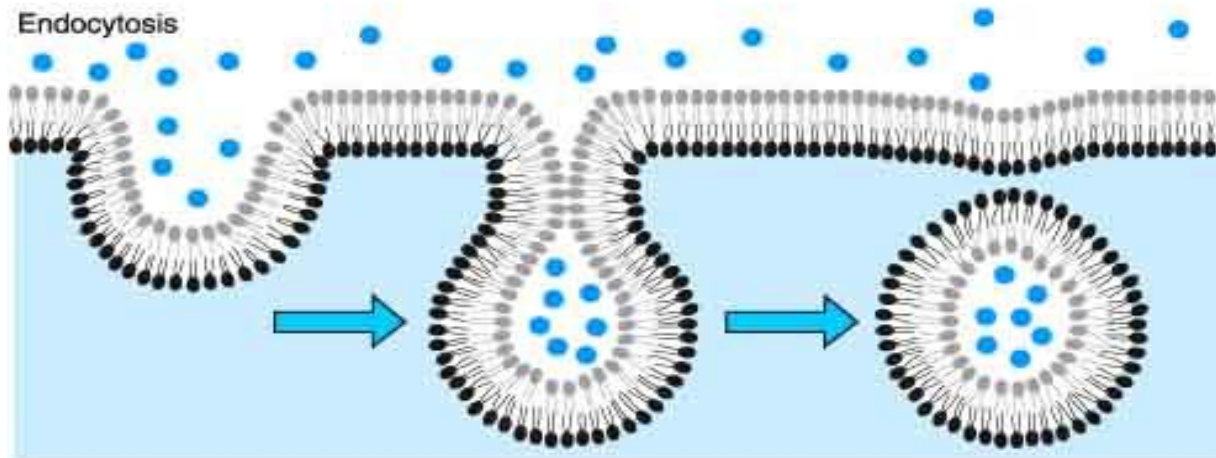
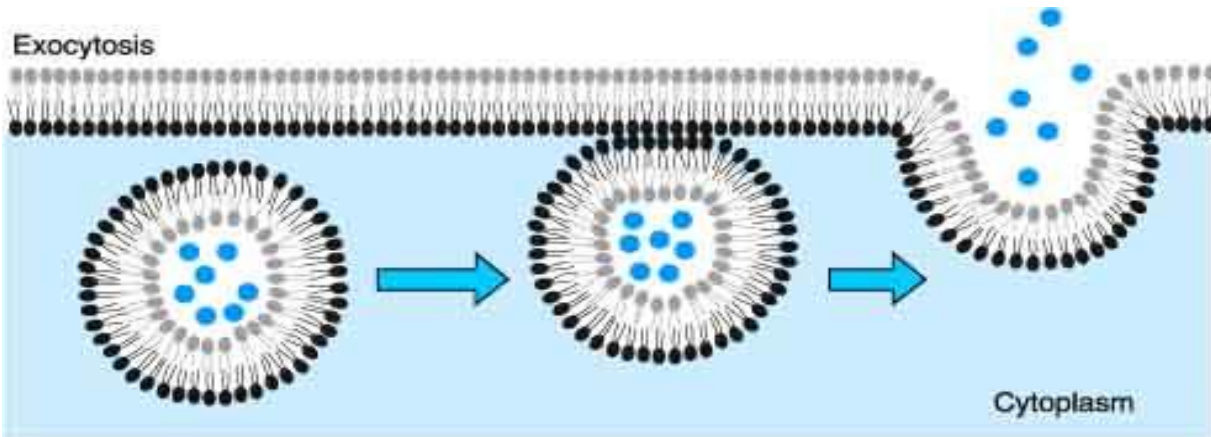


# VESICULAR TRANSPORT



- **Phagocytosis**
  - Pseudopod → phagocytic vesicle (phagosome)
- **Pinocytosis**
  - Pinocytic vesicle
- **Receptor-Mediated Endocytosis**
  - Similar to pinocytosis
  - Import needed materials
- **Exocytosis**





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# TRANSPORT ACROSS CELL MEMBRANES



- Transport across cell membranes is accomplished primarily by exocytosis, endocytosis, movement through ion channels, and primary and secondary active transport.



# TRANSPORT ACROSS MEMBRANE

## PASSIVE TRANSPORT

### 1. Simple Diffusion

- Concentration gradient
- Net diffusion
- Equilibrium

### 2. Osmosis

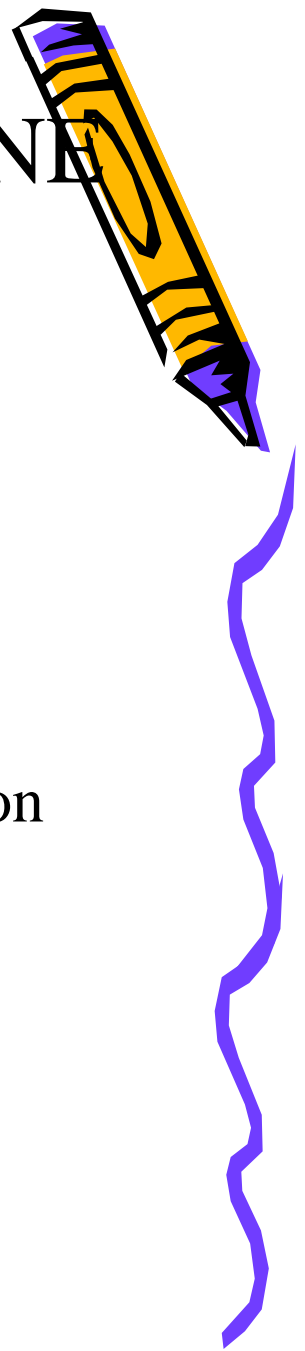
- Osmotic pressure
- Tonicity
  - Isotonic
  - Hypertonic
  - Hypotonic

### 3. Bulk Flow

- Same direction
- Filtration

### 4. Facilitated Diffusion

- Transporter
  - Channel

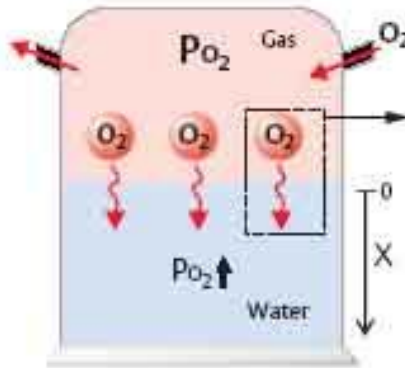


## A. Diffusion in homogeneous media

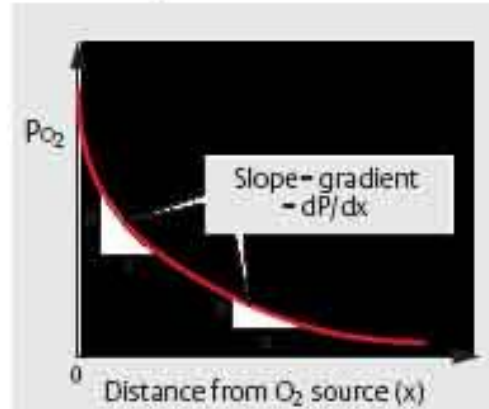
1 Brownian particle movement (~T)



2 Passive transport

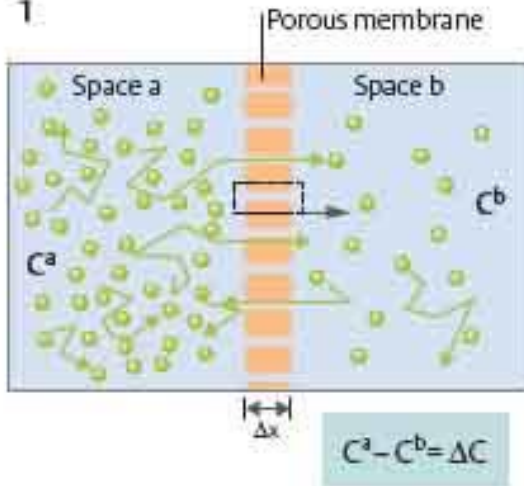


3  $P_{O_2}$  profile

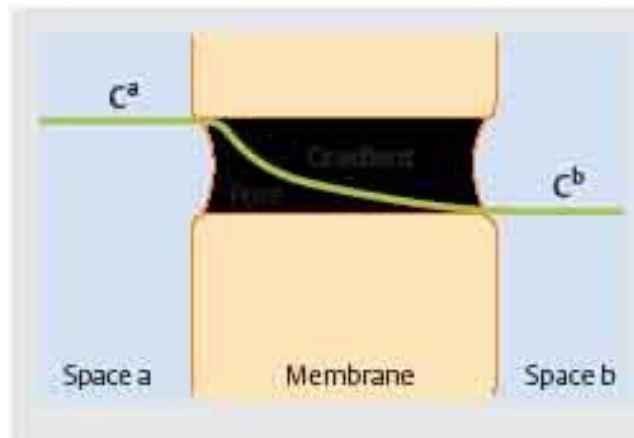


## B. Diffusion through porous membranes

1



2



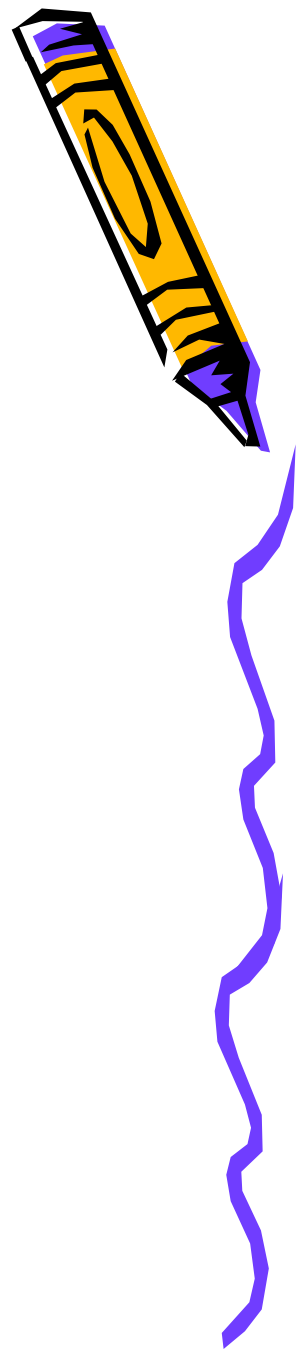
# ACTIVE TRANSPORT

## 1. Primary active transport

- Use ATP as the energy source
  - $\text{Ca}^{2+}$  pump
  - $\text{Na}^+$ ,  $\text{K}^+$  pump

## 2. Secondary active transport

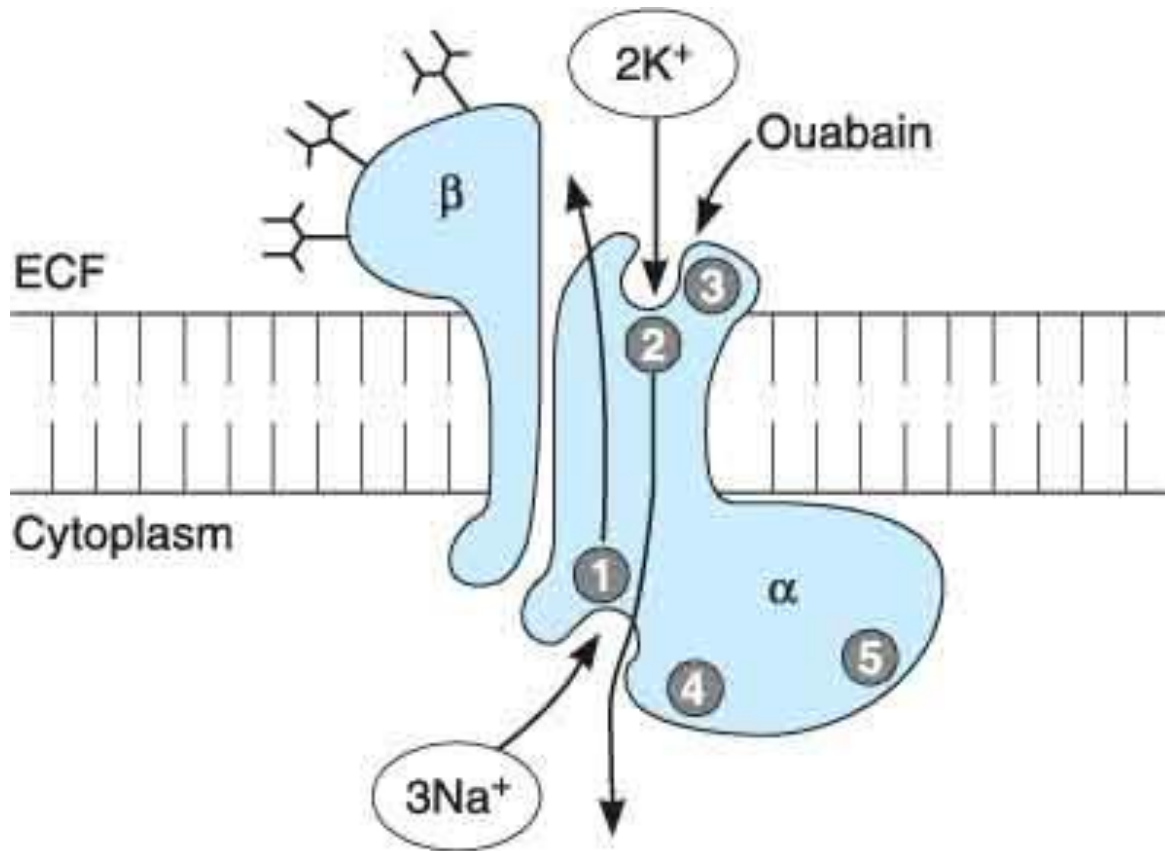
- Use the ionic concentration difference (gradient)
  - Symport (co-transport)
    - Glucose transport
    - Amino acid transport
  - Antiport (counter transport)
    - $\text{Na} - \text{Ca}$  exchange
    - $\text{Na} - \text{H}$  exchange



# Na<sup>+</sup>-K<sup>+</sup> ATPase

- Na<sup>+</sup>-K<sup>+</sup> ATPase catalyzes the hydrolysis of ATP to adenosine diphosphate (ADP) and uses the energy to extrude three Na<sup>+</sup> from the cell and take two K<sup>+</sup> into the cell for each molecule of ATP hydrolyzed. It is an **electrogenic pump** in that it moves three positive charges out of the cell for each two that it moves in, and it is therefore said to have a **coupling ratio** of 3:2. It is found in all parts of the body.

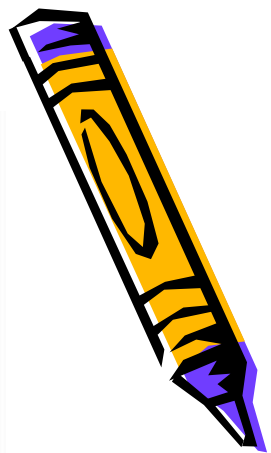
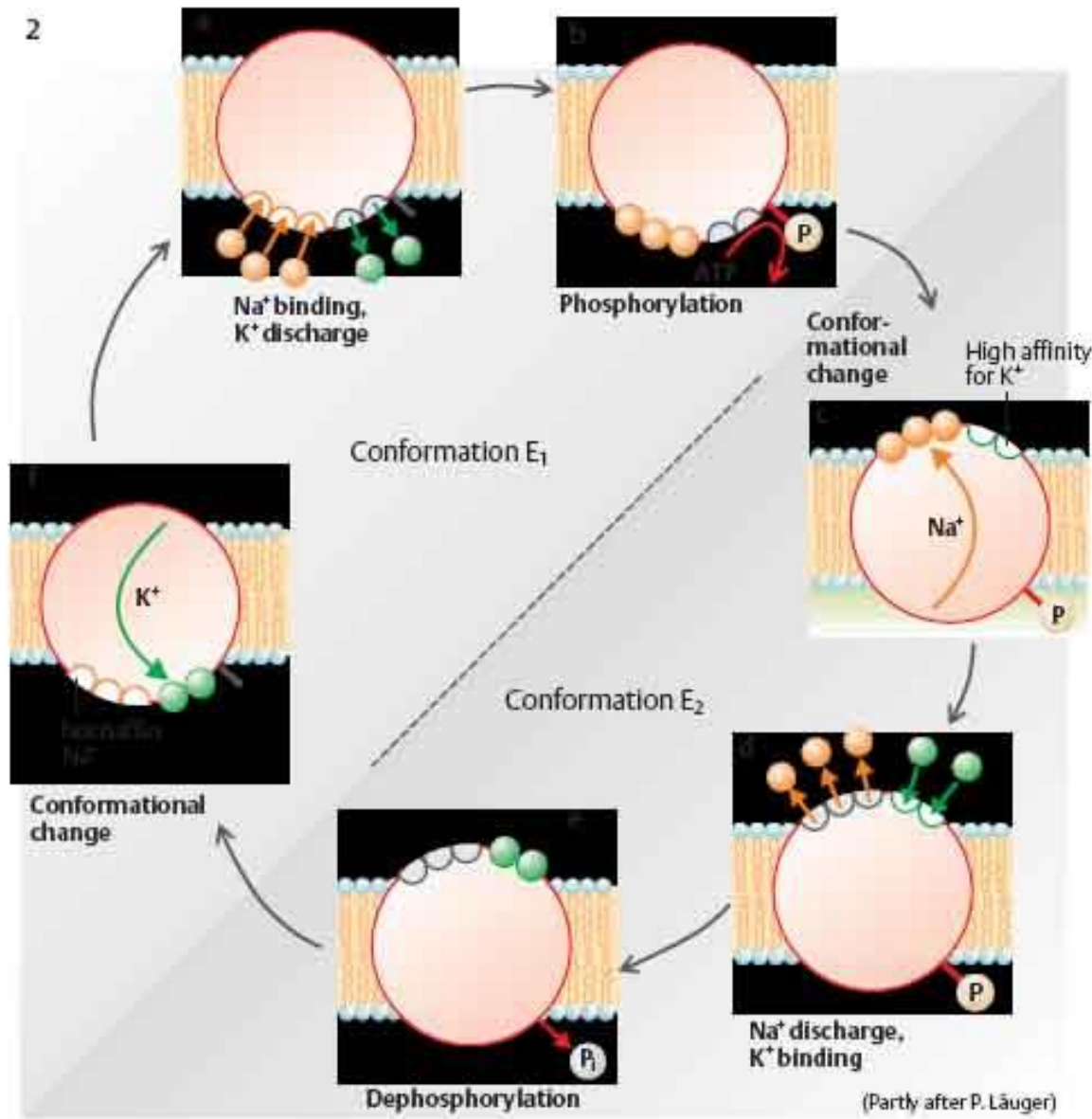




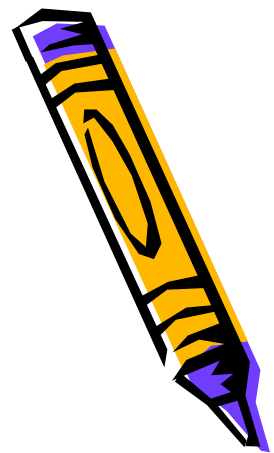
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2



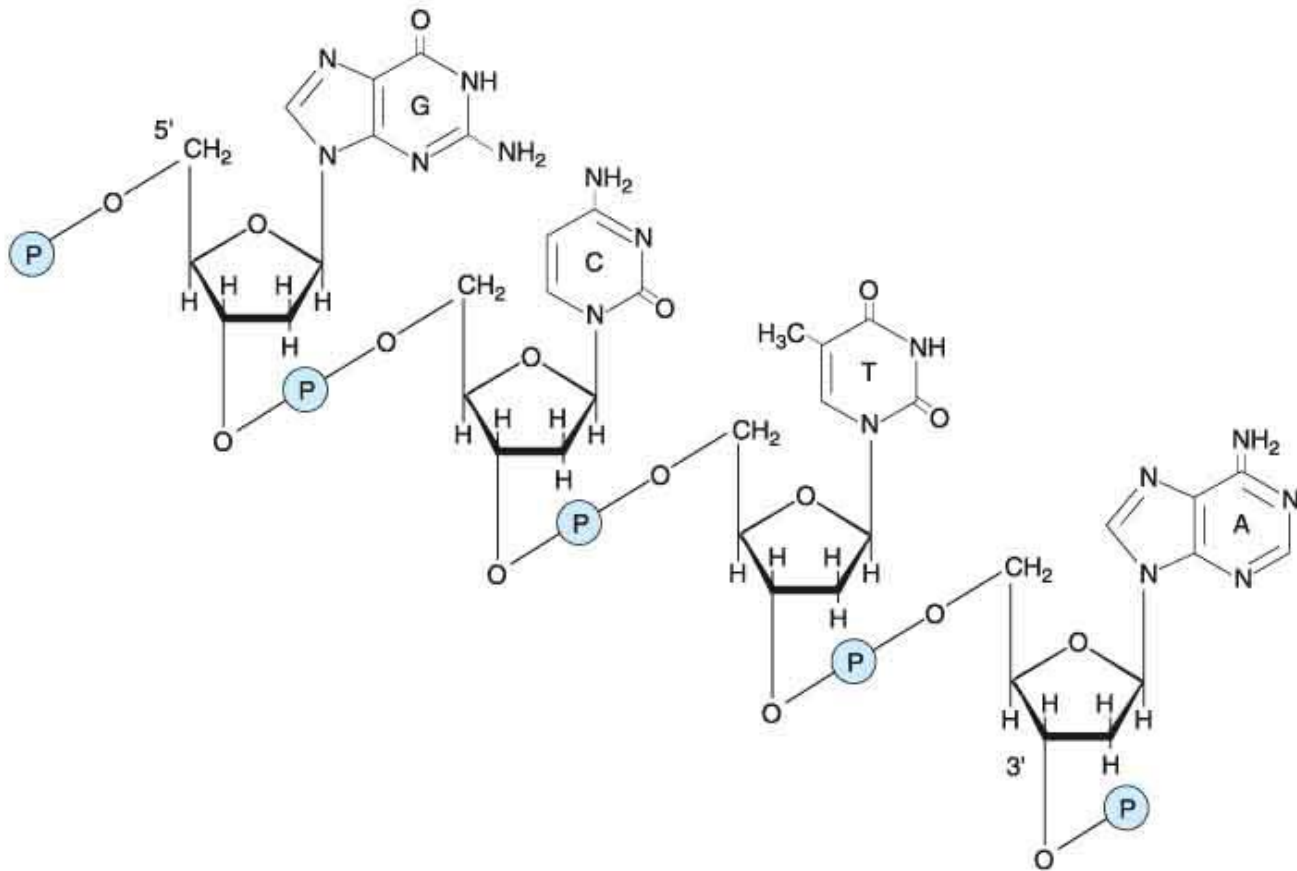
# STRUCTURE & FUNCTION OF DNA & RNA



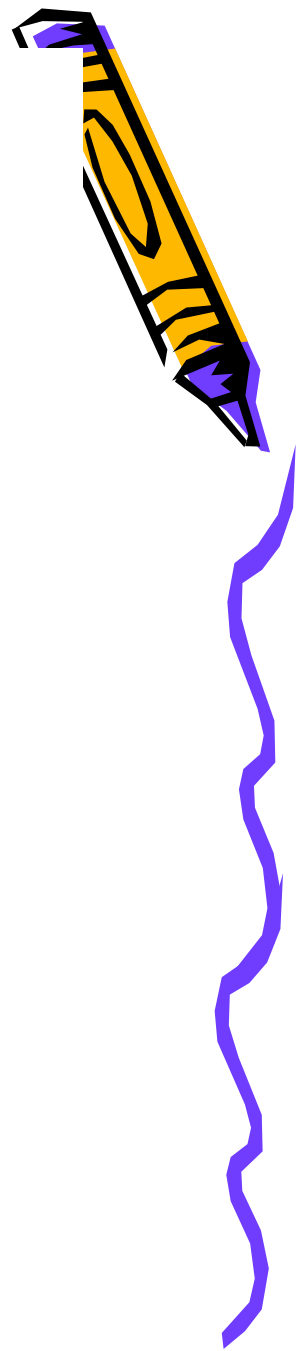
- The Genome
  - DNA is found in bacteria, in the nuclei of eukaryotic cells, and in mitochondria. It is made up of two extremely long nucleotide chains containing the bases adenine (A), guanine (G), thymine (T), and cytosine (C)

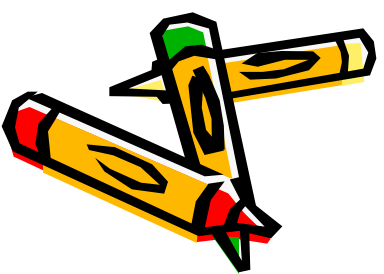
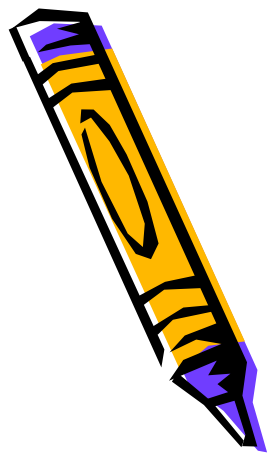
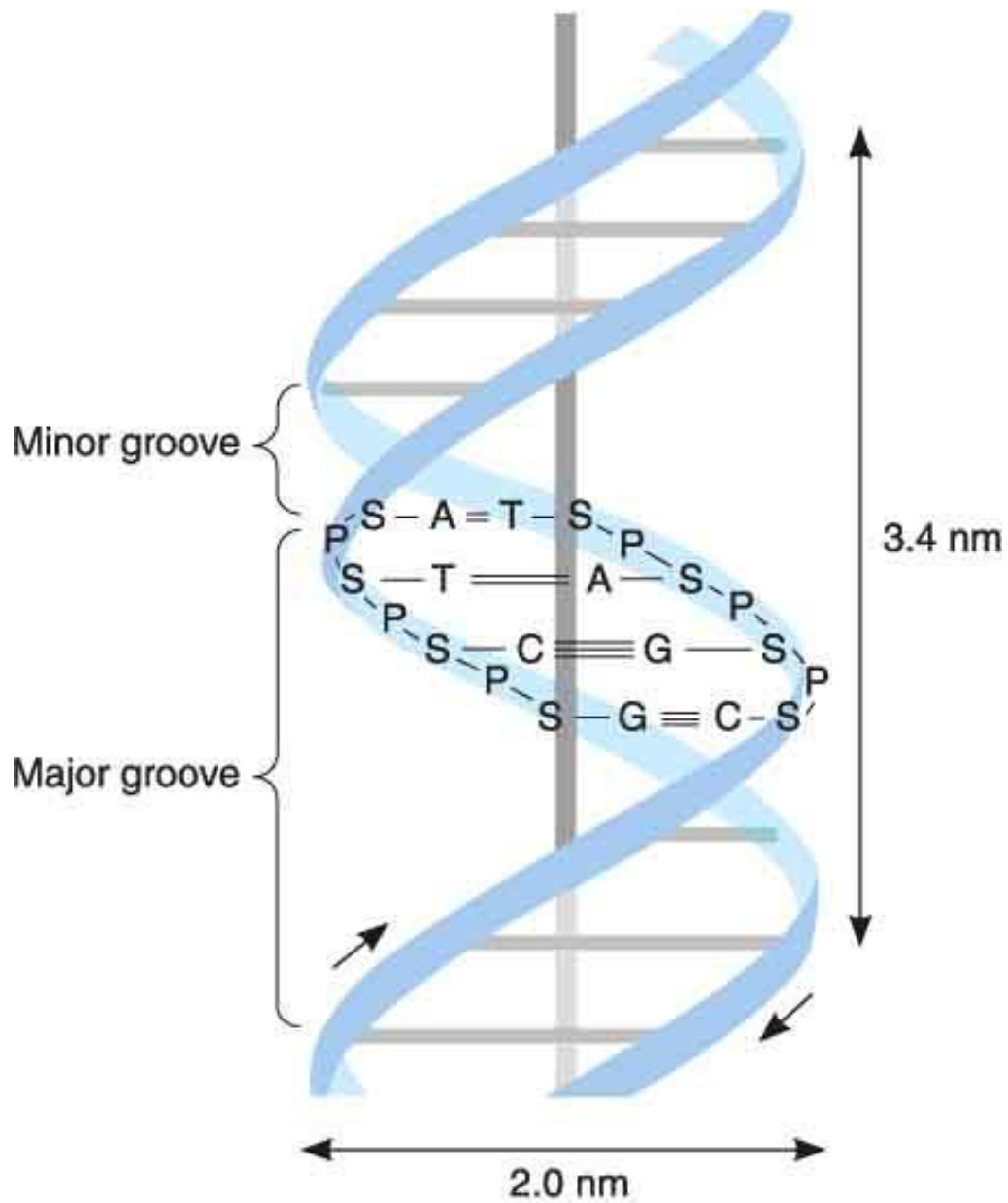






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- DNA is the component of the chromosomes that carry the "genetic message," the blueprint for all the heritable characteristics of the cell and its descendants.
- Each chromosome contains a segment of the DNA double helix. The genetic message is encoded by the sequence of purine and pyrimidine bases in the nucleotide chains.
- The text of the message is the order in which the amino acids are lined up in the proteins manufactured by the cell. The message is transferred to ribosomes, the sites of protein synthesis in the cytoplasm, by RNA.





- RNA differs from DNA in that it is single-stranded, has uracil in place of thymine, and its sugar moiety is ribose rather than 2'-deoxyribose.
- The proteins formed from the DNA blueprint include all the enzymes, and these in turn control the metabolism of the cell.
- A gene used to be defined as the amount of information necessary to specify a single protein molecule. However, the protein encoded by a single gene may be subsequently divided into several different physiologically active proteins.





- In addition, different mRNAs can be formed from a gene, with each mRNA dictating formation of a different protein.
- Genes also contain promoters, DNA sequences that facilitate the formation of RNA.
- **Mutations** occur when the base sequence in the DNA is altered by ionizing radiation or other mutagenic agents.





- The Human Genome

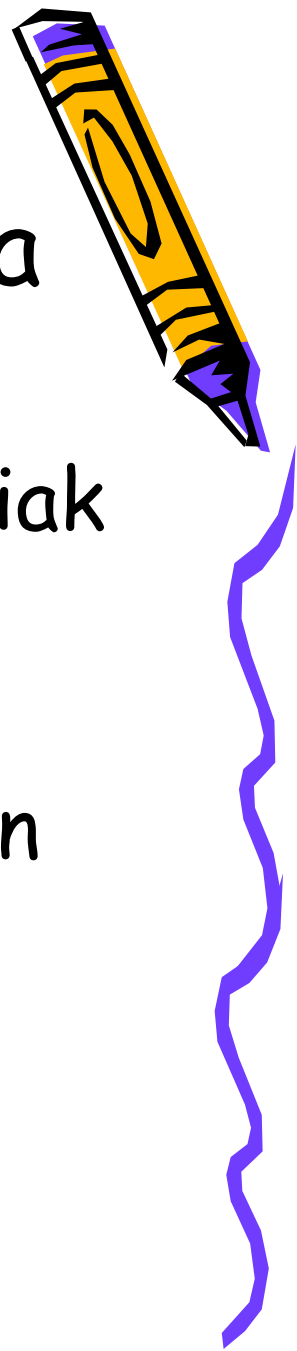
- When the human genome was finally mapped several years ago, it contained about 30,000 genes

- Genetic Code

- The genetic code consists of successive "triplets" of bases--that is, each three successive bases is a code word. The successive triplets eventually control the sequence of amino acids deposited in a protein molecule to be synthesized in the cell. the genetic code is *GGC, AGA, CTT*, the triplets being separated from one another by the arrows. we see that these three respective triplets are responsible for successive placement of the three amino acids, proline, serine, and glutamic acid, in a molecule of protein.



# Pengendalian Pertumbuhan Sel dan Perkembangbiakannya



- Sel sel darah, Sel kulit dan epitel usus → Tumbuh dan berkembangbiak selamanya.
- Sel otot polos & sel saraf tdk berkembangbiak selama bbrp tahun
- Sel liver tumbuh dan berkembangbiak dengan cepat sekali sampai tercapai massa yg normal



# Cara Untuk mengatur Pertumbuhan Sel



- Diatur oleh faktor pertumbuhan yg berasal dari bagian lain tubuh.
- Sel sel yg normal akan berhenti tumbuh bila sudah melebihi ruang untuk tumbuh.
- Sel sel yg sedang tumbuh dalam jaringan biakan akan berhenti tumbuh bila cairan sekresinya dibiarkan terkumpul pada media biakan tsb.



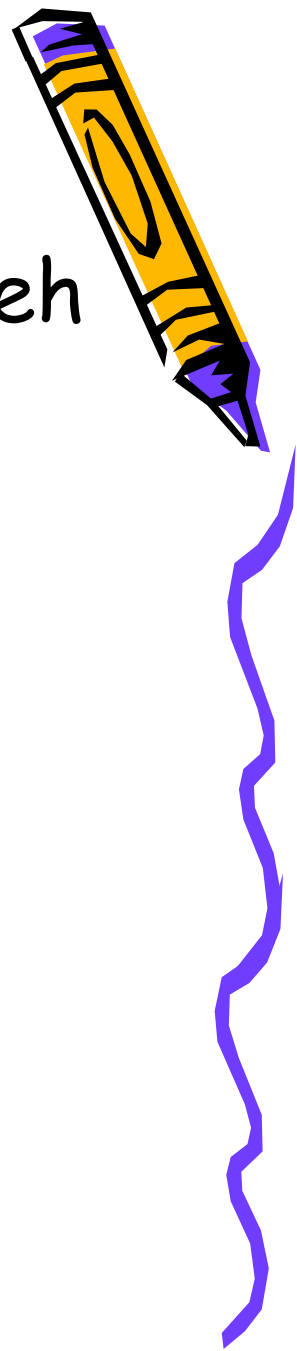


# Kanker

- Disebabkan oleh mutasi gen yg mengatur pertumbuhan sel dan proses mitosis.
- Sel sel kanker tidak mengikuti batas batas pertumbuhan sel yg normal
- Sel kanker kurang adhesif shg cenderung untuk menyebar melalui jaringan, memasuki aliran darah dan ditransportkan ke seluruh tubuh.



- Sel kanker bisa membunuh sel lain karena persaingan untuk memperoleh nutrisi. Sehingga akan terjadi kematian nutritif.



# THANK YOU

