Introduction to physiology

Physiology is the science that seeks to explain the physical and chemical mechanisms that are responsible for the origin, development, and progression of life. Each type of life, from the simplest virus to the largest tree or the complicated human being, the vast field of physiology can be divided into viral physiology, bacterial physiology, cellular physiology, plant physiology, invertebrate physiology, vertebrate physiology, mammalian physiology, human physiology, and many more subdivisions.

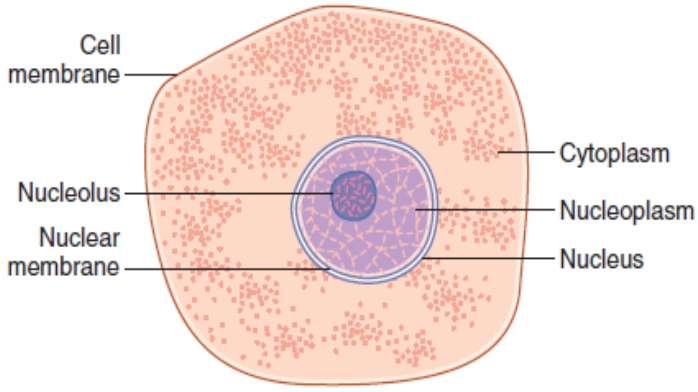
Human Physiology. The science of human physiology attempts to explain the specific characteristics and mechanisms of the human body that make it a living being. The fact that we remain alive is the result of complex control systems. Hunger makes us seek food, and fear makes us seek refuge. Sensations of cold make us look for warmth.

CELLS ARE THE LIVING UNITS OF THE BODY

The basic living unit of the body is the cell. Each organ is an aggregate of many different cells held together by intercellular supporting structures. Each type of cell is specially adapted to perform one or a few particular functions. For instance, the red blood cells, numbering about 25 trillion in each human being, transport oxygen from the lungs to the tissues. Although the red blood cells are the most abundant of any single type of cell in the body, about 75 trillion additional cells of other types perform functions different from those of the red blood cell. The entire body, then, contains about 100 trillion cells. Although the many cells of the body often differ markedly from one another, all of them have certain basic characteristics that are alike. For instance, oxygen reacts with carbohydrate, fat, and protein to release the energy require for all cell function also most of cell can be reproduce additional cell when some of them destroyed .all cells essentially live in the same environment – extracellular fluid –(60% of the body is fluid although most of this percent is inside the cell one third is out of cell consist of water , ions and nutrient which is essential to cell ,also it constant motions in the body from blood diffuse to tissue through capillary) so it called internal environment of the body. There are many differences between extracellular and intracellular fluid in component

*extracellular fluid contain high percent of sodium ,chloride, bicarbonate ions plus nutrient for cell such as oxygen ,amino acid, fatty acid ,glucose, also carbon dioxide to be transported from cell to the lunge to be excreted plus other waste product to be transported to the kidney and excreted .

*intracellular fluid contain potassium. ,meg. and phosphate ions also it contain high percent of cholesterol and protein ,phospholipids ,neutral fat which essential to cell division and multiplication.



*Structure of the cell

Homeostasis

The maintenance of nearly constant conditions of internal environment which mean that all tissue and organ perform functionally to maintain these internal conditions for example

*lunge provide oxygen to extracellular fluid to replenish oxygen used by cell

*the kidney maintain ion concentration

*GIT provide nutrients

So all of these substances in ECF and ICF have range value in the body and this depend on many factor as starvation ,division ,disease. All organ and tissue share in the maintenance of homeostasis .

THE CELL AND ITS FUNCTIONS

Cells are the building blocks of the body providing structure of the organ and tissue ingesting nutrient and converting them to energy and perform specialize functions.cells also contains the hereditary code that control the substances that synthesis by the cells

Atypical cell contain two major parts the nucleus and the cytoplasm ,nucleus separated from the cytoplasm by nuclear membrane ,and the cytoplasm separated from the surrounding fluid by plasma membrane ,the all substances that make the cell collectively called protoplasm and composed mainly of five basic substances

1.**water** the principles fluid medium is water all cells except of fat cell it concentration about 70 to 85 percent many chemicals dissolved in water and other suspended as solid particles

2.**ions** important ions inside the cell is pot. Meg. Sulfate and bicarbonate and less constant sod, chloride and calcium .these ions provide inorganic chemicals for cellular reaction also it necessary for some cellular control mechanisms ,also ions acting on the cell membrane are required for electrochemical impulses .

3.**protiens** after water proteins consider the most abundant substances in the cell constitute 10 to 20 percent of cell mass proteins can be divided to structural protein(mainly form microtubules that provide cytoskeleton of such cellular organelles as cilia, nerve axons and functional protein(mainly enzyme and other adherent to membranous structure inside the cell that have role in catalyze several intracellular chemical reaction.

4.**lipid** it form around 2 percent of total cell mass most important lipid phospholipids and cholesterol it only soluble in fat solvent so it grouped together in cell ,because of its insolubility in water it used to form the intracellular membrane barriers that separate the different cell compartments

Also some cell have other type of lipid which is called triglyceride and it form about 95 percent so it called neutral fat or fat cell and these cell consider the fat storage in the body and so on the store house of energy release when the body needed.

5. **carbohydrate** it have little percent in the cell and less functional properties except as nutrition of the cell it consider as part of glycoprotein molecule .it has 1 percent of the cell and increase to 3percent in muscle cell and 6 percent in liver cell.

PHYSICAL SRTUCTURE OF THE CELL

All organelles of the cell covered by the membrane these membrane consist of lipid and protein such as cell membrane ,nuclear membrane ,membrane of endoplasmic reticulum and membrane of mitochondria ,lysosomes, and Golgi apparatus. the lipid in the membrane is to impeded of water and water soluble substances movement from cell compartment to another protein provide specialize pathway to penetration through the membrane

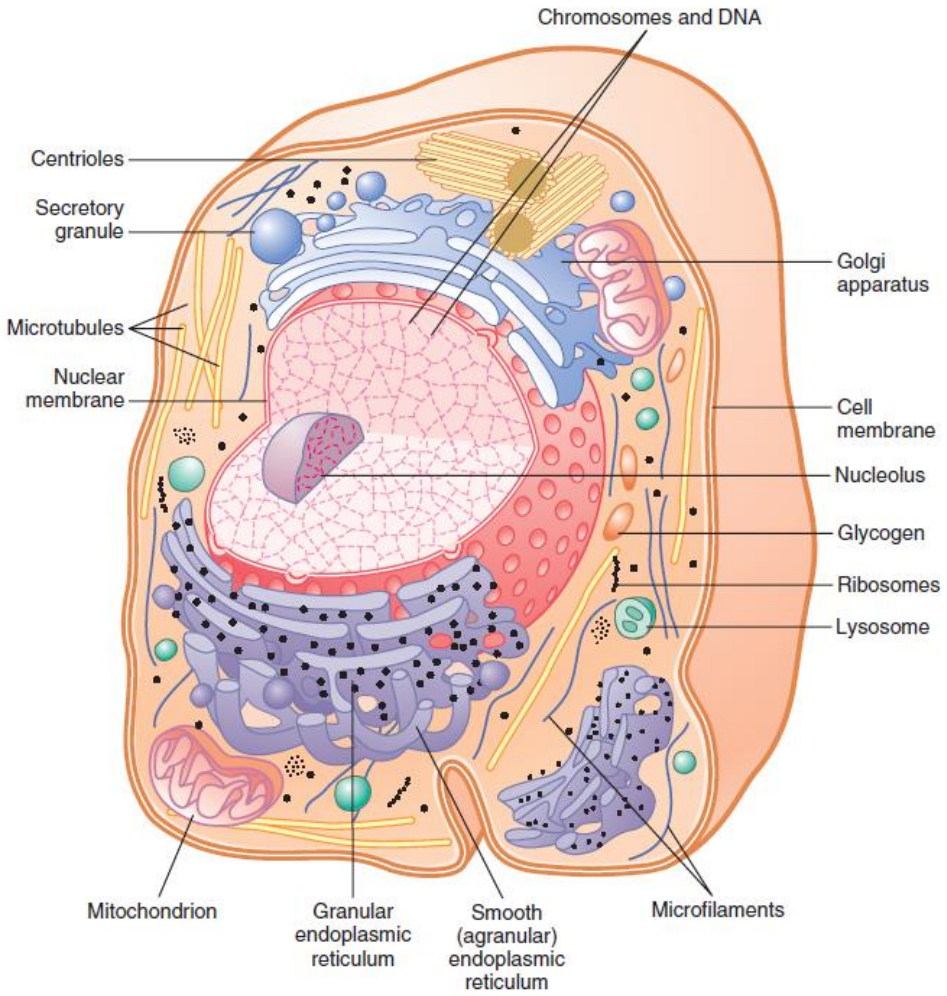


Figure 2-2. Reconstruction of a typical cell, showing the internal organelles in the cytoplasm and in the nucleus.

CELL MEMBRANE

Also called plasma membrane enveloped the cell and its thin ,pliable ,elastic structure only 7.5 to 10 nanometers thick consist of lipid and protein ,protein 55%,phospholipid 25%,cholesterol 13% ,other lipid 4%, carbohydrate 3% .the basic structure of cell membrane is lipid bilayer double layered of film of lipid –each layer is only one molecule thick- interspersed in this lipid film large globular proteins.

The basic of this lipid bilayer is consist of three type of lipid phospholipids ,sphingolipid, and cholesterol .phospholipid is the most abundant one ,one end of this phospholipid is water soluble we call it hydrophilic the other end of it only soluble in fat called it hydrophobic.

The lipid layer in the middle of membrane impermeable to the water soluble substances such as ions ,glucose ,urea while fat soluble such as oxygen ,carbon dioxide ,alcohol, are ease to pass through it .

Sphingolipid also have hydrophilic and hydrophobic end group but it find in small amount in cell membrane especially in nerve cell

Cholesterol molecules also in the membrane is lipid and fat soluble it dissolved in the bilayer of the membrane .they help to determine the degree of permeability or impermeability of the bilayer to water soluble substances of body fluid so it control the fluidity of the membrane as well.

Protein is globular masses floating in the lipid bilayer all protein is glycoprotein and two type of membrane protein integral protein (protrude all the way through membrane)and peripheral protein (attach only to one surface of the membrane and don't penetrate all the way through).so integral protein can serve as:

1.provide pores or channels to pass water soluble substances as ions from ECF to ICF.

2.many of them act as carriers protein transport substances that couldn't pass through pores of lipid bilayer and some time act against or opposite to their electrochemical gradient which is call active transport.

3. act as enzyme

4.some of integral protein act as receptor for some substances such as peptide hormones that don't easily penetrate the cell membrane .

Peripheral protein serve as enzymes or as controller of transporter of substances through cell membrane (pores).

Membrane carbohydrate- the cell "Glycocalyx"

Carbohydrate attach to protein or lipid in cell membrane in form glycoprotein or glycolipid ,in fact most of integral protein is glycoprotein and about one to tenth is glycolipid ,the glycoprotein is protrude from outside of membrane and dangling outward from cell surface

There are many advantage of CHO moieties in the cell membrane

1.have –ev charge that give all surface of cell –ve charge that repels all –ve charge

2.act as receptor for many substances as hormones such insulin

3.the glycocalyx of some cell attach to another glycocalyx and attach cell one another

4.some CHO moieties inter in the immune reaction

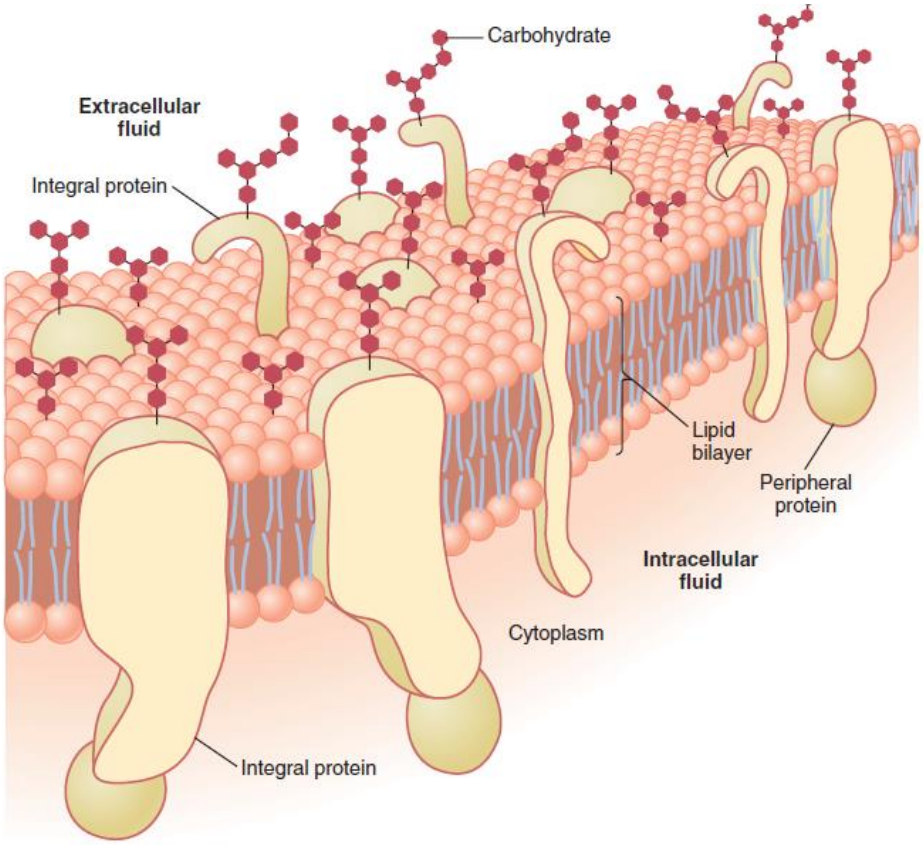


Figure 2-3. Structure of the cell membrane, showing that it is composed mainly of a lipid bilayer of phospholipid molecules, but with large numbers of protein molecules protruding through the layer. Also, carbohydrate moieties are attached to the protein molecules on the outside of the membrane and to additional protein molecules on the inside. *(Modified from Lodish HF, Rothman JE: The assembly of cell membranes. Sci Am 240:48, 1979. Copyright George V. Kevin.)*

CYTOPLASM AND ITS ORGANELLES

The cytoplasm is filled with both minute and large dispersed particles and organelles. The jelly-like fluid portion of the cytoplasm in which the particles are dispersed is called cytosol and 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

network of tubular and flat vesicular structures in the cytoplasm, which is the endoplasmic reticulum. This organelle helps process molecules made by the cell and transports them to their specific destinations inside or outside the cell .also their membrane contain large number of protein as cell membrane . Attached to the outer surfaces of many parts of the endoplasmic reticulum are large numbers of

minute granular particles called ribosomes. Where these particles are present, the reticulum is called the granular endoplasmic reticulum. The ribosomes are composed of a mixture of RNA and proteins, and they function to synthesize new protein molecules in the cell

Agranular Endoplasmic Reticulum. Part of the endoplasmic reticulum has no attached ribosomes. This parts called the agranular or smooth, endoplasmic reticulum. The agranular reticulum functions for the synthesis of lipid substances and for other processes of the cells promoted by intrareticular enzymes.

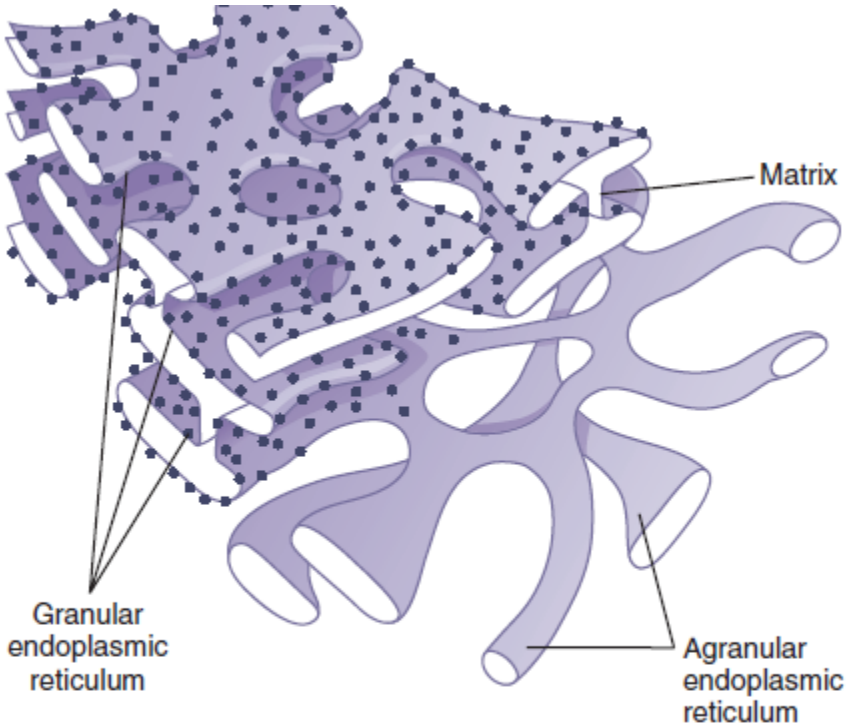


Figure 2-4. Structure of the endoplasmic reticulum. *(Modified from DeRobertis EDP, Saez FA, DeRobertis EMF: Cell Biology, 6th ed. Philadelphia: WB Saunders, 1975.)*

Golgi Apparatus

The Golgi apparatus, is closely related to the endoplasmic reticulum. It has membranes similar to those of the agranular endoplasmic reticulum. The Golgi apparatus is usually 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, where 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.

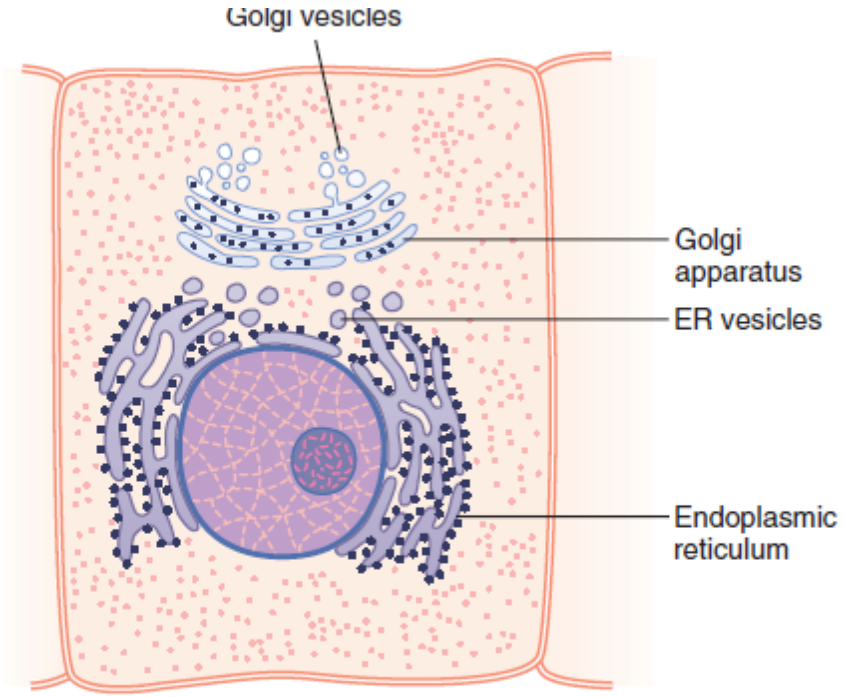


Figure 2-5. A typical Golgi apparatus and its relationship to the endoplasmic reticulum *(ER)* and the nucleus.

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 (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 various cell types, but it is usually 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. Hydrolytic enzymes are highly concentrated in lysosomes. Ordinarily, the membrane surrounding the lysosome prevents the enclosed hydrolytic enzymes from coming in contact with other substances in the cell and therefore prevents their digestive actions.

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 from the Golgi apparatus. Second, they contain oxidases rather than hydrolases. Several of the oxidases are capable of combining oxygen with hydrogen ions derived from different intracellular chemicals to form hydrogen peroxide (H2O2). Hydrogen peroxide is a

highly oxidizing substance and 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. about half the alcohol person drinks is detoxified into acetaldehyde by the peroxisomes of the liver cells in this manner. A major function of peroxisomes is to catabolize long chain fatty acids.

Mitochondria

The mitochondria, are called the “powerhouses” of the cell. Without them, cells would be unable to extract enough energy from the nutrients, and essentially all cellular functions would cease a hundred up to several thousand, depending on the amount of energy required by the cell. The cardiac muscle cells (cardiomyocytes), for example, use large amounts of energy and have far more mitochondria than do fat cells (adipocytes), which are much less active and use less energy. Further, the mitochondria are concentrated in those portions of the cell that are responsible for the major share of its energy metabolism. They are also variable in size and shape. Some mitochondria are only a few hundred nanometers in diameter and are globular in shape, whereas others are elongated and are as large as 1 micrometer in diameter and 7 micrometers long.

The basic structure of the mitochondrion, is composed mainly of two lipid bilayer–protein membranes outer membrane and an inner membrane. Many enfolding of the inner membrane form a shelves or tubules called cristae onto which oxidative enzymes are attached. The cristae provide a large surface area for chemical reactions to occur. 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 cristae 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). ATP is then transported out of the mitochondrion and diffuses throughout the cell to release its own 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 a need in the cell for increased amounts of ATP. Indeed, the mitochondria contain DNA similar to that found in the cell nucleus

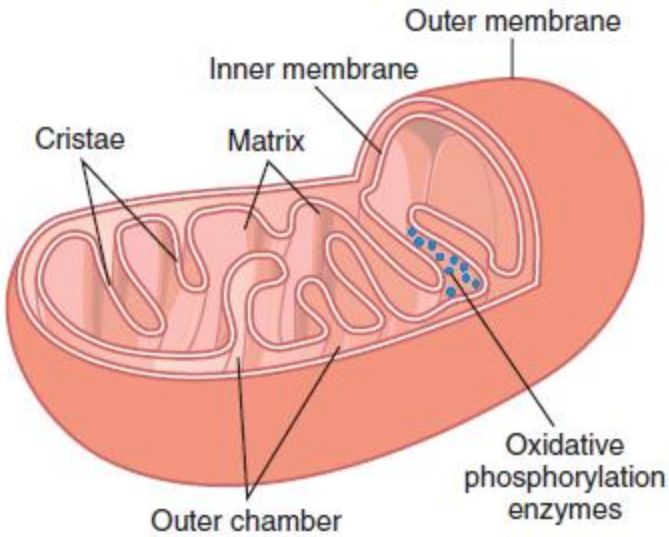


Figure 2-7. Structure of a mitochondrion. *(Modified from DeRobertis EDP, Saez FA, DeRobertis EMF: Cell Biology, 6th ed. Philadelphia: WB Saunders, 1975.)*

Nucleus

The nucleus, which is the control center of the cell, sends messages to the cell to grow and mature, to replicate, or to die. Briefly, the nucleus contains large quantities of DNA, which comprise the genes. The genes determine the characteristics of the cell's proteins, including the structural proteins, as well as the intracellular enzymes that control cytoplasmic and nuclear activities. The genes also control and promote reproduction of the cell. The genes first reproduce to create two identical sets of genes; then 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 gen.

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 highly staining structures called nucleoli. The nucleolus, unlike most other organelles discussed here, 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.

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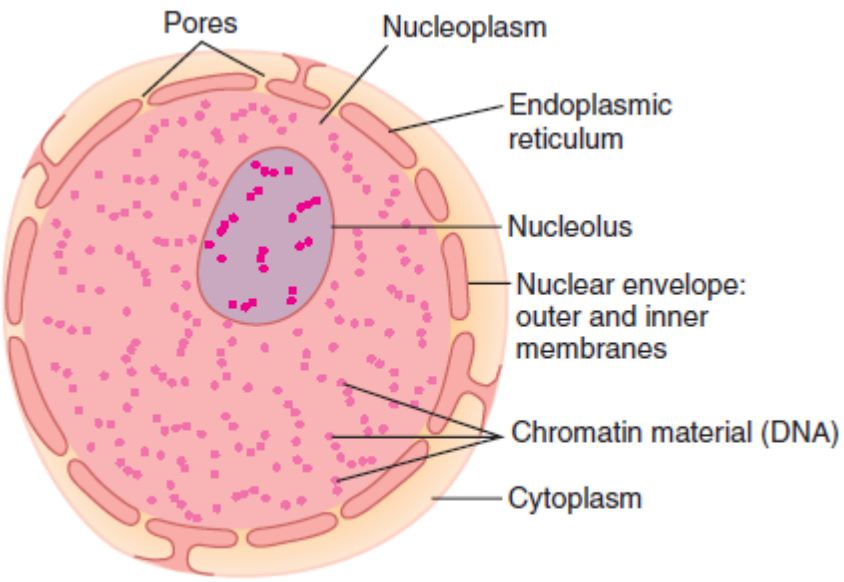

Figure 2-9. Structure of the nucleus.