Biomedik I Module

(Cells, Tissues, and Organs)

For Students

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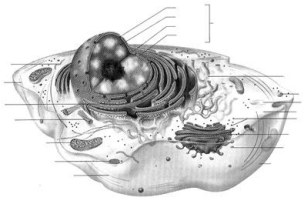

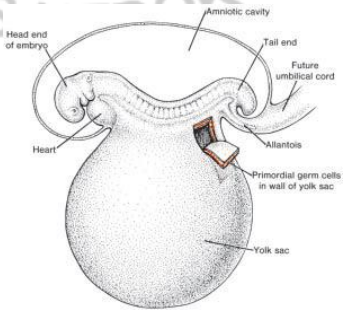

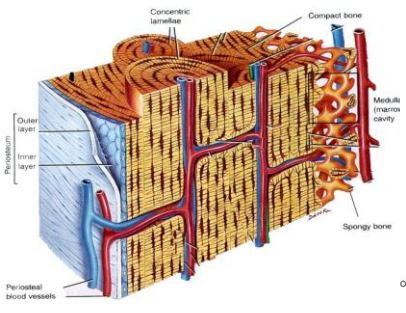

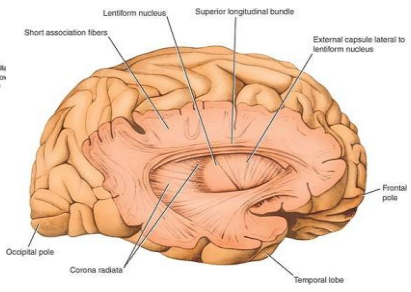

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CHAPTER I
INTRODUCTION TO CELL

INTRODUCTION

A question many medical students consider is: Why should we learn about cell? An obvious answer is that is that for the student to obtain passing grades in histology, pathology, biochemistry, physiology, and other medical school courses, they should have a basic knowledge of cell biology. Pathologic changes were due to malfunction in cells, and can be expanded to include infectious agents, which are bacterial cells, parasitic organism, or viruses that take up residence in human cells. For a physician who is fighting disease that the arena in which those battles are fought is as the cell surface and within the cell.

Today, most modern clinical treatments involve either surgically removing aberrant or damaged cells, modulating the biochemical or metabolic activity of cells, specifically killing cells, or influencing the communications that occur among cells in the body. It is hope that, in the future, increased knowledge of cells and disease will lead to clinical advances such as new vaccines, immunomodulatory drugs that either heighten or suppress the activity of the immune system, new drugs for fighting viral infections and specifically for destroying cancerous growths, more effective diagnostic reagents, and, perhaps, the ability to replace damage or lacking genes within cells with healthy copies. For physician to keep abreast of the rapid changes that occur in clinical treatment of disease, knowledge of cell biology will be essential.

Cells are the smallest functional unit of the body. They contain structures that are strikingly similar to those needed to maintain total body function. Cells can be separated into two categories: prokaryotic and eukaryotic. We will be chiefly concerned with eukaryotic cells, which, by definition (the Greek word karyon means “nucleus”), contain a nucleus. Eukaryotic cells comprise protists, fungi, plants, and animals, and are generally 10-100 μm in linear dimension. Prokaryotic cells (bacteria and and Cyanobacteria) are relatively small (1-10 μm diameter) and contain simple internal structure. The prokaryotic plasma membrane, often surrounded by a rough protective cell wall, encloses a single cytoplasm compartment that contains DNA, RNA, proteins, and other small molecules.

The structure of a eukaryotic cell can be visualized by the modern light microscope are approximately 0.5 μm wide. Therefore, in the light microscopic view of the cell, we can see a plasma membrane that defines the outer boundaries of the cell and surrounds the cell's protoplasm or contents. The protoplasm includes the nucleus where the eukaryotic cell's DNA is compartmentalized away from the remaining contents of the cell (the cytoplasm). The nucleus is the control center for the cell. It also contains most of the hereditary material. In addition to the nucleus, the cytoplasm contents other organelles, which are better visualized with an electron microscope that can view components as small as 2 nm. The eukaryotic cell's organelles include the nucleus, mitochondria, ribosomes, endoplasmic reticulum (ER), Golgi apparatus, lysosomes, peroxisomes, and cytoskeleton. Mitochondria supplies the energy needs of the cell, the ribosomes synthesize proteins and other materials needed for cell function, while ER functions as a tubular communication system that transports substances from one part of the cell to another and as the site of protein (rough ER), carbohydrate, and lipid (smooth ER) synthesis. Golgi apparatus modifies materials synthesized in the ER and packages them into secretory granules for transport within the cell or for export from the cell. Lysosomes and peroxisomes have function as the cell's digestive system.

Besides its organelles, the cytoplasm contains a network of microtubules, microfilaments and intermediate filaments. Because they control cell shape and movement, these structures are a major component of the structural elements called the cytoskeleton.

The microtubules are slender tubular structures composed of globular proteins called tubulin. Microtubules function in many ways, including development and maintenance of cell form. They participate in intracellular transport mechanisms, including axoplasmic transport in neurons, and melanin dispersion in pigment cells of the skin. Other functions include formation of the basic structure for several complex cytoplasmic organelles, including the centrioles, basal bodies, cilia and flagella.

Microfilaments are thin, threadlike cytoplasmic structures. Three classes of microfilaments exist: thin microfilaments, which are equivalent to the thin actin filaments in muscle; intermediate filaments, which are heterogeneous group of filaments with diameter sizes between the thick and thin filaments; and thick myosin filaments, which are present in muscle cells but may also exist temporarily in other cells.

Electron microscopy showed that a plasma membrane surrounds every cell. We now know that the plasma membrane of the cell is a highly differentiated structure containing specific proteins that help to control the intracellular milieu and interact with specific molecules to influence the cell's behavior. Membrane-bound enzymes catalyze reactions that would occur with difficulty in an aqueous environment. Other proteins in the plasma membrane provide anchors for cytoskeletal fibers or for components of the extracellular matrix that give the cell its shape. Still other proteins bind signaling molecules, provide a passageway across the membrane for certain molecules, or regulate the fusion of the membrane with others in the cell.

All membrane, regardless of their source, contains proteins as well as lipids. The protein-lipid ratio varies enormously: the inner mitochondrial membrane is 76 percent protein; the myelin membrane, only 18 percent. The protein content of myelin is low because it electrically insulates the nerve cell from its environment. The lipids composition also varies greatly among different membrane. Bound carbohydrates increase the hydrophilic character of lipids and proteins and help to stabilize many membrane protein structures. In mammals, certain glycolipids form blood-group antigens.

The basic structural of unit of virtually all biological membranes is the phospholipids bilayer. Because all phospholipids are amphipathic, hydrophobic interactions between the fatty acyl chains of glycolipid and phospholipids molecules create a sheet containing two layers of phospholipid molecules whose polar head groups face to surrounding water and the fatty acyl chains form a continuous hydrophobic interior about 4 nm thick. Each layer of phospholipids is called a leaflet. Lipids are not the only component; all biological membranes, no matter how carefully purified, are found to contain proteins. The percentage and exact nature of the adhering proteins vary considerably with membrane type.

Movement through the cell membrane occurs in essentially two ways: passively, without an expenditure of energy, or actively, using energy-consuming processes. The cell membrane can also engulf a particle, forming a membrane-coated vesicle; this membrane-coated vesicle is moved into the cell by endocytosis or out of the cell by exocytosis.

Electrical potentials exist across the membranes of most cells in the body. Because these potentials occur at the level of the cell membrane, they are called membrane potentials. In excitable tissues, such as nerve and muscle cells, changes in the membrane potential are necessary for generation and conduction of nerve impulses and muscle contraction.

There are various technique are use today for studying cells. Because cells and organelles are too small to be examined by the naked eye, the backbone of cell biology is the microscope, whether light or electron microscope that permits the investigation of living cells. Light microscopes can be manipulated further by coupling the microscopes to video monitors and computer systems to allow maximal image resolution. Electron microscopes are also equipped with cameras so that data can be collected and analyzed in detail.

Tissues are usually treated with stains and dyes before being viewed microscopically. These dyes interact in a somewhat specific fashion with various cellular and extracellular materials, permitting easy viewing of tissue substructure. Because tissue pieces are much too thick to be observed at high resolution with the light microscope, fixed tissue must be cut into very thin slices before being stained and observed. These slices, or sections, are produced by using a machine called microtome.

In addition to being a powerful research practice, immunofluorescence microcopy is also used for several practical pathologic-testing procedures. For example, certain tumor types can be identified because of specific marker antigens.

CHAPTER 2
CELL DIVISION, GAMETOGENESIS, EMBRIOLOGY

INTRODUCTION

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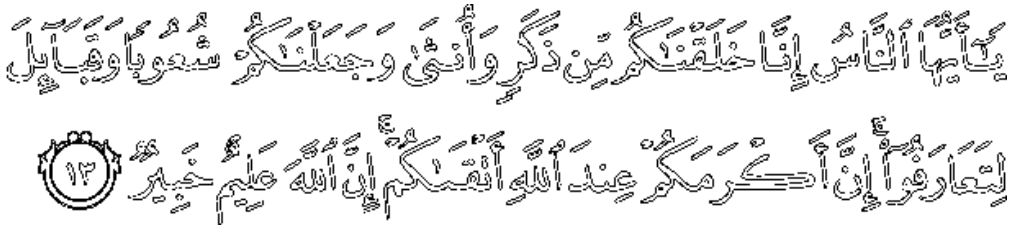
Qur'an says about reproduction function in Al Hujurat vese 13,



"O mankind, indeed We have created you from male and female and made you peoples and tribes that you may know one another. Indeed, the most noble of you in the sight of Allah is the most righteous of you. Indeed, Allah is Knowing and Acquainted."

Allah SWT in this verse says that all humanity was derived from the same male and female. Thus, the reproduction involved two different genders produces new human beings, and allows hereditary traits to be passed from both parents to their children.

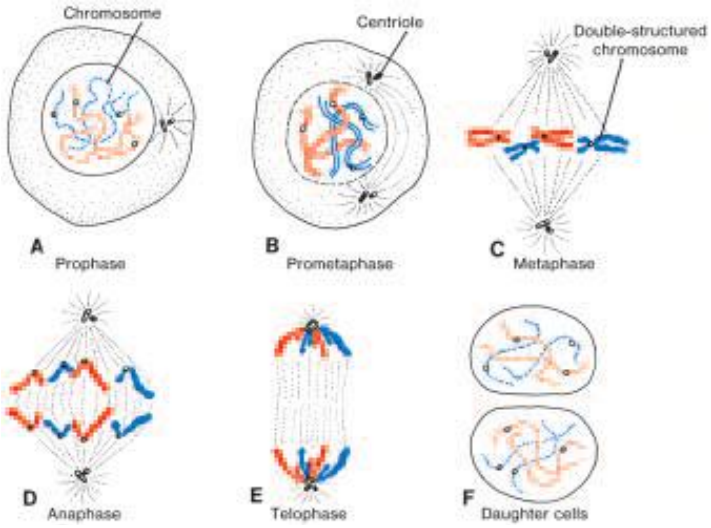
Sexual reproduction always involves the union of two parental sex cells, an ovum from the mother and a sperm from the father. This allows the hereditary material (DNA) from both parents to combine, forming a new individual with a unique combination of genes.

Development begins with fertilization, the process by which the male gamete (spermatozoon) , the sperm, and the female gamete (ovum), the oocyte, unite to give rise to a zygote. Gametes are derived from primordial germ cells (PGCs) that are formed in the epiblast during the second week and that move to the wall of the yolk sac. During the fourth week these cells begin to migrate from the yolk sac toward the developing gonads, where they arrive by the end of the fifth week. Mitotic divisions increase their number during their migration and also when they arrive in the gonad. In preparation for fertilization, germ cells undergo gametogenesis, which includes meiosis, to reduce the number of chromosomes and cytodifferentiation to complete their maturation.
Cell division, cell migration, programmed cell death, differentiation, growth, and cell rearrangement transform the fertilized oocyte, a highly specialized, totipotent cell, a zygote, into a multicellular human being. Although most developmental changes occur during the embryonic and fetal periods, important changes occur during later periods of developme nt: infancy, childhood, adolescence, and early adulthood Development does not stop at birth. Important changes, in addition to growth, occur after birth (e.g., development of teeth and female breasts).

MITOSIS

Mitosis is the process whereby one cell divides, giving rise to two daughter cells that are genetically identical to the parent cell. Each daughter cell receives the complete complement of 46 chromosomes. Before a cell enters mitosis, each chromosome replicates its deoxyribonucleic acid (DNA). During this replication phase the chromosomes are extremely long, they are spread diffusely through the nucleus, and they cannot be recognized with the light microscope. With the onset of mitosis the

chromosomes begin to coil, contract, and condense; these events mark the beginning of prophase.



Each chromosome now consists of two parallel subunits, chromatids, that are joined at a narrow region common to both called the centromere. Throughout prophase the chromosomes continue to condense, shorten, and thicken, but only at prometaphase do the chromatids become distinguishable.

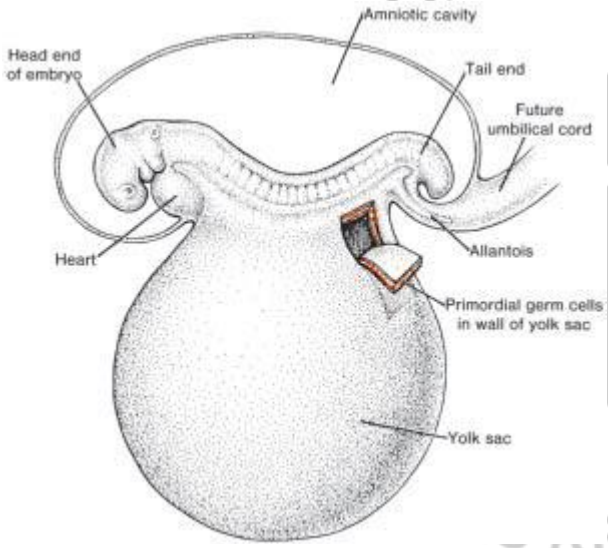
During metaphase the chromosomes line up in the equatorial plane, and their oubled structure is clearly visible . Each is attached by microtubules extending from the centromere to the centriole, forming the mitotic spindle. Soon the centromere of each chromosome divides, marking the beginning of anaphase, followed by migration of chromatids to opposite poles of the spindle. Finally, during telophase, chromosomes uncoil and lengthen, the nuclear envelope reforms, and the cytoplasm divides .
Each daughter cell receives half of all doubled chromosome material and thus maintains the same number of chromosomes as the mother cell.

Human development begins at fertilization when a male gamete or sperm unites with a female gamete or oocyte to form a single cell, a zygote. This highly specialized, totipotent cell marks the beginning of each of us as a unique individual. The zygote, just visible to the unaided eye, contains chromosomes and genes (units of genetic information) that are derived from the mother and father. The unicellular zygote divides many times and becomes progressively transformed into a multicellular human being through cell division, migration, growth, and differentiation.
Although development begins at fertilization, the stages and duration of pregnancy described in clinical medicine are calculated from the commencement of the mother's last normal menstrual period, which is approximately 14 days before conception occurs. Although referred to as the gestational (menstrual) age, this method overestimates the fertilization age by approximately 2 weeks. However, gestational age is widely used in clinical practice because the onset of the last normal menstrual period is usually easy to establish. Before describing the beginning of development, gametogenesis and the female reproductive system are reviewed.
Second week :
Implantation of the blastocyst is completed during the second week. As this process occurs, morphologic changes in the embryoblast produce a bilaminar embryonic disc composed of epiblast and hypoblast. The **embryonic disc** gives rise to the germ layers that form all the tissues and organs of the embryo. Extraembryonic structures forming

during the second week are the amniotic cavity, amnion, umbilical vesicle (yolk sac), connecting stalk, and chorionic sac.
Third week
Formation of Germ Layers and Early Tissue and Organ Differentiation:
Rapid development of the embryo from the embryonic disc during the third week is characterized by

- Appearance of primitive streak
- Development of notochord
- Differentiation of three germ layers

The third week of embryonic development coincides with the week following the first missed menstrual period; that is, 5 weeks after the first day of the last normal menstrual period. Cessation of menstruation is often the first indication that a woman may be pregnant. Approximately 3 weeks after conception, approximately 5 weeks after the last normal menstrual period. a normal pregnancy can be detected with ultrasonography.



An embryo at the end of the third week, showing the position of primordial germ cells in the wall of the yolk sac, close to the attachment of the future umbilical cord. From this location, these cells migrate to the developing gonad

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Organogenetic Period: Fourth to Eighth Weeks
All major external and internal structures are established during the fourth to eighth weeks. By the end of this period, the main organ systems have begun to develop; however, the function of most of them is minimal except for the cardiovascular system. As the tissues and organs form, the shape of the embryo changes, and by the eighth week, it has a distinctly human appearance. Because the tissues and organs are differentiating rapidly during the fourth to eighth weeks, exposure of embryos to teratogens during this period may cause major congenital anomalies. Teratogens are agents such as drugs and viruses that produce or increase the incidence of congenital anomalies

CHAPTER 3
MICROSTRUCTURE OF HUMAN TISSUE ANATOMY OF SKELETON

Introduction

In some ways, the human body is like a complex machine such as a car. Both consist of many parts, which are made of materials consistent with their specialized functions. For example, the windows of a car are made of transparent glass, the tires are made of synthetic rubber reinforced with a variety of fibers, and the engine is made of a variety of metal parts, and the hoses that move water, air, and gasoline are made of synthetic rubber or plastics. All parts of an automobile cannot be made of a single type of material. Metal capable of withstanding the heat of the engine cannot be used for windows or tires. Similarly, the many parts of the human body are made of collections of specialized cells and the material surrounding them. Muscle cells, which contracted to produce movement of the body, are structurally different and have different functions than those of epithelial cells, which protect, secrete, or absorb. Also, cells in the retina of the eye, specialized to detect light and allows us to see, do not contract like muscle cells or exhibit the function of epithelial cells.

The structure and functions of tissues are so closely that you should be able to predict the function of a tissue when given its structure, and vice versa. Knowledge of tissue structure and function is important in understanding the structure and function of organs, organ systems, and the complex organism. You have to discuss in brief about *tissue,types of tissue* and describe the structural and functional characteristics of the major tissue types: *epithelial tissue*, *connective tissue*, *muscle tissue*, and *nervous tissue*. In addition you have to explain about *membrane*, *inflammation*, and *tissue repair*.

LEARNING OBJECTIVES OF THE PROBLEM

The learner would demonstrate the ability to analyze the basic science(s) by outlining the structure and function of the appropriate tissue system(s) that important to help in learning and solving the problem.

CHAPTER 4
HISTOLOGY, ANATOMY, AND PHYSIOLOGY OF NERVE

In the Name of Allah, the Compassionate, the Merciful

INTRODUCTION

The major function of the nervous system are to detect, analyze, and transmit information. Information is gathered by sensory systems, integrated by the brain, and used to generate signals to motor and autonomic pathways for control of movement and visceral and endocrin function. Imagine the most complex and suphisticated electronic computer ever built. The human's brain is far more complex and suphisticated. Your entire nervous system is even more complex. **Allah created the human being in perfect form. (QS At-Tiin 95: 4 QS Al-A'raaf 7:179)**

In order to maintain homeostasis, the body is constantly reacting and adjusting to changes in the outside environment and within the body itself. Under normal conditions, activities of the muscles and glands are coordinated, so that our body parts work in harmony toward directed homeostatic goals. Examples of such efforts to maintain homeostasis are the maintenance of a relatively constant body temperature and the coordinated activities of muscles during movements. Homeostasis allows us to function normally despite constant changes in the environment.

In order to function properly, nerve cells within the brain must have a continuous supply of blood, oxygen, and glucose (blood sugar). If this supply is impaired, parts of the brain may stop functioning temporarily. If the impairment is severe, or lasts long enough, brain cells die and permanent damage follows. Because the movement and functioning of various parts of the body are controlled by these cells, they are affected also. The symptoms experienced by the patient will depend on which part of the brain is affected.