III. GENERAL CHARACTERISTICS OF EK CELLS

Human cells as well as other animal and vegetal cells have a great variety regarding the morphology, dimensions, structure and ultrastructure, mobility degree, differentiation and specialization.

III.1. MORPHOLOGICAL CHARACTERS

III.1.1. CELL FORM

Cell form is the result of the interacting genotype medium. EK cells have a much diversified form, which depends on various factors: genetic, functional, or the chemical and physical characters of the medium as well as the density of the cells which grow and diversify in this medium and the relations established between the cells. There is a great morphological diversity from one tissue to another, from one cell type to another and depending on the cell age. The cell form is also influenced by internal factors: viscosity, synthesis processes and accumulation of specific substances, the formation of cellular organelles and surface tension of the plasma membrane, the function they fulfil, as well as the normal and pathological conditions.

Primary spherical form - can be found in egg cells, young, undifferentiated cells and generally in cells from less dense media (hematopoietical marow). According to form, cells can be classified in:

a) Cells with variable form are cells which can be found suspended in liquid medium (blood, lymph, cerebrospinal liquid). They can issue temporary, ectocytoplasmic extensions.

b) Cells with unchanged form are differentiated cells which can be found in tissue or organ structures. They fulfil a specific function.

Tissues may be defined as aggregates or groups of cells organized to perform one or more functions - In examining the structure of the body at the light microscope level, it soon becomes apparent that the cells and extracellular components comprising the various organs of the body exhibit certain recognizable and often very distinctive patterns of organization. This organized arrangement is a reflection of the cooperative effort that like cells perform in a carrying out a particular function. Thus, when we speak of an organized aggregation of cells that function in a collective manner, we are, by definition, referring to a tissue.

Although it is frequently said that the cell is the basic functional unit of the body, it is really the tissues, through the collaborative efforts of their individual cells that are responsible for maintaining body functions. Furthermore, it is now well known that cells within certain tissues can communicate through specialized intercellular junctions (gap junctions), thus facilitating collaborative effort and allowing the cells to operate as a functional unit. Other mechanisms also exist that permit cells of a given tissue to function in a unified manner. This includes the presence of specific membrane receptors, neural innervation, and noncommunicating junctions between cells.

The concept of tissues provides a basis for understanding and recognizing the many cell types within the body and how they interrelate. Despite variations in general appearance, structural organization, and physiologic properties of the various body organs, the cell aggregations that make them up are reduced to and classified under four tissue types. These ***basic*** or ***fundamental tissues*** are:

a) Epithelial tissue (epithelium), which covers body surfaces, lines body cavities, and forms glands.

b) Connective tissue, which underlies or surrounds and supports the other three basic tissues, both structurally and functionally.
c) Muscular tissue, which is made up of contractile cells and is responsible for movement of the body and its parts.
d) Nervous tissue, which gathers, transmits, and integrates information from outside and inside the body to control the activities of the body and its parts.

Each of these basic tissues is defined by a set of general morphologic characteristics or by functional properties. Each type may be further subdivided on the basis of more specific characteristics of the various cell populations as well as on the basis of intercellular substances in those cases where they present special characteristics.

In considering the basic tissues, recognize that two different parameters are employed. The basis for definition of epithelium and connective tissue is primarily morphologic, whereas the basis for the definition of muscular and nervous tissue is functional. Moreover, the same variations in parameters exist in designating the tissue subclasses. For example, while muscle tissue itself is defined by its function, it is sub classified into smooth and striated categories, a purely morphologic distinction, not a functional one. Another kind of contractile tissue, though functionally muscle, is typically designated as an epithelium (myoepithelium) because of its location.

a) Ephithelium

Epithelia are layers of cells that form barriers with specific properties. Important characteristics of epithelia include the following:

- an epithelium always has a free surface exposed to environment or to some internal chamber or passageway.
- an epithelium is attached to underlying connective tissue at a basement membrane.
- an epithelium does not contain blood vessels. Because of this avascular condition, epithelial cells must obtain nutrients from deeper tissues or from their exposed surfaces.

Epithelia cover both external and internal body surfaces. In addition to covering the skin, epithelia line internal passageways that communicate with the outside world, such as the digestive, respiratory, reproductive, and urinary tracts. These epithelia form selective barriers that separate the deep tissues of the body from the external environment.

Epithelia also line internal cavities and passageways, such as the chest cavity, fluid-filled chambers in the brain, eye, and inner surfaces of blood vessels and the heart. These epithelia prevent friction, regulate the fluid composition of internal cavities, and restrict communication between the blood and tissue fluid.

Functions of epithelia - Epithelia perform four essential functions which can be summarized as follows:

1. Providing physical protection - Epithelia protect exposed and internal surfaces from abrasion, dehydration, and destruction by chemical or biological agents. For example, as long as it remains intact, the epithelium of your skin resists impacts and scrapes, restricts water loss, and prevents invasion of internal tissues by bacteria.

2. Controlling permeability - Any substance that enters or leaves the body must cross an epithelium. Some epithelia are relatively impermeable, whereas other are easily crossed by compounds as large as proteins.

3. Providing sensations - Specialized epithelial cells can detect changes in the environment and relay information about such changes to the nervous system. For example, touch receptors in the deepest layers of the epithelium of the skin respond by stimulating neighbouring sensory nerves.

4. Producing specialized secretions - Epithelial cells that produce secretions are called ***gland cells***. In a ***glandular epithelium*** most or all of the cells actively produce secretions. These secretions are classified according to their discharge location:

- ***exocrine secretions*** are discharged onto the surface of the skin or other epithelial surface. Enzymes entering the digestive tract, perspiration on the skin, and milk produced by mammary glands are examples.

- ***endocrine secretions*** are released into the surrounding tissues and blood. These secretions, called hormones, regulate or coordinate the activities of other tissues, organs, and organ systems. Endocrine secretions are produced in organs such as the pancreas, thyroid, and pituitary gland.

To maintain its structure, the epithelium must continually repair and renew itself by replacing exposed cells. Epithelial cells may survive for just a day or two, for they are lost or destroyed by exposure to disruptive enzymes, toxic chemicals, pathogenic bacteria, or mechanical abrasion. The only way the epithelium can survive is by replacing itself over time through the continual division of unspecialized cells known as stem cells or germinative cells. These are found in the deepest layers of the epithelium, near the basement membrane.

Epithelia are classified according to the number of cell layers and the shape of the exposed cells. This classification scheme recognizes two types of layering (simple and stratified) and three cell shapes (squamous, cuboidal, and columnar). In sectional view, the cells at the surface of the epithelium usually have one of three basic shapes:

1. Squamous - In a squamous epithelium, the cells are thin and flat and the nucleus occupies the thickest portion of each cell.

2. Cuboidal - The cells of a cuboidal epithelium resemble little hexagonal boxes; in typical sectional view, however, they appear square, and the nuclei near the center of each cell form a neat row.

***3. Columnar* -** In a columnar epithelium the cells are also hexagonal, but taller and more slender. The nuclei are crowded into a narrow band close to the basement membrane, and the height of the epithelium is several times the distance between two nuclei.

b) Connective tissue

Connective tissues are deep tissues that are never exposed to the environment outside the body. They have many important functions, including:

- **Providing support and protection** - The minerals and fibers produced by connective tissue cells establish a bony structural framework for the body, protect delicate organs, and surround and interconnect other tissue types.
- **Transporting materials -** Fluid connective tissue provides an efficient means to move dissolved materials from one region of the body to another.
- **Storing energy reserves -** Fats are stored in connective tissue cells called adipose cells until needed.
- **Defending the body** - Specialized connective tissue cells respond to invasions by microorganisms through cell-to-cell interactions and the production of antibodies.

Connective tissues are the most diverse tissues of the body. Bone, blood, and fat are familiar connective tissues that have very different functions and properties. All connective tissues have three basic components: specialized cells; protein fibers; ground substance (a fluid that varies in consistency). The extracellular fibers and ground substance constitute the matrix that surrounds the cells. Whereas epithelial tissue consists almost entirely of cells, the extracellular matrix accounts for most of the volume of connective tissues.

Classification of connective tissues

Several classes of connective tissues are recognized on the basis of the physical properties of their ground substance:

- **connective tissue proper** refers to connective tissues with many types of cells and fibers surrounded by a syrupy ground substance. Examples include the tissue that underlies the skin, fatty tissue, and tendons and ligaments.
- **fluid connective tissues** have a distinctive population of cells suspended in a watery ground substance that contains dissolved proteins. There are two fluid connective tissues, *blood* and *lymph.*
- **supporting connective tissues** are of two types, *cartilage* and *bone*. These tissues have a less diverse cell population than connective tissue proper and a matrix of dense ground substance and closely packed fibers. The fibrous matrix of bone is said to be calcified because it contains mineral deposits, primarily calcium salts, which give the bone strength and rigidity.

Connective tissue proper contains fibers, a syrupy ground substance, and a varied cell population. That population includes the following cell types:

- ***fibroblasts*** are the most abundant cells in connective tissue proper. They are responsible for the production and maintenance of the connective tissue fibers and the ground substance.
- ***macrophages*** are scattered among the fibers. These cells phagocytize damaged cells or pathogens that enter the tissue and release chemicals that mobilize the immune system. When an infection occurs, additional macrophages are drawn to the affected area.
- ***fat cells*** are known as adipose cells, or simply adipocytes. A tipical adipocyte contains such a large droplet of lipid that the nucleus and other organelles are squeezed to one side of the cell. The number of fat cells varies from one connective tissue to another and from individual to individual.
- ***mast cells*** are small, mobile connective tissue cells often found near blood vessels. The cytoplasm of a mast cell is packed with vesicles filled with chemicals that are released to begin the body's defensive activities after an injury or infection.

In addition to mast cells and free macrophages, both phagocytic and antibody-producing white blood cells may move through the connective tissue. Their numbers increase markedly if the tissue is damaged, as does the production of antibodies, proteins that destroy invading microorganisms or foreign substances.

Fluid connective tissues

Blood and lymph are connective tissues that contain distinctive collections of cells in a fluid matrix. A single cell type, the *red blood cell*, accounts for almost half the volume of blood. Red blood cells transport oxygen in the blood. The watery ground substance, called plasma, also contains small numbers of ***white blood cells***, which are important components of the immune system, and ***platelets***, which function in blood clotting.

Supporting connective tissues

Cartilage and bone are called supporting connective tissues because they provide a strong framework that supports the rest of the body. In these connective tissues the matrix contains numerous fibers and, in some cases, deposits of insoluble calcium salts.

In cartilage***, chondrocytes*** are the only cells found within the matrix. Because cartilage lacks blood vessels, chondrocytes must obtain nutrients and eliminate waste products by diffusion through the matrix.

In bone, the cells are called ***osteocytes.*** Diffusion cannot occur through the bony matrix, but osteocytes obtain nutrients via cytoplasmatic extensions that reach blood vessels and other osteocytes.

c) Muscle tissue

Muscle tissue is specialized for contraction. A large skeletal muscle cell may be 100 micrometers in diameter and 25 cm long. Because skeletal muscle cells are relatively long and slender, they are usually called ***muscle fibers.***

Muscle cell contraction involves interaction between filaments of_***myosin*** and ***actin***, proteins found in the cytoskeletons of many cells. In muscle cells, however, the filaments are more numerous and arranged so that their interaction produces a contraction of the entire cell.

There are three types of muscle tissue: ***skeletal, cardiac***, and ***smooth muscle tissue***. The contraction mechanism is the same in all of them, but the organization of their actin and myosin filaments differs.

- **Skeletal muscle tissue -** contains very large, multinucleated fibers (cells) tied together by loose connective tissue. The collagen and elastic fibers surrounding each cell and group of cells blend into those of a tendon that conducts the force of contraction, usually to a bone of the skeleton. Contractions of muscle tissue cause the bones to move.

Because the actin and myosin filaments are arranged in organized groups, skeletal muscle fibers appear to be marked by a series of bands known as ***striations***. Skeletal muscle fibers will not usually contract unless stimulated by nerves. Since the nervous system provides voluntary control over its activities, skeletal muscle is described as ***striated voluntary muscle***.

- **Cardiac muscle tissue -** is found only in the heart. Cardiac muscle cells are much smaller than skeletal muscle fibers, and each cardiac muscle cell usually has a single nucleus. Cardiac muscle cells are interconnected at ***intercalated discs***, specialized attachment sites containing gap junctions and desmosomes. The muscle cell branch, forming a network that efficiently conducts the force and stimulus for contraction from one area of the heart to another.

Unlike skeletal muscle, cardiac muscle does not rely on nerve activity to start a contraction. Instead, specialized cells, called pacemaker cells, establish a regular rate of contraction. The nervous system can provide voluntary control over individual cardiac muscle cells. In short, cardiac muscle can be considered as ***striated involuntary muscle***.

- **Smooth muscle tissue** - can be found in the walls of blood vessels; around hollow organs such as the urinary bladder; and in layers around the respiratory, circulatory, digestive, and reproductive tracts.

A smooth muscle cell is small and slender, tapering to a point at each end. There is one nucleus in each smooth muscle cell. Unlike skeletal and cardiac muscle, the actin and myosin filaments in smooth muscle cells are scattered throughout the cytoplasm, and there are no striations.

Smooth muscle cells may contract independently or their contractions may be triggered by neural activity. The nervous system usually does not provide voluntary control over smooth muscle contractions, and ***smooth*** muscle is therefore categorized as ***nonstriated involuntary muscle***.

d) Neural tissue

Neural tissue is specialized for the conduction of electrical impulses that convey information or instructions from one region of the body to another. Most of the neural tissue is concentrated in the brain and spinal cord, the control centres for the nervous system.

Neural tissue contains two basic types of cells: ***neurons*** and several different kinds of supporting cells, or ***nevroglia***.

Neurons transmit the actual signals as electrical events affecting their cell membranes. The nevroglia provide physical support for neural tissue, maintain the chemical composition of the tissue fluids, and defend the tissue from infection.

A typical neuron has a cell body, or ***soma***, that contains the nucleus. The stimulus that results in the production of an electrical impulse usually affects the cell membrane of one of the ***dendrites*****.** Stimulation alters the permeability of the cell membrane, eventually producing an electrical impulse that is conducted along the length of the axon. ***Axons*****,** which may reach a meter in length, are often called ***nerve fibers***. Each axon ends at a specialized intercellular junction called a ***synapse***.

III.1.2. CELL DIMENSIONS

Cell dimensions can be found out using the micrometric and stereological method. The dimensions of the same type of cells are constant, regardless of the individual's size, but they vary depending on the cell age and the metabolic activity of the cell. Young cells and those in full activity have generally greater dimensions than the old ones. The dimensions of human cells are measured in microns. By diameters, cells can be classified in three categories:

- **small sized cells** (with diameters lower than 10μ), small lymphocytes (5-6μ), molecular neurons (3-4μ), erythrocytes (7.5μ), spermatozoid's head (4-5μ);

- **medium sized cells** (with diameters between 10-30μ) - are the most cells of the human body: hepatocytes, enterocytes, splenocytes, nefrocytes;

-big sized cells (with diameters upper than 30μ): pseudounipolar neurons from the spinal ganglions (40-60μ), Purkinje neurons (30-50μ), pyramidal neurons (80-120μ), the ovule (200μ), skeletal striated muscle cell (longitudinal diameter of 12cm; transverse diameter upon to 100μ).

III.1.3. CELL VOLUME

The cell volume is usually invariably for the same type of cell. The volume changes during certain periods of the cell's life as well as at certain moments of its activity, for example, when the cell accumulates and stores substances produced or caught from the extracellular medium.

Figure 19**.**
Neural tissue

The volume of human cells varies from c er between 300-15oooμ^3. Generally, the volume of a certain cell type is cons species or the size of the organism (mouse, human or elephant hepatocyte size). Consequently, the dimensions of an organ are not determined by the cell volume, but by the number of cells which form the organ. This is called the law of constant (remaining) volume.

The cell volume is influenced by a series of factors: cell main factors (cell age, cell function) and surface factors (the resistance of the lipoproteinic film of the plasmalema, network resistance of the membranous cytoskeleton and of the extracellular collagen).

III.1.4. CELL NUMBER

Cell number is usually estimated by establishing the nuclear equivalent. The human organism is made up by a very great number of cells. It is appreciated that the total number of cells in an adult is of 10^{17}. The blood cells form the most numerous cellular population. In an adult the number of red cells is of several tens of thousands of milliards, nevroglia -1000 milliards.

III.1.5. LIFE SPAN AND CELLULAR TUROVER

The cellular life span varies, depending on the cell type from 10 minutes to the whole life span of the individual. So, the nervous cells and the cardiac muscle cells have a life span equivalent to the organism's life span. The intestinal epithelium cells have a life span of 3-4 days, red cells of 120 days.

Aged cells and /or dead cells are replaced with other cells originated from the division process. In the adult human organism over 4 million cellular divisions take place every second. One day, 350 milliards divisions take place and in one year 10^{14}.

The cells consist of molecules, macromolecules, organelles which are in a continuous process of renewal. The transformation rhythm of the various organisation levels of the living world is called ***turnover***. The process is the basis of the persistence and continuity of the living cell.

III.2. INTERNAL COMPARMENTS OF THE CELL

The EK cell presents a strict internal order and is divided into compartments by a system of endomembranes, which delimit the cytoplasmic organelles and enables their functioning. The basic structure of all endomembranes is similar to the cellular membrane, the pattern of this structure being the "fluid mosaic model".

The main intracellular compartments formed by the endomembranes are:

1. nuclear compartment realised by the nuclear cover, delimiting the nucleus from the cytoplasm;

2. cytoplasmic compartment where all the vital processes and synthesis of the cellular components take place, cytoplasmatic compartmet consists of:

a) plasmatic compartment represented by the cytosol and the elements of the cellular cytoskeleton;

b) cisternal compartment represented by the matrices of the cytoplasmic organelles delimited by endomembranes;

c) secondary compartments represented by the mitochondrial matrix and the cloroplastidial matrix.