Unit-I

Introduction to human body as a whole

Introduction to anatomy

Anatomy forms the basis for the practice of medicine. A deep knowledge and thorough understanding of the anatomy and physiology helps the healthcare professionals to make better clinical judgments, while performing the physical examination or using the most advanced imaging techniques. The ability to make an accurate interpretation of the clinical findings (signs and symptoms) of a patient is therefore the endpoint of a sound anatomical understanding.

Definition and Divisions of anatomy

Definition:

The term 'anatomy' is derived from the Greek word 'temnein' meaning 'to cut'. Anatomy is the study of those structures of the body that can be seen grossly (without the aid of magnification) and microscopically (with the aid of magnification). In other words anatomy is the branch of medical science that deals with the structures of the body and the relationship of various parts to each other.

Divisions (Subject matter of anatomy):

1. Cytology : study of cells
2. Histology: study of tissues
3. Osteology: study of bones
4. Mycology: study of muscles
5. Orthrology: study of joints
6. Splanchnology: study of organs
7. Neurology: study of the nervous system.

Terms of location, position and planes

Three major pairs of terms are used to describe the location of structures relative to the body as a whole or to other structures, they are; Anterior (ventral) and posterior (dorsal) , medial and lateral, superior and inferior.

- **Location:**

Anterior (ventral) and posterior (dorsal): Anterior (or ventral) and posterior (or dorsal) describe the position of structures relative to the "front" and "back" of the body. For example, the nose is an anterior (ventral) structure, whereas the vertebral column is a posterior (dorsal) structure. Also, the nose is anterior to the ears and the vertebral column is posterior to the sternum.

Medial and lateral describe the position of structures relative to the median sagittal plane and the sides of the body. For example, the thumb is lateral to the little finger. The nose is in the median sagittal plane and is medial to the eyes, which are in turn medial to the external ears.

Superior and inferior describe structures in reference to the vertical axis of the body. For example, the head is superior to the shoulders and the knee joint is inferior to the hip joint.

Other terms related to location are as : Proximal and distal, cranial and caudal,
and rostral

• **Proximal and distal** are used with reference to being closer to or farther from a structure 's origin, particularly in the limbs. For example, the hand is distal to the elbow joint. The glenohumeral joint is proximal to the elbow joint. These terms are also used to describe the relative positions of branches along the course of linear structures, such as airways, vessels, and nerves. For example, distal branches occur farther away toward the ends of the system, whereas proximal branches occur closer to and toward the origin of the system.

• **Cranial (toward the head) and caudal (toward the tail)** are sometimes used instead of superior and inferior, respectively.

• **Rostral** is used, particularly in the head, to describe the position of a structure with reference to the nose. For example, the forebrain is rostral to the hindbrain.

Superficial and deep: Two other terms used to describe the position of structures in the body are superficial and deep . These terms are used to describe the relative positions of two structures
with respect to the surface of the body. For example, the sternum is superficial to the heart, and the stomach is deep to the abdominal wall. Superficial and deep can also be used in a more absolute fashion to define two major regions of the body. The superficial region of the body is external to the outer layer of deep fascia. Deep structures are enclosed by this layer. Structures in the superficial region of the body include the skin, superficial fascia, and mammary glands . Deep structures include most skeletal muscles and viscera. Superficial wounds are external to the outer layer of deep fascia, whereas deep wounds penetrate through it.

- **Anatomical planes:**

Three major groups of planes pass through the body in the anatomical position (Fig. 1)
Coronal planes are oriented vertically and divide the body into anterior and posterior parts.

Sagittal planes also are oriented vertically but are at right angles to the coronal planes and divide the body into right and left parts . The plane that passes through the center of the body dividing it into equal right and left halves is termed the median sagittal plane.

Transverse, horizontal, or axial planes divide the body into superior and inferior parts.

- **Anatomical position**

The anatomical position is the standard reference position of the body used to describe the location of structures (Fig.1). The body is in the anatomical position when standing upright with feet together, hands by the side and face looking forward. The mouth is closed and the facial expression is neutral. The rim of bone under the eyes is in the same horizontal plane as the top of the opening to the ear, and the eyes are open and focused on something in the distance. The palms of the hands face forward with the fingers straight and together and with the pad of the thumb turned 90 ° to the pads of the fingers. The toes point forward.

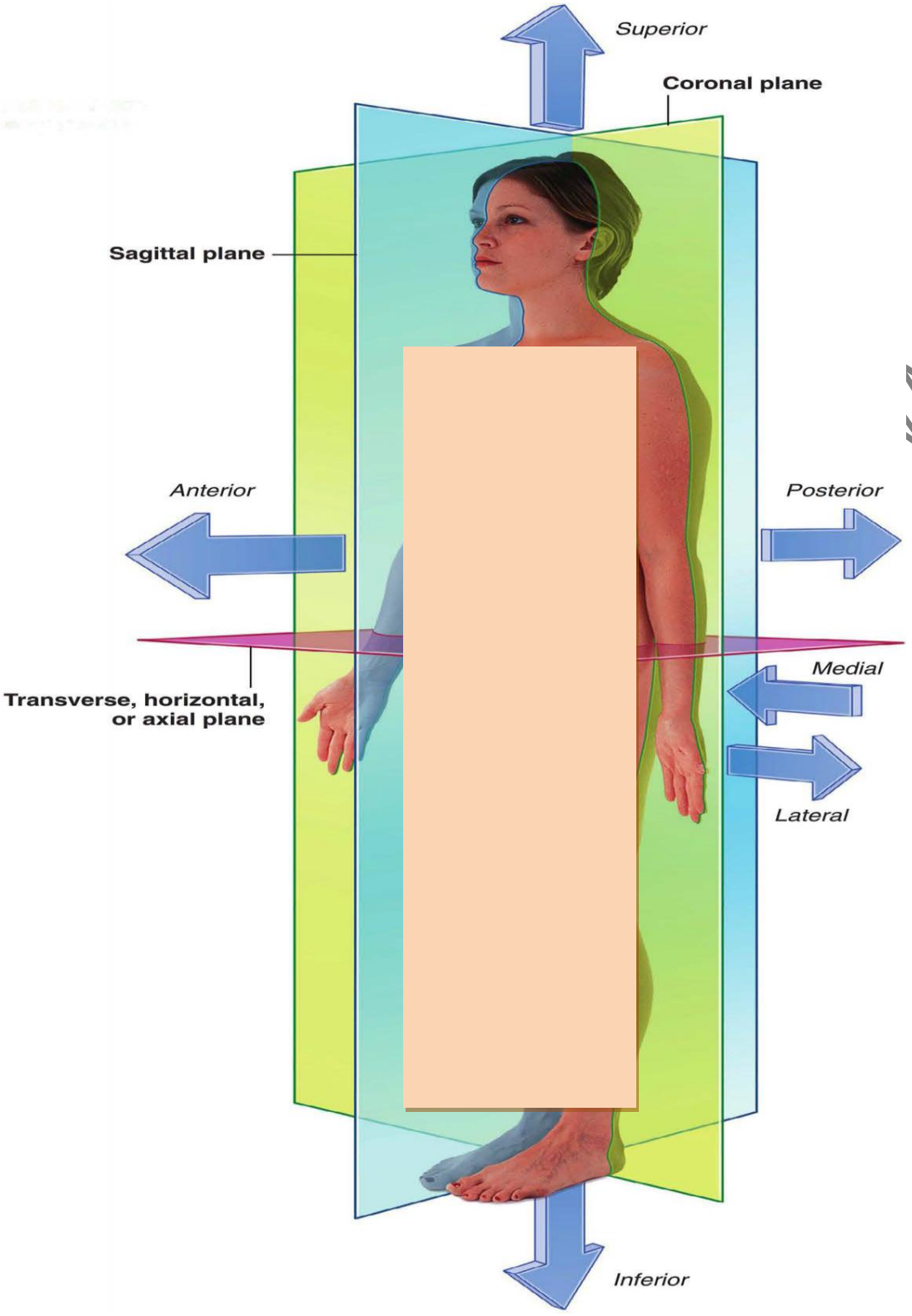


Fig. 1.1 The anatomical planes and position

Cell and its organelles

Structure of the human cell:

A cell is the smallest functional unit of the body. Usually an animal cell is the small mass of nucleated protoplasm enclosed by an outer covering of the cell membrane. Cells are grouped together to form tissues, each of which has a specialized function (e.g. blood, bone, muscle).different cells of the human body differ in size and shape but there are certain structural characteristics common to all of them. A cell consists of a plasma membrane inside which are a number of organelles suspended in a watery fluid called as **cytosol**. Organelles have their unique functions and are often covered by their own membranes. The cell structures are discussed blow:

Plasma membrane: the cell membrane or plasma membrane is the outer covering of the cell. The membrane is about $70A^{o}$ thick. It consists of two layers of phospholipids with protein and sugar molecules embedded in then. The phospholipid molecules have a hydrophilic head(water loving) and a hydrophobic (water hating) tail, the heads are aligned outside and the tails are aligned inside forming a water repelling layer on inner side of the phospholipid layer. This special alignment helps in the transfer of substances across the membrane. In addition to the transport of materials some other functions performed by plasma membrane include; helps in protection of the cell, receives stimuli from the outside, takes in food and excretes waste products . When broken it is quickly regenerated from the cytoplasm possibly with the help of surface tension.

Cytoplasm: The whole of the cell content except the nucleus is known as cytoplasm, it is the region lying between the nucleus and the cell membrane . The cytoplasm contains cell organelles like endoplasmic reticulum, golgi apparatus, mitochondria, lysosomes, etc.

Nucleus: Every cell in the body has a nucleus except the mature erythrocytes (red blood cells). The nucleus is the largest organelle and is contained within the nuclear envelope. The nucleus contains the body's genetic material, which directs all the metabolic activities of the cell. The nucleus has further two parts ; **a)** nucleolus: a highly coiled filamentous structure and the site for ribosomal RNA(Ribonucleic acid) synthesis, **b)** chromatin: these are fibrous threads present in the nucleus and are composed of DNA (deoxyribonucleic acid) and proteins. These chromatin threads carry the genetic information and each species has a unique genetic setup with particular chromosome (condensed chromatin at the time of cell division) number. Humans have 23 pairs of chromosomes.

Mitochondria: these are sausage shaped structures in the cytoplasm , sometimes described as 'powerhouse' of the cell. The dimensions vary from 0.5-5µ and are surrounded by a double membrane, the inner one of which remains folded and forms a number of partsions. They are made up of phospholipids ,proteins, and RNA(ribonucleic acid). They also contain some enzymes and oxidizing agents. They are involved in aerobic respiration , the process through which chemical energy is made available to the cell, in the form of ATP(adenosine tri-phosphate). The most active cell types have the greatest number of mitochondria, e.g. liver cells, muscle cells and spermatozoa.

Ribosomes: these are tiny granules composed of RNA and protein. They synthesize proteins from amino acids, using RNA as the template.

Endoplasmic reticulum: A series of interconnecting membranous canals in the cytoplasm form the endoplasmic reticulum. These are of two types ;

1) Granular or rough endoplasmic reticulum: it contains ribosomes, which act as the sites for synthesis of proteins that are exported out from the cells.
2) Agranular or smooth endoplasmic reticulum: this type do not contain ribosomes and is concerned with the synthesis of lipids and steroid hormones

Golgi apparatus: the golgi apparatus consists of stacks of closely folded flattened membranous sacs. It is found in all cells but is abundant in those cells that synthesize and export proteins. The proteins are transferred from golgi apparatus to endoplasmic reticulum where they are packed into membrane bound vesicles called as **secretary granules.** These vesicles are stored and exported out when needed.

Lysosomes: these are a type of secretory vesicles formed by the golgi apparatus. They contain a number of hydrolytic enzymes involved in the breakdown of cellular debris , large molecules(e.g. RNA, DNA, Carbohydrates etc)inside the cell into smaller particles that are either recycled or extruded out as a waste material.

Microsomes: minute sub microscopic particles- making up about 25% of the dry weight of the cell. Chemical composition is same as that of mitochondria but microsomes contain more fat. The diameter of the microsomes vary from 16-18 milimicrons

Cytoskeleton: this consists of tiny strands of proteins.

Microfilaments: these are the smallest fibers. They provide the structural support , maintain the characteristic shape of the cell and permit contraction(e.g. in muscle cells)

Microtubules: these are larger contractile protein fibers that are involved in movement of

- Organelles within the cell
- Chromosomes during cell division
- Cell extensions

Centrosome: this consists of another specialized part of clear cytoplasm. Centrosome consists of a pair of centrioles (small clusters of microtubules) and has an important role during cell division.

Cell extensions: these are the extensions of plasma membrane mainly composed of microtubules. They help in movement. These include Cilia(small hair-like projections, e.g. cilia in respiratory tract) and Flagella(long whip-like projections, e.g. flagella in spermatozoa

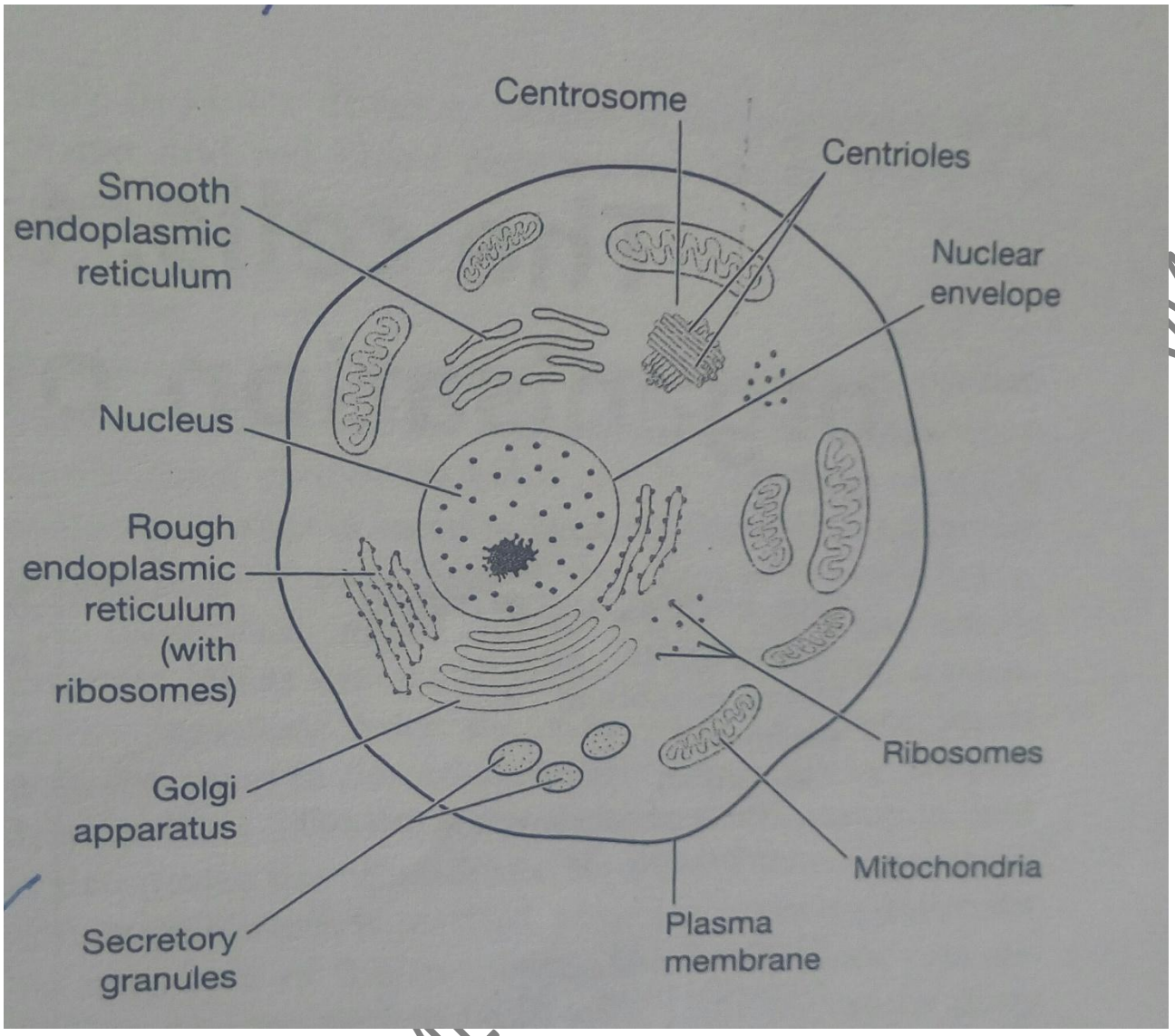


Fig. 1.2 The cell with organelles

Cell division

Daughter cells are formed from parent cells by the process of cell division. Most body cells divide by mitosis, a process that results in the formation of two genetically identical daughter cells. Formation of gametes (sex cells), i.e. ova and spermatozoa takes place by meiosis and the four daughter cells are genetically different from the parent cell and each other

Mitosis:

This is a continuous process of cell division that involves four distinct stages(Fig. 1.3), seen under light microscope.

Prophase: during this phase there is disintegration of the nuclear membrane, chromatids become visible and the mitotic apparatus appears, this consists of two centrioles separated by the mitotic spindle. These two centrioles move away from each other, one to each end of the cell forming two poles.

Metaphase: In this stage the chromatids assemble at the center of the spindle, attached with their centromeres.

Anaphase: the centromeres separate and one of each pair of sister chromatids migrates to each pole or end of the spindle.

Telophase: During this stage the cell becomes narrower at the center , a gradually elongated nuclear envelop reforms. Following telophase the cytoplasm and plasma membrane of the cell divide into two identical daughter cells. The organelles of the daughter cells are not complete at the time of cell division but develop during interphase. The daughter cells grow and in turn reproduce by mitosis.

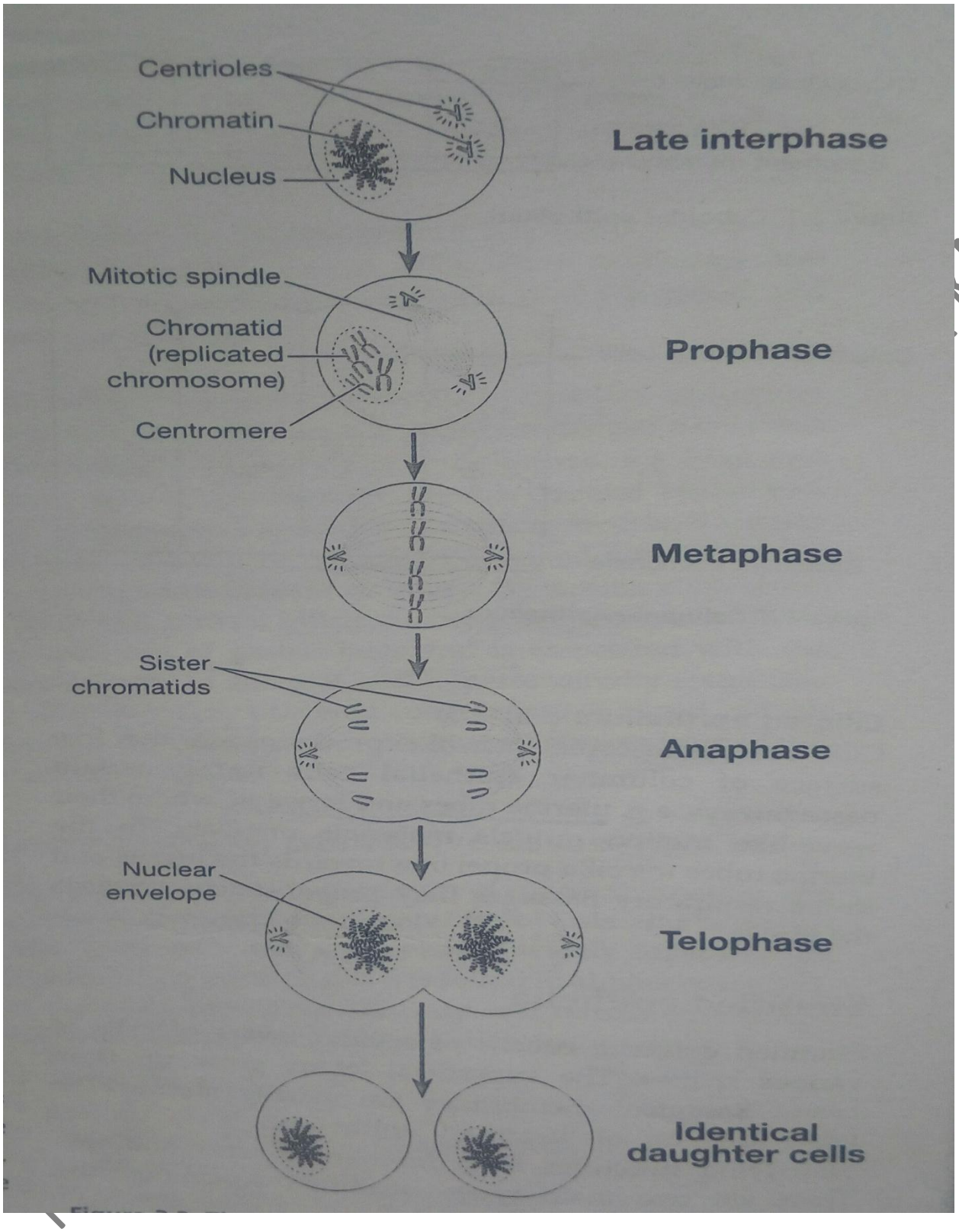


Fig.1.3 The stages of Mitosis

Meiosis: Meiosis produces gametes (ovum and sperm). Meiosis involves two distinct cell divisions rather than one(Fig 1.4). Meiosis produces four daughter cells, not two, all different from the parent cell and each other.

This is the main reason for genetic diversity and uniqueness of each individual. The gametes thus formed are having 22autosomes and either an X or Y chromosome in it (haploid in nature). On fertilization the haploid ovum and haploid sperm cell unite and form the diploid zygote.

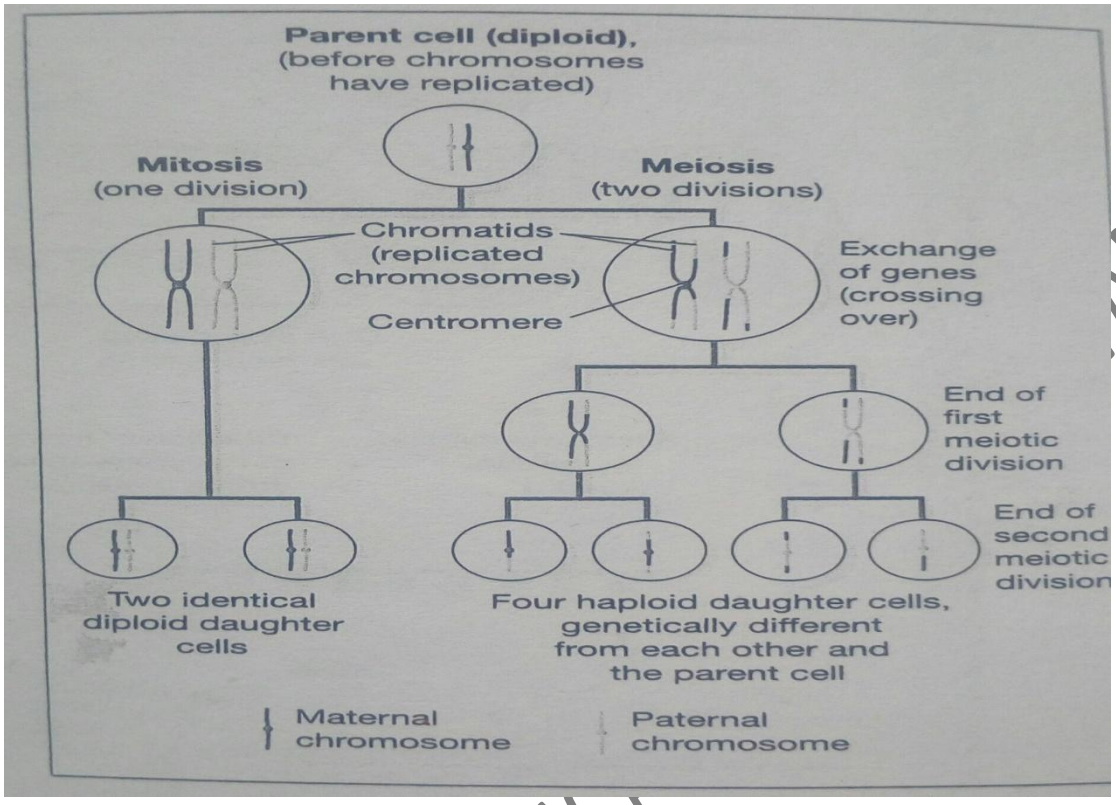


Fig. 1.4 The stages of Meiosis

The Tissue

A tissue is defined as a group of cells having same origin, shape and specific or generalized function. The tissues of the body are classified according to the shape ,size, and functions of these cells. There are four main types of tissues and they are;

- Epithelial tissue or epithelium

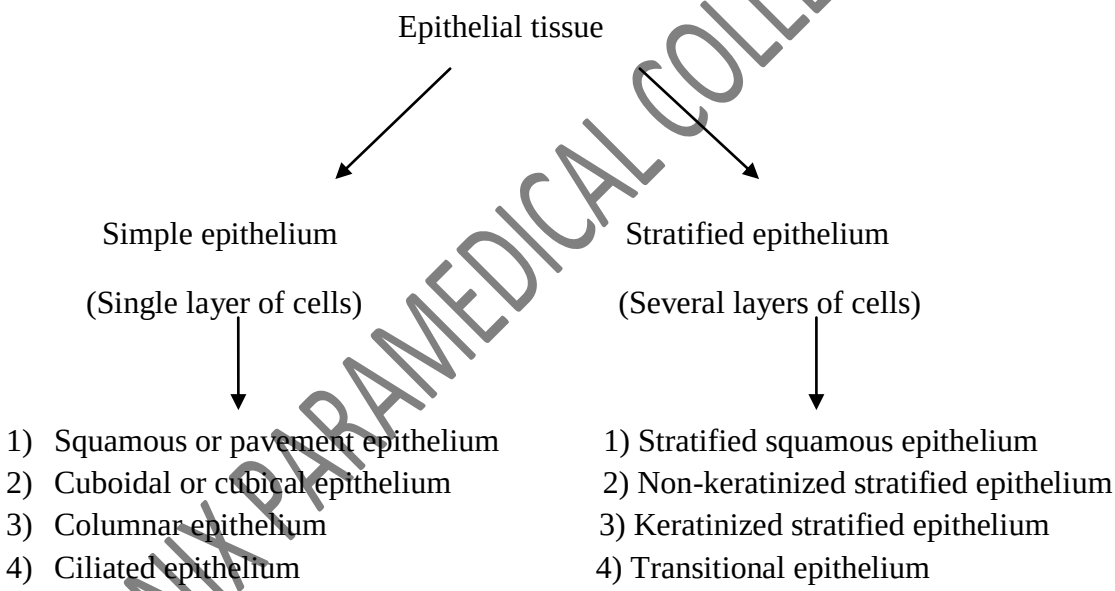
- Connective tissue
- Muscle tissue
- Nervous tissue

Epithelial tissue (Epithelium):

Epithelial tissue is found covering the body and lining the cavities, tubes and hollow organs. It is also found in glands. The epithelial cells are closely packed and the matrix(intercellular substance) is very less but they are arranged on a basement membrane. The epithelium is structured according to its function and the main functions are as:

- *Protection* of underlying structures (e.g. from dehydration, injury etc.).
- *Secretion* of special chemical substances.
- *Absorption*
- *Excretion.*

Classification of epithelial tissue



Simple epithelium

It consists of a single layer of similar cells resting on a basement membrane. It is sub-divided into four types .The types are named according to the shapes of the cells which differ according to their function.

Squamous epithelial tissue: This is composed of a single layer of flattened cells, which fit closely like flat stones forming a thin and very smooth membrane. This thin layer ensures diffusion in the structures like heart, blood vessels, blood vessels and alveoli of the lungs.

Cuboidal epithelial tissue: It is composed of cube-shaped cells, fitted closely together, lying on a basement membrane. It is found in kidney tubules and some glands. This tissue is actively involved in secretion, absorption and excretion. Since it is found in simple glands producing glandular secretions, it is also called as secretive epithelium.

Columnar epithelial tissue: It is formed by a single layer of rectangular or cylinder shaped cells, residing on a basement membrane. This tissue is found lining the organs of the alimentary tract. Special columnar cells (goblet cells) secrete a thick substance in the alimentary canal called as *mucus*.

Ciliated epithelial tissue: It is a type of columnar epithelial tissue with fine, microscopic hair-like projections on its surface. It covers certain passageways where there wave-like motion propels materials one-way, e.g. in uterine tubes and airway.

Stratified epithelial tissue

This type of epithelial tissue consists of several layers of cells of varying shapes. Usually basement membranes are not present here. Stratified epithelium mainly functions as a protective agent for underlying structures against mechanical wear and tear. It is subdivided into following types;

Stratified Squamous Epithelium: This is composed of a number of layers of cells of different shapes. The deepest layers of the cells are columnar in shape and as they grow towards the surface, they become flattened. This is because of the constant migration of cells from the deeper layers towards the surface. When the surface is reached, the cells die and lose their nuclei.

Non-keratinized stratified epithelium: This tissue is found on wet surfaces subject to wear and tear but are protected from drying ,e.g. conjunctiva of the eyes, lining of vagina, lining of mouth etc.

Keratinized epithelium: This is found on dry surfaces subject to wear and tear i.e. skin, hair and nails. The surface layer consists of dead epithelial cells that contain keratin protein, forming a tough and relatively waterproof covering.

Transitional epithelium: This is composed of several layers of pear-shaped cells and represents a stage between simple and stratified epithelium. Its superficial layer is of flattened cells, intermediate layer is made of longer and polyhedral cells and the lower most layer is made of Cuboidal cells.

Diagrams of different types of epithelial tissues

Connective tissue

It is the most abundant tissue in the body. The cells are more widely separated from each other than in epithelial tissue. Connective tissue connects various structures of the body with each other. It is also called as supporting tissue or communicative tissue. The intercellular substance is more and it usually contains certain fibers which may be semisolid jelly-like or dense and rigid depending upon the position and function of the tissue. Major functions of connective tissue include;

- ✓ Binding and structural support.
- ✓ Transport
- ✓ Protection
- ✓ Insulation

Components of connective tissue

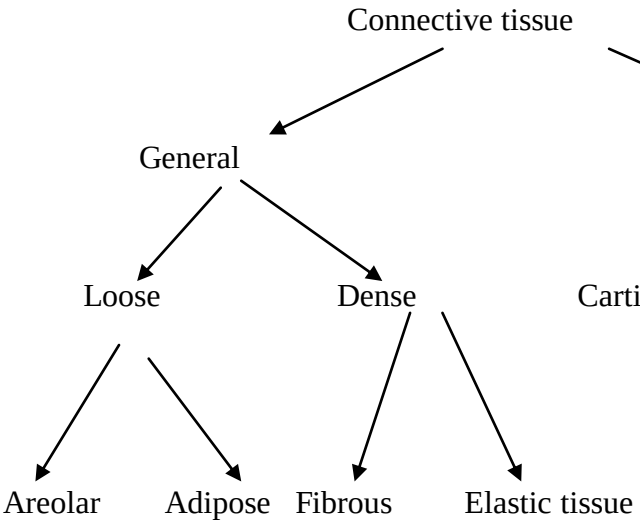
Connective tissue is made up of three basic elements and they are;

1) An amorphous ground substance or intercellular substance(it can be compared to cement)
2) Fibres (can be compared to metal or iron rods)
3) Cells (can be compared to bricks or granite).

Cells of connective tissue:

Connective tissue excluding blood is found in almost all organs supporting the specialized tissue. The different types of cells include fibroblasts, fat cells, macrophages, leukocytes and mast cells. this tissue consists of two types of fibres; white and yellow fibres.

Classification of connective tissue



Loose areolar connective tissue: it consists of a loose network of fibres. It has a semisolid matrix with many fibroblasts, some fat cells, mast cells and macrophages separated by collagen and elastic fibres. It is found in almost all body parts and provides tensile strength and elasticity.

Adipose tissue: it consists of fat cells (adipocytes), containing large fat globules. It has further two types; White adipose tissue and Brown adipose tissue.

White adipose tissue: It makes up about 20-25% of body weight in well nourished adults. It is found supporting the kidneys, eyes, between the muscles and under the skin(acts as a thermal insulator and energy store).

Brown adipose tissue: It is present in newborns. It generates more heat and less energy ,when metabolized hence maintains the body temperature in them. It is also found in some adults but in very small amount.

Dense connective tissue: It contains more fibres and less cells than loose connective tissue.

Fibrous tissue: It consists of closely packed bundles of collagen fibres with little matrix. It is found forming the ligaments(which bind bones together), periosteum(protective covering of bone), protective coverings of kidneys, brain etc and muscle sheaths that become tendons(attaching muscle to bone).

Elastic tissue: It is capable of considerable extension and recoil. It is found in organs where stretching or alteration of shape is required, e.g. in large blood vessels, trachea, bronchi and the lungs.

Blood: this is a fluid connective tissue and is discussed in detail in the separate chapter (Blood).

Cartilage:

It is a special type of fibrous tissue. It is firmer than other connective tissue and cells are called as chondrocytes. It is very strong and forms the framework for the outer part of the nose. It is divided into three types; hyaline cartilage, fibro cartilage and elastic fibro cartilage.

Hyaline cartilage: it is a smooth bluish-white tissue. It provides flexibility , support and smooth surfaces for movement at joints. It is found at long bone endings, in costal cartilages(which attach the ribs to the sternum) and in larynx, trachea and bronchi.

Fibro cartilage: It is made of dense masses of white collagen fibres in the matrix with widely separated cells. It is a tough , slightly flexible ,supporting tissue and is found as semilunar cartilages at articulating surfaces of the knee joint bones, as ligaments ,etc.

Elastic fibro cartilage: This elastic tissue consists of yellow elastic fibres lying in a solid matrix. It provides support and maintains shape of the earlobe(pinna), epiglottis, and part of the tunica media of blood vessels.

Bone

It is the hardest connective tissue of the body. Bone cells (osteocytes) are surrounded by a matrix of collagen fibres strengthened by inorganic salts, especially calcium and phosphate. The fibrous material gives it the toughness while the mineral matter gives it the characteristic rigidity. This tissue forms the skeletal system and is of two types; compact bone and cancellous bone.

Compact bone: It makes up about 80% of the body bone mass. It is made up of a large number of tube shaped units called as osteons (Haversian system), which have well defined characteristics. A central Haversian runs longitudinally and contains blood vessels, lymph vessels , capillaries and nerves. Each central canal is surrounded by series of cylindrical plates of bone called as lamellae, between the lamellae there are spaces called as lacunae containing osteocytes. Lacunae communicate with each other through tiny channels called as canaliculi, lymph carrying nourishment flows through the canaliculi.

Cancellous bone: It is also called as spongy bone. When seen with naked eye it looks like a honeycomb. Microscopically it shows trabeculae (little beams) which are made up of a few lamellae and osteocytes interconnected by canaliculi. The spaces between the trabeculae contain red bone marrow.

Muscular tissue

It is contractile and is therefore able to provide movement. All muscles contain bundles of fibres which run in the same direction. Each muscular fibre is able to contract and relax. There are three types of muscular tissue; 1)Voluntary 2) Involuntary or Smooth muscle and 3) Cardiac muscle.

1) Voluntary Muscle: it is described as skeletal and striated muscle also. It is under the conscious control or under the control of will The muscle fibres are roughly cylindrical in shape and are about 10-40 cm long . Sarcolema is the fine sheath surrounding each muscle fibre and several nuclei are situated under it. The muscle fibres lie parallel to each other and show transverse light and dark bands.

2) Involuntary or smooth muscle: it is described as non-straited or visceral muscle also. The cells are spindle shaped with only one nucleus. It is not under conscious control. It has an intrinsic ability to relax and contract , but autonomic nerve impulses and some hormonal effects also stimulate contractioncontraction of smooth muscle is slower but more sustained than skeletal muscle.it is found in the walls of the hollow organs, blood vessels, lymph vessels, alimentary canal , bladder and the uretors.
3) Cardiac muscle: it is found exclusively in the walls of the heart It is not under the conscious control. The cardiac tissue shows cross strips similar to that of voluntary muscles, each cell has a nucleus and one or more branches. The ends and branches of cells are connected to each other forming intercalated discs. This end to end connectivity is significant in relation to the way the heart contracts. A wave of contraction spreads from cell to cell across intercalated discs, throughout the heart and no external stimulation is required.

Nervous tissue

The nervous tissue carries the special function of carrying the messages or stimuli and responses in the body. The nervous tissue has the property of conductivity and irritability. Nervous tissue is composed of three kinds of matter;

1) Gray matter that forms the nerve cells.
2) White matter that forms the nerve fibres.
3) Neuroglia, which a supporting tissue. It holds together and supports nerve cells and nerve fibres.

The impulses are conducted along the special cells 'neurons' they initiate, receive, conduct and transmit information. Each neuron consists of a nerve cell and its processes (axon and dendrites)

Cell bodies: nerve cells vary considerably in size and shape but they are too small to be seen by the naked eye. These form the grey matter of the nervous system and are found in the periphery of the brain and center of the spinal cord.

Axons and dendrites: these are the extensions of the nerve cells and form the white matter of the nervous system. They are found deep in the brain and at periphery in the spinal cord. They are termed as nerves or nerve fibres outside the brain and spinal cord.

Axons : each nerve cell has only one axon, carrying nerve impulses away from the cell body and are usually longer than the dendrites(sometimes as long as 100cm). the membrane of the axon is called as the **axolemma** and contains axoplasm. Large axons are surrounded by a consisting of a series of schwann cells and fatty substance (myelin) in between them. There are tiny areas of exposed axolemma between adjacent Schwann cells called as *nodes of ranvier*.

Dendrites: These are short processes that receive and carry impulses towards the cell bodies. they are shorter than axons but have same structure. They form part of synapses in motor neurons and sensory receptors in sensory neurons.

Types of neurons:

Sensory or afferent: these nerves transmit impulses from the periphery of the body to the spinal cord and then brain. E.g. sense of taste, smell etc.

Motor or efferent neurons: these carry the impulses from the brain towards the other parts of the body. E.g. stimulating glandular secretions, muscle contraction etc.

Mixed or interconnecting neurons: in the spinal cord sensory and motor neurons are arranged in separate groups but outside the spinal cord when sensory and motor neurons are covered under the same sheath of connective tissue they are called as mixed nerves.

Synapses: there is always more than one neuron involved in the conduction of nerve impulse. The point where axon of one neuron meets the dendrite of another neuron is called as synapse. Various chemical substances called as the neurotransmitters are secreted at the synapse and are involved in the conduction of nerve impulse.

Glands

Glands are groups of epithelial cells that produce specialized secretions. Each gland has a rich blood supply and extracts necessary materials from blood stream, to utilize them in making secretions. Glands are classified as exocrine glands and endocrine glands.

Exocrine glands: these are the glands that discharge their secretions onto the epithelial surfaces either directly or through ducts, e.g. mucus, saliva, etc.

Endocrine glands: These are the glands that discharge their secretions directly into the blood and lymph. Their secretions are hormones, e.g. thyroid hormone, insulin etc.