ANIMAL TISSUE

Introduction : Body of an animal is formed of several kinds of cells. There are about 200 different types of specialized cells in the human body. The cell of one or more kinds are arranged together in a characteristic manner and cooperate to perform a specific role. Such a group of cells is called a tissue. The cell of a tissue may secrete between them a nonliving intercellular material. Thus, a tissue may be defined as a group of one or more types of cells having a similar origin and specialized for a specific function or functions along with the intercellular material.

Branch of biology dealing with the study of tissue is called histology. The term 'tissue' was introduced by *Bichat* and also known as 'Father of histology'. *Mayer* coined the term 'histology' and the founder of histology is *Marcello Malpighi***.** Histological study of an organ called Microscopic Anatomy. *Marcello Malpighi* is the father of microscopic anatomy. *Hertwig* introduced the term 'mesenchyme' for mesodermal tissue. The formation of tissues from germinal layer is called as histogenesis. The tissue classified into four main groups on the basis their location and functions, are Epithelial tissue, Connective tissue, Muscular tissue and Nervous tissue.

1.1 Epithelial Tissue

An epithelium is a tissue composed of one or more layers of cells that cover the body surface and lines its various cavities. It serves for protection, secretion and excretion. The word 'epithelium' was introduced by *Ruysch*. It was applied originally to thin skin covering the nipple (G. *epi* = upon, *thele* = nipple). They are located on the outer surfaces of organs, including the skin. They form the linings of tracts, cavities and vessels. Epithelial tissue evolved first in animal kingdom. It originate from all the three primary germ layers. *e.g.* Epidermis arises from ectoderm, Coelomic epithelium from the mesoderm and epithelial lining of alimentary canal from the endoderm.

(i) **Structure :** Cells are arranged in one or more layers, cells are compactly arranged and there is no inter cellular matrix between them. Neighbouring cells are held together by intercellular junctional complexes like desmosomes, tight junctions, interdigitations etc. the cells of lowermost layers always rest on a non living basement membrane or basal lamina. Basement membrane is made up of no cell product of epithelial tissue. It is formed of mucopolysacharides, glycoprotein and collagen or reticular fibres. The epithelial cells are held together by small amounts of cementing substances is mainly composed of glycoprotein secreted by the cell themselves. Blood vessels are absent in the epithelial tissues. However, nerve endings may penetrate the epithelium. The free surface of cells may be smooth or may have fine hair like cilia, sterocilia and microvilli. Epithelium is subjected to continuos wear and tear and injury. Hence it posses very high capacity of renewal (mitotic cell division). The following types of modifications and junctions are found in the plasma membrane of adjacent epithelial cells to keep the cells together.

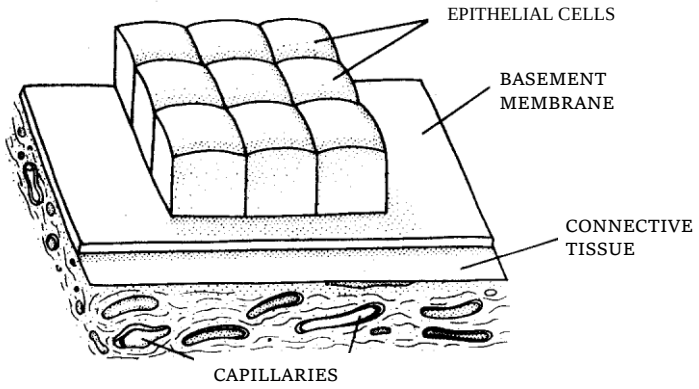


Fig. – Diagram to show an epithelium with its basement membrane resting upon

(a) **Microvilli :** It is simple and minute cytoplasmic processes arising from free exposed surfaces of the cell. They absorb material.

(b) **Stereocilia :** It is non-motile cytoplasmic processes.

(c) **Cilia :** It is contractile motile fibrous processes arising from basal granules.

(d) **Tight junctions (Zona occludens) :** At certain places the plasma membranes of adjacent cells are tightly packed or even fused together.

(e) **Desmosomes :** Desmosome is present in epithelial tissue. They consist of thickened area and several fine tonofibrils extending from each plasma membrane into cytoplasm of respective cells. Macula adherens is a kind of desmosome.

(f) **Gap junction :** At place, the adjacent cells form ion-rich gap junctions for intercellular communication and chemical exchange. These junctions probably do not provide physical support.

(g) **Interdigitations :** These are interwoven finger-like processes of plasma membranes of adjacent cells.

(h) **Intercellular bridges :** These are minute projections that arise from adjacent cell membranes. The intercellular bridges make contact with one another.

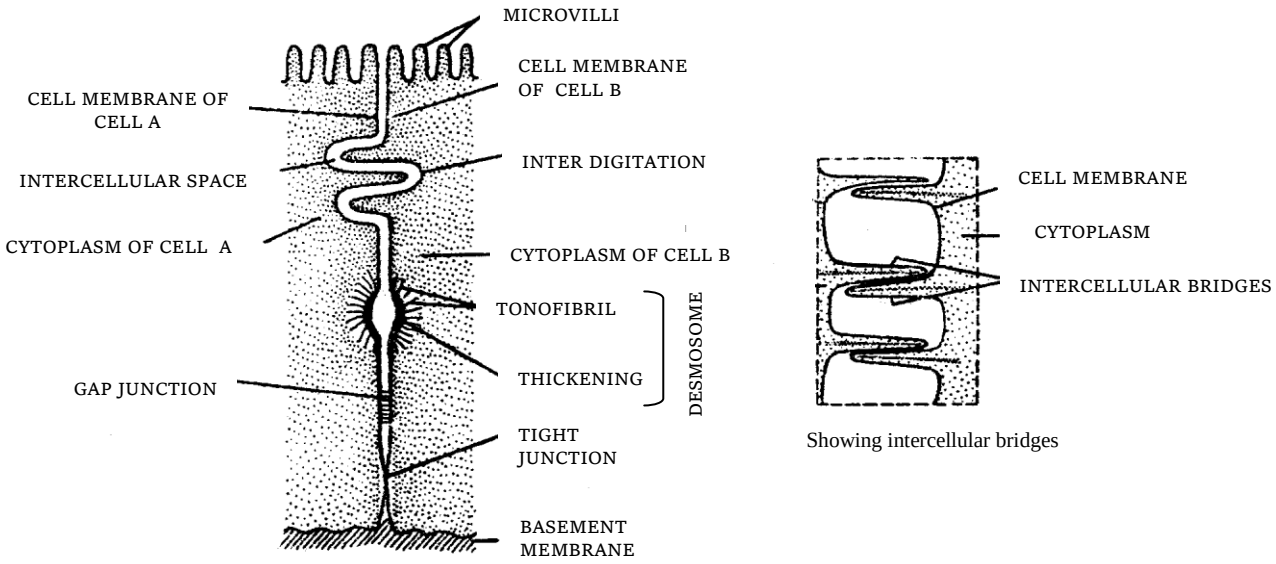


Fig. – Electron microscopic view of two adjacent epithelial cells, basement

(ii) **Functions :** Epithelial tissues have a wide spread distribution throughout the body and serve several important functions –

(a) **Protection :** Generalized protection is the most important function of membranous epithelium. It is the relatively tough and impermeable epithelial covering of the skin that protects the body from mechanical and chemical injury and also from invading bacteria and other disease causing micro-organisms.

(b) **Sensation :** Epithelial structures specialized for sensory functions are found in the skin, nose, eye and ear.

(c) **Secretion :** Glandular epithelium is specialized for secretory activity, secretory products include hormones, mucous, digestive juices and sweat.

(d) **Absorption :** The epithelium lining of the gut and respiratory tracts allows the absorption of nutrients from the gut.

(e) **Excretion :** It is the specialized epithelial lining of kidney tubules that makes the excretion and concentration of excretory products in the urine.

(f) **Conduction :** Ciliated epithelium moves fluid, mucous and other materials in the organs it lines.

(g) **Reproduction :** Germinal epithelium of the seminiferous tubules and ovaries produces spermatozoa and ova respectively.

(h) **Regeneration :** The ability of epithelia to regenerate quickly helps in the healing of wounds.

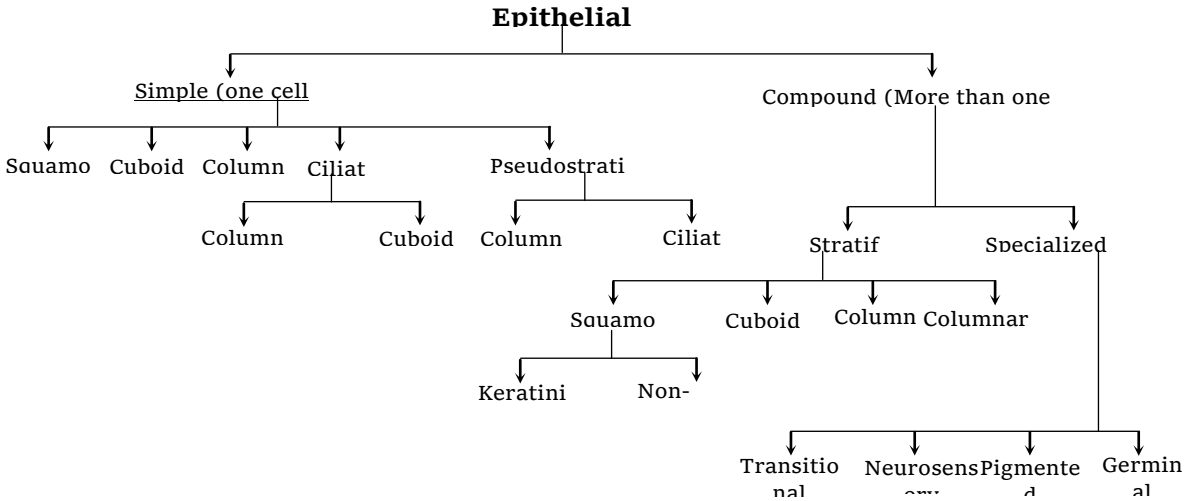
(i) **Pigmentation :** Pigmented epithelium of retina darkens the cavity of eyeball.

(j) **Selective barrier :** The epithelia check the absorption of harmful or unnecessary materials.

(k) **Respiration :** Epithelium of alveoli of the lungs brings about exchange of gases between blood and air.

(l) **Exoskeleton :** Epithelium also produce exoskeletal structures such as scales, feathers, hair, nail, claws, horns and hoofs.

(iii) **Classification of epithelial tissue :** It is mainly based on the location and functions of tissue.



(a) **Simple epithelium :** It is simple in structure and basically formed by single layer cells.

(1) **Simple squamous epithelium :** It is consists of only one layer of flat, scale like cells, usually polygonal cells which are closely fitted together like the tiles of a mosaic. It is also known as pavement epithelium. There is a round nucleus in the centre of cell and covers those moist places where friction causes wear and tear such as inner lining of cheeks and associated with filtration and diffusion in mammalian tissue. Blood and lymphatic vessels linings are called endothelium and surface of the pleura, pericardium and peritoneum are called mesothelium**.** The cells of endothelium and mesothelium become wavy and called tessellated. e.g. It forms lining of blood vessels, lymph vessel, heart, peritoneum, pleura, Bowman's capsule, inner surface of tympanic membrane, thin segment of loop of Henle and lung alveoli.

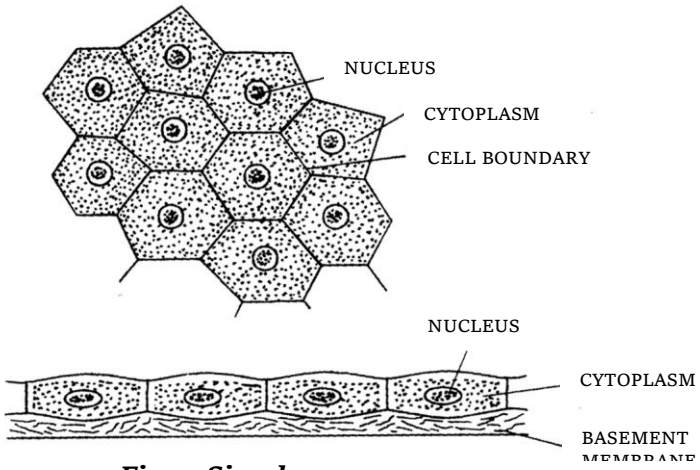


Fig. – Simple squamous

(2) **Simple cuboidal epithelium :** The simple cuboidal epithelium is composed of one layer of cuboidal shaped cells resting on a basement membrane. The nuclei are situated centrally. The cells of cubical epithelium often form microvilli on their free surface border called brush bordered cuboidal epithelium. e.g. the cubical epithelium is present in the small salivary and pancreatic ducts, thyroid vesicles, parts of membranous labyrinth, nephrons of kidneys, ovaries, seminiferous tubules of testes, ciliary bodies, choroid, iris of eyes, thin bronchioles and sweat gland of mammalian skin.

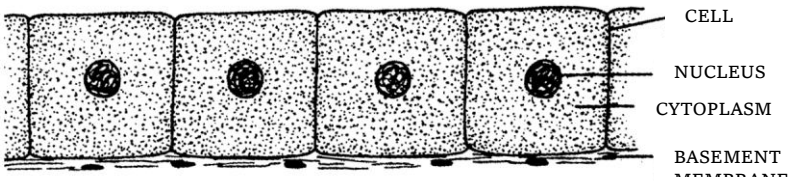


Fig. – Simple cuboidal

(3) **Simple columnar epithelium :** It consists of a single layer cells, many of which have modified structure. Three common modifications are goblet, cilia and microvilli. In the intestine plasma membranes of many columnar cells extend out in hundreds and hundreds of microscopic finger like microvilli, to increase the absorptive surface area and is called brush bordered columnar epithelium Certain cells of this epithelium contain mucous or goblet cells along with under lying supporting connective tissue is called mucous membrane. Simple columnar epithelium is present in the stomach and intestine. e.g. located inner lining of gall bladder and bile duct. It also occurs in the gastric gland, intestinal glands, pancreatic lobules, respiratory bronchioles and PCT (Proximal Convoluted Tubules).

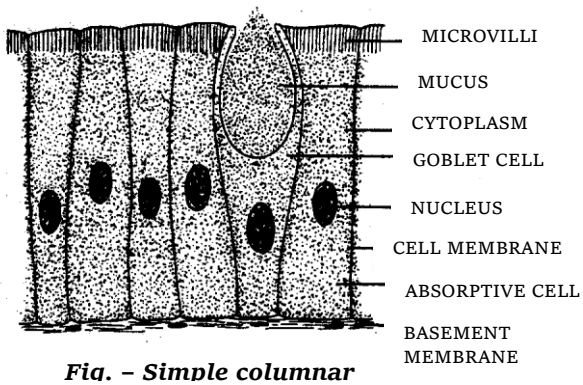


Fig. – Simple columnar

(4) **Simple ciliated epithelium :** It bears numerous delicate hair like outgrowths called cilia arising from basal granules help to create a current to transport the materials. The ciliated epithelium is of two types –

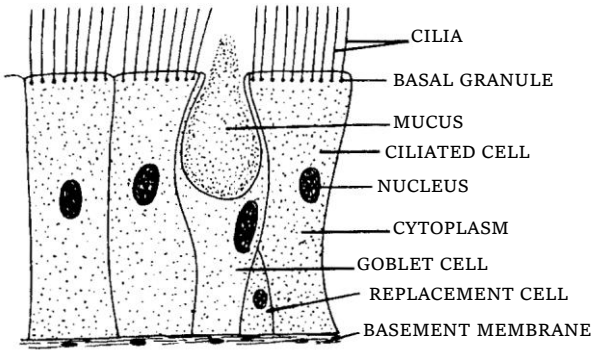


Fig. – Simple columnar ciliated

(i) **Ciliated columnar epithelium :** It lines respiratory tract, fallopian tubes (oviducts), ventricles of brain (ependyma), central canal of spinal cord, tympanic cavity and auditory tube (Eustachian tube).

(ii) **Ciliated cuboidal epithelium :** It occurs in certain parts of nephrons of the kidneys.

(5) **Pseudostratified columnar epithelium :** It is always consist of single layer of irregularly shaped columnar cells, touches the basement membrane. The cells are of differing heights and many are not tall enough to reach the upper surface of the epithelial sheet. Being unequal sized cells, their nuclei lie at different levels. The long cells have oval nuclei however, short cells have rounded nuclei although epithelium is one cells thick, but it gives the appearance of a stratified epithelium, hence it is called pseudostratified epithelium. Mucous secreting goblet cells are numerous and cilia are present. It is of two types –

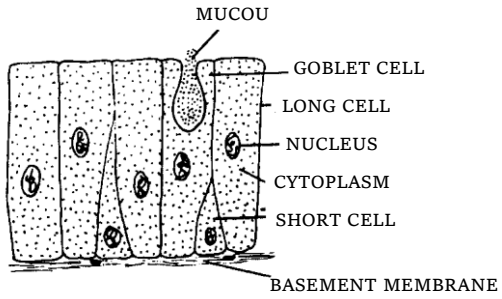


Fig. – Pseudostratified

(i) **Pseudostratified columnar ciliated epithelium :** It is found in the lining of trachea and bronchi.

(ii) **Pseudostratified columnar epithelium :** It is found in certain segments of human male urethra and parotid salivary gland, vasa deferentia and epididymis.

(b) **Compound epithelium :** It is complexed in structure and basically formed by two or more than two layers of cells.

(1) **Stratified squamous keratinised epithelium :** Stratified squamous epithelium is characterized by multiple layers of cells with typical flattened squamous cells at the free or outer surface of the sheet. The presence of keratin in these cells contributes to the protective qualities of skin covering the body surface. Keratin is dead and waterproof so it protects the underlying tissues from abrasion and infection e.g. epidermis of the skin of land vertebrates.

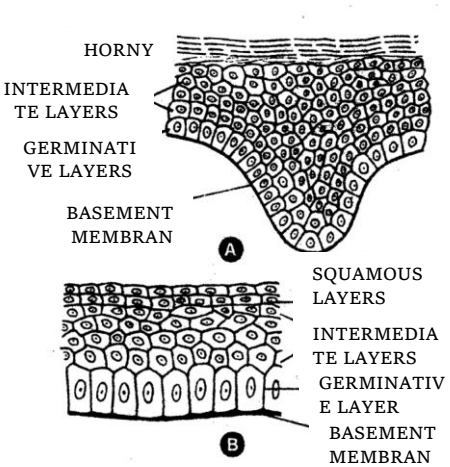


Fig. – Stratified squamous epithelium

(2) **Stratified squamous non keratinised epithelium :** Its free surface is moist, and the outer epithelial cells, unlike those found in the skin, do not contain keratin. This type of epithelium serves a protective function. It is found lining the oral cavity (buccal cavity), pharynx, oesophagus, anal canal, lowerpart of urethra, vocal cords, vagina, cervix (lower part of uterus) and conjunctiva of eyes.

(3) **Stratified cuboidal epithelium :** It is consists of two or more rows of low cuboidal-shaped cells which are arranged randomly over a basement membrane. It is found in the sweat gland ducts, larger salivary and pancreatic ducts.

(4) **Stratified columnar epithelium :** It is protective epithelium has multiple layers of columnar cells, only the most superficial cells are truly columnar in appearance. Epithelium of this type is rare. It is found in male urethra and in the mucous layer near the anus. It also lines mammary gland ducts and epiglottis.

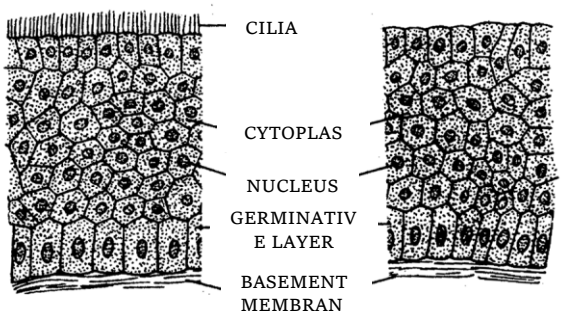


Fig. – Stratified columnar ciliated

Fig. – Stratified columnar epithelium

(5) **Stratified columnar ciliated epithelium :** It lines the larynx and upper part of the soft palate.

(c) **Specialized epithelium :** This type of epithelium are specialized to perform specific activity hence, specialized in structure also. They are as follows –

(i) **Transitional epithelium (Urothelium) :** It is often consists ten or more layers thick. It lacks germinative layer, basement membrane. Stratified transitional epithelium is typically found in the body areas such as the wall of urinary bladder, ureter and renal pelvis. It is located in all the hollow viscera subjected to stress and protects organ wall from tearing.

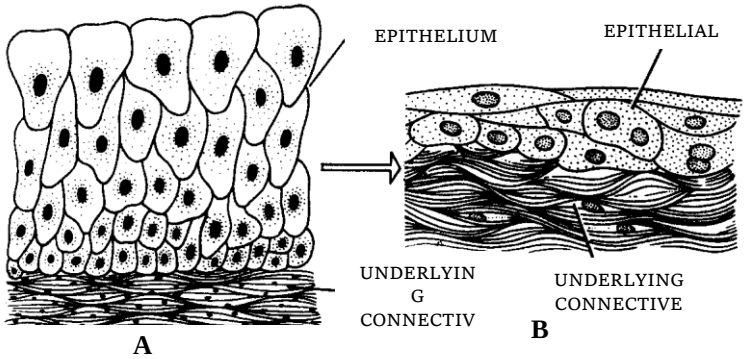


Fig. – A and B. Transitional epithelium in wall of nondistended and distended urinary

(ii) **Neurosensory epithelium :** Olfactory mucosa, called Schneiderian membrane, lining of internal nares, retina of eyes and epithelial covering of tongue containing taste buds are examples of neurosensory epithelia. These contain neurosensory cells, singly or in groups, interspersed between epithelial (supporting) cells. The sensory cells bear, at their free ends, slender "sensory hairs" to receive specific stimuli. Basely, these cells are connected, by means of synapses, with fine fibrils of sensory nerves.

(iii) **Pigmented epithelium :** The epithelial cells of the basal layer of retina contain pigment. Hence, this layer is often referred to as a pigmented epithelium. e.g. – Pigmented layer of retina, iris and skin.

(iv) **Germinal epithelium :** Specialized cuboidal cells capable of producing gametes as found in gonads. Germinal epithelium produces gametes e.g., ova (Female gametes) and sperms (Male gametes)

1.2 GLANDS

Glandular epithelium are specialized for secretory activity. A cell, tissue or organ which secretes a useful chemical material is known as gland. Glands are made up of cuboidal epithelial cells which are more secretory. All glands arise as folding of epithelia. The golgi body in gland cells are larger and more secretory. Most of the glands of body are merocrine types. It originate from all three germinal layers. (ecto, meso and endoderm). Liver is the largest gland of the body and lined by glandular epithelium.

(i) **Types of glands**

(a) **Unicellular gland :** It consist of unicellular gland cells which are called as goblet cells or chalice cells. They secrete mucous and found in mucosa of intestine and stomach. Mucous lubricates the food for easy peristalsis. Their life span is about 2–3 days.

(b) **Multicellular gland :** It consist of many cells and are generally located in underlying connective tissue *e.g.* gastric and intestinal glands.

(c) **Exocrine gland :** These are those glands which discharge their secretory products into ducts. It is also called ducted glands or glands of external secretion. e.g. Salivary glands, Mammary glands and Tear glands.

(d) **Endocrine gland :** It is often called ductless gland, because they discharge their secretory products (hormones) directly into the blood. e.g. Pituitary gland, thyroid, parathyroid and adrenal glands.

(e) **Heterocrine gland :** These are those glands which are partly endocrine and partly exocrine in function. e.g. Pancreas.

(ii) **Structural classification of exocrine glands :** Multicellular exocrine glands are classified by structure, using the shape of their ducts and the complexity (branching) of their ducts system as distinguishing characteristics. Shape include tubular and alveolar (Sac like). Simple exocrine glands *e.g.* intestinal glands, mammalian sweat glands, cutaneous glands of frog etc. have only one duct leading to surface. Compound exocrine glands have two or more ducts *e.g.* liver, salivary glands etc.

Type	Example
Simple tubular	Intestinal glands, crypts of Lieberkuhn in ileum.
Simple coiled tubular	Sweat glands in man
Simple branched tubular	Gastric (stomach) gland, and Uterine gland.
Simple alveolar	Mucous gland in skin of frog, Poison gland of toad and seminal vesicle.
Simple branched alveolar	Sebaceous glands
Compound tubular	Brunner's gland, bulbourethral gland and liver.
Compound alveolar	Sublingual and submandibular parotid salivary gland
Compound tubulo alveolar	Parotid salivary glands, Mammary gland and Pancreas.

(iii) **Classification of glands on the basis of their mode of secretion –**

(a) **Apocrine gland :** Apocrine glands collect their secretory products near the apex or tip, of the cell and then release it into a duct by pinching off the distended end. This process results in some loss of cytoplasm and damage to the cell. e.*g.* Mammary glands. (Modified sweat gland)

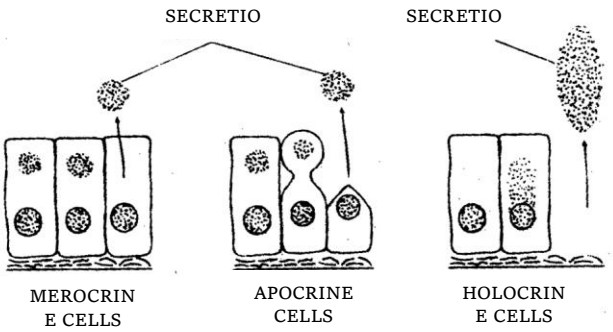


Fig. – Types of glands regarding the mode of secretion

(b) **Holocrine gland :** Holocrine glands collect their secretory products inside the cell and then rupture completely to release it. These cells self destruct to complete their functions. e.*g.* Sebaceous glands. In case of rabbit sebaceous glands are found in dermis of skin. Pineal body and thymus can also be considered as holocrine gland.

(c) **Merocrine gland :** Merocrine glands (Eccrine or Epiccrine glands) discharge their secretory product directly through the cell or plasma membrane, without injury to the cell wall and without loss of cytoplasm. *e.g.* Sweat glands, exocrine region of vertebrate pancreas, salivary glands and intestinal glands etc.

(iv) **Classification of glands on the basis of nature of product**

(a) **Mucous gland :** Secret slimy mucous e.g. goblet cells, palatine gland, gland of uterus, some gastric gland and gland of colon.

(b) **Serous gland :** Produce watery secretion. e.g. pancreas, parotid, salivary gland, sweet gland and intestinal gland.

(c) **Seromucous gland :** Secrete mixed liquid. e.g. Most gastric gland, sublingual, submaxillary salivary gland.

(d) **Cytogenic gland :** They produce cells e.g. Testis and ovary.

Important Tips

- Study of tissue outside the body in a glass tube is known as in vitro, while study of living tissues in situ is known as in vivo.
- Among epithelia, simple epithelia were first to evolve.
- Transitional epithelium also called plastic epithelium or urothelium. It lacks basement

membrane

- False epithelium derived from mesenchyma (a diffuse network of tissue derived from embryonic mesoderm) and lining the synovial cavities.
- Mammary glands without teats are present in prototheria.
- A malignant tumour arising from an epithelium is called a carcinoma. If it arises from a squamous epithelium it is a squamous cell carcinoma and if it arises from glandular epithelium it is called an adenoma.
- The epithelial lining of brain ventricles and central canal of spinal cord is known as ependyma.
- Stereocilia are elongated membrane outgrowths found in certain parts of male reproductive tract.
- The cuboidal or columnar cells of germinative layer rest upon a basement membrane and continuously divide mitotically to produce new layer of cells.
- Brush bordered cuboidal epithelial cells bear microvilli on their free ends.
- Myoepithelium made up of fusiform or stellate cells capable of contraction.
- Basement membrane of epithelial tissue is non-cellular.
- Recent work suggests that basement membranes may play a role in cell-organisation as molecules within the membrane interact with receptors on cell surfaces substances present in the membrane may influence morphogenesis of cells to which they are attached.
- Cilia are fine fibres having 9 + 2 internal structure and connected with cell internally by basal granules.
- In frog and snakes, moulted skin is stratum corneum of flat cells. Sweat glands of skin of mammals are simple coiled tubular glands while those of armpit are simple branched tubular glands.
- Bartholins duct is lined by cuboidal epithelium.
- Stereocilia present in Epididymis.

1.3 Connective tissue

It connects and supports all the other tissues, the intercellular element predominating. The cellular element is usually scanty. In function this tissue may be mechanical, nutritive and defensive. It is a tissue made up of matrix (abundant intercellular substance or ground substance) and living cells that connects and support different tissues. Connective tissue was called mesenchyme by Hertwig (1893). Connective tissue is one of the most widespread tissue in the body, found in or around every organ of the body constituting about 30% of body mass and present between ectoderm and endoderm. All connective tissues in the body are formed by mesoderm.

(i) **Structure :** There are large intercellular spaces between the cells. Intercellular spaces are filled with large amount of extracellular materials formed of insoluble protein fibres lying in an amorphous, transparent ground substance called matrix. Ground substances is formed of mucopolysaccharides chondritin–6–sulphate of hyaluronic acid. Ageing of an animal body is associated with deterioration in its connective tissues. With advancing age, the amount of the jelly like amorphous ground substance in connective tissues of the body decreases, while the fibres become thicker and more numerous. Moreover, calcium salts get deposited in the elastin fibres of all connective tissues and particularly those of the wall of blood vessels. Consequently, the connective tissues gradually lose elasticity, resiliency and normal tone. Wrinkles in skin, poor blood supply to various tissues due to hardening of the wall of blood vessels etc., are the ultimate results of this ageing process.

(ii)**Functions**

(a) **Attachment :** Their chief function is to bind other tissues together in the organs.

(b) **Storage :** Certain connective tissues such as adipose tissues store fat.

(c) **Support :** Skeletal connective tissues like bones and cartilages provide the body with a supporting skeletal frame work.

(d) **Transport :** Fluid connective tissues such as blood and lymph transport various materials in the body.

(e) **Defence and Scavenging :** Plasma cells synthesize antibodies, viz., macrophages. Lymphocytes ingest cell debris, harmful bacteria and foreign matter. Thus these cells of connective tissues are protective in function.

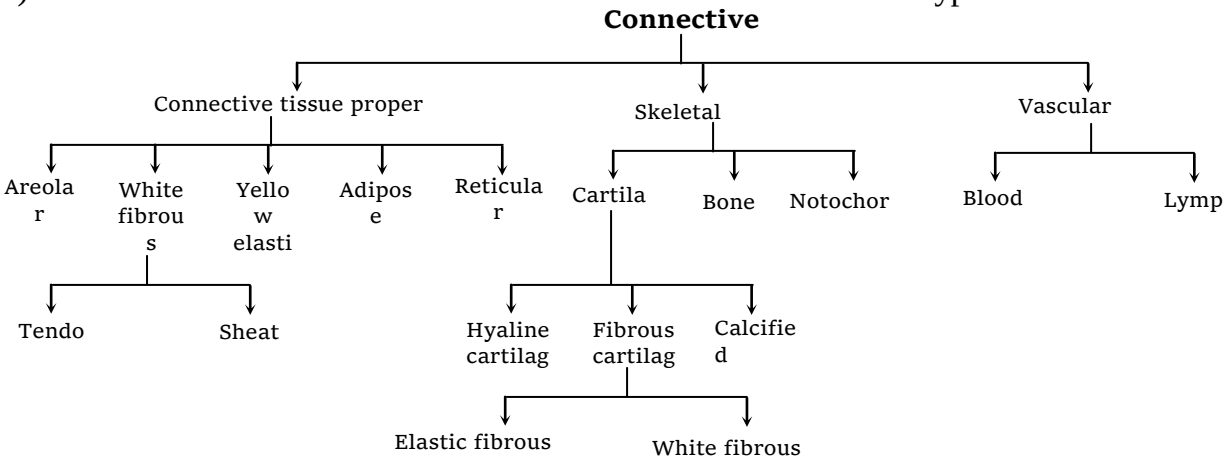
(f) **Shock-proof cushions :** The jelly-like ground substance of connective tissues acts as shock absorber around some organs such as eye balls and kidneys.

(g) **Formation of blood corpuscles :** The bone marrow produces blood cells.

(h) **Packing material :** Areolar tissue acts as packing material in various organs.

(i) **Repair :** Collagen fibres of connective tissue help in repair of injured tissues.

(iii) **Classification of connective tissues :** It is classified into three types –



1.4 CONNECTIVE TISSUE PROPER

Connective tissue proper possess soft viscous semisolid or semi-fluid matrix.

(i) **Areolar Tissue :** Areolar tissue is loose connective tissue, possess transparent gelatinous, highly vascular and sticky matrix which have variety of cells and fibres. It allows movement of part connected by it (Muscle and their compound). Areolar tissue mainly consist of different types of cells and fibres.

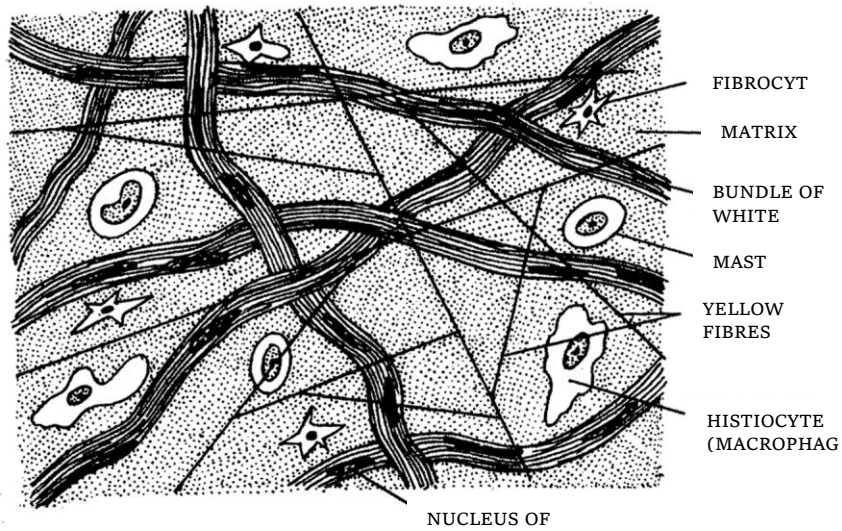


Fig. – Areolar connective

(a) **Cells of areolar tissue :** It has following types –

(1) **Fibroblast :** It is most abundant cells, produces fibres, called as fibroblasts in their young active phase and fibrocytes when old and inactive. It synthesize proteins (Collagen, elastin and reticulin). These are undifferentiated mesenchyme stem cells, capable to give rise other cells of connective tissue. Collagen and elastin are formed by fibroblasts.

(2) **Histiocytes or Macrophages or Clasmatocytes :** These are polymorphic cells. These are amoeboid cells and these are main phagocytes of connective tissue. They are having most active lysosomes and phagocytise dead cells and pathogens. Some of these are called "fixed macrophage" bearing filopodia (Stellate cells) others called "wandering macrophages". It perform "mopping up" operations. Macrophages remove the dead cells and damaged cells and clean the body so called scavenger cell. All types of macrophages take part in phagocytosis.

Macrophage

Monocyte	Alveolar Phagocyte	Dust cells	Microglia	Astrocytes (Spinal	Reticular cells (Reticulo endothelial	Kupffers cells (Liver)

(3) **Reticular cells :** Present only in the reticular tissue and stellate in appearance. Infact they are modified fibroblast producing reticular fibres.

(4) **Mast cells :** Mast cells were discovered by *Paul Echrlich*. It is large, irregular ovoid cells found in areolar tissue. and its number increase during allergies. It produces or secretes histamine (vasodilator), serotonin (vasoconstrictor) and heparin (anticoagulant). Histamine dilate the blood vessels in allergic and inflammatory conditions. Heparin checks the clotting of blood inside the blood vessels. Serotonin act as vasoconstrictor to arrest bleeding.

(5) **Lymphocytes :** These are the smallest, less numerous and spherical or ovoid cells resembling lymphocytes of blood and lymph. These actively move about by pseudopodia. Their function is to form and carry antibodies. That is why, they are seen in large numbers of sites of inflammation.

(6) **Plasma cells (Plasmacytes) :** These are usually small and rounded, superficially resembling lymphocytes but are sluggishly amoeboid and short-lived (only 2 or 3 days). These are the most potential antibody-forming cells of body presumably, mature lymphocytes (B-lymphocytes form antibody) transform into plasma cells or proliferate to form plasma cells.

(7) **Fat or Adipose cells (Adipocytes or Lipocytes) :** A few, large and spherical cells occur in areolar tissue, singly or in clusters around small blood vessels. Each cell contains a large globule of fat surrounded by a thin peripheral layer of cytoplasm having a nucleus.

(8) **Eosinophils :** These cells closely resemble the eosinophilic leucocytes of blood. These probably play a phagocytic role in inflammatory and allergic reactions.

(9) **Chromatophores :** These are pigment cell present in specialised areas such as skin and eye. They are much branched and packed with pigment granules. They are stellate (Star like) cells, which are phagocytic in nature. They phagocytes melanin producing cells and retain melanin hence they provide colour to the skin and other organs. Melanin is black pigment which protects body from ultraviolet rays of sun.

(10) **Mesenchyme cells :** These are reserve undifferentiated cell which can be transformed into other types of cells when needed.

(b) **Fibres of areolar tissue :** These are made up with protein and non living structures of protein produced by fibroblasts and present in matrix of connective tissue and are of three types –

(1) **Collagenous fibres :** These are the most abundant fibrous element of areolar and other connective tissues. There are long, unbranched fibres of a soluble and shining collagen protein (tropo collagen). Some fibres and slender and straight, but most are coarse and wavy. In fact, the coarse fibres are bundles of slender fibres. Each slender fibre is, in turn, a bundle of fine fibrils, and a fibril is formed of microfibrils, which are aggregates of filamentous *tropocollagen molecules*. These fibres are more strengthful and provide maximum tensile strength. These are colourless and hyaline, yet called white fibres to distinguish them from yellow elastin fibres. When boiled in water, collagen (an albuminious protein) changes into gelatin. Collagen protein is the most abundant protein of the body constitutes 25% the total body protein. Collagen fibre can be stained by eosin. When collagen fibres are removed from the areolar tissue they become loose and elastic.

(2) **Yellow elastin fibres :** Formed of elastin protein, these fibres are less numerous, thinner, branched, anastomosing, and of a pale yellow colour. These are very elastic and remain streched due to tension in the areolar tissue, when broken in teased preparations, these coil and curl like tense wires. Elastin is probably the most resistant of all body proteins to chemical changes. Thousands of years old 'mummies' still have their arteries intact due to well-preserved elastin fibres. They are the orceinophilic i.e. stained by orcein.

(3) **Reticulin fibres :** These are delicate, freely branching and inelastic fibres of reticulin protein, found interwoven, to form networks. These are very abundant in embryos, new born babies and in healing and regenerating wounds. In areolar tissues of adults, these are mostly replaced by collagen fibres, but remain abundant in lymphoid and blood forming tissues and in the stroma of pancreas, liver

etc. Chemically, reticulin is also a type of collagen. Refractive index is similar to ground substance, so without stain they can't be seen. They are stained with *AgBr* and $AgNO_3$ hence are called Argentophillic or Argyrophillic. On boiling collagen and reticular fibres both convert in glue.

(ii) **White fibrous tissue :** It is modified form of areolar tissue. Only collagen fibres are present in the matrix and cells are mainly fibroblasts, present at the joints between skull bones and makes them immovable, also found in the dermis of higher mammals. It is of two types :

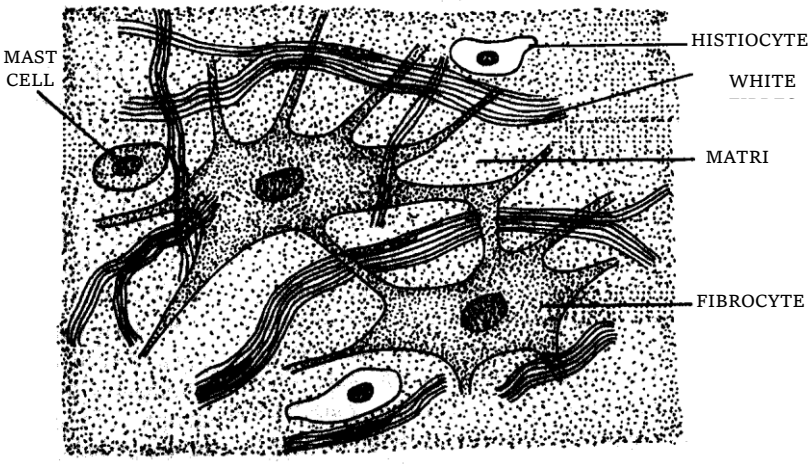


Fig. – White fibrous tissue

(a) **Tendons :** A tendon is non-elastic but flexible tissue consists of parallel bundles of collagenous fibres between which rows of fibroblasts are present. It joins the muscles to bones. It also form chordae tendinae which joins the cusps of atrioventricular valves of heart with the wall of ventricles.

(b) **Sheath :** In a sheath, the bundles of white fibres lie in a criss-cross manner. The fibroblasts are not in rows but are scattered in the areolae. The sheath form protective covering.

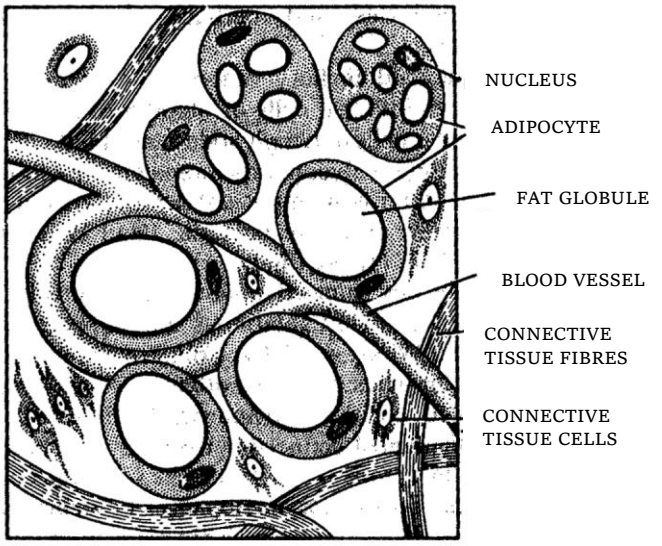


Fig. – Adipose connective

(iii) **Yellow fibrous tissue :** The matrix is with numerous and closely packed yellow or elastin fibres which are similar to but thicker than those of areolar connective tissue. Fibroblasts are scattered irregularly in the matrix. A few bundles of small sized white fibres are also present. It is elastic and flexible. It forms wall of blood vessels, lungs, true vocal chords, trachea, capsule of spleen and bronchioles. It also forms sheet in ligaments. Ligaments is a modified yellow elastic fibrous tissue and connects bone to bone.

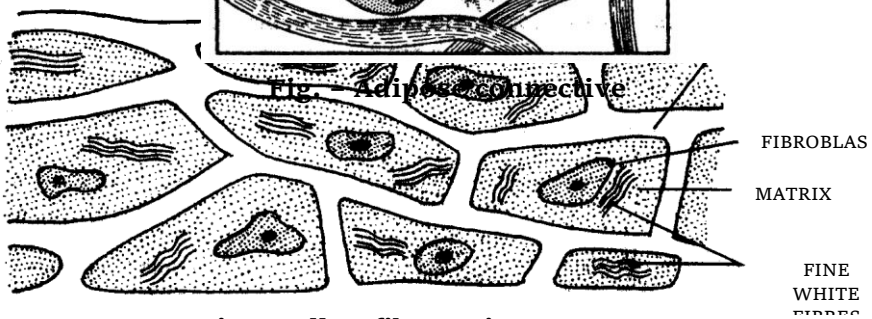


Fig. – Yellow fibrous tissue

(iv) **Adipose tissue :** It is modified form of areolar tissue made up of specialized large spherical fat cells (below the skin) or adipocytes. Mast cells and eosinophils also occur but other cell types are uncommon. Adipose tissue chiefly act as "Food reserves" or fat depots for storage and metabolism of lipids. Besides this, they also act as heat insulators and pressure, pull and push

absorbers. Panniculus adiposus under the skin of human beings is partly responsible for difference in the body contours of man and women. Adipocytes are of two types :

(a) **Unilocular adipocyte (White adipose tissue) :** Common fat of body, having single large fat globule, maintain body temperature, found beneath skin subcutaneous fat panniculus adiposus, blubber of whales and elephants, hump of camel and tail of merino sheep, yellow bone marrow, around kidneys and blood vessels, mesentries, omenta and the fat bodies of frog.

(b) **Multilocular adipocyte (Brown fat) :** Each multilocular adipocytes have several small fat globules, contain more number of mitochondria, found in rats and other rodents, polar bear, penguins, seal, walrus, in new born human babies and hibernating mammals (rats and other rodents) on oxidation it yields about 20 times more energy than ordinary fat.

(v) **Reticular tissue :** It is a modified form of areolar connective tissue characterized by the matrix is fluidy in nature. The matrix contains large number of stellate-shaped reticular cells, each with a number of protoplasmic processes. The protoplasmic processes of adjoining cells are interconnected to form a close network. The reticular cells secrete reticular fibres formed of a protein called reticulin. Reticular tissue is found in spleen, thymus, tonsils, lymph glands, liver, bone-marrow, lamina propria of mucosa of stomach and intestine. The reticular cells act as phagocytes and form a part of defence system of the body. Phagocytic endothelial cells of blood vessels in bone marrow and liver (kupffer cells), reticular cells of lymph nodes and spleen, macrophages of areolar tissue, dust cells of pulmonary alveoli and monocytes of blood constitute a reticulo-endothelial system. The latter is an important defence system of body, because its various components remove infective bacteria, dead cells and harmful foreign matter from blood, lymph and tissue fluid.

Important Tips

- Argentaffin cells which produce a precursor of serotonin, a potent vasoconstrictor hormone, occurs in intestinal cells.
- The brown adipose tissue in human is restricted till third month of post natal life.
- White fibres yield gelatin on boiling and are digestible with enzyme pepsin but yellow (elastic) fibres are not digestible by enzyme trypsin.
- The fat in the globules is stored in the form of triglycerides.
- The Cytoplasmic granules basophils contain histamine.
- Sprain – Excessive pulling of ligaments.
- Myeloid tissue – It is modification of reticular tissue. Its ground substance is plasma. It posses heavy network of reticular fibres. In active form the cells are myeloblasts. It is found in red bone marrow or haemopoitic tissue and fat reserve of yellow bone marrow.
- Mucoid tissue – An embryoid tissue found in umbilical cord also called wharton's jelly. It is most primitive type of tissue, found in vitreous humour of eye and cock's comb.
- Heparin – A polysaccharides made of glucosamine, glucoronic acid and sulphuric acid secreted

by mast cells, also from liver and other organs, prevents conversion of prothrombin into thrombin, neutralizes the thrombin already formed.

- Plasma cells are also called as "Cart wheel cells".
- Collagen constitutes about 33% of total body protein.
- Mummies – Preservation of elastic fibres of body by chemical treatment.
- Red muscle fibres are rich in mitochondria.
- The term "blubber" refers to a subcutaneous deposition of fat in whales.
- Aponeurosis – Bands of white fibrous connective tissue in which fibres are thinner and interwoven. It is flat tendon which also connects muscle to bone or bone to bone. It may also connect muscle to muscle.
- Brown fat also called "hibernating gland" as found in hibernating mammals. Each brown fat is polylocular and contains iron containing cytochrome pigments. Brown colour is due to cytochrome oxidase enzyme.
- Morfan syndrome – It is a genetic disease related to defective connective tissue specially collagen and elastin fibres. Person have long hands long fingers and have abnormal face and person may have cardiac problems.
- Ligamentum flava – connects adjacent vertebrae and the ligaments between the phalanges, fingers and toes.
- Ligamentum nuchae – Found in the neck of quadrapeds to bear the weight of head when grazing.
- Pigmented connective tissue – Connective tissues of choroid and iris of eyes and skin dermis (corium) or black people contain large and branched (stellate) pigment cells or chromatophores (melanophores) which are laden with yellowish brown, black or blue melanin pigment granules. These are, therefore, called pigmented connective tissues. Melanin is, in fact, produced by other cells called melanocytes. Chromatophores simply phagocytes the melanin from melanocytes like macrophages.

1.5 Skeletal tissue

It provide support and surface for attachment of muscle. Skeletal connective tissue form the frame work of body. It provide rigidity to body. These protect the various organ and help in locomotion. It is of three types.

(i) **Cartilage :** Cartilage is a solid but semi-rigid and flexible connective tissue. Cartilage is a nonvascular connective tissue, consisting of cells embeded in a resilent matrix of chondrin. Chondrin is a protein of cartilage. Cartilage differs from other connective tissue in that only one cell type the chondrocytes is present; Chondrocytes are found in small opening called lacunae. Chondroblast, a cartilage forming cells are embeded in firm, translucent matrix younger cartilage are possesing phagocytic cells called chondroclasts which eats up extra matrix of cartilage to provide new shape to

the cartilage. It is a vascular so, nutrient must reach by process of diffusion movement is through the matrix from blood vessels located in a specialized connective tissue membrane called perichondrium, a outer covering of cartilage. Regeneration of cartilage can occur from its peri-chondrium. Cartilage is said to be metabolically nearly inactive. In kids the cartilage cells show 2 types of growth.

- **Appositional or Perichondral or Secondary or Exogenous growth :** It is due to deposition of matrix and division of chondrogenic cells of periphery. It leads to growth in thickness.

- **Endogenous or Interstitial growth :** It is due to deposition of matrix and division in inner cells of cartilage. It leads to growth in size.

(a) **Types of cartilage :** It is of following types –

(1) **Hyaline cartilage :** It is most primitive and glass like cartilage. Its matrix is transparent homogenous and pearly white or bluish green in colour, contain chondrin. When the chondrocytes or cartilage cells are arranged in groups of two, four etc. in a single lacuna it is called a cell nest. It is slightly elastic and also known as articular cartilage because it forms the articular surface of joints. Hyaline cartilage is found in trachea, larynx and bronchi, limb bones (called hyaline cap), sternum, in the hyoid apparatus nasal septum, ribs (sternal parts) larynx (cricoid, thyroid), nasal cartilage (nasal septum).

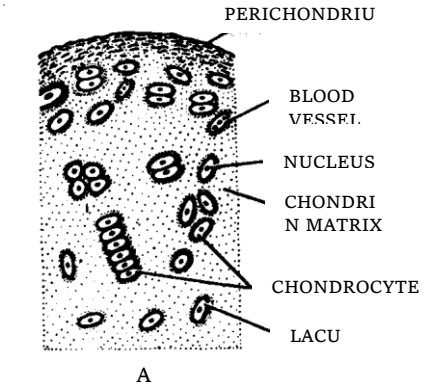


Fig. – Hyaline cartilage

(2) **Fibro cartilage** (White fibrous cartilage) **:** In this cartilage, the small amount of matrix of cartilage is packed with large number of bundles of thick white (collagen) fibres. So it is toughest and less flexible. Between the bundles of white fibres, there are scattered lacunae, each containing a chondrocyte. It is found in intervertebral discs and acts as shock absorber. It is also found in pubic symphysis and helps in parturition (child birth). The intervertebral discs remain contracted when the body is active, but relaxed when the body is at rest. That is why, our body becomes a bit taller during sleep and after death.

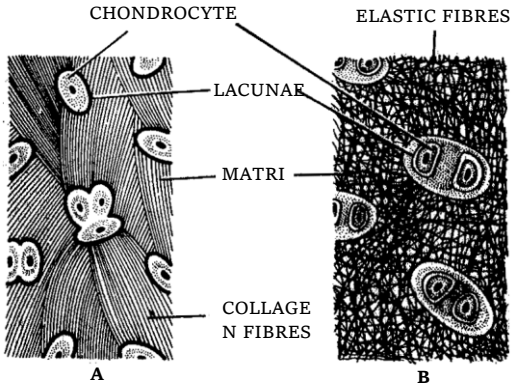


Fig. – Fibrocartilage A. White

(3) **Elastic cartilage** (Yellow elastic cartilage) **:** In this cartilage, the matrix is packed with yellow or elastic fibres which run in all directions to form a network. It appears yellow and opaque. The chondrocytes are present in lacunae between the yellow fibres. Owing to the presence of yellow fibres, it is very flexible. It gives recoiling power to structures. It is found in mammalian pinna, pharyngotympanic tube, epiglottis, some laryngeal and bronchiolar cartilages.

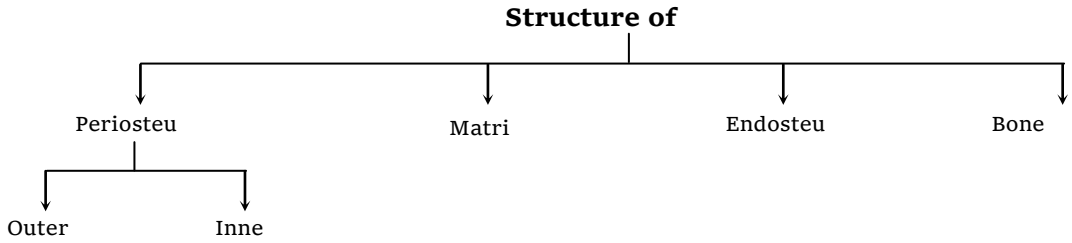
(4) **Calcified cartilage :** It is modified hyaline cartilage, It is hard and non elastic due to deposition of calcium salt-hydroxy appetite in matrix. It is found in pubis of old frog, supra-scapula of frog, quadrate cartilage of frog., shark vertebrae, in man ends of long bone, head of humerus and

femur. Calcification may also occur as a regular growth process of bone due to age. It reduces elasticity of the cartilage and makes it more rigid.

Differences between Bone and Cartilage

Bone	Cartilage
1. Matrix is composed of a tough, inflexible material, the ossein.	**1.** Matrix is composed of a firm, but flexible material, the chondrin.
2. Matrix is always impregnated with calcium salts.	**2.** Matrix may be free or impregenated with calcium salts.
3. Bone cells lie in lucunae singly.	**3.** Cartilage cells lie in lacunae singly or in groups of two or four.
4. Osteocytes are irregular and give off branching processes in the developing bone.	**4.** Chondroblasts are oval and devoid of processes.
5. Lacunae give off canaliculi.	**5.** Lacunae lack canaliculi.
6. There are outer and inner layers of special bone forming cells, the osteoblasts, that produce new osteocytes, which secrete new lamellae of matrix.	**6.** There are no special cartilage-forming cells. Cartilage grows by division of all chondroblasts.
7. Matrix occurs largely in concentric lamellae.	**7.** Matrix occurs in a homogenous mass.
8. Bone is highly vascular.	**8.** Cartilage in nonvascular.
9. Bone may have bone marrow at the centre.	**9.** No such tissue is present.

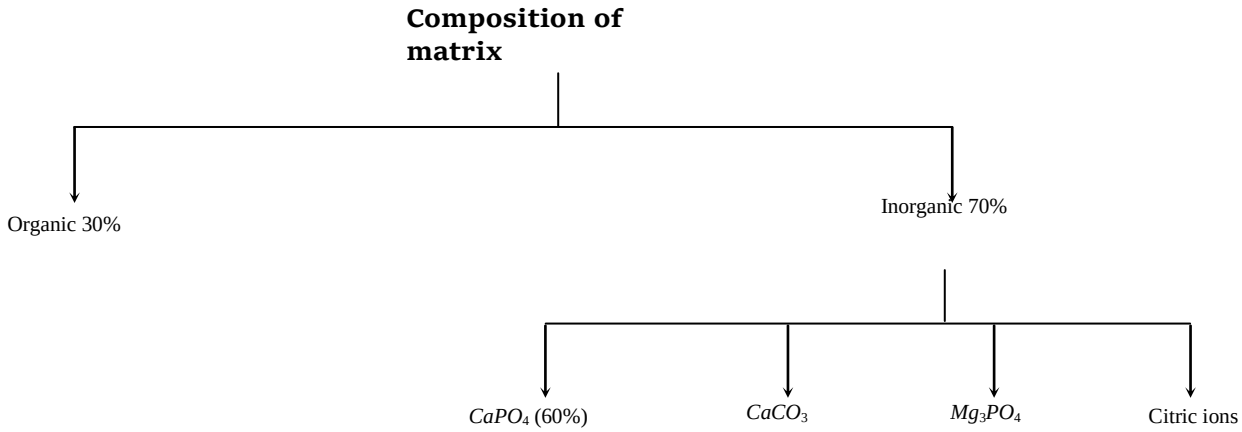
(ii) **Bone :** Bone is a highly calcified (mineralized), hard and rigid connective tissue. It is the major component of adult vertebrate endoskeleton. Besides its mechanical function of supporting the body architecture and internal organs as a frame work, of protecting delicate organ like brain, heart, etc. of forming to muscles to facilitate movement and locomotion, the bone is also a metabolically dynamic tissue which functions as a homeostatic reservoir of ions of calcium, magnesium, phosphorous, etc. About 97% of total calcium of body occurs in the endoskeleton.



(a) **Periosteum :** It is a membrane that forms an envelop around the bone. Periosteum is comprises of two distinct layers. Outer layer consist of thin white fibrous connective tissue. Inner layer consist of osteoblasts, osteoblasts are spider like bone cells, also known as bone forming cells, because they produces new bone materials.

(b) **Matrix :** Matrix is composed of protein called ossein. The matrix forms thin plates called lamellae. Lamellae are of three types. *Haversian lamellae* (occur around Haversian canal) concentric or

circumferential lamellae (inner to periosteum and outer to endosteum) and interstitial, lamellae (between Haversian system). In the lamellae minute bone cells osteocytes are present.



(c) **Endosteum :** It is present outer to the bone marrow cavity. Endosteum is a membrane which lines the marrow cavity. It is comprises of two distinct layers, one is of fibrous connective tissue and another is osteoblasts.

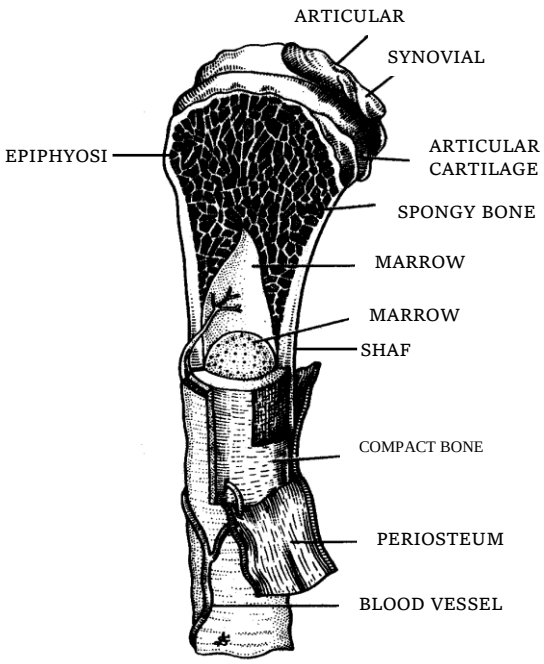


Fig. – Parts of long bone

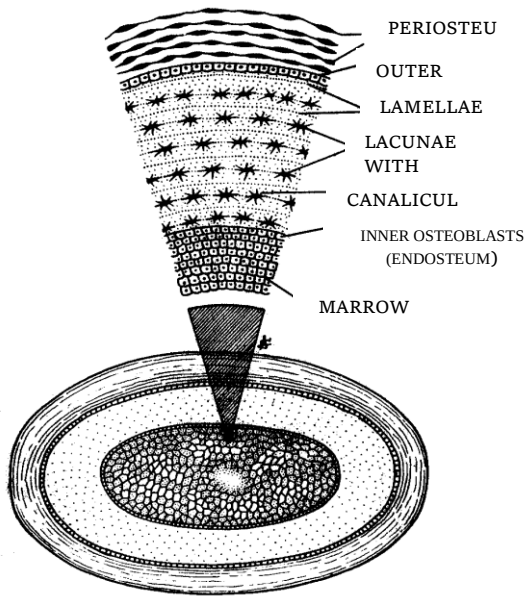


Fig. – T.S of decalcified

(d) **Bone marrow :** Bone marrow is a specialized type of soft, diffuse connective tissue called "Myeloid tissue". It takes part in production of blood cells hence known as haemopoietic tissue. It is composed of adipose tissue, areolar tissue and blood. It is of two types –

(1) **Red bone marrow :** Red in colour due to presence of lot of blood vessels. In foetal life and at birth present in entire skeleton. After 5^{th} year red bone marrow replaced by yellow bone marrow, at 20-25 years red bone marrow present at ribs, sternum, clavicles, vertebrae, scapula, pelvis, epiphysis of humerus and femur. Produces RBCs, WBC, monocytes, eosinophils and platelets.

(2) **Yellow bone marrow :** Yellow in colour and has much fatty tissue (adipose tissue), present in shaft of long bones. Produces blood cells in emergency i.e. at the time of excessive loss of blood, yellow bone marrow may be replaced by red bone marrow in anaemia.

(e) **Haversian system :** A haversian canal, its lamellae and osteocytes form a haversian system. Haversian canals are found in bone matrix of long bone, like humerus of mammals. Haversian canals contain artery and veins, osteoblasts in areolar tissue, nerves and lymph. It is also called osteon.

(f) **Types of bone cells :** Three types of cells are found in bone :

(1) **Osteoblast :** Bone forming cells found in all bone surfaces. It is small cells synthesize and secrete osteoid, an important part of ground substance. Process of osteoblast is called canaliculi.

(2) **Osteocyte :** Mature, nondividing osteoblast surrounded by matrix, lying within lacunae.

(3) **Osteoclast :** Bone destroying cells take part in resorption of bones**,** contain large amount of acid phosphatase enzyme. 4-Osteoprogenitor.

(g) **Types of bone**

(1) **On the basis of their texture :** The bones are divided into two categories spongy or cancellous or tubecular bones and compact or periosteal bones.

Differences between Spongy bone and Compact bone.

Characters	Spongy bone	Compact bone
Arrangement of lamellae	There is no regular Haversian system so have spongy texture.	Have regular Haversian system
Occurrence	In skull bones, ribs, centrum of vertebrae and epiphyses of long bones	In the shaft (diaphysis) of long bones
Marrow cavity	Broad	Narrow
Type of bone marrow	Red marrow in the spaces between lamellae	Yellow marrow in marrow cavity
Function	Marrow forms RBCs and Granular WBCs	Marrow stores fats

(2) **On the basis of origin of bone :** Ossification or osteogenesis is the process of bone formation. A bones are classified into four categories.

Differences between Cartilaginous, Dermal, Sesamoid and Visceral bones

Cartilaginous (Endochondrial) bone	Dermal (Intramembranous) bone	Sesamoid bone	Visceral bone
These are formed by ossification directly on the cartilages and formation involves deposition of	These are formed by ossification in the dermis of the skin.	These are formed by ossification at the joints of the bones or	They are formed in the soft organs.

body matter by osteoblasts and resorption by osteoclast.		on the tendon and ligament.	
These are elongated and hard bones Examples : Vertebrae, humerus, femur and fibula.	These are membrane-like bones. Examples : skull bones, phalanges, clavicles.	These are small sized disc like bones. Example : patella bone (knee cap).	Examples : oscordis, ospenis, osclitoris.

(3) **On the basis of treatment :** These are of two types

Differences between Dried bone and Decalcified bone

Characters	Dried bone	Decalcified bone
Type of treatment	Subjected to high temperature.	Subjected to dilute solution of *HCl*.
Nature of matter left	With only mineral matter.	With only organic matter.
Marrow cavity	Empty.	With bone-marrow.
Fate of cells	Periosteum, endosteum, osteoblasts and osteocytes are absent being killed by high temperature.	Periosteum, endosteum, osteoblasts and osteocytes all are present.
Lacunae	Lacunae present.	Lacunae absent.

(h) **Functions of bone :**

(1) **Support :** Bones form the framework of the body and contribute to the shape, alignment and positioning of the body.

(2) **Protection :** Bony "boxes" protect the delicate structures they enclose,

(3) **Movement :** Bones with their joints constitute levers that move as muscle contract.

(4) **Mineral storage :** Bones are the major reservoir for calcium, phosphorus and other minerals.

(5) **Haematopoiesis :** Blood cell formation is carried out by myeloid tissue.

(iii) **Notochord :** It is found in all chordate, It is replaced by vertebral column in vertebrate. Notochord is rod like structure. Notochord is made up of chordal cells.

(iv) **Structure of frog's bone :** A typical long bone of an adult vertebrate, such as a limb bone (humerus, femur, etc.), is distinguishable into the long, middle, cylindrical shaft (diaphysis) and the roughly spherical articular heads (Epiphyses). The shaft is hollow. Its cavity, called marrow or medullary cavity, is filled with a soft and semisolid fatty neurovascular tissue, yellow bone narrow. The latter is yellow in middle part of the shaft, but red due to abundant blood vessels towards the epiphysis. In mammals the, red bone marrow contains erythroblast cells which form red blood corpuscles. A thin single layered epithelium called endosteum, lines the marrow cavity. Cells of endosteum are young, unbranched and some what flattened bone cells, called osteoblast, which secrete the osteoid matrix or ossein of the bone when active. The ossein is deposited towards outer side in concentric rings called lamellae (lamellar bone). The middle line of each lamella is marked by an

angular ring of lacunae. Each lacuna encloses a branched mature bone cell (osteocyte). As new lamellae are laid down by endosteum, its osteoblasts also divide and form the lacunar rings of the lamellar matrix. Thus the role of endosteum is to add to the thickness of the bone from its inner side. The endosteum also contains bone reabsorbing cells called osteoclast**.** A thick and tough sheath, called periosteum, forms an envelope around the bone. It comprises two distinct layers – a thin outer layer of dense fibrous connective tissue with fibroblast and a thin inner layer of osteoblast like those of endosteum.

(v) **Structure of mammalian long bone :** Mammalian bones are quite different and complicated in structure than those of frog and other vertebrates. Since mammals have attained larger body size in evolution, their bones are thicker and stronger. Osteocytes of deep seated lacunae in those bones become cut off from the vascular supply of periosteum and bone marrow. Hence, mammalian bones have a wide spread network of vascular supply embedded in their matrix. Within the matrix of the compact bone of the shaft of a long mammalian bone, such as humerus, femur, tibia, etc., blood vessels are lodged in a matrix of slender branching canals. The main canals, called *Haversian canals*, usually run parallel to the long axis of a bone. Numerous transverse and oblique *Volkmann's canals* connect the haversian canals with each other and with the marrow cavity and periosteum. Haversian canals or ventral canals or central canals are possessing nerve, lymphatics, blood vessels (either artery or vein or both otherwise capillary only), areolar tissue, bone marrow. To provide the osteocytes with maximum facility of chemical exchange, the matrix of compact mammalian bones is laid down in a very orderly but highly complicated system of lamellae. On basis of the arrangement of the lamellae, such a bone can be divided into 4 zones :

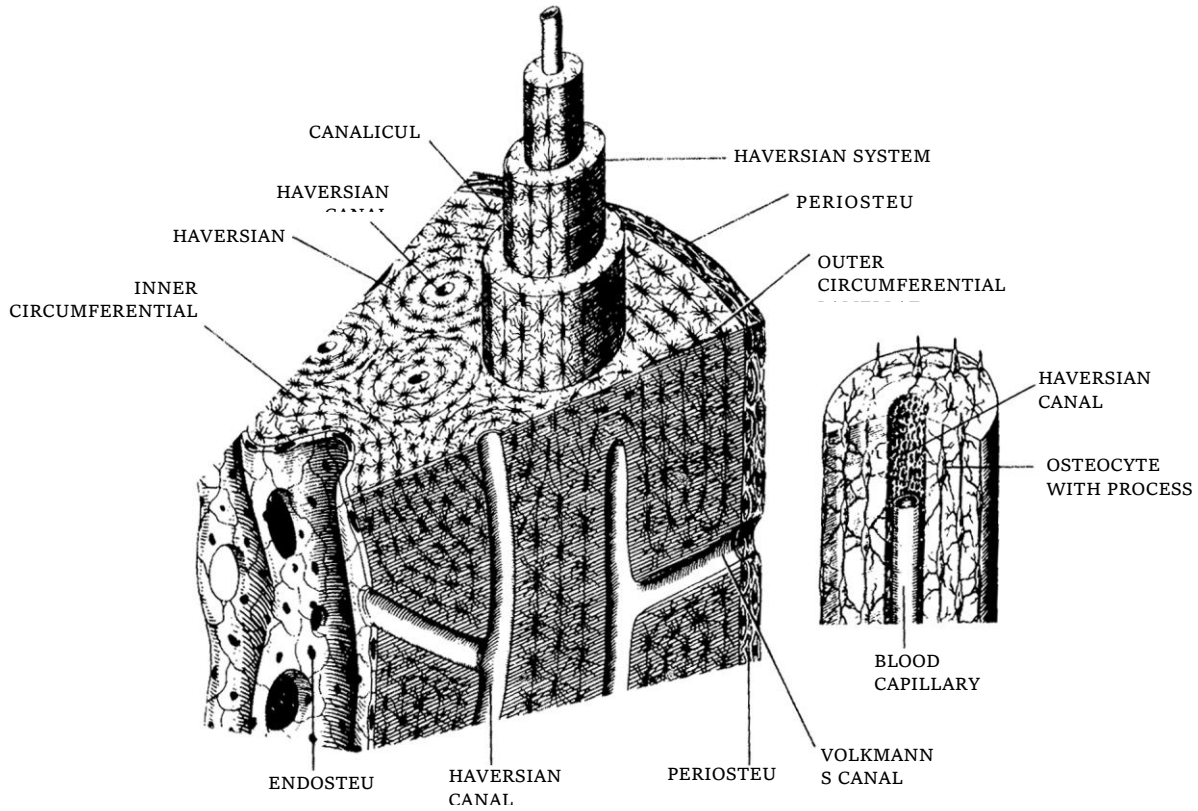


Fig. – Longitudinal and transverse section of long bone

(a) **Zone of Haversian systems or Osteons :** Four to twenty concentric rings of lamellae surround each haversian canal, establishing a cylindrical unit of bone structure, called "Haversian system or

Osteon". The major, medullary part of the bone is formed of osteons (osteonal bone). All lacunae of an osteon communicate with their own haversian canal by means of canaliculi. Hence, the osteocytes of these lacunae carry their chemical exchange with the blood vessel lodged in this haversian canal.

(b) **Interstitial zone :** Since remodelling of bone in some bones continues throughout life, osteons are continuously reabsorbed and formed again and again. The narrow gaps, left between completed osteons are, therefore, remnants of former lamellae or osteons. These are irregular and called interstitial lamellae.

(c) **Outer circumferential zone :** This is the thin peripheral zone of compact bone between haversian zone and periosteum. Lamellae of bone matrix in this zone run parallel to the long axis of the bone.

(d) **Inner circumferential zone :** This is the thin zone of bone between haversian zone and endosteum. This also comprises longitudinal lamellae. Osteocytes of outer and inner circumferential zones communicate with the blood vessels, respectively of periosteum and bone marrow. Haversian systems are absent in spongy bone of mammals.

(vi) **Formation and growth of bone :** The process of bone-formation is called osteogenesis or ossification. It is a 2-phased process – first the special organic matrix is laid down by osteoblasts and then, follows its mineralization or calcification. Bone formation starts in foetal life in second month. It produce four types of bones with regard to their source.

(a) **Endochondral ossification :** Most bones of the body are more or less elongated. These are all cartilaginous bones formed by endochondral osteogenesis. Each such bone replaces an elongated, rod like embryonic model of hyaline cartilage which is usually completely destroyed during osteogenesis. The cartilaginous model is covered by a functional perichondrium and it continues growing even during its ossification. Before the onset of ossification, the cartilaginous model undergoes some regional differentiation of its tissue –

(1) Cartilage cells (chondrocytes) at the centre of diaphysis become large and vacuolated. Their lacunae also become large. The cartilage matrix (chondrin) between these lacunae becomes calcified. This is now the primary centre of ossification. Its chondrocytes gradually die and disintegrate.

(2) The perichondrial sheath around the central diaphysial region of the cartilage differentiates into bone sheath or periosteum; cells of its inner layer become osteogenic, i.e., osteoblasts.

(3) Buds containing blood vessels and overlying osteoblasts now grow inwards from the periosteum and erode their way into the primary center of ossification. Destruction of the calcified cartilage during the erosion is perhaps performed by

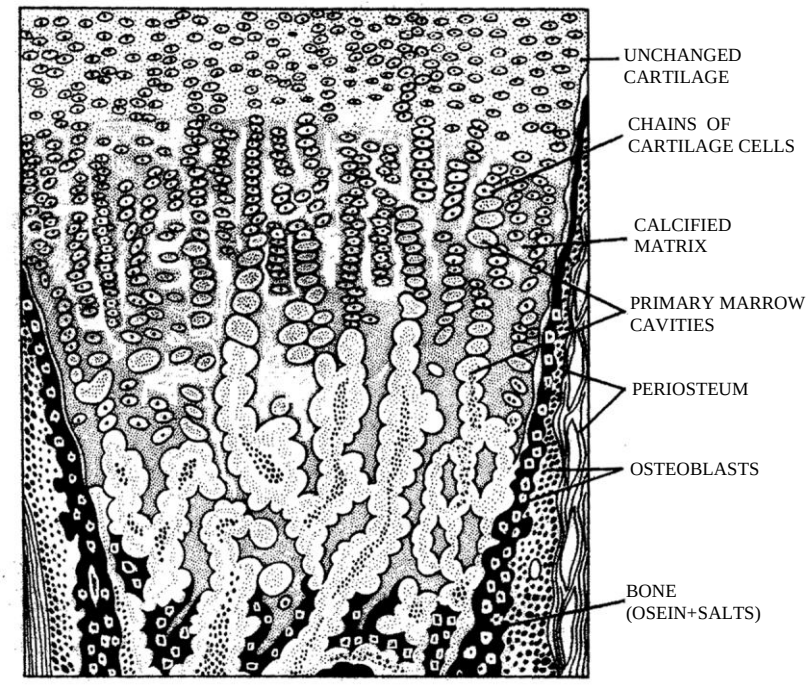


Fig. – Osteogenesis of bone

certain large, multinucleate and phagocytic bone-eating cells called osteoclasts. The latter are probably formed by fusion of several osteoblasts which have assumed bone eroding function. Due to irregular erosion, narrow strips or bars of original calcified cartilage are left here and there, and original lacunae form an irregular system of intercommunicating medullary spaces, called primary marrow cavities. Branches of blood vessels and osteoblasts fill up the spaces in the form of an embryonic bone marrow.Now ossification begins at two sites. The osteoblasts of periosteum lay down a "periosteal collar" of compact bone around the middle region of the cartilage mode. Simultaneously, the osteoblasts of embryonic marrow become arranged in linear series and start ossification around the cartilage bars, forming bone trabeculae of a primary spongy bone. Both of these sites of ossification progressively thicken and extend towards both ends of the cartilage model. Osteoblasts, which are entrapped within the bone matrix, become branched osteocytes. The spaces, these cells occupy in the matrix, become branched lacunae. Owing to a continuous process of bone remodelling i.e., bone-eating or reabsorption by osteoclasts and bone – laying by osteoblasts. Most of the bony trabeculae in axial part of shaft region are removed. Hence, a continuous marrow cavity, lined by endosteum, is formed. Later, new (secondary) centres of ossification establish in the terminal (epiphysial) parts of the cartilage model. Hence, spongy bone is laid down in these parts. Eventually, the entire cartilage model, except thin articular surfaces at the two ends, is replaced by bone. That is why, bones formed in this way are called cartilage or replacing bones. All bones of limbs, girdles (except clavicles) and vertebral column, and some of the skull are cartilage bones.

(b) **Intramembranous ossification :** This type of ossification occurs, not in a prior cartilage model, but in collagenous connective tissue membranes beneath embroyonic skin. It begins at certain fixed centres which are marked by profuse capillary networks. Fibroblasts in these centres differentiate into osteoblasts which cluster around the respective capillary network and start forming osteoid bone around themselves. Mineralization of osteoid bone begins. Some osteoblasts become completely surrounded by bone. These thus become osteocytes in lacunae. Other osteoblasts remain closely applied to the surfaces of the bone. These proliferate, spread over the first-formed bone and continue osteogenesis. The latter is more rapid at certain points than at others. This results in formation of spongy bone. While spongy bone is, thus, formed around the centre of ossification, the surround cells of periosteum are potentially osteogenic. These lay down a covering sheet of compact bone upon the surface. Typical dipolic bones are formed in this way. These become invested upon original cartilaginous box of skull and at some other cartilages, giving these strength and protection. These are, therefore, also called investing bones. All flat bones of cranium, facial skeleton, clavicles of pectoral girdles and terminal phalanges are investing bones. By continued remodelling, some of these may completely change into compact bones.

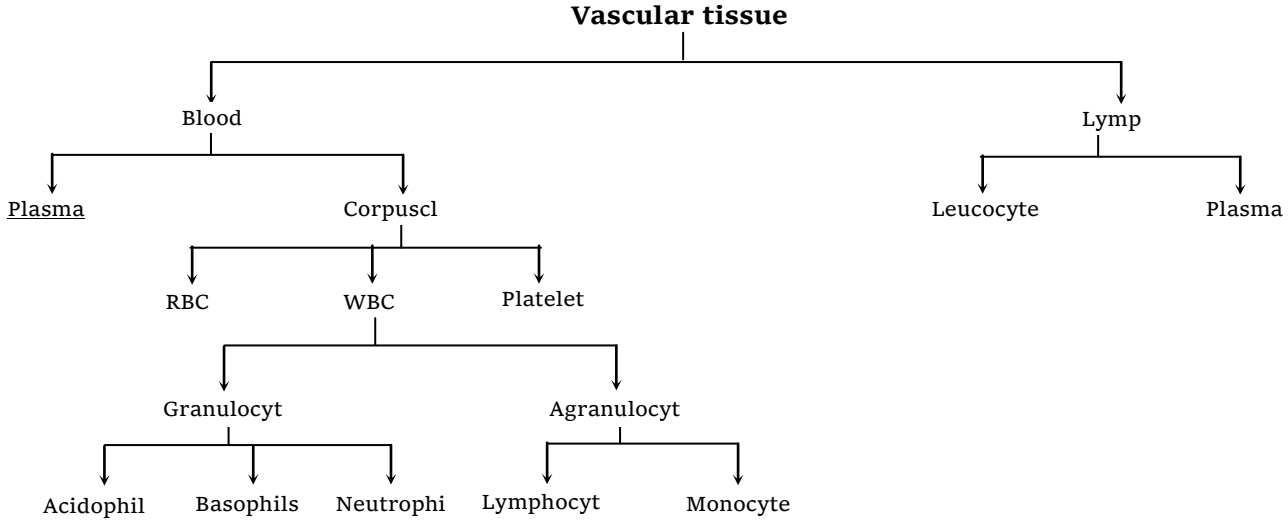
(c) **Intratendinous ossification :** These bones are formed by the ossification of tendons (white collagen tissue). e.g. – Patella (knee cap) present at knee joint and pisiform (pea shaped) present in wrist. Tendinous bones are called sesamoid bones.

Important Tips

- Teeth are made up of dentine (bone) and its crown is covered by enamel, which is the hardest substance of the body.
- Astronauts pass out calcium in their urine due to faster breaking down of bones, due to absence of gravitational pull.
- Hardening materials in bones are mainly phosphate of calcium and magnesium.
- Strongest cartilage is fibrocartilage due to collagen fibres.
- Osteoid is the uncalcified matrix of bone.
- Diploic bone – Bone with compact surfaces and cancellous middle e.g., skull bone, vertebrae.
- Calcination – Process of burning of bone till it becomes white.
- Beside calcium phosphate (major constituents) the bones contain pottassium, magnesium phosphate.
- Bone glister in night due to phosphorence.
- Study of cartilage is called chondrology.
- Study of bone is called osteology.
- Long bones possess pits of Howship.

1.6 Vascular tissues

As the size and organizational complexity of body increased in evolution, most cells of the body got separated away from organs that receive external supplies and organs of elimination. Hence, internal transport of materials between various parts of the body became a highly specialized and important function. A vascular system, therefore, evolved in higher invertebrates and vertebrates. Blood and lymph evolved as the fluid transportation media which circulate throughout the body, carrying materials from one part to the others. These have a common fluid intercellular substance or matrix, called plasma. Several types of numerous small cells, termed corpuscles, move above or float in the plasma. There are no fibres in the plasma. Unlike other connective tissues, the plasma is not formed by the corpuscles themselves.

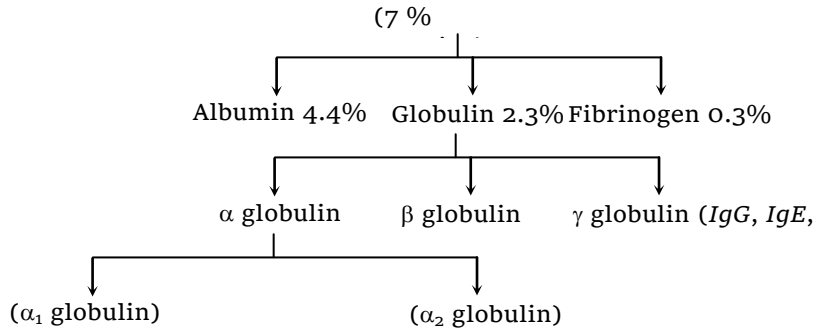


(i) **Blood :** In chordates, and in annelids amongst the non chordates, the blood is a red and opaque fluid of salty taste and peculiar smell. It is a little heavier than water. Its specific gravity and viscosity is 1.04 – 1.07 and 4.7 respectively. Its is 7.4 so it is slightly alkaline. In human beings, the quantity of blood is about 7% to 8% of total body weight. Thus a person, weighing about 70 kg has about 5 to 6 litres of blood, occupying about $1/13^{th}$ part of the body by volume. Percentage of blood in women is slightly lower. The study of blood is called haematology. It is red coloured liquid connective tissue which originates from the mesoderm. It reaches into the various organs through the blood vessels and transports various chemical substances between different tissues. During embryonic state, the blood is mainly formed in the liver but little blood is also formed in the spleen and ribs. In adults, the blood is formed in the red bone marrow. The blood formation is called as haemopoiesis.

(ii) **Plasma :** It constitutes about 5% of body weight. It represents matrix of blood. Plasma is slightly alkaline and transparent. It forms 55-60% by volume of blood. Plasma contains : Water (91-92%), Solid (8-9%). Plasma solid part consists of organic (7%) and inorganic (1%) substances which are as follows :

(a) **Organic constituents of plasma :** Some are its own constituents, while others are those which are transported by it. All these are divisible into following categories :

(1) **Plasma proteins :** Protein constitute about 7% part of plasma and remain in it as colloid particles. These mainly include albumins, globulins, prothrombin and fibrinogen.



Globulins are mainly formed by plasma cells in lymphoid organs. Other plasma proteins are mainly formed in liver. These render the plasma viscous, and maintain its osmotic pressure (7.5 atmospheric) and pH. Prothrombin and Fibrinogen are essential for blood clotting. Albumins are mainly responsible for maintaining osmotic pressure in plasma and for osmoregulation in cells and tissue fluids. Globulins help in osmoregulation and transport of proteins and other substances, but most globulins are immunoglobulins, which act as antibodies, destroying harmful bacteria, virus and toxins in blood and tissue fluids. Some proteins, acting as enzymes, also occur in the plasma.

(2) **Digested nutrients :** These include glucose, fats, fatty acids, phospholipids, cholesterol, nucleosides, amino acids, vitamins etc. These are the supplied by the blood to all cells of body.

(3) **Excretory substances :** These chiefly include ammonia collected by blood from body cells and urea, uric acid, creatine, creatinine etc., collected mainly from the liver and transported to kidneys for excretion.

(4) **Hormones :** These are secreted and released in blood by endocrine glands.

(5) **Dissolved gases :** Each 100 ml. of water of blood plasma contains about 0.29 ml of O_2, 5 ml. of CO_2 and 0.5 ml of nitrogen dissolved in it.

(6) **Defence compounds :** Certain immunoglobulins or antibodies and some other substances, such as lysozyme (a polysaccharide) and properdin (a large protein) always occur in the plasma. These serve to destroy bacteria, viruses and toxic substances that may enter into the blood from outside, or from body tissues.

(7) **Anticoagulant :** Mast cells of connective tissues continuously release, in blood plasma, a conjugated polysaccharide, named heparin. The latter serves to prevent coagulation of blood while it is flowing in intact blood vessels.

(b) **Inorganic constituents of plasma :** Chloride and Bicarbonate salts of sodium are the main inorganic constituents. Traces of other salts, like phosphates, bicarbonates, sulphates and iodides of calcium, magnesium and potassium are also found. All salts constitute about 1% of plasma. These remain as ions (electrolytes) and maintain the alkalinity of plasma. A balanced quantity of salt ions in the plasma is essential for proper functioning of nervous system, muscles and other tissues.

(iii) **Blood corpuscles :** Blood corpuscles form 40-50% of the blood and are of three types *viz.* Red blood corpuscles, white blood corpuscles and platelets.

(a) **Red blood corpuscles (RBC's or Erythrocytes) :** These occur only in vertebrates and are the most abundant (99%) of blood corpuscles, imparting the characteristic red colour to the blood. The shape, size and structure of RBCs vary in different types of vertebrates, but their function is the same in all, namely to transport respiratory gases, especially the oxygen. (O_2).

(1) **RBCs of frog :** Amphibian RBCs are largest amongst the vertebrates. Those of Amphiuma and Proteus are largest amongst amphibians. Those of frog measure about 35µ by 16µ (µ=1/1000 of a milimetre, i.e., 0.001 mm) and number about 4 lacs per cubic mm. of blood. These are flattened and oval, disclike, but slightly biconvex due to a large oval and centrally-placed nucleus.

(2) **RBCs of mammals :** Mammals have smallest RBCs amongst the vertebrates. Those of Musk deer are smallest amongst the mammals. Whereas the RBCs of other vertebrates are oval and nucleated, those of mammals are roughly circular (except those of the family camellidae – camels, llamas, dromedaries – which are oval in shape) and non-nucleated. Absence of a nucleus imparts a biconcave, disc-like shape to mammalian RBCs. During the process of their formation, mammalian RBCs lose, not only their nucleus, but also other important organelles like mitochondria, golgi bodies, centrosome, ribosomes, etc. This change in mammalian RBCs appears to be an evolutionary advancement, because it increases the surface area of RBCs and enables these to contain more heamoglobin.

(3) **RBCs of human :** They are about 7.4µ in diameter and its thickness is 1 to 1.5µ. It is pale yellow in colour but appear to be red in group. Surface area of all RBCs of a person totals about 1500 to 2000 times the surface area of the body itself. Erythrocyte count increases during exercise and stress, and decreases during rest, sleep, menstruation and pregnancy. Hill people have more RBCs, possibly causing their rosy cheeks. RBCs count sharply falls in anaemia and rises in polycythemia.

(4) **Structure of RBCs :** Each RBC is bounded by a dynamic, enzyme-containing plasma membrane. The interior has a cytoskeletal framework of a structural protein, the stromatin, and some

lipids including cholesterol. The corpuscle is soft, flexible and elastic, so that it squeezes through vessels narrower than its own diameter and resumes its normal shape afterwards. In a human RBC, about 26.5 crore molecules of haemoglobin are packed in the intracellular framework. Some RBCs are probably adsorbed upon plasma membrane. Water constitutes about 60% of an RBC. The rest is solid. Haemoglobin forms about 34% of wet and 90% of dry weight of an RBC. Thus, 100 ml of normal human blood contains about 15 gm of haemoglobin on an average. An apparatus named haemoglobinometer is used to determine the haemoglobin contents of blood. Besides stromatin, lipids and haemoglobin, RBCs contain a number of enzyme systems, vitamins, salts, etc.

(5) **Structure of haemoglobin :** Haemoglobin is a purple coloured iron [in the form of Fe^{+2}] containing respiratory pigment of RBCs. It consists of two parts haem (5%) and globin (95%). It is conjugated protein and made up of 4 globin chains with each attached to haem molecule by Co-ordinate bond. Globin is formed of 4 polypeptide chains α (141 amino acid), β (146 amino acid), γ (146 amino acid) and δ (146 amino acids). Each RBC contains approximately 200 to 300 million molecules of haemoglobin. One-gram haemoglobin binds 1.34 ml oxygen. Molecular formula of haemoglobin is $C_{3032}\ H_{4816}\ O_{780}\ S_8\ Fe_4$. Amount of *Hb* is measured with the help of haemometer. A male has a greater amount of haemoglobin than a female. The amount of haemoglobin in normal man and woman is 14-16 gm/100 ml and 12–14 gm/100 ml respectively, while in children is slightly higher about 16.5 gm/100 ml of blood.

(6) **Number of RBC :** The number of RBC are counted by instrument haemocytometer. The total number of RBC per cubic mm of blood is called RBC count. RBC count is slightly lower in women than a man and number of RBC is more in people who live on mountains because there is less oxygen. RBC are absent in cockroach.

S.No.	Organism	Number of RBCs
1.	Male	5 – 5.4 million / cubic mm of blood
2.	Female	4.5 – 5 million / cubic mm of blood
3.	Infants	65 – 70 lacs/ cubic mm of blood
4.	Embryo	85 lacs/ cubic mm of blood
5.	Rabbit	70 lacs / cubic mm of blood
6.	Frog	4 lacs / cubic mm of blood

(7) **Life span of RBC :** The life span of red blood corpuscles circulating in the blood stream varies in different animals. RBC have longest life span in blood. The mammalians RBC have short life span due to absence of nucleus, which is disappeared during development.

S.No.	Organism	Life span of RBCs
1.	Mammals and Human	120 days or 4 months
2.	Rabbit	80 days
3.	Frog	100 days
4.	New born	100 days

(8) **Function of RBCs :** The major function of erythrocytes is to receive O_2 of respiratory surfaces and then transport and readily deliver it to all cells of body. This important function is performed by haemoglobin which has a great ability to combine loosely and reversibly with O_2 and is, hence, called "respiratory pigment". Haemoglobin, in annelids, is dissolved in the plasma because of absence of red blood corpuscles. In mollusc and some arthropods, etc., a different respiratory pigment, haemocyanin is found dissolved in the plasma. This pigment is bluish due to presence of copper in place of iron.

(9) **Formation of RBC :** The process of formation of RBC is known as erythropoiesis and organ which produce RBC is called erythropoietic organs. In man erythropoiesis takes approximately 72 hrs. to complete. The process of erythropoiesis is controlled by hormone erythropoietin formed by kidney, required B_{12} for maturation of RBC and assisted by Fe^{2+}. The erythrocytes are formed in liver, spleen and lymph nodes in the embryo; and in the red bone marrow in the adult. The red bone marrow is present in the cancellous bone at the extremities of long bones and between layers of compact bone in flat and irregular bones such as the cranium, vertebrae, ribs, sternum, clavicles, scapula and pelvis. The development of a mature red corpuscles takes about a week, during which the endothelial cell enlarges, divides, forms haemoglobin and finally loses its nucleus. This process is called maturation and takes place along the following lines :

Stems cells or Myeloblasts $\rightarrow$ *Proerythroblasts* $\rightarrow$ *Erythroblasts* $\rightarrow$ *Normoblasts* $\rightarrow$ *Reticulocytes* $\rightarrow$ *Erythrocytes.*

Myeloblast is an amoeboid cell with fairly abundant cytoplasm and a relatively primitive, undifferentiated nucleus. Proerythroblast is larger than the myeloblast. Its nuclear network is slightly coarser and the cytoplasm is deeply basophilic due to the presence of ribonucleic acid (RNA). Erythroblasts are half the size of the proerythroblasts due to mitosis in that stage. The nucleus is checked with coarse chromatin masses. The cytoplasm is losing its RNA and is acquiring haemoglobin. Normoblasts are derived from erythroblasts by mitosis, hence they are smaller in size. The nucleus becomes progressively smaller and mitosis ceases after this stage. The cytoplasm stains strongly acidophilic due to haemoglobin. Reticulocytes are young, immature erythrocytes with a delicate network of ribonucleic acid in the cytoplasm. The nuclei of normoblasts have been lost by extrusion in this stage. Erythrocytes are mature, enucleated cells which are also called red blood corpuscles.

The normal maturation of a red blood corpuscles requires the presence of a number of different chemical substances such as vitamin B_{12} (cynacobalamin or erythrocyte-maturing factor) and folic acid are necessary for the development of the proerythroblast successively into erythroblast and normoblast.

Vitamin B_{12} is present in food (mainly animal protein) but its absorption from the small intestine is dependent upon a mucopolysaccharide the intrinsic factor, secreated by the parietal cells of the gastric mucosa. Iron is necessary for the provision of haemoglobin to fill the immature erythrocytes before they can become the mature red corpuscles. Lack of iron in diet or loss of iron in bleeding causes iron-deficiency anaemia. In addition to a normal diet containing protein and iron, small amount of cobalt, copper, nicotinic acid, riboflavin and vitamin C are also essential for erythropoiesis.

The development of red blood corpuscles is controlled by a feed-back mechanism. Deficiency of oxygen following haemorrhage or because an individual, lives at high altitudes where the oxygen pressure in the atmospheric air is reduced; and a hormone called erythropoitin, secreted by the kidneys, are the two main factors that stimulate the bone marrow to increase its production of erythrocytes.

(10) **Metabolism of RBCs :** The mature mammalian erythrocyte lacks mitochondria; hence the cytochrome system is absent and the tricarboxylic acid cycle is not evident. The energy of the mature erythrocyte is supplied primarily by anaerobic glycolysis and the phosphogluconate pathway. RBC are created and destroyed at approximately 100 million per minute in an adult and homeostatic mechanisms operate to balance the number of cells formed against the number of cells destroyed. The excess of erythrocytes (blood) is stored in spleen, which act as a blood bank.

(11) **Destruction of RBC :** Aged, abnormal or damaged RBCs are phagocytosed by macrophages in the spleen and liver. Breakdowns of haemoglobin released from the RBCs yields globin and haem or iron. The globin convert to amino acids and used as an energy source or for protein synthesis. The released haem is further degraded into iron which may be stored or used immediately to produce new haemoglobin and bilirubin which is ultimately exerted in the bile.

(12) **Haemolysis :** Due to bursting of plasma membrane of RBCs. Its haemoglobin comes out. This process is called haemolysis. Some fat solvent and snake venom cause haemolysis. When RBCs are placed in hypotonic solution haemolysis take place. When human RBCs are placed in pure water or distilled water they will swell and burst. Some times in haemolysis, the RBCs lose their contents by diffusion and hence maintain their emptied forms intact. These are then called "shadows" or **"**ghosts**"** of RBCs.

(13) **Rouleaux formation :** If a drop of fresh blood is placed on a slide under coverslip. RBCs adhere together by their concave surfaces like stacks or pile coins. This is called Rouleaux formation. It occurs probably due to forces of surface tension. It may also occur temporarily in blood vessels wherever circulation becomes unduly slow for some time.

(14) **ESR :** It is called erythrocyte sedimentation rate. This test is measured by **"**Wintrobe's tube**"** and **"**Western blotting**"** method. It is the rate of sinking/settling down of RBC in the plasma to form rouleaux. Man has lower ESR as compared to women and it is lowest in new born. Normal value of ESR in male is about 5 mm and in female 10 mm in first hour. A rise in ESR indicates the presence of infective/ destructive/ inflammatory diseases.

(b) **White blood corpuscles (W.B.C.) or Leucocytes :** They are nucleated, colourless and complete cells. They are bigger than RBC but their number is less. WBC shown least constancy in

shape. The number of WBC is 8,000 to 10,000 per cubic mm. They are formed in red bone marrow, spleen, thymus and lymph nodes from myelocytes and the process is called as myelecoeisis. The life of WBC is of 15 hours to 2 days. The WBC are destroyed outside the blood vessels and the process by which the come out is called as diapedesis. An increase in the number of white blood corpuscles is called leucocytosis. More than 12,000 per cubic mm. indicates some disease. A decrease below 6000 is called leucopenia as in typhoid fever. The leucocytes are divided into two main varieties.

(1) **Granular leucocytes :** These cells develop in the red bone marrow from the same parent cells as the erythroblasts, i.e., myeloblast in the red bone marrow. Before entering the blood stream, they develop through promyelocyte and myelocyte stages. As these cells develop, specific granules appear in larger number and they retain their nucleus. These are granular leucocytes of roughly spherical shape, 10µ to 15µ in diameter, actively amoeboid and containing a large number of stainable granules. Their nucleus is irregular and divided into 2 to 5 interconnected lobes. Hence, these are also called polymorphonuclear leucocytes.

(i) **Eosinophils** (**Acidophils or Oxyphils**) **:** These comprise 1% to 5% of total WBC count in blood, i.e., 70 to 300 per cu. mm. of blood. Their nucleus is distinctly bilobed with the lobes connected only by a thin strand. Their granules (lysosomes) are larger, contain important hydrolytic enzymes and stain by acid dyes like eosin. These corpuscles play important role in immunity, allergy and hypersensitivity. A rise in their number in the blood is called eosinophilia which generally occurs in parasitic worm infestations.

(ii) **Basophils :** These are the least numerous (only about 0.5 % to 2% of leucocytes (35 to 150 per cu. mm. of blood). Two or three lobes of their twisted, S-shaped nucleus are less distinct. Their granules (lysosomes) are larger and fewer. These stain with basic dyes like methylene blue. These corpuscles contain heparin, histamine and serotonin. Hence, these are related, but not identical, to mast cells of connective tissues.

(iii) **Neutrophils (Heterophils) :** These are the most numerous (60 to 70% = 4000 to 5000 per cu. mm. of blood) and most active type of WBC's. Their nucleus has 2 to 5 distinct lobes. Their granules (lysosomes) are small, but most numerous, stain with neutral dyes and contain hydrolytic enzymes capable of digesting bacteria and other pathogens. These corpuscles are actively motile and most actively phagocytic. Certain neutrophils in female mammals possess a small spherical lobe attached to their nucleus by a stalk. This lobe is called drumstick. It is formed by transformation of an X chromosome like the Barr-body of the cells of peripheral tissues in female mammals of many other species.

(2) **Agranular leucocytes :** They have a few non-specific or no granules in the cytoplasm and the nucleus is spherical to kidney shaped. They comprise about 25–30 % of all leucocyte and have two varieties.

(i) **Lymphocytes :** These are small roughly spherical (6µ to 16µ in diameter) corpuscles, comprising about 20% to 40% of the leucocytes (about 1500 to 2500 per cu. mm. of blood). These are comparatively less motile, possess a large, subspherical, central nucleus and produce antibodies. The lymphocytes are produced in the lymphatic tissue of the body which is present in the spleen, lymph nodes, thymus, tonsils and more scattered nodular masses.

Functions : Lymphocytes are concerned with the process of immunity. They produce serum globulin (β and γ globulins), one of the plasma proteins, which gives rise to antibodies and antitoxins. They contribute to scar-formation after injury and thus facilitate wound-healing. Lymphocytes play an important role in the immunological reactions to tissue transplantation.

(ii) **Monocytes :** These comprise only about 2% to 7% of the leucocytes (i.e. 200 to 700 per cu.mm. of blood) but are the largest cells of the blood (12μ to 20μ in diameter). These have a large reniform or horse-shoe-shaped, excentric nucleus, and are actively motile and phagocytic. After entering into tissue fluid, these transform into macrophages for phagocytising invading microbes. They known as big police man of the blood. The monocytes originate from a system of primitive cells, the rectioulo-endothelial system which is found in organs such as the liver, spleen, lungs and lymphatic glands.

Functions : Their function closely resembles that of the neutrophils in that they are actively motile, phagocytic in action and will leave the blood capillaries to ingest micro-organisms and other foreign material that may be introduced into the tissue. They are the prime scavangers of cells and tissue debris. They play a vital role in removing damaged tissue and thus preparing the way for regenerative processes of the body.

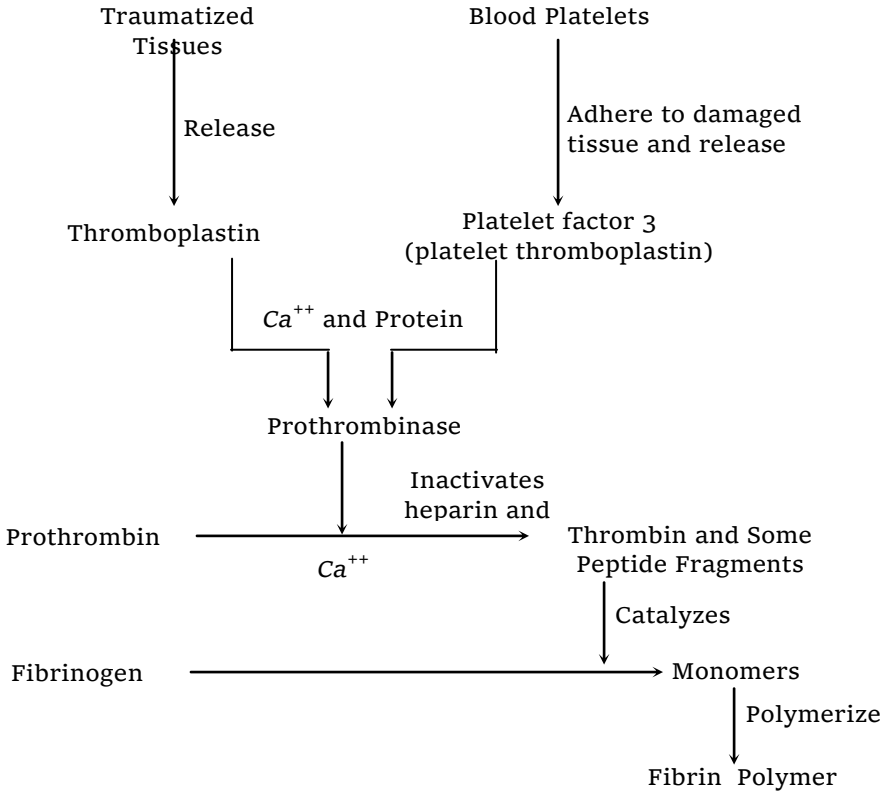
(c) **Blood platelets :** These are protoplasmic disks that are found in mammalian blood (lower vertebrates have spindle-shaped cells named thrombocytes). Platelets arise as detached tips of protoplasmic processes extending from the cytoplasm of giant cells, megakaryocytes, of red bone marrow. The shape is oval to round, often stellate. They are 2-3μ in diameter. The protoplasm is granular and deeply basophilic in the centre but is pale and homogenous on the periphery. There are approximately 300,000 platelets in a cubic millimetre of blood. Platelets are non-nucleated. Life span is about 10 days. Name platelet was given by Bizzazero. Agglutinated platelets are associated with blood clotting, both inside and outside of blood vessels.

(1) **Coagulation or Clotting of blood :** Process of formation of blood clot is also known as blood coagulation. Normal time of blood clotting is 3 to 8 minutes. Blood clotting is checked in blood vessels by presence of anticoagulant. Anticoagulant removes the cations to check the coagulation. Few important anticoagulants are heparin formed in liver and mast cells, hirudin found in leech. When an injury is caused to a blood vessel bleeding starts which is stopped by a process called blood coagulation or clotting. This process can be described under three major steps.

First step : At the site of an injury, the blood platelets disintegrate and release a phospholipid, called platelet factor-3 (Platelet thromboplastin). Injured tissues also release a lipoprotein factor called thromboplastin. These two factors combine with calcium ions (Ca^{++}) and certain proteins of the blood plasma to form an enzyme called prothrombinase.

Second step : The prothrombinase inactivates heparin (or antiprothrombia anticoagulant) in the presence of calcium. Prothrombinase catalyzes breakdown of prothrombin (inactive plasma protein) into an active protein called thrombin and some small peptide fragments.

Third step : Thrombin acts as enzyme and first brings about depolymerization of fibrinogen (a soluble plasma protein) into its monomers. Later thrombin stimulates repolymerization of these monomers into long insoluble fibre like polymers called fibrin. The thin, long and solid fibres of fibrin



The process of blood-clotting

form a dense network upon the wound and trap blood corpuscles (RBCs, WBCs and platelets) to form a clot. A clot is formed at the wound in about 2 to 8 minutes after injury. The clot seals the wound and stops bleeding. Soon after the clot starts contracting and a pale yellow fluid, the serum, starts oozing out. This serum is blood plasma minus fibrinogen and blood corpuscles.

Recent theory of blood clotting is cascade theory given was Macferlane. According to this theory 13 factors are required for blood clotting.

(2) **Coagulation factors**

Factor	Name	Factor	Name
I	Fibrinogen	VIII	Antihemophilic factor
II	Prothrombin	IX	Christmas factor or plasma thromboplastin component (PTC)
III	Thromboplastin	X	Stuart factor or Stuart-Prower factor
IV	Calcium ions	XI	Plasma thromboplastin antecedent (PTA)
V	Proaccelerin (Labile factor)	XII	Hageman factor
VI	Hypothetical factor	XIII	Fibrin stabilizing factor (FSF)
VII	Serum prothrombin conversion accelerator (Stable factor)		

(3) **Anticoagulants**

(i) Any chemical substance that prevents clotting is an anticoagulant.

(ii) Coagulation of blood in vessels is prevented during normal circulation by heparin, a quick acting anticoagulant.

(iii) Heparin inhibits conversion of prothrombin to thrombin and is used in open-heart surgery.

(iv) Vitamin K (Phylloquinone) is required for the synthesis of prothrombin necessary for blood clotting.

(v) Dicumarol acts as an antagonist for the synthesis of prothrombin necessary for blood clotting.

(vi) CPD (Citrate phosphate dextrose), ACD (Acid citrate dextrose) and EDTA (Ethylene diamino tetra acetic acid) are used by blood banks to prevent blood samples from clotting.

(vii) Blood clotting can be prevented in a test tube by adding a little oxalate or citrate (Na and K)

(viii) Oxalate or citrate react with calcium to form insoluble compound, so free calcium ions necessary for clotting are not available.

(ix) Blood is stored with an anticoagulant at $4°C$ At normal temperature due to potassium pump, K ions are more inside RBC than plasma. Low temperature stops the potassium pump *i.e.*, inhibit active transport. K ions come out from RBCs resulting in ionic equilibrium.

(x) Hirudin is an anticoagulant present in the saliva of leech.

(4) **Functions of blood :** On basis of the above account, the general functions of blood can be briefly enumerated as follows :

(i) **Transportation of materials :** Blood is the fluid medium which transports different materials between various parts. It thus acts as the body's chief "supply line", and maintains liaison with outside environment for intake of useful materials and disposal of metabolic wastes. With the help of its haemoglobin. It takes up oxygen from external environment in respiratory organs and gives off CO_2. Then, it supplies the O_2 to the tissues and collects CO_2 from these. In intestinal wall, it absorbs digested nutrients and distributes these to the various tissues. In return, it collects metabolic wastes from the tissues and transports these to excretory organs. It also receives hormones from endocrine glands and circulates these into all parts of the body.

(ii) **Defense against infection and disease :** The leucocytes of blood play the important role of defense by inactivating and destroying harmful toxins and invaders like bacteria, viruses, fungi and animal parasites.

(iii) **Scavenging :** Blood leucocytes phagocytes and destroy cell debris and inert foreign particles in blood and tissues. Thus, these act as "scavengers" to clean the body's internal environment.

(iv) **Control of body temperature :** Blood maintains the normal temperature of body. It prevents a sharp rise or fall in temperature which may be caused in any tissue due to abnormal rate of metabolism.

(v) **Healing of wounds :** By coagulating at an injury, and by stimulating repairing of damaged tissues, the blood helps in rapid healing of wounds and injuries.

(vi) **Homeostasis :** Blood helps in the maintenance of a proper internal environment in the body by regulating the amount of salts, acids, bases and water, etc. in the tissue fluids.

(iv) **Lymph :** Blood, tissue fluid and lymph are almost contiguous parts of the body's "supply line". Infact the tissue fluid is a part of blood plasma that oozes out of arterial capillaries into intercellular substance and lymph is a part of tissue fluid. The blood plasma, tissue fluid and lymph have a basic similarity. The lymph is like the blood but, having no RBCs, it is colourless. It normally has more WBCs than the blood, and of these the lymphocytes are in large majority. It contains little of O_2 , but lot of CO_2 and metabolic wastes. It has the ability to coagulate like the blood. It coagulates outside the body.

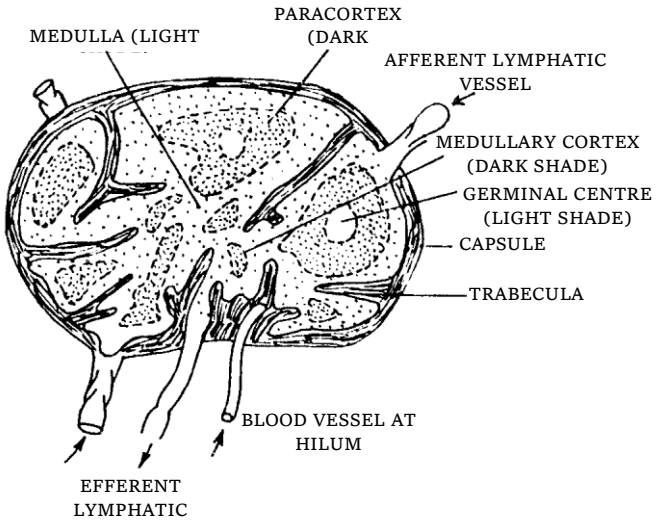


Fig. – Structure of a

In mammals, lymph sinuses and lymph hearts are absent which are found in frog. The tissue of the mammals have lymph capillaries which join to form lymph vessels. In lymph vessel, the lymph flows from organs into the hearts. They are provided with semilunar valves to prevent reverse flow of the lymph. The lymph vessels are provided with lymph nodes which are found mainly in the head, neck, arm pits, near big blood vessels etc. The lymph nodes form lymphocytes, they clean the lymph by filtration and they form antibodies. Lymph nodes also from Payer's patches. The lymph vessels finally open into subclavian veins. The lymph capillaries in the villi of intestine are also called as lacteals. Cisterna chyle is also called as second heart which is situated just below the diaphragm in the abdominal cavity.

Functions of lymph : The basic function of lymph is to bring back, into the vascular circulation, the cell debris, large colloid particles and the part of the blood plasma that had diffused out from arterial capillaries into the tissue fluid but has failed to return back into venous capillaries. The white corpuscles of the lymph are the same as those of the blood and have the same functions of defense and of assistance in tissue repair and healing. In intestinal wall, lymph capillaries, called lacteals, are specially meant for absorption of fats.

Comparison of blood and lymph

Blood	Lymph
1. Red corpuscles present.	**1.** These are absent.
2. White corpuscles fewer, neutrophils most numerous.	**2.** White corpuscles more; lymphocytes most numerous.
3. Soluble proteins more than insoluble proteins.	**3.** Insoluble proteins more than soluble proteins.
4. Amount of nutrients and O_2 comparatively more.	**4.** Amount of nutrients and O_2 comparatively less.

5. Amount of CO_2 and metabolic wastes normal.	**5.** Amount of these much more.

Important Tips

- Normal blood glucose level is 60 – 80 mgms/100 ml.
- Strontium – 90 is the chemical which causes damage to WBC, bone marrow, spleen, lymph nodes and lungs.
- Bone marrow is absent in birds due to Pneumatic bones.
- Granulocyte are formed inside Red bone marrow.
- Haemocytometer is used for red cell counting.
- Phagocytosis was first of all seen by Metchnikoff.
- Blood doping or blood boosting is the transfusion of one's own blood or frozen RBC to increase haemoglobin content to carry more oxygen.
- Spleen also acts as "graveyard" of RBC. If spleen is removed than filtration of dead RBC will stop.
- Polycythemia – Abnormal rise in number of RBC.

1.7 Muscular tissues

Contractility and motility (movement) are fundamental properties of protoplasm. That is why, all cells possess potential motility. Contraction for motility in the cells results essentially from the interaction of two contractile proteins, actin and myosin. These proteins enter into the composition of microfilaments of cellular cytoskeleton. During evolution, organism achieved enhancement in motility by various means. For example, unicellular organisms and cells of lower metazoans (mesozoa and parazoa) acquired the ability to form pseudopodia, flagella, or cilia as locomotory organelles. Then, in eumetazoans began the evolution of specialized contractile cells having much more of actin and myosin proteins. In the lowest eumetazoans (cnidarians), basal ends of epithelial cells are drawn out into elongated contractile processes. That is why, these cells are called epitheliomuscular or myoepithelial cells. In the eumetazoans higher than cnidarians, independent contractile cells, called muscle cells (myocytes), occur and form muscular tissues (muscles). These tissues are obviously responsible for movements of organs and locomotion of the body in response to stimuli. These develop from embryonic mesoderm except for those of the iris and ciliary body of eyes, which are ectodermal in origin. About 40% to 50% of our body mass is of muscles. The muscle cells are always elongated, slender and spindle-shaped, fibre-like cells, These are, therefore called muscle fibres. These possess large numbers of myofibrils formed of actin and myosin. The myofibrils are obviously stuffed in a small amount of cytoplasm due to thin, fibre-like shape of muscle cells. Muscle cells are highly contractile (contracting to 1/3 or 1/2 the resting length). Muscle cells lose capacity to divide, multiply and regenerate to a great extent. Study of muscle is called myology. Types of muscle are following –

(i) **Striated or striped muscles :** Most muscles of body are striated. These generally bring about voluntary movements under conscious control of brain and, hence, called voluntary muscles. Most of these are inserted at both ends upon bones in different parts of the body depend upon these muscles. Hence, these are also called skeletal muscles. Movements of limbs and the body solely depend upon these muscles. Hence these are also called somatic muscles. These are also called phasic type of muscles, because contraction in these is rapid, but brief and fatigue occurs quickly.

(a) **Structure of striated muscles :** Each striated muscle consists of numerous muscle fibres segregated into several small and parallel bundles, called Fasciculi. Fibres of each fascicule are bound together by a connective tissue sheath, called endomycium. All fasciculi of a muscle are bound together by a connective tissue termed perimycium which also forms a sheath around each fascicule. Similarly, the whole muscle itself is covered by a connective tissue sheath, called epimycium. The latter extends as a tendons at each end of the muscle to insert it on to bones. Endomycium, perimycium and epimycium contain collagen and elastin fibres and also reticular fibres in some muscles.

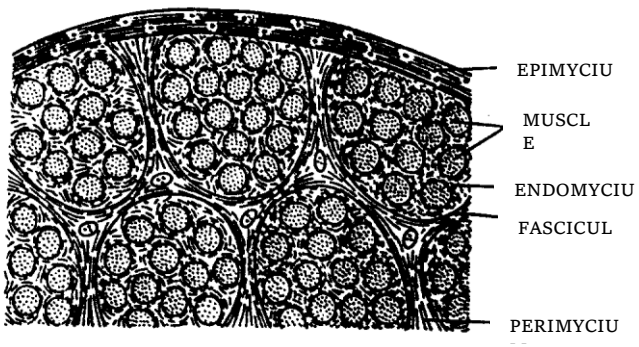


Fig. – T.S. of striated muscle

(b) **Structure of striated muscle fibres :** Striated muscle fibres are 0.01mm to 30 cm long, slender, cylindrical, unbranched (except some of the tongue and facial muscles) and multinucleated. Their covering envelope is called sarcolemma. The homogeneous, semifluid cytoplasm is called sarcoplasm. Two types of fibres can be recognized in most striated muscles, viz. white fibres and red fibres. Three soluble proteins myoalbumin, myoglobin (a haemoglobin like protein capable of binding oxygen) and myogen, a number of enzymes, glycogen granules and lipid droplets are found in the sarcoplasm of all fibres. The formed elements include many oval and compressed nuclei, mitochondria (sarcosomes), a small golgi apparatus, sarcoplasmic (endoplasmic) reticulum, etc. The red fibres are shorter, have more numerous and more deeply situated nuclei, more myoglobin and more numerous mitochondria producing more ATP. These are thus, adapted for prolonged and continued muscle activity required to support the body against gravity and for long continuing athletic events like marathon races. These are, therefore also called slow fibres. The white fibres (fast fibres) are longer, peripherally situated nuclei and fewer mitochondria, but these degrade glucose rapidly by glycolytic process to obtained energy at a faster rate. Thus, these are adapted for very rapid and powerful muscle contractions required for jumping, fast running etc. Due to multinucleate condition each striated muscle fibre is regarded a multicellular syncytial body, instead of a single cell. This is so, because each fibre is formed by fusion of a number of embryonic stem cells, called myoblasts. Most part of each striated muscle fibre is studded with several hundred to several thousand longitudinally oriented and parallel, slender myofibrils or sarcostyles.

(c) **Fine structure of striated muscle fibres :** Striated muscle fibres shows transverse striation in the form of regular alternate dark A (anisotropic) and light I (isotropic) bands. The ‘A’ band contains

about 120Å thick and 1.8 μ long "myosin filaments". The I band contains about 60Å thick and 1.0μ long "actin filament" which are twice as many as myosin filaments. Each I band is divided into two equal halves by a thin, fibrous and transverse zig-zag partition, called 'Z' band (' Z' disc) or Krause's membrane. Each segment of a fibril between two adjacent 'z' bands is called a sarcomere. It is 2.3μ long in uncontracted mammalian striated fibres. A slender transverse line, the 'M' or Hansen's line is visible in middle of each 'A' band. The major, middle region of 'A' band is comparatively lighter, but its terminal parts appear darker. The middle lighter region is called 'H' zone. Due to the geomatric bonding pattern, the end of each myosin filament is, thus, encircled by the ends of six actin filaments (hexagon), while the end of each actin filaments is encircled by the ends of three myosin filaments (trigon).

(d) **Ultrastructure of myofilaments :** At the molecular level, each myosin filament is composed of about 500 thread-like myosin molecules. Three different kinds of proteins participate in the composition of actin filaments. The major part of an actin filament is a coiled double helical strand whose each arm is a linear polymer of small and globular molecules (monomers) actin protein. Another coiled double helical, but thiner, strand runs along the whole length of actin strand. Each arm of this strand is a polymer of fibre-like molecules of tropomyosin protein. The third protein is troponin.

(e) **Working of striated muscles :** H.E. Huxley and A.F. Huxley in 1954 proposed a theory to explain the process of muscular contraction. This theory is known as sliding filament theory. It was observed that when a fibril contracts, its 'A' bands remain intact, while the 'I' bands progressively shorten and eventually disappear when the fibril has shortened to about 65% of its resting length. At this stage. 'H' zones also disappear because the actin filaments of both sides in each sarcomere reach, and may even overlap each other at the "M" line, and the 'Z' lines now touch the ends of myosin filaments. It was further observed that if a fibre is mechanically streched, the zones of overlap between thick and thin filaments are shorter than in resting condition, resulting in

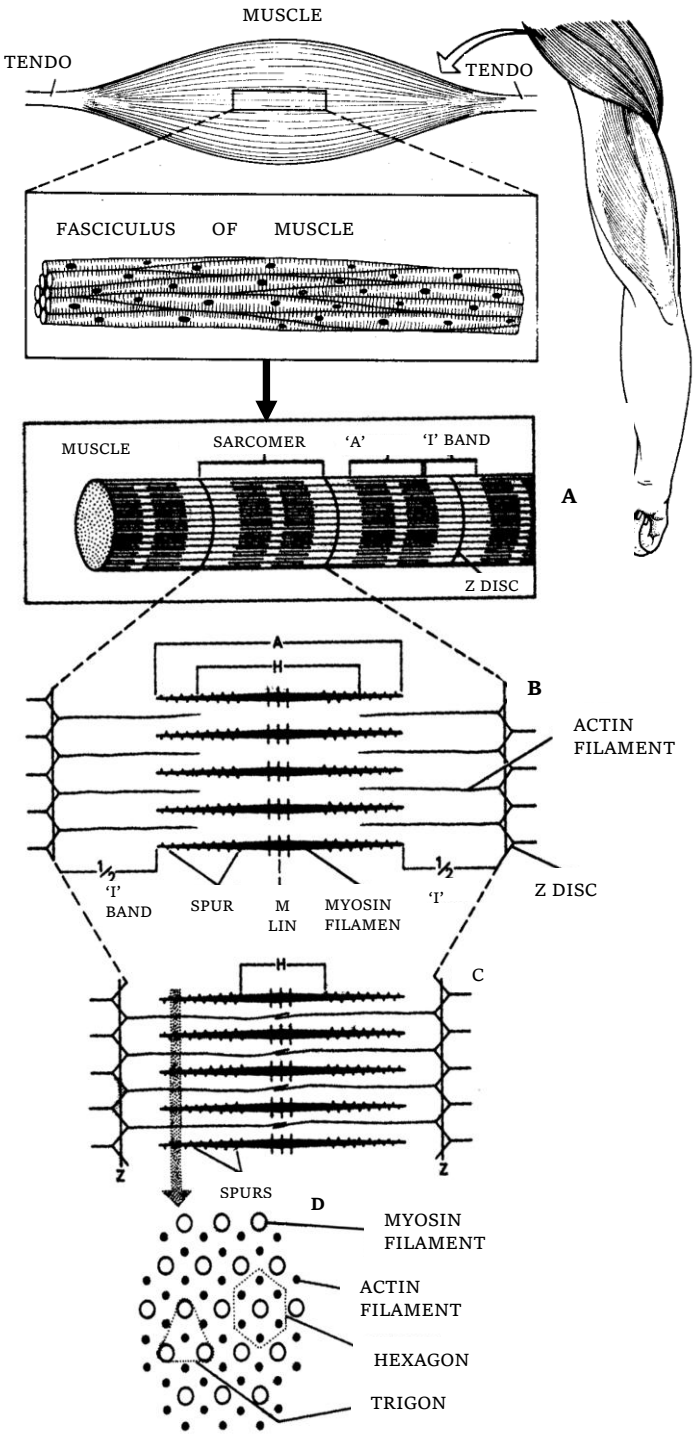


Fig. Ultrastructure of a relaxed striated myofibril (A) and a sarcomere (B); (C) a contracted sarcomere; (D) T. S. through

wider 'H' zones. These observations led Huxley to propose that shortening of the fibrils in contraction is brought about by sliding movement of actin filaments over myosin filaments towards "M" line by means of rapidly forming and breaking cross bridges or rachets at the spurs of myosin filaments. Thus, the sarcomere were recognised as the 'ultimate units of contraction'.

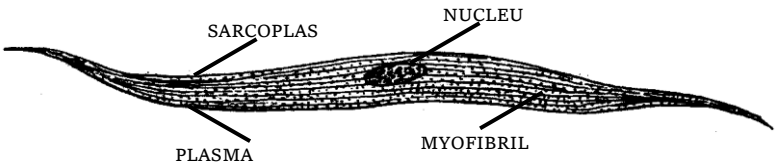
It was also proved that the 'A' band occupies about 2/3 length of a sarcomere, so that as its maximum contraction, a muscle shortens by about 1/3 of its length. Actin has a strong affinity to myosin; if uninhibited, it readly combines with myosin to form a contractile complex called actomyosin. Normally, tropomyosin and troponin of actin filaments inhibit formation of actomyosin. As a muscle fibre is stimulated by a motor nerve fibre, a large number of calcium ion (Ca^{++}) are released from the sarcoplasmic reticulum. Troponin has a strong affinity to (Ca^{++}). As these ions combine with troponin, the tropomyosin troponin complex is inactivated so that actin is now free to interact with the spurs of corresponding myosin filaments. Thus cross bridges of actomyosin are formed at the spurs.

The energy required for this interaction is provided by hydrolysis of ATP molecules in the spurs of myosin which contain ATPase enzyme for this purpose. Immediately after this process the Ca^{++} are forcefully pumped back into the endoplasmic reticulum by spending a large amount of energy of ATP. This reactivates the tropomyosin – troponin complex which, in turn inactivates the actin. The actomyosin of cross bridges, therefore, split back into actin and myosin and spurs spring back to their normal position. As it clears from above account, muscle fibres requires a large amount of energy, not only for contraction, but also for relaxation (pumping back of Ca^{++} into endoplasmic reticulum). That is why, these fibres contain more numerous mitochondria and produce more ATP. Besides this, an additional "high-energy compound" creatine phosphate, acts as a "reservoir of high energy phosphate bonds" in these fibres.

(f) **Stimulation of striated muscles :** Striated muscles are neurogenic, *i.e.*, these are stimulated to contract by somatic motor nerve fibres of central and peripheral nervous systems. A motor neuron innervates a group of muscle fibres by its axon terminalis, forming a motor fibres by its axon terminalis, forming a motor end plate. The motor neuron, together with the fibres it innervates, constitutes a "motor unit (neuromotor unit)". The junctions of the axon terminalis with the muscle fibre are called neuromuscular or myoneural junctions. The axon terminals release acetylcholine at these junctions to transmit excitation impulses to the sarcolemma of the fibres. Acetylcholine depolarises the sarcolemma and thus triggers a self-propagating action potential spreading towards both ends of the fibres. The conduction of the impulse in the sarcolemma is electrochemically similar to that found in the neurons.

(ii) **Smooth muscles :** These are called smooth, plain nonstriated involuntary or unstriped muscles due to absence of striations. These occur in the walls of hollow internal organs (alimentary canal, gall bladder, bile ducts, respiratory tracts, uterus, urinogenital ducts, urinary bladder, blood vessels, etc.), in capsules of lymph glands, spleen etc., in iris and ciliary body of eyes, skin dermis, penis and other accessory genitalia, etc. There is no connection of these muscles with bones. Smooth muscles of skin dermis, called arrector pilli muscles, are associated with hair roots, and are

responsible for goose-flesh (erection of hairs). Those of penis form a muscular network which helps in its erection and limping.



Smooth

(a) **Structure :** Smooth muscle fibre is unbranched spindle shaped, uninucleated and has no sarcolemma. Contraction is slow, involuntary under the control of ANS. Functionally smooth muscles are of two types **:**

(1) **Single-unit smooth muscle :** Single unit smooth muscle fibres are composed of muscle fibres closely joined together, contract as a single unit. e.g., urinary bladder and gastrointestinal tract.

(2) **Multi-unit smooth muscles :** Are composed of more independent muscle fibres, contract as separate units e.g. – hair root muscle, muscles on the wall of large blood vessels, ciliary muscles and muscles of iris.

Contractility in smooth muscle fibres also depends upon interaction between myosin and actin filaments. At chemical and mechanical levels, the mechanism of contraction and relaxation in smooth muscle fibres is basically the same as in striated fibres. Smooth muscles are innervated only by the fibres of autonomic nervous system. The multiunit muscles are principally neurogenic, i.e., these contract on nervous stimulations. The visceral or single unit muscles are, on the other hand, principally myogenic, i.e., self-excitatory, because the action potential is generated spontaneously within the muscles themselves due to non-nervous intrinsic factors like mechanical stretching, temperature, or chemical stimulation by hormones and other substances. For example, when the gut wall gets stretched

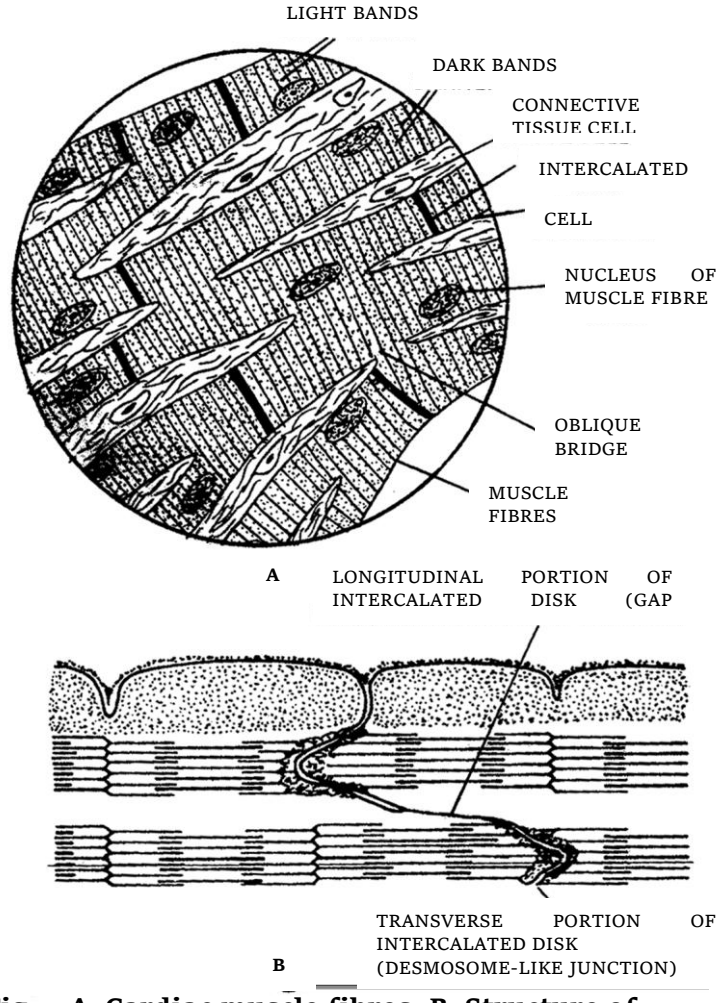


Fig. – A–Cardiac muscle fibres, B–Structure of intercalated disc

due to arrival of food, its muscles undergo rhythmic contractions and relaxations, bringing about the well-known peristalsis of gut wall. Similar peristalsis occurs in most other tubular viscera.

(iii) **Cardiac muscles :** Heart wall (also the wall of large veins just where these enter into the heart) is made up of cardiac muscles and, hence, called myocardium. Structurally, these muscles resemble striated muscles but, functioning independently of the conscious control of brain, these are involuntary like the smooth muscles. Cardiac muscle cells of fibres are comparatively shorter and thicker, cylindrical, mostly uninucleate with a central nucleus, somewhat branched and covered by a sarcolemma. The mechanism of contraction and relaxation in fibres of these muscles is the same as in skeletal muscle fibres, except that the duration of contraction is much longer in cardiac muscle fibres. Cardiac muscles require a large amount of energy of ATP for their incessant working throughout life. That is why, fibre of cardiac muscles contain comparatively very numerous, large and elongated mitochondria. Cardiac muscles cells divided at places by intercalated disc. Cardiac muscles are contract quickly and do not get fatigued. These muscles continue rhythmic contraction throughout life under the control of ANS. Heart is composed of three cardiac muscles viz. atrial muscle, ventricular muscle and self excitatory and conducting muscle.

Differences between three types of muscle fibres

S.No.	Feature	Striated or Striped or Skeletal or Voluntary muscle fibres	Non-striated or Unstriped or Smooth or Visceral or Involuntary muscle fibres	Cardiac muscle fibres
1.	Shape	Long cylindrical	Fusiform (thick in middle tapering at ends) (0.02 nm to 0.2 nm long)	Network of fibres
2.	Stripes	Dark A bands and light I bands present	Absent	Present
3.	Nucleus	Many (syncytial) at periphery	Single at the centre of each cell	Many nuclei between successive end plates central position
4.	Unit	Sarcomeres, cylindrical long myofibrils placed end to end forming cylindrical myofibrils	Fusiform cells with inconspicuous borders	Oblique cross-connecting fibres make this muscle an interconnected bundle of myofibrils
5.	Attachment	To bones	To soft organs or viscera	Not attached to other organs except major blood vessels which are isolated and covered by

				pericardium
6.	Sarcolemma	Distinct	Absent	Absent
7.	Sarcoplasmic Reticulum	Well developed	Less extensive	Poorly formed
8.	Blood supply	Rich	Poor	Rich
9.	Contraction	Quick, fatigue fast	Slow, sustained contraction	Rhythmic, contractions originate in heart (pace maker immune to fatigue)
10.	Location	Generally peripheral, tongue, proximal part of oesophagus	Central, in hollow visceral organs, iris of the eye, dermis of the skin	Only in heart
11.	Intercalated discs	Absent	Absent	Present
12.	T-tubule system	Well developed	Lacking	Well developed
13.	Innervated nerves	Motor nerves from central nervous system (neurogenic)	Nerves from autonomic nervous system (neurogenic)	Nerves from central and autonomic nervous system (myogenic)
14.	Fibres	Unbranched	Unbranched	Fibres join by short oblique bridges
15.	Action	Voluntary	Involuntary	Involuntary

Important Tips

- **Antagonistic muscles –** The striated muscles occur in antagonistic pairs; one pulls a bone in one direction, while the other pulls it back in reverse direction to its normal position. For example, the biceps muscle, extending from shoulder to radius, bends or flexes the arm at the elbow, whereas the triceps extending from ulna to the shoulder, straightens the arm. Thus, biceps is a flexor and triceps an extensor for bending the arm.
- **Single twitch –** When a muscle receives a single excitation impulse, it respond by a sudden partial contraction (twitch) lasting for about 0.5 second in man. Each twitch is followed by a refractory period during which the muscle does not respond to next stimulus. The refractory period is, however, so short (0.002 second) that the muscle can respond to the second stimulus while still in contraction phase in response to the first stimulus.
- **Tetanus –** Generally, whole muscles contract, not in a single twitch, but in sustained

contractions evoked by a series of nerve impulses reaching them in rapid succession. Such a sustained contraction is called tetanus. Described above should not be confused with the disease of "tetanus" (lock jaw) caused by tetanus bacillus. This disease is characterised by abnormal muscular contractions. Nor it should be confused with "tetany" which is muscular spasm occurring due to deficiency of parathyroid hormone.

- **Muscle tone or "Tonus" –** Even at rest the striated muscles normally remain in a state of mild sustained partial contraction to maintain the body posture. This is called muscle tone. It is a mild state of tetanus.
- **Paralysis –** When supply of motor impulses to a muscle is completely cut off due to destruction, either of the control centres in brain, or of the concerned motor nerves, or due to blocking of myoneural junctions by the use of certain drugs, the muscle function is completely impaired. This is called paralysis of the muscle.
- **Muscle fatigue –** A muscle that has contracted many times at short intervals, exhausts its store of ATP and glycogen and accumulates lactic acid. Hence its contractility gradually decreases and finally stops.
- **Oxygen debt –** During active work or exercise, the rate of oxygen supply by the lungs falls short of the requirement of the muscles. Hence, lactic acid accumulates in the muscles and the breathing gradually becomes hard to enhance O_2 intake by the lungs. This is called oxygen debt.
- **Involuntary action of skeletal muscles –** Muscles are capable of utilizing, in their mechanical work, only about 20% to 40% of energy liberated from glucose. The unutilized energy is lost as "heat" dissipated into the environment. This heat helps in maintenance of body temperature. "Shivering with cold" in winter is caused by a quick involuntary reaction of striated muscles.
- **Rigor mortis –** Rigidity that develops in the muscles after death is known as rigor mortis. It is due to permanent irreversible contraction, establishment of permanent link between actin and myosin and also fall in the concentration of ATP molecules.
- **Cori's cycle –** Lactic acid is transported by blood to liver and there it is converted to glycogen through Cori's cycle.
- **Contraction period –** Time taken in sliding of filament is called contraction time. (10 to 100 milli second).
- **Relaxation time –** It is time taken in relaxation of fibre i.e. active transport of calcium from sarcoplasm to cisternae. (10 to 100 milli second)
- **Refractory period –** It is time in a muscle or nerve fibre when they are non responding to second stimulus. Infact in this period there is temporary loss of excitability. Refractory period for skeletal and cardiac muscle is 5 and 300 milli second respectively.
- **Latent period –** After application of stimulus genesis of impulse and release of calcium from cisternae take some time within this time there is no contraction in muscle it is called latent period. (2 milli second)

- **Hypertrophy and Atrophy of muscles –** Muscles which are put to excessive work become thick and strong. This is called their hypertrophy. Conversely, if certain muscles are not used for a long period, those become thin and weak. This is called their atrophy (disuse atrophy). Cardiac muscle have a poor regenrative power.
- When muscles contract they have squeezing effect on veins running though them. It is termed as muscle pump.
- T-tubules are present in sarcolemma near the junction between A-band and I-band.
- **Tongue** – muscles and muscles of upper part of oesophagus are striated muscles, but without any bone.
- **Myoepithelium** – They have characteristic of both muscles and epithelium, occur in epithelium where contract to expel secretions such as saliva, milk and sweat from the respective glands, salivary gland, milk gland, and sweat gland.
- Cholesterol concentration is highest in cardiac muscle.
- Phospholipids concentration is maximum in cardiac muscle.
- The muscles change gradually from voluntary to involunatry in the upper part of oesophagus.
- Lohman Reaction : ADP + Phospho Creatine $\rightarrow$ ATP + creatine
- **Myokinase Action –** 2ADP $\rightarrow$ ATP + AMP
- Ions needed for single combination are Ca^{2+}, For double combination they are Ca^{2+}, K^{+}, For Triple combination are Ca^{2+}, K^{+}, Mg^{2+}.
- **Speed of muscular contraction –** Skeletal muscles = .01 sec per contraction, Involuntary muscles = 3-180 sec per contraction, Cardiac muscles = .85 sec per contraction
- In shivering only 30-40% energy is utilized in shivering
- Myosin protein is more contractile than actin
- **Chronaxie** is defined as the shortest duration of stimulus required to excite a tissue by a current strength.
- Painful contractions of muscles is called muscle cramp.
- **Myogram** – The graph representing force of contraction in relation to the time is called myogram.
- Total number of muscles in human body is 639
- Largest muscle is gluteus maximus (Buttock muscle).
- Smallest muscle is stapedius.
- Longest muscle is sartorius.
- Papillary muscle are associated with heart.
- Biceps brachii is associated with forearm.

- Gastrocnemius (calf muscle) is the muscle of shank.
- Pectoralis major is flight muscle in bird.
- Latissimus dorsi is the muscle of shoulder.
- Ciliary muscle is associated with eye-change focal length of lens.
- **Masseter –** Lower jaw, the strongest muscle in the body.
- **Rectus abdominis –** Longest visceral muscle found in abdomen.
- **Myology** – Study of muscles.
- **Myogram** – Recording of muscular contraction.
- **Muscular dystrophy** – A hereditary disease of muscle.
- **Poliomyelitis** – Viral disease that weakens the muscles.

1.8 Nervous tissue

A most complex tissue in the body, composed of densely packed interconnected nerve cells called neurons (as many as 10^{10} in the human brain). It specialized in communication between the various parts of the body and in integration of their activities. Nervous tissue is ectodermal (from neural plate) in origin. It forms the nervous system of the body which controls and coordinates the body functions. Nerve cells (neurons) are specialized to receive the external and internal stimuli. A stimulus of adequate strength (threshold stimulus) causes the depolarization or reversal of polarity of the neuron locally and initiates a nerve impulse. The neurons are capable of conducting this depolarization as a wave along their length in a particular direction either to other nerve cells or to effectors like muscles and glands which give the response. There response may be in the form of muscle contraction or glandular secretion. Therefore, excitability and conductivity two fundamental properties of nervous tissues. There is no intercellular matrix between neurons. These have permanently lost the power of division as have no centriole and have minimum power of regeneration. So these cannot be cultured in vitro. Irritability is the main function of nervous tissue.

(i) **Composition of nervous tissue :** Nervous tissue is formed of four types of cells :

(a) Neurons (nerve cells) (b) Neuroglia

(c) Ependymal cells (d) Neuro-secretory cells

(a) **Structure of neurons :** A neuron is a nerve cell with all its branches. Neuron is formed from neuroblast. It is the structural and functional unit of nervous system. It is the longest cell of the body.

(1) **Cyton :** It is also called perikaryon or soma or cell body. Its granular cytoplasm is called neuroplasm which has following structures :

(i) A large, spherical, centrally placed nucleus with a single nucleolus.

(ii) Numerous fine threads called neurofibrils for the conduction of nerve impulses.

(iii) A number of small, basophilic granules called Nissl's granules formed of rough endoplasmic reticulum with ribosomes and are sites of protein synthesis.

(iv) Neuroplasm has large number of mitochondria to provide high energy for impulse conduction.

(v) Neuroplasm may have melanophores with melanin pigment and lipochromes with orange or yellow pigment.

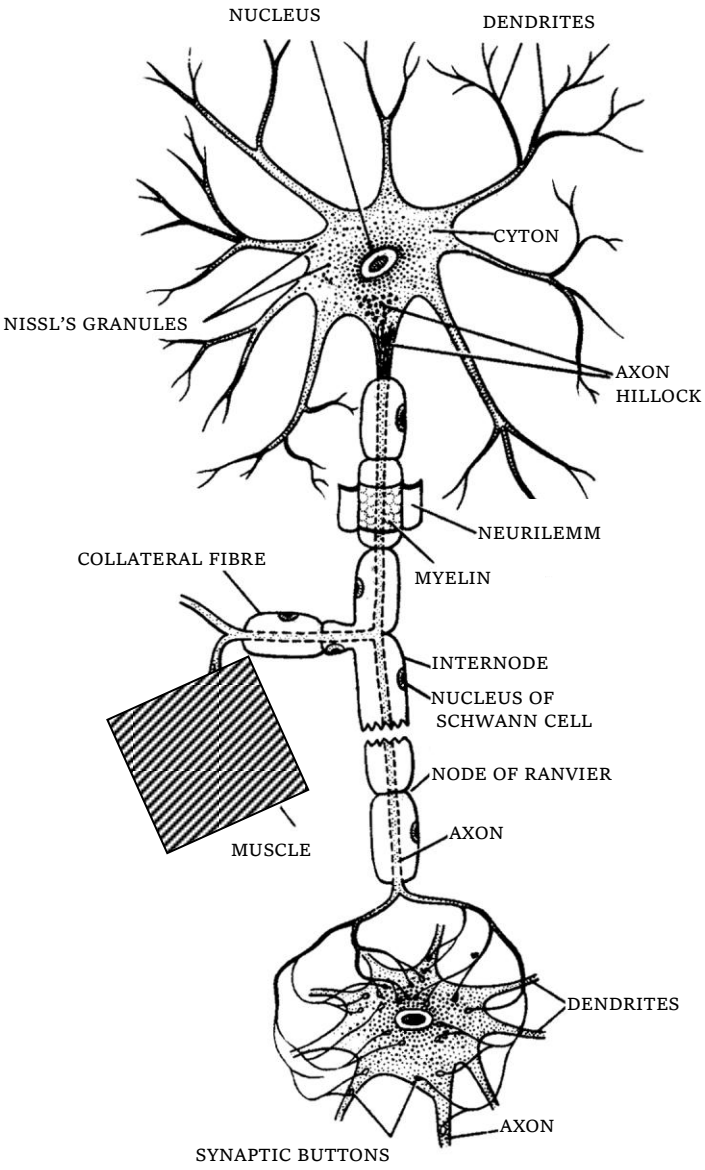


Fig. – An Enlarged Neuron and its synapses

(vi) A mature neuron has no centriole, so it cannot divide.

(vii) A "**Barr body**" is often seen abutting against the inner surface of nuclear membrane of cytons in females. This has been proved to be a transformed '*X*' chromosome.

(viii) Certain neurons having flask-shaped cytons and called purkinje cells, occur in the cerebellum of the brain.

(2) **Neuron processes :** The processes of neurons, called neurites, extend varying distances from the cyton and are of two types – dendrites or dendrons and an axon or axis cylinder (neuraxon).

(i) **Dendron :** These are several short, tapering much branched processes. The dendrites contain neurofibrils, neurotubules, Nissl's granules and mitochondria. They conduct nerve impulse towards the cell body.

(ii) **Axon :** This is a single very long, cylindrical process of uniform diameter. It arises from a conical projection, the **axon hillock**, of the cyton. The axon contains neurofibrils and neurotubules but lacks Nissl's granules. The axon is therefore dependent on the cell body for supply of proteins. The cell membrane of axon is called axolemma and its cytoplasm is called axoplasm. The axon conducts impulses away from the cell body. It may give off lateral branches termed collateral fibres. The latter arise from a node at right angle. Axon is usually branched only terminally into slender branches called telodendria. The latter have knobbed ends called endbulbs or axon terminals or buttons or synaptic knobs or end plates. The synaptic knobs contain mitochondria and secretory vesicles.

Differences between Axon and Dendron

Characters	Axon	Dendron
1. Number	Always single	May be one or more in number
2. Structure	Formed of neuroplasm with only neurofibrils but no Nissl's bodies.	Formed of neuroplasm with both neurofibrils and Nissl's bodies
3. Size	Long sized processes	Small sized processes
4. Direction of new impulses	Always away from the cell body	Always towards the cell body
5. Nature	Efferent	Afferent
6. Branching	Generally absent	Generally present

(b) **Neuroglia or Glia cells :** Neuroglia consists of the supporting and packing cells found in the brain, spinal chord and ganglia. These are non nervous cells. These are ten times more numerous than neurons. In some parts of body the neuroglial cells are called by certain other name such as muller cells in retina, pituicytes in posterior pituitary gland and satellite cells in ganglia.

(1) **Types :** The neuroglia cells are of three types –

(i) **Astrocytes :** These are large sized and star-shaped cells with numerous processes.

(ii) **Oligodendrocytes :** These have a few branched processes which resemble the dendrons of the neurons.

(iii) **Microglial cells :** These are small sized and spindle-shaped. The microglia cells act as the defensive phagocytes in central nervous system. They arise from the monocytes.

Differences between Neurons and Neuroglia

Neurons (Nerve cells)	Neuroglia (Glial cells)
1. Have a relatively small cell body and long processes.	**1.** Have a relatively large cell body and short processes.
2. Processes arise from the two opposite ends of the cell body.	**2.** Processes arise from nearly all over the cell body.
3. Processes are of 2 types : short dendrons and along axons.	**3.** Processes are all alike.
4. Neurons occur end to end in chains.	**4.** Glial cells are aggregated in masses.
5. Neurons set up and conduct nerve impulses	**5.** Glial cells form a supporting and packing tissue that insulates the neurons. Some (microglia cells) are phagocytic.
6. All neurons arise from the ectoderm.	**6.** Most glial cells arise from the ectoderm, microglia cells arise from the monocytes.
7. Neurons form synapses.	**7.** Glial cells do not form synapses.

(2) **Functions :**

(i) These are capable of division and help in wear and tear of the central nervous system.

(ii) These insulate the adjoining neurons and prevent the lateral transmission of impulses.

(iii) These provide nutrition to the neurons.

(iv) These act as phagocytes and eat up the microbes.

(v) These help in memory processes.

(vi) They acts as Blood brain barrier (BBB) i.e. they inhibit contact between neuron and blood, along with endothelium of capillary. The exchange of material between blood and neuron is always through these neuroglial cells i.e., they are mediator.

(c) **Ependymal cells :** These are cuboidal and ciliated epithelial cells which lines the cavities of brain (ventricles) and spinal chord (central canal). These form an epithelium called ependyma.

(d) **Neurosecretory cells :** These are special type of neurons of the hypothalamus of brain. These are endocrine in function and secrete neurohormones which are carried by the blood of hypophyseal portal system to anterior lobe of pituitary gland and stimulate the secretion of their trophic hormones e.g., TSH, STH, FSH, LH, ACTH, etc.

(ii) **Types of neurons :** Neurons are divided into different categories on different basis.

(a) **On the basis of functions :** Neurons are divided into three categories :

(1) **Sensory (afferent) neurons :** These are found in sense organs. Their dendrons receive the nerve impulse from the nerve process of the receptor cell while their axon forms the synapse with

dendron of the next neuron. These may be naked or encapsulated e.g. olfactoreceptors and gustatoreceptors.

(2) **Internuncial neurons :** These are located in the dorsal horn of the spinal cord. Their dendrons form the synapse with the axon of sensory neuron while their axon forms the synapse with the dendron of the motor neuron. These are called association neurons (when their axon synapses with the dendron of motor neuron of same side) or commissural neuron (when their axon synapses with the dendron of motor neuron of opposite side).

(3) **Motor (efferent) neurons :** These are always present in the ventral horn of the spinal cord. Their axon ends into the muscle fibres or glands cells. These conduct the nerve impulses to the effector organs which respond to the stimuli.

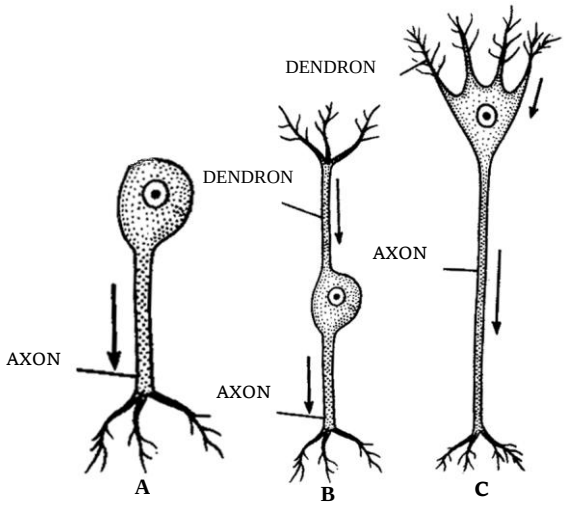


Fig. – Types of Neurons A – Unipolar; B – Bipolar; C –

(b) **On the basis of number of nerve processes :** Neurons are of three types –

(1) **Unipolar neurons :** In these neurons, only one nerve process arises from the cyton which acts as axon but there is no dendron. These are found only in early embryos. The unipolar neuron of the adult gives rise to a single nerve process, which immediately divides into a dendron and an axon. Such unipolar neurons are called pseudo-unipolar neurons. These are found in the dorsal root ganglia of spinal nerves and in the roots of V, IX and X cranial nerves.

(2) **Bipolar neurons :** In these neurons, the cyton gives rise to two nerve processes out of which one acts as an axon while other acts as a dendron. These are found in the olfactory epithelium of nasal chamber and retina of eye. These may be isopolar or heteropolar (dendrons being irregularly branched).

(3) **Multipolar neurons :** In these neurons, the cyton gives rise to several nerve processes out of which one acts as an axon while remaining nerve processes act as dendrons. These are found in the central nervous system and the ganglia of autonomic nervous system.

(iii) **Nerve fibres :** Axon or dendron of a nerve cell covered with one or two sheath is termed as nerve fibre. The nerve fibres are of two types – medullated or myelinated and non medullated or non myelinated regarding their structure.

(a) **Medullated nerve fibres :** A medullated nerve fibre typically consists of a central core, the axis cylinder, or neuraxis, surrounded by two sheaths : inner thick medullary sheath and outer thin neurilemma.

(1) **Axis cylinder :** The axis cylinder is simply the axon or dendron of a nerve cell. It contains longitudinal neurofibrils and mitochondria in its neuroplasm, called axoplasm, limited by cell membrane termed axolemma. It is the axolemma that conducts the nerve impulses.

(2) **Medullary sheath :** The medullary sheath is composed of a shinning, white, fatty substance called myelin. This sheath perhaps serves as an insulating layer, preventing loss of energy of the nerve impulse during its passage along the fibre. The medullary sheath is continous around the fibres in the

central nervous system, but in the fibres of the peripheral nerves it is absent at certain points known as the Node of Ranvier. The part of a nerve fibre between two successive nodes is termed the internode.

(3) **Neurilemma :** The neurilemma consists of tubular sheath cells (Schwann's cells) placed end to end. The neurilemma is continuous over the Nodes of Ranvier. The function of the Schwann's cells is to produce the myelin sheath around the neuraxis. Outside neurilemma is a thin layer of connective tissue. It is called endoneurium. It keeps the nerve fibre held to the others in a nerve. The medullated nerve fibres within the brain and spinal chord lack neurilemma. Instead, they have an incomplete covering of neuroglia cells, which probably produce the myelin sheath. Neurilemma present around the peripheral nerve fibres enables them to regenrate after injury. Nerve fibres in the brain and spinal chord do not regenrate after injury due to lack of neurilemma. The medullated nerve fibres occur in the white matter of the brain and spinal chord and in the cranial and spinal nerves.

(b) **Non medullated nerve fibres :** A non medullated nerve fibre consists of an axis cylinder enclosed by neurilemma and connective tissue. These fibres appears grey in colour in the fresh state. The non-medullated nerve fibres occur in the autonomic nerves.

Difference between medullated and non-medulated nerve fibre

Characters	Medullated nerve fibres	Non-medullated nerve fibres
1. Occurrence	Found in white matter of brain, spinal cord, cranial and spinal nerves	Found in grey matter of brain and spinal cord, and in autonomic nervous systems.
2. Sheaths.	Neuraxis covered by inner medullary sheath and outer neurilemma	Neuraxis covered by only neurilemma. Medullary sheath is absent
3. Nodes of Ranvier and internodes	Present	Absent
4. Diameter	More	Less
5. Colour	White	Grey
6. Speed of conduction of nerve impulses.	Faster due to saltatory conduction of nerve impulses	Slower
7. Collateral branches	Present	Absent

(iv) **Nerves**

(a) **Structure :** The nerves are thread like structures extending between the central nervous system and the receptor of effector organs of the body. These conduct the nerve impulses to and from the central nervous system.

Each nerve is formed of several bundles of nerve fibres, called fasciculi. Each nerve fibre of the bundle is covered by a thin sheath of connective tissue called endoneurium**,** while each fasciculus is enclosed by another sheath of white fibrous connectiveS

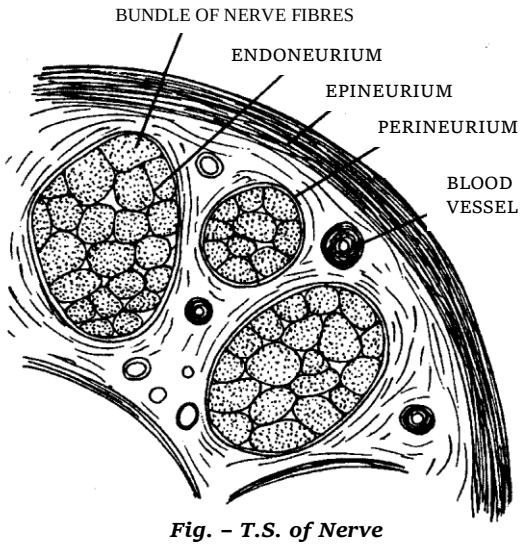


Fig. – T.S. of Nerve

tissue called perineurium**.** All the fasciculi are held together by the connective tissue and are enclosed by a thick coat of white fibrous connective tissue called epineurium**.** On average, a nerve contains about twice as many unmyelinated fibres as myelinated fibres.

(b) **Types of nerves :** The nerves are of three types according to the nature of the nerve fibres they are composed of

(1) **Sensory or afferent nerves :** The nerves with sensory fibres are called sensory nerves. Example – Olfactory, optic and auditory nerves.

(b) **Motor or efferent nerves :** The nerves having efferent fibres are termed motor nerves. Example – Oculomotor, Pathetic and abducens nerves.

(c) **Mixed nerves :** Some nerves have both afferent and efferent fibres. These are known as mixed nerves. Example – Trigeminal, facial, glossopharyngeal and vagus nerves.

Important Tips

- The value of resting membrane potential is – 60 to – 90 mV.
- Na^+ and K^+ Ions are required for nerve conduction.
- GABA is slow neurotransmitter substance.
- Synapse is a junction between dendrites and Axons ends.
- Neuro glial cells differs from neurons in having no Nissls granules.
- Nerve fibres are different from the muscles fibres due to the presence of dendrites.
- Branched ends of nerve cells are called telodendria which establish the functional contact with other nerve cell this connection is called **synapse.**
- Most of the neurons of our body are multipolar.
- Nissil's bodies is absent in axon and axon hillock.

ASSIGNMENT

EPITHELIAL TISSUE

Basic Level

1. Cells of the epithelial tissue rest on a basement membrane which is made up of
(a) Monosaccharides (b) Mucopolysaccharides (c) Disaccharides (d) Lipids

2. The cells of a tissue are similar in
(a) Structure (b) Function (c) Origin (d) Both (a) and (b)

3. The intercellular matrix is negligible or absent in which of the following tissue
(a) Connective tissue (b) Epithelial tissue (c) Muscular tissue (d) Cardiac tissue

4. The basement membrane acts as
(a) Plasma membrane (b) Plasmalemma (c) Both (a) and (b) (d) None of these

5. The filaments arising from desmosomes are called
(a) Tonofibril (b) Tonofilament (c) Both (a) and (b) (d) None of these

6. Pseudostratified epithelium is always
(a) Single layered (b) Double layered (c) Multilayered (d) Uncertain

7. Most of the glands of the body are of
(a) Holocrine type (b) Merocrine type (c) Apocrine type (d) None of these

8. Reproductive cells (germinal epithelium) are made up of which of the following epithelial tissue
(a) Cuboidal (b) Columnar (c) Squamous (d) Sensory

9. In chordates the peritoneum covers
(a) Heart (b) Skin (c) Kidney (d) Liver

10. Covering of lungs is called
(a) Pericardium (b) Pleura (c) Peritoneum (d) Serosa

11. Schneiderian membrane is found in
(a) Nasal passage (b) Trachea (c) Bowman's capsule (d) Loop of Henle

12. Cells of squamous epithelium are
(a) Tall with elongated nuclei (b) Cube like
(c) Flat and tile like (d) Columnar or cuboidal in shape

13. Which of the following makes heart wall more thick
(a) Pericardium (b) Epicardium (c) Myocardium (d) Endocardium

14. Internal surface of large intestine is
(a) Lined by muscular tissue (b) Lined by epithelial tissue
(c) Lined by both types of tissue (d) Lines by all four types of tissue

15. Desmosomes are the feature of

(a) Epithelial tissue (b) Nervous tissue (c) Muscular tissue (d) None of these

16. Simple epithelium is

(a) One cell thick (b) Two cells thick (c) Two or three cells thick (d) All of these

17. The cellular layers in epidermis of skin consists of

(a) Glandular cells (b) Columnar cells

(c) A squamous stratified cornified epithelium (d) A complex stratified epithelium

18. Pavement epithelium is another name for

(a) Cuboidal epithelium (b) Ciliated epithelium

(c) Simple squamous epithelium (d) Stratified epithelium

19. Rapid healing of wounds is found in

(a) Epithelial tissue (b) Muscular tissue (c) Connective tissue (d) Nervous tissue

20. Microvilli are present in

(a) Stratified squamous epithelium (b) Cuboidal epithelium

(c) Columnar epithelium (d) Ciliated epithelium

21. Stereocilia are present on

(a) Epithelial cell of respiratory tract (b) Epithelial cells of female genital tracts

(c) Epithelial cells of epididymis (d) None of these

22. Gland which is both exocrine and endocrine is

(a) Tubular glands (b) Saccular glands (c) Apocrine glands (d) Heterocrine glands

23. Nature of mammary gland is

(a) Apocrine (b) Merocrine (c) Holocrine (d) None of these

24. Kinocilia are

(a) Motile (b) Non-motile

(c) Both (a) and (b) according to function (d) None of these

25. Stratified keratinized squamous epithelium is found in

(a) Trachea (b) Epidermis

(c) Mouth cavity (buccal) (d) Lining of blood vessels

26. Compound stratified squamous non keratinised epithelium is found in

(a) Stomach (b) Intestine (c) Trachea (d) Pharynx

27. Epithelial tissue serves as

(a) Protective covering (b) Reproductive structures (c)Corpuscles (d) Nerve cells

28. Which tissue evolved first in the animals

(a) Muscular tissue (b) Connective tissue (c) Epithelial tissue (d) Skeletal tissue

29. Basement membrane is made up of

(a) Epidermal cell only (b) Endodermal cell

(c) No cell product of epithelial cell (d) Both (a) and (b)

30. The endothelium of blood vessel is composed of

(a) Cuboidal epithelium (b) Squamous epithelium

(c) Columnar epithelium (d)Ciliated epithelium

31. Ciliated cells are found in

(a) Bronchus (b) Pancreas (c) Liver (d) Uterus

32. Outer layer of skin is made up of keratinized epithelium, this is because

(a) It is exposed thus subjected to wear and tear (b) It covers the whole body

(c) It is thick (d) It prevents the entry of pathogens

33. Brush bordered epithelium is found in

(a) Fallopian tube (b) Small intestine (c) Oesophagus (d) Trachea

34. Epithelial cells involved in the process of absorption of digested food have on their surface

(a) Pinocytic vesicles (b) Microvilli (c) Zymogen granules (d) Phagocytic vesicles

35. The name 'tissue' was given by

(a) Bichat (b) Mayer (c) Robert Hooke (d) A Maximow

36. Which of the following is non living substance

(a) Protoplasm (b) Cytoplasm (c) Nucleus (d) None of these

37. The basis for the classification of various types of tissues is its

(a) Function (b) Structure

(c) Location and function (d) Intercellular material

38. Study of living tissue in situ is known as

(a) Innate (b) Ecesis (c) In vivo (d) In vitro

39. Pseudostratified columnar ciliated epithelium is found in

(a) Mouth (b) Stomach / Oesophagus (c)Kidney (d) Trachea

40. Cells lining the blood capillaries are called

(a) Oxyntic cells (b) Endothelial cells (c) Parietal cells (d) Haemocytes

41. The epithelium found in the lining layer of stomach and intestine is

(a) Columnar (b) Squamous (c) Stratified (d) Pseudostratified

42. Germinal epithelium of ovary is formed of

(a) Columnar epithelium (b)Squamous epithelium

(c)Cuboidal epithelium (d) Stratified epithelium

43. Ciliated epithelium is found in

(a) Ovary and trachea (b) Nephron and trachea (c) Lung and trachea (d) Liver and trachea

44. Blood vessels are internally lined by

(a) Ciliated epithelium (b) Columnar epithelium

(c) Squamous epithelium (d) Striated epithelium

45. In cuboidal epithelial cells the nuclei are situated

(a) Centrally (b) Apically (c) Basally (d) Accentrically

46. Brush border is characteristic of

(a) Secretory cells (b) Absorptive cells (c) Osteocytes (d) Nerve cells

47. Schneiderian membrane is for

(a) Gustation (b) Rheoreceptor (c) Olfaction (d) Thigmoreceptor

48. Glandular epithelium is found in

(a) Mouth (b) Oesophagus (c) Lungs (d) Liver

49. Another name for transitional epithelium is

(a) Tessalated epithelium (b) Urothelium (c) Pigmented epithelium (d) All of these

50. Transitional epithelium is found in

(a) Trachea (b) Urethra (c) Kidney pelvis (d) Both (b) and (c)

51. Squamous epithelial cells are found in

(a) Lungs (b) Stomach (c) Uriniferous tubule (d) Testis

52. The word epithelium was coined by

(a) Malpighii (b) Ruysch (c) Bichat (d) None of these

Advance Level

53. Only tissue which is originated from all the three layers of embryo

(a) Connective tissue proper (b) Epithelial tissue

(c) Muscular tissue (d) All of these

54. When the cell membrane of cells at certain places fuses, they are called as

(a) Nexus (b) Macula occludens (c) Zonula occludens (d) All of these

55. Simple cuboidal epithelium is found in

(a) Sweat gland (b) Choroid of eye (c) Thin bronchioles (d) All of these

56. The cells of sensory epithelium are found

(a) Singly (b) In groups

(c) Interspersed between epithelial cells (d) All of these

57. The ducts of mammary gland are lined by

(a) Stratified columnar epithelium (b)Stratified cuboidal epithelium

(c) Transitional epithelium (d)All of these

58. The function of villi in the intestine is

(a) Absorption of food (b) Increase in the absorptive surface of food

(c) Control of intestinal movement (d) Hinderance in the movement of food

59. Peritoneal layer of body cavity is made up of

(a) Squamous epithelium (b)Ciliated epithelium

(c) Columnar epithelium (d)Glandular epithelium

60. The ciliated epithelium in our body may be found in

(a) Ureter (b) Trachea (c) Bile duct (d) Uterine tube

61. Vagina and oesophagus have a common inner lining of

(a) Squamous epithelium (b)Ciliated epithelium

(c) Columnar epithelium (d)Stratified squamous non keratinised epithelium

62. Epithelial tissue performs the following functions

(a) Protection, secretion, absorption only (b) Protection, secretion, sensation, absorption

(c) Protection, secretion, absorption, digestion (d) None of these

63. Epithelium in case of serous membranes is called

(a) Ectothelium (b) Endothelium (c) Mesothelium (d) Serothelium

64. Normal wear and tear of cells in simple epithelia is negligible because

(a) Epithelial cells are very tough

(b) Epithelial cells are closely fitted like tiles of a mosaic

(c) Epithelial cell are kept moist due to the material that diffuse through it

(d) Epithelial cell is protective in function

65. A gland cell and an epithelial cell perform different function, because

(a) They are located differently

(b) Different genes of each of these cells are active while others are not

(c) They do not contain all the necessary genes

(d) During early and fast differentiation of these cell types some genes of each are destroyed

66. Pseudostratified columnar epithelium is found in

(a) Wall of cloaca (b) Upper part of male urethra

(c) Oviduct (d) Oesophagus

67. Sweat, salivary and pancreatic ducts are lined by

(a) Stratified squamous epithelium (b)Non keratinized stratified cuboidal epithelium

(c) Stratified columnar epithelium (d)Stratified ciliated columnar epithelium

68. Tissue which has power of division and regeneration throughout life

(a) Epithelial tissue (b) Muscular tissue (c) Connective tissue (d) Nervous tissue

69. Epithelial tissues arise from

(a) Ectoderm (b) Endoderm (c) Mesoderm (d) All of these

70. The epithelium in the bronchioles is

(a) Pseudostratified and columnar (b) Squamous and sensory

(c) Pseudostratified and sensory (d) Cuboidal and columnar

71. Epithelial tissue which lines the spinal cord is known as

(a) Endothelium (b) Endocardium (c) Ependymal cells (d) Mesothelium

72. Which type of epithelium is found in oesophagus, cornea and vagina

(a) Transitional epithelium (b) Columnar epithelium

(c) Non-keratinized stratified epithelium (d) Keratinized stratified epithelium

73. Stratum germinativum is an example of which kind of epithelium

(a) Cuboidal (b) Ciliated (c) Columnar (d) Squamous

74. Transitional epithelium is found in

(a) Lungs (b) Liver (c) Urinary bladder (d) Stomach

75. Which of the following is the characteristics of epithelial tissues

(a) They are highly vascularised (b) They never produce glands

(c) They have large intercellular spaces (d) They have a rapid rate of cell division

76. The type of epithelium found in conjunctivas of eye is

(a) Stratified cuboidal (b) Stratified columnar

(c) Stratified squamous (d) Transitional epithelium

77. Which of the following in mammalian tissues is associated with filtration and diffusion

(a) Simple columnar (b) Simple squamous (c) Stratified squamous (d) Stratified columnar

78. Ciliated epithelium occurs in frog in

(a) Buccal cavity and oviduct (b) Stomach and urinary bladder

(c) Blood vessels and lymph vessels (d) Kidney and stomach

79. Epithelial tissue with thin flat cells appearing like packed tiles occurs on

(a) Inner lining of cheek (b) Inner lining of stomach

(c) Inner lining of fallopian tubes (d) Outer surface of ovary

80. Inner lining of gut, stomach and liver is made of

(a) Simple squamous epithelium (b)Simple columnar epithelium

(c) Simple cuboidal epithelium (d)All of these

81. Nonkeratinized stratified squamous epithelium is found in

(a) Epidermis of skin of land vertebrates (b) Oral cavity and pharynx

(c) Vagina and cervix (d) Both (b) and (c)

82. Stratum germinativum is an example of which kind of epithelium

(a) Cuboidal (b) Ciliated (c) Columnar (d) Both (a) and (c)

83. Ciliated epithelium lines the

(a) Tracheal and fallopian tube (b) Bile duct and ureter epithelium

(c) Trachea and oesophagus (d) Pharyngeal and stomach mucosae

84. Macula adherens is a kind of

(a) Desmosome (b) Mesosome (c) Filament (d) Membrane

85. Vertebrate salivary glands and exocrine part of pancreas are

(a) Apocrine (b) Holocrine (c) Epicrine (d) Merocrine

86. Layer of columnar cells with uneven appearance and lining trachea is

(a) Brush border epithelium (b) Pseudostratified epithelium

(c) Stratified epithelium (d) Ciliated epithelium

CONNECTIVE TISSUE

Basic Level

87. Abnormal rise in number of R.B.C. is called

(a) Anaemia (b) Polycythemia (c) Leukemia (d) All of these

88. Average life span of human R.B.C. is

(a) 100 days (b) 90 days (c) 120 days (d) None of these

89. The tendon are formed of

(a) White fibrous tissue (connective) (b) Yellow fibrous tissue (connective)

(c) Areolar tissue (d) Adipose tissue

90. Which of the following tissue is more elastic

(a) Bone (b) Cartilage

(c) Both are equally elastic (d) Both are not elastic

91. All the cartilaginous bones are previously

(a) Elastic cartilage (b) Hyaline cartilage (c) Calcified cartilage (d) Fibrous cartilage

92. Lacunae are connected with

(a) Canaliculae (b) Sublacunae (c) Both (a) and (b) (d) None of these

93. The fibrous tissue which connects the two bones is

(a) Connective tissue (b) Tendon (c) Ligament (d) Adipose tissue

94. Long shaft of a bone is called as

(a) Epiphysis (b) Diaphysis (c) Metaphysis (d) None of these

95. Monocytes are how much percent of total W.B.C.

(a) 5.3% (b) 30% (c) 0.4% (d) 1.3%

96. Ligaments and tendons are

(a) Connective tissue (b) Muscular tissue

(c) Fibrous connective tissue (d) Skeletal tissue

97. The matrix of hyaline cartilage contains

(a) Collagen (b) Chondrin (c) Ossein (d) All of these

98. R.B.C. in adult are formed

(a) In the red bone marrow of long bones (b) In the spleen

(c) In the thymus (d) In the liver

99. Sprain is caused due to stretching of

(a) Muscle (b) Ligament (c) Tendon (d) Nerve

100. Collagen fibres of connective tissue are

(a) White (b) Yellow (c) Colourless (d) Red

101. Covering around bone is called

(a) Perichondrion (b) Periosteum (c) Epiosteum (d) Endosteum

102. Cartilage is formed by

(a) Osteoblast (b) Fibroblast (c) Chondrocyte (d) Submucosa

103. Ligament is a structure which joins

(a) Two bones (b) Two muscles (c) Muscle and bone (d) Nerve and Muscle

104. Mast cells are found in

(a) Connective tissue (b) Muscular tissue (c) Nervous tissue (d) Blood

105. Erythrocytes in camel are

(a) Oval and non-nucleated (b) Oval and nucleated

(c) Circular, biconcave and non-nucleated (d) Circular, biconvex and nucleated

106. Shape of the nucleus of WBC is usually

(a) Spherical (b) Irregular (c) Oval (d) Spindle shaped

107. Lymph differs from blood in having

(a) No W.B.C. (b) No protein (c) Much more of water (d) No R.B.C.

108. Which of the following is not the cell of areolar tissue

(a) Macrophages (b) Schwann cell (c) Plasma cell (d) Adipose cell

109. Lymph nodes are to fight against

(a) R.B.Cs (b) Germs (c) W.B.Cs (d) None of these

110. *pH* of human blood is

(a) 7.4 (b) 6.2 (c) 9.0 (d) 10.00

111. The strongest cartilage is

(a) Fibrous cartilage (b) Hyaline cartilage (c) Elastic cartilage (d) None of these

112. Below the skin, the fat is in the form of

(a) Lipoproteins (b) Adipose tissue (c) Mucous layer (d) Lymphoid tissue

113. Usually chordates have red blood containing red blood corpuscles. The blood is red due to the presence of the following pigment

(a) Myoglobin (b) Anthocyanin (c) Anthocyanin (d) Haemoglobin

114. Red marrows of the bone produce

(a) Lymphocytes (b) Eosinophils (c) Plasma (d) RBC

115. In the matrix lies the bone cells, called

(a) Chondroclasts (b) Osteoclasts (c) Osteoblasts (d) Osteocytes

116. The skeletal tissue consists of organic matrix called as

(a) Hyaline (b) Chondrin (c) Osteoblast (d) Chondroblast

117. The types of fibres found in connective tissues are

(a) Collagen fibres (b) Elastic fibres (c) Reticular fibres (d) All of these

118. The membrane that covers cartilage is known as

(a) Periostium (b) Perichondrium (c) Perineurium (d) Pericardium

119. The major protein of the connective tissues is

(a) Keratin (b) Collagen (c) Melanin (d) Myosin

120. A connective tissue

(a) Has no matrix (b) Covers the skin (c) Has abundant matrix (d)None of these

121. Most of the cells in areolar tissue are

(a) Fibroblasts (b) Macrophages (c) Mast cells (d) All of these

122. The white fibrous tissue occurs in

(a) Ligaments (b) Tendons (c) Cartilage (d) Bone

123. External ear (pinna) contains a hard, flexible structure composed of

(a) Bone (b) Cartilage (c) Tendon (d) Ligament

124. The cells of cartilage are

(a) Osteocytes (b) Chondriocytes (c) Pinnacocytes (d) Oenocytes

125. Marrow cavity present at the ends of long bone is internally lined by

(a) Periosteum (b) Endosteum (c) Epiosteum (d) Sarcolemma

126. Histiocyte is a connective tissue cell, the function of which is

(a) Phagocytic (b) Secretion (c) Fibre production (d) None of these

127. Mineral present in red pigment of vertebrate blood is

(a) Magnesium (b) Iron (c) Copper (d) Calcium

128. Humerous and muscles are connected with

(a) Ligament (b) Tendons (c) Both (a) and (b) (d) None of these

129. Fats are richly found in

(a) Alveolar tissue (b) Lymph glands (c) Adipose tissue (d) Liver cells

130. Blood is formed of

(a) Plasma and bone marrow cells (b) Plasma, white and red blood cells

(c) Plasma and white blood cells (d) Plasma and red blood cells

131. The rate of erythropoiesis is controlled by

(a) An enzyme (b) A harmone (c) Spleen (d) Brain

132. "Graveyard of RBCs' is

(a) Liver (b) Spleen (c) Kidney (d) All of these

133. Articular cartilage is

(a) Hyaline cartilage (b) White fibrous cartilage

(c) Yellow elastic fibrous cartilage (d) Calcified cartilage

134. Alkalaemia is

(a) Blood *pH* less than 7 (b) Blood *pH* is 7.3 – 7.4

(c) Blood *pH* more than 7.45 (d) Removal of inorganic salts from plasma

135. The main difference in white and yellow fibres is of

(a) Protein (b) Colour of the fibres (c) Both (a) and (b) (d) None of these

136. Sarcoplasm is the

(a) Cytoplasm of nerve fibres (b) Cytoplasm of muscle fibres

(c) Unit of muscle contraction (d) None of these

137. White adipose tissue contains

(a) Multilocular fat cells (b)Bilocular fat cells (c) Unilocular fat cells (d) Alocular fat cells

138. Osteon is found in the

(a) Femur of frog (b) Femur of bird

(c) Femur of rabbit (d) Femur of man and rabbit

139. Formation of cartilage is known as

(a) Diapedesis (b) Chondrogenesis (c) Haemopoiesis (d) Ossification

140. Vascular tissue or fluid tissue is made up of

(a) RBC, WBC and plasma (b) RBC, plasma and platelets

(c) RBC, WBC, plasma and platelets (d) WBC, plasma and platelets

141. The life span of human WBC is approximately

(a) Less than 2 days (b) Between 20 to 30 days

(c)Between 2 to 3 months (d) More than 4 months

142. Leucocytes (WBCs) are considered as true cells because

(a) They possess nucleus (b) They do not contain haemoglobin

(c) They show great power of movement (d) They are responsible for phagocytic activity

143. Phagocytosis was first of all seen by

(a) Huxley (b) Haeckal (c) Metchnikoff (d) Strasburger

144. Highest content of iron is found in

(a) WBC (b) Bone cells (c) RBC (d) Protein

145. Role of bone-marrow in mammals is

(a) To assist kidneys (b) To act as haemopoietic tissue

(c) To assist liver (d) To control blood pressure

146. Where would you find mast cells

(a) Adipose tissue (b) Areolar tissue

(c) Yellow fibrous tissue (d) White fibrous tissue

147. Platelets released during blood clotting is

(a) Thrombin (b) Prothrombin

(c) Thrombokinase (Thromboplastin) (d) Fibrinogen

148. Which of the following have longest life in blood

(a) Eosinophils (b) Red blood corpuscles (c) Basophils (d) Neutrophils

149. The connective tissue that connects the skin to the underlying structures is

(a) Areolar tissue (b) Serous membrane

(c) Reticular tissue (d) Dense connective tissue

150. Which one occurs in greatest proportion

(a) Neutrophils (b) Eosinophils (c) Basophils (d) Lymphocytes

151. Hyaline cartilage forms

(a) Tracheal rings (b) Pubic symphysis (c) Epiglottis (d) External ear

152. Cells which secrete the bone matrix are

(a) Osteoblast cells (b) Osteoclast cells

(c) Bone cells (d) Bone cells and osteoclast cells

153. Connective tissue originates from

(a) Ectoderm (b) Endoderm (c) Mesoderm (d) Meso-endoderm

154. The ground substance of connective tissue is basically composed of

(a) Mucopolysaccharides (b)Lipids (c) Monosaccharides (d) Phospholipids

155. Adipocytes are mainly found in

(a) Bones (b) Cartilages (c) Connective tissue (d) Nerves

156. The largest corpuscles in mammalian blood are

(a) Basophils (b) Erythrocytes (c) Monocytes (d) Lymphocytes

157. Ends of long bones are covered with

(a) Cartilage (b) Muscles (c) Ligaments (d) Blood cells

158. Fluid part of blood after removal of corpuscles is

(a) Plasma (b) Lymph (c) Serum (d) Vaccine

159. Which is the correct explanatory word for composition of protoplasm

(a) Emulsion (b) Suspension

(c) Complex colloidal solution (d) Molecular solution

160. The main function of tendon is

(a) To join two bones (b) To join two muscles

(c) To join muscles and bones (d) To join muscles and nerves

161. Antibody is produced by

(a) B-Lymphocyte (b) Heparin (c) T-Lymphocyte (d) Both (a) and (b)

162. Ligament is a

(a) Modified white fibrous tissue (b) Modified yellow elastic fibrous tissue

(c) Inelastic white fibrous tissue (d) None of these

163. Which of the following is loose connective tissue

(a) Areolar (b) Adipose (c) Blood (d) Nervous tissue

164. Bone-forming cells are known as

(a) Chondroclasts (b) Osteoblasts (c) Chondroblasts (d) Osteoclasts

165. In mammals, histamine is secreted by

(a) Fibroblasts (b) Histiocytes (c) Lymphocytes (d) Mast cells

166. Protein present in cartilage is

(a) Chondrin (b) Oesein (c) Cartilagin (d) Ossein

167. Which of the following is agranulocyte

(a) Lymphocyte (b) Eosinophil (c) Basophil (d) Neutrophil

168. Which of the following cells is phagocytic in nature

(a) Mast cells (b) Podocytes (c) Macrophages (d) Fibroblast cells

169. Which of the following is not a granulocyte

(a) Basophils (b) Monocytes (c) Acidophils (d) Neutrophils

170. Processes from osteoblasts are called

(a) Dendrites (b) Lamellae (c) Canaliculi (d) Haversian canals

171. Cartilage is made up of

(a) Collagen (b) Dermin (c) Matrigen (d) None of these

172. Which of the following is a transparent tissue

(a) Tendon (b) Ligament (c) Fibrous cartilage (d) Hyaline cartilage

173. Volkmann's canals are found in

(a) Bones of birds (b) Bones of amphibians

(c) Bones of mammals (d) Cartilage of mammals

174. During an injury, nasal septum gets damaged and for its recovery which cartilage is prefused

(a) Hyaline cartilage (b) Elastic cartilage (c) Calcified cartilage (d) Fibro cartilage

175. Red muscle fibres are rich in

(a) Golgi bodies (b) Mitochondria (c) Ribosome (d) Lysosomes

176. Which of the following is enucleate

(a) Squamous epithelial cell (b) Mature human erythrocyte

(c) Mature frog erythrocyte (d) Human osteocyte

177. Which of the following cartilage is present on the end of long bones

(a) Elastic cartilage (b) Fibrous cartilage (c) Calcified cartilage (d) Hyaline cartilage

178. What will happen, if the ligaments are cut or broken

(a) No movement at joint (b)Bone will become unfix

(c) Bone will become fixed (d)Bones will move freely at joints

179. Collagen is

(a) Lipid (b) Carbohydrate (c) Globular protein (d) Fibrous protein

180. Which one of the following contains the largest quantity of extra cellular material

(a) Myelinated nerve fibres (b)Striated muscle (c) Areolar tissue (d) Stratified epithelium

181. An antibody is a

(a) Component of the blood

(b) Secretion of mammalian erythrocyte

(c) White corpuscle which attack invading bacteria

(d)Molecule that specifically inactivate an antigen

182. Which of the following work as phagocytes

(a) WBCs (b) RBCs (c) Enzymes (d) Hormones

183. Resorption of bone is carried out by

(a) Osteoclasts (b) Osteoprogenitors (c) Osteoblasts (d) None of these

184. Regeneration of cartilage can occur from its

(a) Matrix (b) Plasma

(c) Perichondrium (d) A piece without perichondrium

185. Processes of osteocytes lie in

(a) Dendrites (b) Haversian canals (c) Canaliculi (d) Lamella

186. Large irregular ovoid cells found in areolar tissue are

(a) Fibroblasts (b) Macrophages (c) Mast cells (d) Chromatophores

187. B- and T- cells required for immune system are produced in

(a) Bone marrow (b) Liver (c) Spleen (d) Lymph nodes

188. Number of erythrocytes per mm^3 of human blood is

(a) 4 million (b) 5 million (c) 6 million (d) 0.5 million

Advance Level

189. When the count of W.B.C. falls below the optimum number in blood, it is called

(a) Leukopenia (b) Leukemia (c) Anaemia (d) All of these

190. Glisson's capsule is a delicate connective tissue capsule covering the

(a) Spleen (b) Liver (c) Kidney (d) Gall bladder

191. Haversian system is a diagnostic feature of

(a) Avian bones (b) All animals

(c) Mammalian bones only (d) Reptilian bones

192. Which part of body's weight is formed by connective tissue

(a) 40% (b) 30% (c) 20% (d) 60%

193. In connective tissue, the tissue fluid is trapped between

(a) Hyaluronic acid (b) Lactic acid (c) Sphygmomyelin (d) None of these

194. The mast cells secrete the following substance

(a) Heparin (b) Histamine (c) Serotonin (d) All of these

195. The giant cell is formed by the fusion of

(a) Macrophage (b) Plasma cell (c) Mast cell (d) All of these

196. Which of the following cell forms all other cells of connective tissue

(a) Fibroblast (b) Macrophage (c) Glial cell (d) Adipocyte

197. Which of the following tissue is called as "homeostatic reservoir"

(a) Cartilage (b) Bone (c) Calcified cartilage (d) All of these

198. Inorganic phosphate found in the bones are called

(a) Hydroxy apatite (b) Ossein (c) Both (a) and (b) (d) None of these

199. Achondroplasia is a disease related with the defect in the ossification of

(a) Membrane (b) Cartilage (c) Both (a) and (b) (d) None of these

200. Atavistic epiphysis is a/an

(a) Cartilage (b) True epiphysis (c) Independent bone (d) None of these

201. In embryonic stage R.B.C. are formed in

(a) Liver (b) Spleen (c) Yolk Sac (d) All of these

202. The areolar tissue connects

(a) Two bones (b) Muscle and the bone

(c) Muscle and the fat tissue (d) Muscle and their compound

203. Bone marrow is made up of

(a) Muscular fibre and fatty tissue (b) Fatty tissue and areolar tissue

(c) Fatty tissue and cartilage (d) Fatty tissue, areolar tissue and blood

204. Phagocytic cells of liver are called

(a) Kupffer cells (b) Deiter cells (c) Hensen cells (d) Aciner cells

205. Haversian canals of long bones have

(a) One vein and one artery (b) One nerve and one lymphatic

(c) Some bone cells, fat and areolar tissue (d) All of these

206. In mammals Haversian canals are connected with each other by transverse canals, which are called

(a) Semicircular canals (b) Volkmann's canals (c) Inguinal canals (d) Bidder's canals

207. Camel's hump is made up of

(a) Skeletal tissue (b) Muscular tissue (c) Cartilage (d) Adipose tissue

208. Exchange of materials between blood and tissue cells occur through

(a) Lymph (b) Plasma (c) Water (d) Tissue fluid

209. Major constituent of bone is

(a) Calcium phosphate (b) Magnesium phosphate

(c)Calcium carbonate (d) Sodium chloride

210. White blood corpuscles divide by

(a) Mitosis (b) Meiosis (c) Amitosis (d) None of these

211. A tendon gets ossified to form a type of bone called

(a) Sesamoid (b) Membranous (c) Dermal (d) Cartilage

212. Concave surface of mammalian R.B.Cs is helpful in

(a) Formation of more haemoglobin (b)Increasing surface area of R.B.Cs

(c) Reducing surface tension of plasma membrane (d)Providing more space for haemoglobin

213. Least constancy of shape is shown by

(a) Epithelial cells (b) White blood corpuscles

(c)Red blood corpuscles (d) Blood platelets

214. If kept in 0.8% *NaCl*, R.B.Cs will

(a) Shrink (b) Remain same (c) Burst (d) None of these

215. Lymph can be defined as

(a) Blood minus RBCs (b) Blood minus plasma (c) Blood minus WBCs (d) Corpuscles

216. Blood clotting can be prevented in a test tube by adding a little

(a) Sodium oxalate (b) Sodium chloride

(c) Sodium hydroxide (d) Ammonium chloride

217. Growth of young cartilage take place by

(a) Division of young chondrocytes (b)Formation of more intercellular substance

(c) Deposition of new layer of cartilage at its surface (d)All of these

218. Intervertebral disc is made up of

(a) Elastic cartilage (b) Fibrous cartilage (c) Calcified cartilage (d) Hyaline cartilage

219. If red blood cells are placed in distilled water, they will

(a) Shrink and collapse (b) First increase in volume and then burst

(c) Stick together (d) None of these

220. Adipose tissue is found in mammals

(a) In epidermis (b) In muscles (c) In dermis (d) Below dermis

221. Which of the following helps in maintaining body hot

(a) Sweat glands (b) Connective tissue (c) Adipose tissue (d) Hair

222. Whale is a warm-blooded animal which lives in cold sea. Which organ of its body makes it hot

(a) Blubber (b) Pelage (c) Muscles (d) Blood vessels

223. Primary function of subdermal fat in the skin of mammals is

(a) To preserve collected sum (b) To act as a heat-proof matter

(c) To prevent the jerks (d) To protect the body

224. Elastic pads at the ends of articular end of the bones are made up of

(a) Hyaline cartilage (b) Muscle (c) Ligaments (d) Tendons

225. A bone is different from cartilage due to the presence of

(a) Collagen (b) Blood vessels (c) Lymph vessels (d) Haversian canals

226. Which of the following cells are associated with immune system of body

(a) Neutrophils (b) Macrophages (c) Lymphocytes (d) All of these

227. Egyptian mummies are having still intact artery, it is due to

(a) Resistivity of elastin protein to chemical changes (b)Cold weather conditions of Egypt

(c) Hot weather conditions of Egypt (d)It is only a God gift

228. Cartwheel arrangement of heterochromatin is found in

(a) Macrophages (b) Plasma cells (c) Adipocytes (d) Mastocytes

229. The chemical which causes damage of WBC, bone marrow, spleen, lymph nodes and lungs is

(a) Iodine – 131 (b) Calcium (c) Strontium – 90 (d) Iodine – 127

230. The term "blubber" refers to

(a) A substitute for natural rubber (b)A subcutaneous deposition of fat in whales

(c) The irregular heart-beat sound (d) None of these

231. The connective tissue of the vertebrate body is built up from fibres of the protein collagen, embedded in a polysaccharide matrix to form

(a) Cartilage (b) Blood vessel (c) Heart (d) Lung

232. Polymorphonuclear leucocytes are

(a) Monocytes (b) Lymphocytes (c) Granulocytes (d) Agranulocytes

233. A femur is kept in dilute *HCl* for three days, it becomes

(a) Brittle (b) Soft and elastic (c) Remains as it is (d) Harder

234. The intercellular substance found in connective tissue is

(a) Fatty in nature (b) Muco-polysaccharide

(c) Mainly protein in nature (d) All are correct

235. The lymph resembles composition of blood plasma, but contains

(a) Less amount of protein, same number of leucocytes and a few erythrocytes

(b) More protein, same number of leucocytes but mainly lymphocytes and a few erythrocytes

(c) Less amount of protein, large number of leucocytes chiefly granulocytes and a few erythrocytes

(d) Less amount of protein, large number of leucocytes chiefly lymphocyte and a few granulocytes

236. In human embryo, main haemopoietic tissue is

(a) Spleen (b) Liver (c) Both (a) and (b) (d) Kidney

237. The colour in the brown fat is due to

(a) Its larger capacity for generating heat (b) Large number of mitochondria present

(c) A high concentration of iron containing cytochrome pigments

(d) Presence of chromatophores

238. Red marrow is found in

(a) Amphibians (b) Reptiles (c) Mammals (d) All of these

239. During sleeping the rate of RBC formation

(a) Increases (b) Decreases (c) Remains constant (d) None of these

240. When collagen fibres are removed from the areolar tissue

(a) Tissue becomes hard (b) Tissue becomes loose and elastic

(c) Tissue becomes hard and inelastic (d) Remains unchanged

241. Lymphocytes are seen in large numbers at sites of inflammation because

(a) Their function is phagocytic (b) They prevents clotting of blood

(c) Their functions is to form and carry antibodies (d) All of these

242. The tissue present in umbilical cord is

(a) Fatty connective tissue (b) Reticular connective tissue

(c) Mucous connective tissue (d) Pigmented connective tissue

243. Diploic bone is

(a) Compact bone found in ribs (b) Spongy bone found in skull

(c) Both (a) and (b) (d) None of these

244. The main function of connective tissue is

(a) Binding together other tissues (b) Supporting various parts of the body

(c) Forming a packing around organs (d) All of these

245. Oedema is

(a) An abnormal accumulation of tissue fluid in intercellular spaces

(b) An abnormal accumulation of tissue fluid in epithelial tissue cells

(c) An abnormal accumulation of extra cellular fluid in intercellular spaces

(d) Allergic disease of skin

246. Intracellular fluid and extra cellular fluid forms

(a) 24% and 40% of body weight respectively (b) 40% and 24% of body weight respectively

(c) 6 – 10% of the body weight (d) 30 – 35% of the body weight

247. Match the following

Types of leucocytes	**Function**
A. Neutrophils	1. Heparin and histamine secretion
B. Basophils	2. Antibodies formation
C. Acidophils	3. Scavanger
D. Monocytes	4. Phagocytes
E. Lymphocytes	5. Antiallergic and healing of wounds

The correct pairing sequence is

(a) 3, 1, 5, 4, 2 (b) 1, 4, 5, 3, 2 (c) 3, 2, 1, 4, 5 (d) 2, 3, 1, 4, 5

248. Function of adipose tissue is

(a) Fat storing tissue (b) Helps in homeothermy

(c)Acts as shock absorber (d)All of these

249. Choose the correct

(a) Haversian canals are transverse canals

(b) Volkmann's canals are longitudinal canals

(c) Haversian canals are longitudinal whereas Volkmann's canals are transverse canals

(d) None of these

250. Patella bone is an example of

(a) Cartilaginous bone (b) Dermal bone (c) Spongy bone (d) Sesamoid bone

251. Match the following

Disease	**Cause**
A. Diabetes	1. Rise in WBC count
B. Uraemia	2. Deficiency of vitamin B_{12}
C. Anaemia	3. Rise in RBC count
D. Polycythemia	4. Fall of WBC count
E. Pernicious or Megaloblastic anaemia	5. Fall in RBC count
F. Leukemia	6. Increase in blood sugar level
G. Thrombocytopenia	7. Urea is in excess in blood
H. Leucopenia	8. Pathological increase in WBC
I. Leucocytosis	9. Decrease in the number of platelets

The correct matching sequence is

(a) 1, 3, 4, 2, 5, 6, 7, 9, 8 (b)6, 7, 5, 3, 2, 8, 9, 4, 1

c)6, 7, 3, 5, 8, 2, 9, 1, 4 (d)7, 6, 5, 3, 2, 9, 8, 4, 1

252. New born mammals generally do not shiver inspite of lower temperature outside because of

(a) Brown fat which has larger capacity for generating heat

(b) White fat which has larger capacity for generating heat

(c) Chromatophores present in them (d) Skeletal tissue present in them

253. An osteon contains

(a) One Haversian canal and Haversian lamellae (b) Haversian canal and Volkmann's canal

(c) Haversian canal and circumferential lamellae (d) Haversian canal, Haversian lamellae and osteoblast layer

254. Reticular connective tissue is found in

(a) Stomach (b) Spleen (c) Kidneys (d) Skin

255. Pits of Howship are present in

(a) Nervous tissue (b) Striated muscle fibres (c) Long bones (d) Fibrocartilage

256. Reticulocytes may also be called

(a) Blood platelets (b) Immature erythrocytes (c)Lymphocytes (d) WBCs

257. Which of the following is a living substance

(a) Protoplasm (b) Cytoplasm (c) Nucleus (d) All of these

258. Amount of nucleic acids in protoplasm is about

(a) 2% (b) 10% (c) 20% (d) 35%

259. Ca^{++} ions are needed for

(a) Muscular contraction (b)Blood coagulation (c) Bone formation (d) All of these

260. The percentage of inorganic and organic salts in the matrix of a bone is

(a) 40% inorganic, 60% organic (b)67% inorganic, 33% organic

(c) 80% inorganic, 20% organic (d)85% inorganic, 15% organic

261. Lymph contains

(a) Only leucocytes (b)99% lymphocytes, no RBCs and other leucocytes

(c) 50% leucocytes and 50% erythrocytes (d)99% of erythrocytes and 1% small lymphocytes

262. Blood does not clot inside the blood vessels due to the presence of

(a) Heparin (b) Fibrinogen (c) Vitamin K (d) Thrombin

263. Which is the principal cation in the plasma of the blood

(a) Calcium (b) Sodium (c) Potassium (d) Magnesium

264. γ – globulins are synthesised inside

(a) Liver (b) Bone marrow

(c) Lymph and lymphoid tissue (d) Kidney

265. Which of the following in not the main function of lymph glands

(a) Forming WBC (b) Forming antibodies (c) Sping RBC (d) Destroying bacteria

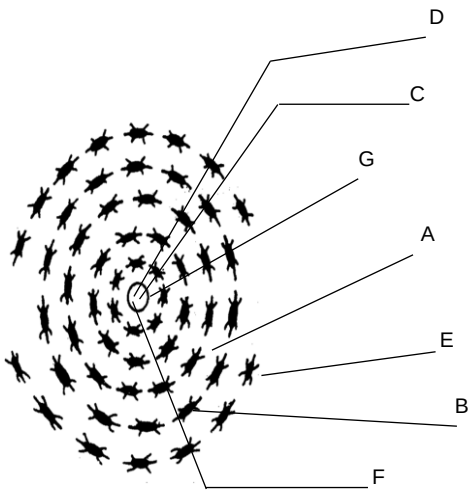
266. Haversian canals are found in

(a) Bone marrow (b) Hyaline cartilage (c) Bone matrix (d) Calcified cartilage

267. Which cells are not true in blood

(a) Platelets (b) Monocytes (c) Neutrophils (d) Basophils

268. In the diagram of the section of bone tissue given below, certain parts have been indicated by alphabets; choose the answer in which these alphabets have been correctly matched with the parts which they indicate



(a) A = Interstitial lamellae, B = Lacuna with osteocytes, C = Blood vessels, D = Nerve, E = Canaliculi, F = Haversian canal, G = Lamellae

(b) A = Interstitial lamellae, B = Osteocytes in the lacuna, C = Blood vessels, D = Nerve, E = Canaliculi, F = Haversian system, G = Canaliculi

(c) A = Lamellae, B = Lacuna with osteocytes, C = Artery, D = Lymphatic vessels, E = Canaliculi, F = Vein, G = Haversian canal

(d) A = Interstitial lamellae, B = Osteocytes, C = Nerve, D = Blood Vessel, E = Lamellae, F = Haversian canal, G = Canaliculi

269. Connective tissue is

(a) Ectodermal in origin with intercellular spaces

(b) Mesodermal in origin without intercellular spaces

(c) Ectodermal in origin without intercellular spaces

(d)Mesodermal in origin with intercellular spaces

270. Pubis in the frog's pelvic girdle is actually a

(a) Calcified cartilage (b) Cartilaginous bone (c) Membrane bone (d) None of these

271. Vitreous humour is

(a) Mucoid connective tissue (b) Solid crystalline

(c) Watery fluid (d) All of these

272. Which one of the following is not a fibrillar protein

(a) Elastin (b) Collagen (c) Myosin (d) Albumin

273. Enzyme causing lysis of fibrin during fibrinolysis is

(a) Fibrinogen (b) Plasmin (c) Thrombin (d) VIII Platelet factor

274. In mammals yellow fibres are found in

(a) Ear pinna (b) Tip of nose (c) Epiglottis (d) All of these

275. In which state iron is present in haemoglobin

(a) Un-ionic (b) Fe^{2+} (c) Fe^{3+} (d) None of these

276. In which bones shall have Haversian system

(a) Panther (b) Python (c) Pigeon (d) Pipe Fish

277. Blood platelets occur in the blood of

(a) Birds (b) Mammals (c) Reptiles (d) Amphibians

278. Ruptured blood cells are not trapped in

(a) Liver (b) Spleen (c) Bone marrow (d) Both (a) and (c)

279. Structure absent from fresh frozen blood plasma is

(a) Immunoglobulin (b) Plasma (c) Albumin (d) Platelets

280. Granules contain histamine in

(a) Neutrophils (b) Eosinophils (c) Acidophils (d) Basophils

281. Number of cell types present in human bone are

(a) 1 (b) 2 (c) 3 (d) 4

282. Mast cells of connective tissue contain

(a) Heparin and calcitonin (b)Serotonin and melanin

(c)Vasopressin and relaxin (d)Heparin and histamine

283. Match the types of WBC listed in column I with the shape of nucleus given under column II. Choose the answer which gives the correct combination of alphabets of two columns

	Column I		**Column II**
	Type of WBC		**Shape of Nucleus**
a	Neutrophils	*p*	Kidney shaped
b	Eosinophils	*q*	S-shaped
c	Basophils	*r*	3 – 5 lobes
d	Monocytes	*s*	2 lobes
		t	Disc shaped

(a) *a = r, b = t, c = p, d = q* (b) *a = t, b = r, c = q, d = s*

(c) *a = q, b = p, c = t, d = r* (d) *a = r, b = s, c = q, d = p*

284. In which of the following tissue is the matrix not product of synthesis of its cells

(a) Vascular tissue (b) Osseous tissue

(c) Loose connective tissue (d) Adipose tissue

285. Assertion (A) : RBC production is regulated by kidneys.

Reason (R) : Erythropoietin hormone produced by kidneys reaches red bone marrow where it increases stem cells mitosis and speeds up development of RBCs.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)

(b) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(c) (A) is true but (R) is wrong

(d) (A) and (R) both are wrong

286. Assertion : Histamine is involved in allergic and inflammatory reactions.

Reason : Histamine is vasodilator.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)

(b) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(c) (A) is true but (R) is wrong

(d) (A) and (R) both are wrong

287. Assertion : Mast cells in human body release excessive amount of inflammatory chemicals which cause allergic reactions.

Reason : Allergens in the environment on reaching human body stimulates mast cells in certain individuals.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A)

(b) Both (A) and (R) are true but (R) is not the correct explanation of (A)

(c) (A) is true but (R) is wrong

(d) (A) and (R) both are wrong

MUSCULAR TISSUE

Basic Level

288. Which of the following muscles gets into fatigue very early

(a) Skeletal muscle (b) Smooth muscle (c) Cardiac muscle (d) All of these

289. Unstriped muscles are found in

(a) Neck (b) Urinary bladder (c) Arms (d) Fingers

290. Cardiac muscles are having characters of

(a) Striped muscle (b) Unstriped muscle (c) Both (a) and (b) (d) None of these

291. Unstriped smooth muscles are found in

(a) Thigh (b) Eye muscles (c) Iris (d) Tongue

292. Sarcolemma is the covering of

(a) Nerve fibres (b) Muscle fibres

(c) Bone marrow (d) Liver, kidney and stomach

293. Who propounded the "Sliding filament theory" for muscles contraction

(a) Cori (b) H.E. Huxley

(c) A.F. Huxley (d) H.E. Huxley and A.F. Huxley

294. Striped muscles have

(a) One nucleus (b) Many nuclei (c) Two nuclei (d) No nuclei

295. The protein which maintains the muscular storage of oxygen is

(a) Myoglobin (b) Actomyosin (c) Myosin (d) Haemoglobin

296. Authorythmicity is a special property of the muscles of the

(a) Liver (b) Intestine (c) Heart (d) Kidney

297. Voluntary muscle is present in

(a) Lung (b) Liver (c) Hind limb (d) Heart

298. The muscles immune to fatigue are

(a) Striped (b) Unstriped (c) Cardiac (d) None of these

299. The muscles involved in the movement of the arm are

(a) Unstriped (b) Striped (c) Cardiac (d) All of these

300. Striated and voluntary muscle fibres are found in

(a) Lungs (b) Leg muscles (c) Gall bladder (d) Blood vessels

301. Bundles of striated muscle fibres called fasciculi are enclosed by sheath called

(a) Epimysium (b) Endomysium (c) Perimysium (d) Peritoneum

302. Refractory period of a muscle fibre in mammals is

(a) 0.8001 seconds (b) 0.002 seconds (c) 0.004 seconds (d) 0.005 seconds

303. Strongest muscles in human body are found in

(a) Jaws (b) Thighs (c) Neck (d) Hands

304. The structural and functional unit of the striated muscle fibre is called

(a) Sarcolemma (b) Sarcomere (c) Sarcoplasm (d) Myofibril

305. Which fibres, contractile in nature are found in muscles

(a) White fibres (b) Myofibrils (c) Microfibrils (d) Elastic fibres

306. Unstriated muscle are found in

(a) Veins (b) Arteries (c) Uterus (d) All of these

307. Striped and branched muscle are found in

(a) Iris (b) Heart (c) Leg (d) Brain

308. The ready source of energy in living cells is

(a) Glucose (b) ATP (c) Glycogen (d) ADP

309. Muscular tissue is differentiated into

(a) Unstriped, striped (b) Striped, cardiac

(c) Cardiac muscle, unstriped (d) Unstriped, striated and cardiac

310. Active transport

(a) Requires energy (b) Liberates energy

(c) Is a non-cellular process (d) Needs oxygen

311. Myoglobin is found in

(a) Muscles (b) Blood (c) Liver (d) Spleen

312. Striped muscles are present in

(a) Lungs (b) Gall bladder (c) Blood vessels (d) Limb muscles

313. The stored food material found in muscles is

(a) Protein (b) Glycogen (c) Lipid (d) Phosphogen

314. Striped muscles are

(a) Syncytial (b) Uninucleate (c) Binucleate (d) Anucleate

315. Glycogen is stored in

(a) Liver (b) Muscles (c) Both (a) and (b) (d) Blood

316. Cardiac muscles are different from that of skeletal muscles as

(a) They are striated and involuntary (b) They are non striated

(c) They are smooth (d) They are voluntary

317. The functional unit of contractile system in striated muscle is

(a) Cross bridges (b) Myofibril (c) Sarcomere (d) Z-band

318. In metazoa one of the following is responsible for locomotion and movement of organs

(a) Nervous tissues (b) Epithelial tissues (c) Connective tissues (d) Muscular tissues

319. Ensheathing of muscles is called

(a) Tendon (b) Ligament (c) Peritoneum (d) Epimycium

320. The outermost sheath of connective tissue that surrounds a skeletal muscle is

(a) Epimer (b) Epimere (c) Epimerite (d) Epimysium

321. Largest smooth muscles occur in

(a) Urethra (b) Uterus of pregnant woman(c)Leg (d) Thigh

322. Cross-bridges occur in

(a) Mid brain of Rabbit (b) Mid brain of Frog (c) Cranial nerves (d) Muscle fibres

Advance Level

323. Rigor mortis is the contraction of muscle but without action potential development

(a) After death (b) Before death (c) In childhood (d) In embryo

324. The triceps and biceps muscles are of

(a) Antagonist type (b) Involuntary type (c) Smooth type (d) Sphincter type

325. Smooth muscles are not

(a) Spindle shaped (b) Under control of autonomic nervous system

(c) Very simple in structure (d) Multinucleated

326. Cardiac muscle fibres are

(a) Striated involuntary (b) Striated voluntary

(c) Non-striated involuntary (d)Non-striated voluntary

327. Shivering in cold is a method for

(a) Prevention of radiation of heat from the body (b) Production of healthy muscle friction

(c) Production of heat by muscular contractions (d) Increasing blood supply to skin

328. Cardiac muscles are characteristic in that they contract

(a) Slowly and get fatigued (b) Quickly and get fatigued

(c) Slowly and do not get fatigued (d) Rhythmically and do not get fatigued

329. Cardiac muscles are stripped muscles with

(a) Syncytial muscle fibres which are involuntary in function

(b) Nucleated involuntary fibres

(c) Nucleated voluntary fibres (d) Syncytial involuntary fibres

330. Protein which is both structural and enzymatic

(a) Troponin (b) Myosin (c) Trypsin (d) Actin

331. Which of the following muscles are ectodermal in origin

(a) Muscles of the iris (b) Ciliary body (c) Both (a) and (b) (d) None of these

332. In the myofibrils of muscle fibre

(a) Myosin is found (b) Actin is found (c) ATP is found (d) All of these

333. The single unit smooth muscles are

(a) Neurogenic (b) Myogenic (c) Cardiogenic (d) None of these

334. Skeletal muscles show resemblance with visceral muscles in one aspect. It is in

(a) Shape of muscle fibres (b) Number of nuclei in muscle fibres

(c) Presence of actin and myosin filaments (d) Presence of light and dark band

335. Smooth muscle fibres are

(a) Cylindrical, unbranched, striated, multinucleate and voluntary

(b) Spindle-shaped, unbranched, non-striated, uninucleate and involuntary

(c) Cylindrical, unbranched, non-striated, multinucleated and involuntary

(d) Spindle-shaped, unbranched, striated, uninucleated and voluntary

336. The most abundant tissue in the body is

(a) Nervous (b) Muscular (c) Vascular (d) Epithelial

337. Ciliary muscles are which

(a) Move cilia of some protozoans

(b) Keep valves of heart intact

(c) Change the focal length of human eye and at joint of sclera and iris

(d) Cause erection of human hairs in cold and are situated in skin

338. Energy comes for muscle contraction from

(a) Oxidation of glucose (b)Break down of ATP

(c) Enzymatic action of myosin (d)All of these

339. The heart continuous beating normally even when its nervous supply is completely obliterated because it is

(a) Myogenic (b) Neurogenic (c) Natural process (d) None of these

340. Function of ATP in muscle fibres is

(a) It acts as an enzyme

(b) It keeps the muscle supple and extensible

(c) It is essential for subsequent contraction of rigid muscles by providing energy

(d) Both (b) and (c)

341. In relaxation of muscles

(a) Ca^{++} concentration increases (b) Ca^{++} concentration decreases

(c) Actin filaments slide over myosin filaments (d) Actin filaments form cross bridges

342. Chronaxie is

(a) Abnormal muscle contractions

(b) Minimum time required to bring about excitation of muscle fibres

(c) Maximum time required to bring about excitation of muscle fibres

(d) None of these

343. At $0^{o}C$ and below it

(a) There is increase in muscle contraction (b) There is decrease in muscle contraction

(c) There is loss of irritability in a muscle (d) Coagulation of muscle proteins take place

344. Delayed heat is

(a) Heat required for muscle contraction (b) Heat liberated during relaxation

(c) Both (a) and (b) (d) None of these

345. 'Oxygen debt' is amount of oxygen required for

(a) Muscle contraction (b) Muscle relaxation (c) Muscle recovery (d) All of these

346. Involuntary muscles are

(a) Under the control of will (b) Not under the control of will

(c) Controlled by autonomic nervous system (d) Both (b) and (c)

347. Muscle cramp is

(a) Displacement of muscle from its original position (b)Painful contractions of muscles

(c) One muscle overlaps the other (d)All of these

348. Smooth muscle fibre differ from striated muscle fibre in external covering by

(a) Presence of sarcolemma (b) Presence of plasma membrane

(c) Absence of covering (d) None of these

349. Threshold stimulus is

(a) Stimulus of specific strength which can excite muscle or nerve fibre

(b) Capacity of muscle to contract

(c) Stimulus to indicate the contraction

(d) None of these

350. Hypertrophy of muscle is

(a) Muscles become thin and weak due to excessive work

(b) Muscles become thick and strong due to excessive work

(c) Muscles become thin and weak due to no work

(d)Muscles become thick and strong due to no work

351. Krause membrane or Z-line is a myofibril which separates two adjacent

(a) Sarcomeres (b) *H*–zones (c) *I*–bands (d) *A*–bands

352. In strained muscle contraction

(a) *H*-band is lengthened (b) *H*-band is obliterated

(c) *A*-band decreases in length (d) *Z*-line moves away from *A*-band

353. The muscle fatigue occurs due to accumulation of

(a) Lactic acid (b) Creatine triphosphate (c) Glycogen (d) CO_2 and water

354. Ciliary muscles are contractile structures which

(a) Cause standing of hairs in human skin in cold (b) Keep the valves of heart in position

(c) Move cilia of some ciliated protozoans (d) Change focus of lens in human eye

355. Which of the following is the contractile protein of a muscle

(a) Tubulin (b) Myosin (c) Tropomyosin (d) All of these

356. Which of the following proteins is found in the thick filaments of skeletal muscle

(a) Myosin (b) Actin (c) Tropomyosin (d) Troponin

357. Muscles of alimentary canal are chiefly

(a) Striated and Neurogenic (b) Unstriated and Neurogenic

(c) Striated and Myogenic (d) Unstriated and Myogenic

358. Actin filament is made up of

(a) Actin, troponin and tropomyosin (b) Actin, troponin

(c) Myosin, troponin (d) Actin, tropomyosin

359. In skeletal muscle *Z*-line is connected to

(a) Actin (b) Myosin (c) Tropomyosin (d) Henson's line

360. What is not true of smooth muscle fibres

(a) Spindle shaped (b) Under ANS (c) Syncytial (d) Structurally simple

361. Multi-unit smooth muscles are found in the wall of

(a) Large blood vessels (b) Intestine (c) Stomach (d) Urinary bladder

362. In the region of joining of two cardiac muscle cells is present

(a) Ligament (b) Basement (c) Intercalated disc (d) Fibres

363. ATPase enzyme needed for muscle contraction is located in

(a) Myosin (b) Actin (c) Actinin (d) Troponin

NERVOUS TISSUE

Basic Level

364. Most of the neurons of our body are

(a) Unipolar (b) Bipolar (c) Pseudounipolar (d) Multipolar

365. Schwann cells and Node of Ranvier are found in

(a) Nervous tissue (b) Osteoblast (c) Chondrioblast (d) Gland cells

366. Least power of regeneration is found in

(a) Muscle cells (b) Nerve cells (c) Liver cells (d) Bone cells

367. Longest cell in human body may be

(a) Nerve cell (b) Leg muscle cell (c) Bone cell (d) Heart muscle cell

368. Nerve fibre is different from the muscle fibre due to the presence of

(a) Myofibrils (b) Lines (c) Sarcolemma (d) Dendrites

369. The neurons arise from the embryonic cell is called

(a) Neuroblast (b) Cytoblast (c) Dendrocyte (d) All of these

370. The value of resting membrane potential is

(a) – 90 *mV* (b) – 100 *mV* (c) +100 *mV* (d) + 90 *mV*

371. Reversal potential

(a) Is always negative (b) Is always positive (c) Is always neutral (d) Never develops until death

372. The junction between Schwann cells is known as

(a) Plasmalemma (b) Node of Ranvier (c) Dendrons (d) Synapse

373. Some cells of our body can be over a metre long. These are

(a) Nerve cells (b) Muscle cells (c) Bone cells (d) Gland cells

374. The afferent process of neuron is known as

(a) Axon (b) Dendrite (c) Cyton (d) Neurofibrillae

375. Neurons are classified on the basis of

(a) Number of nucleus present (b)Number of processes arising from the cell body

(c) Number of dendrites present (d)Number of axons present

376. Velocity of impulse is greater in

(a) Thin nerve (b) Thick nerve

(c) Does not depend on thickness (d) Afferent nerve

377. Function of Neuroglial cells is

(a) Acts as packing cells

(b) Provide nutrition to the neurons

(c) Help in memory processes as these store information in the form of an RNA code

(d) All of the above

378. Dendrites are

(a) Afferent in nature and conduct nerve impulse towards cyton

(b) Efferent in nature and conduct nerve impulse towards cyton

(c) Both the above (d) None of these

379. Axon hillock is

(a) Group of axons (b) A swelling of axon

(c) The part of cyton from where the axon arises (d) Plasma membrane of axon

380. Neurohormones are secreted by

(a) Nerve fibre (b) Neuroglia (c) Ependymal cells (d) Neurosecretory cells

381. Which of the following structures, are the specialty of nerve cells

(a) Nucleus and cytoplasm (b)Axon and dendrites

(c)Vacuoles and fibres (d)Synapse and ganglia

382. The entire nerve is enclosed by a white thick sheath of a connective tissue, called

(a) Endoneurium (b) Epineurium (c) Neurilemma (d) Perineurium

383. Active transport involves

(a) Against concentration gradient and require ATP

(b)Against concentration gradient and not require ATP

(c) With concentration gradient and not require ATP (d)None of the above

384. The function of nervous tissue is

(a) Irritability (b) Sensibility (c) Responsiveness (d) Contraction

385. A nerve impulse will travel through a nerve fibre only if the membrane suddenly becomes more permeable to

(a) Chloride ions (b) Potassium ions (c) Sodium ions (d) Calcium ions

386. Two system which exerts opposite influence on the same organs are

(a) Endocrine and exocrine gland systems (b) Muscular and nervous system

(c) Endocrine and nervous system (d) Sympathetic and parasympathetic systems

387. Which type of neurons are found in the retina

(a) Unipolar (b) Pseudo-unipolar (c) Multipolar (d) Bipolar

388. Efferent process of the neuron is called

(a) Synapse (b) Dendrite (c) Buttons terminaux (d) Axon

389. The brain develops from

(a) Ectoderm (b) Mesoderm (c) Endoderm (d) Meso-endoderm

390. Which of the following is regarded as a unit of nervous tissue

(a) Axons (b) Dendrites (c) Neurons (d) Myelin sheath

391. The junction between the axon of one neuron and the dendrite of the next is called

(a) A joint (b) A synapse (c) Constant bridge (d) Junction point

392. Saltatory conduction occurs in

(a) Myelinated nerve fibres (b) Non- myelinated nerve

(c) Both (a) and (b) (d) None of these

393. Which of the following pairs of elements/ions required for nerve conduction

(a) Na^+ and K^+ (b) Ca^{++} and Mg^{++} (c) *Mg* and *K* (d) *Na* and *Mg*

394. Which one of the following is not essentially a part of nervous system

(a) Cyton (b) Axon (c) Myelinated (d) Intermedin

395. Node of Ranvier is found in

(a) Right auricle (b) Muscle bundles (c) Dendrite (d) Axon

396. Myelin sheath is covering of

(a) Muscle cells (b) Axon of neurons (c) Blood vessels (d) Osteocytes

397. Schwann cell is found around

(a) Axon (b) Cyton (c) Dendrite (d) Dendron

398. Which is correct

(a) A medullated nerve fibre appears grey (b) A nonmedullated nerve fibre appears white

(c) Neurilemma is composed of Schwann cells (d) Neurilemma is composed of neuroglia cells

399. Secretion of parasympathetic nerve endings is

(a) Hydroxy triptamine (b) Acetylcholine (c) Glycine (d) Noradrenaline

400. White matter of spinal cord is given this name because it is mainly made up of

(a) Nerve cells (b) Non-myelinated nerve fibres (c) Myelinated nerve fibre (d) Areolar tissue

401. Afferent nerve fibre carries impulses from

(a) Effector to central nervous system (b) Receptor to central nervous system

(c) Central nervous system to muscles (d) Central nervous system to receptors

402. Communication lines in the body are

(a) Muscles (b) Bones (c) Nerves (d) Blood vessels

Advance Level

403. Synapses store

(a) Stimulating chemicals (b)Inhibitory chemicals

(c)Conducting chemicals (d)All of these

404. Branched ends of nerve cells are called telodendria which establish the functional contact with other nerve cell. This connection is called

(a) Sinongium (b) Synapse (c) Synapsis (d) Synapta

405. Largest number of cell bodies of neuron in our body are found in

(a) Retina (b) Spinal cord (c) Brain (d) Tongue

406. Axons form nerve in

(a) Autonomic nervous system (b) Central nervous system

(c) Peripheral nervous system (d) All of these

407. The function of repairing in nervous tissue is done by

(a) Glial cells (b) Nerve cells (c) Cytons (d) Only axons

408. To start conduction of impulse, the value of action potential must not be

(a) Less than threshold value (b)More than threshold value

(c) Equal to threshold value (d)All of the above

409. The interval between the beginning of electrical response and peak of tension recorded is the

(a) Latent period (b) Contraction time (c) Relaxation time (d) None of these

410. Myelin sheath is a layer covering

(a) A nerve fibre in an insect (b)A chick embryo

(c) A muscle fibre in a vertebrate (d)A nerve fibre in a vertebrate

411. Neuroglia cells differ from neurons in having

(a) No Nissl's granules (b) No radiating processes (c)No cyton (d) No nucleus

412. Nissl's granules are characteristically found in

(a) Nephrons (b) Neurons (c) Cytons (d) Dendrites

413. Nissl's granules are found in cyton of nerve cells. These have affinity for basic dyes. The granules are made up of

(a) Mitochondria (b) Cell metabolites (c) Fate granules (d) Ribosomes

414. Which of the following tissues in mammals show the least capacity for regeneration

(a) Epithelial tissue of the skin (b) Endothelium of blood vessels

(c) Skeletal tissue of long bones (d) Nervous tissue of brain

415. Poisons like cyanide inhibit Na^+ efflux and K^+ influx during cellular transport. This inhibitory effect is reversed by an injection of ATP. This demonstrates that

(a) ATP is the carrier protein in the transport system

(b)$Na^+ - K^+$ exchange pump operates in the cell

(c) ATP is hydrolysed by ATPase to release energy

(d)Energy for $Na^+ - K^+$ exchange pump comes from ATP

416. Cell bodies or cyton is found in

(a) Brain (b) Spinal cord

(c) Brain and ganglia (d) Brain, spinal cord and ganglia

417. Nerve fibres conduct impulses in

(a) One direction (b) Two direction (c) Multidirection (d) None of these

418. To stop the impulse

(a) Acetylcholine or sympathin are quickly supplied by enzymes

(b) Acetylcholine or sympathin are quickly destroyed by enzymes

(c) It is an automatic process (d)None of the above

419. Neurons found in early embryos are

(a) Unipolar neurons (b) Bipolar neurons

(c) Pseudo-unipolar neurons (d) Multipolar neurons

420. The axon contains in its axis cylinder a fibrilar component of 90 *Å* thick called

(a) Axial fibrils (b) Myofibrils (c) Neurofibrils (d) Myelinfibrils

421. The neurilemma surrounds the

(a) Axis cylinder (b) Cell body (c) Myelin sheath (d) Endoneurium

422. Neurons divide

(a) Amitotically (b) Mitotically (c) Meotically (d) None of these

423. Saltatory conduction of nerve impulse means

(a) Action potential jumping from node to node

(b) Action potential transmitting along membrane

(c) Simple transmission of action potential (d) All of these

424. Which cell type does not divide in mammals after birth

(a) Neurons and osteocytes (b)Muscle cells (c) Germ cells (d) Nerve

425. Which one of the following acts as slow neurotransmitter

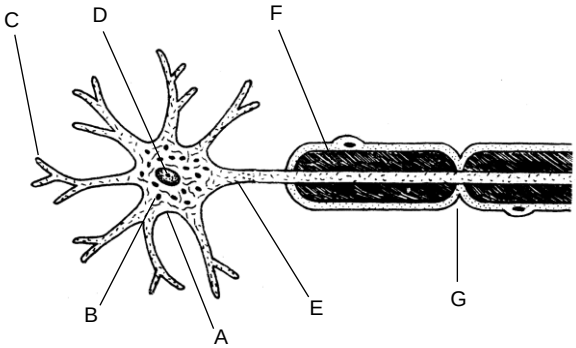
(a) GABA (b) Adrenaline (c) Epinephrine (d) Acetycholine

426. A bipolar neuron has

(a) Two axons and two dendrons (b)One axon and one dendron

(c) Two axons and one dendron (d) One axon and two dendrons

427. In the diagram of multipolar myelinated neuron given below, different parts have been indicated by alphabets; choose the answers in which these alphabets have been correctly matched with the parts which they indicate



(a) A = Cell body, B = Nissl bodies, C = Nucleus, D = Dendrites, E = Naked portion of axon, F = Myelin sheath, G = Node of Ranvier

(b) A = Cell body, B = Nissl bodies, C = Naked portion of axon, D = Dendrites, E = Nucleus, F = Myelin sheath, G = Node of Ranvier

(c) A = Cell body, B = Nissl bodies, C = Naked portion of axon, D = Nucleus, E = Dendrites, F = Myelin sheath, G = Node of Ranvier

(d) A = Cell body, B = Nissl bodies, C = Dendrites, D = Nucleus, E = Naked portion of axon, F = Myelin sheath, G = Node of Ranvier

428. The most appropriate definition of neuroglial cells are that they are

(a) Nonsensory supporting cells (b) Secretory cells

(c) Sensory cells (d) Sensory and supporting cells

429. Thick sheath of connective tissue enclosing the entire nerve is

(a) Neurilemma (b) Endoneurium (c) Epineurium (d) Perineurium

430. Which cells do not form any layer but remain structurally separate

(a) Nerve cells (b) Gland cells (c) Muscle cells (d) Epithelial cells

431. Transmitter substance released at the synapse is

(a) Secretin (b) Cholecystokinin (c) Cholesterol (d) Acetylcholine

432. In nerve cells, proteins are synthesised in

(a) Cell body (b) Axon (c) Dendron (d) Synapses

433. Soma of sensory neuron is located in

(a) Grey matter of spinal cord (b) Receptor organ

(c) Dorsal root ganglion (d) Ventral root ganglion

434. Glial cells forming blood brain barrier are formed of

(a) Ranvier cells (b) Schwann cells

(c) Astrocytes (d) Oligodendroglial cells

435. Direction of nerve impulse is reversed in nerve with

(a) Axo-axonic (b) Axo-dendritic (c) Axo-axondendritic (d) None of these

436. Nonmyelinated nerve fibres occur in

(a) Cranial nerves (b) Autonomic nerves (c) Optic nerves (d) Spinal nerves

437. Neuroglial cells are present in

(a) CNS and spinal cord (b) Kidney (c) Liver (d) All of these

438. The non-excitable, variously shaped and rounded structure between neurons are

(a) Dendrites (b) Nissl bodies (c) Glial cells (d) Schwann cell

439. Axon is a part of neuron, modified for

(a) Transformation of impulse (b) Reception of stimuli

(c) Stimuli of neurons (d) Conduction

440. Acetylcholine is secreted by

(a) Button terminaux of telodendria (b) Parasympathetic nerve endings

(c) Both the above (d) None of these

441. Nissl's granules are absent in

(a) Soma (b) Cyton (c) Both (a) and (b) (d) Schwann cells

ANSWER

ASSIGNMENT (BASIC & ADVANCE LEVEL)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
b	d	b	c	c	a	b	a	d	b	a	c	c	b	a	a	c	c	a	c
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
c	d	a	a	b	d	a	c	c	b	a	a	b	b	a	d	c	c	d	b
41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
a	c	b	c	a	b	c	d	b	d	a	b	b	c	d	d	a	b	a	b
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
d	b	c	c	b	b	b	a	d	d	c	c	a	c	d	c	b	a	a	b
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
d	d	a	a	d	b	b	c	a	b	b	a	c	b	a	c	b	a	b	a
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
b	c	a	a	b	b	d	b	b	a	a	b	d	d	d	b	d	b	b	c
121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140
d	b	b	b	b	a	b	b	c	b	b	b	a	c	c	b	c	d	b	c
141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
a	a	c	c	b	b	c	b	a	a	a	a	c	a	c	c	a	a	c	c
161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180
a	b	a	b	d	a	a	c	b	c	a	d	c	a	b	b	d	d	d	c
181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
d	a	a	c	c	c	a	b	a	b	c	b	a	d	a	a	b	a	b	c
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220
d	d	d	a	d	b	d	d	a	d	a	b	b	b	a	a	d	b	b	d
221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
c	a	b	a	d	d	a	b	c	b	a	c	b	d	d	c	c	c	b	b
241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260
c	c	b	d	a	b	a	d	c	d	b	a	a	b	c	b	d	a	d	b

261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280
b	a	b	c	c	c	a	c	d	a	a	d	b	d	b	a	b	c	d	d
281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
d	d	d	a	a	a	c	a	b	c	c	b	d	b	a	c	c	c	b	b
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
c	b	a	b	b	d	b	b	d	a	a	d	b	a	c	a	c	d	d	d
321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340
b	d	a	a	d	a	c	d	d	b	c	d	b	c	b	b	c	d	a	d
341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360
b	b	c	b	c	d	b	b	a	b	a	b	a	d	b	a	d	a	a	a
361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380
a	c	a	d	a	b	a	d	a	a	b	b	a	b	b	b	a	a	c	d
381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400
b	b	a	a	c	d	d	d	a	c	b	a	a	d	d	b	a	c	b	c
401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420
b	c	d	b	c	d	a	a	a	d	a	c	d	d	d	d	a	b	a	c
421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440
c	d	a	a	a	b	d	a	c	a	d	a	c	c	a	b	a	c	d	c
441																			
d																			