

Animal Tissue

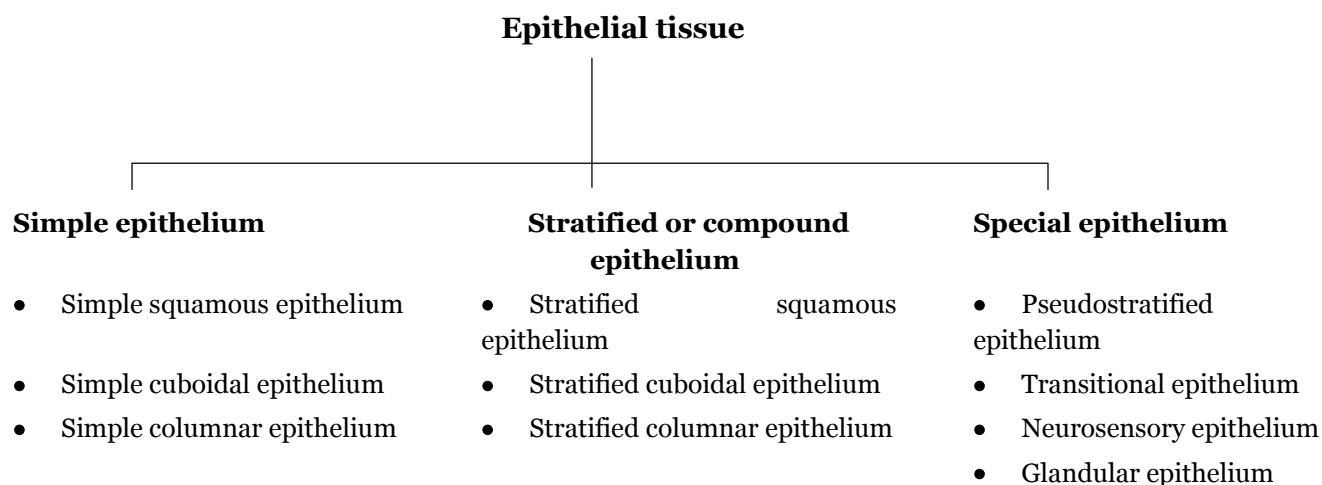
Introduction

The study of microscopic structure of tissues and organs is called **histology** and study of diseased tissue is **histopathology**. Histology as a separate branch was established by **Marcello Malpighi** (1694).

The body of multicellular animals is made up of many cells of different origin, structure and functions. A tissue is a group of cells of similar origin to perform a specific function. Cells of a tissue are often held together by Cell junctions. A number of different types of tissues form larger functional units called **organs** *e.g.* heart, liver, kidney etc. Many organs group together to perform a particular function and form an **organ system** *e.g.* heart, arteries, veins and capillaries form circulatory system. The word “tissue” was used by **Bichat** (1792) and “histology” by **Mayer** (1819). The four basic types of tissues are epithelial tissue, connective tissue, muscular tissue and nervous tissue

1.1 Epithelial tissue

It is also called covering tissue. The epithelial tissue is of ectodermal, mesodermal and endodermal origin. Cells of the epithelium are set very close to each other and the tissue rests on a non-cellular basement membrane. Blood vessels are absent. The epithelial tissue can be divided into three types :



(i) **Structure, location and functions of epithelial tissue :**

Animal Tissue

Structure	Location	Functions
Simple Squamous : Simple layer of flat scale-like cells, large centrally located nucleus.	Alveoli, Bowman's capsule, blood vessel (endothelium) heart, visceral and peritoneal lining of coelom (mesothelium)	Filtration, absorption and secretion
Simple cuboidal : Single layer of cube-shaped cells, centrally located nucleus	Surface of ovary, inner surface of cornea and lens of eye, kidney tubules salivary and pancreatic ducts and thyroid vesicles.	Secretion and absorption.
Simple columnar (Nonciliated) : Single layer of nonciliated rectangular cells, contain goblet cells, nuclei at bases of cells.	Lines stomach, small and large intestine, digestive glands and gallbladder.	Secretion and absorption.
Simple columnar (Ciliated) : Single layer of ciliated rectangular cells, contain goblet cells, nuclei at bases of cells.	Oviduct, fallopian tube, neurocoel of CNS, few portions of upper respiratory tract.	Movement of gametes, cerebrospinal fluid and mucus by ciliary action.
Stratified squamous : Several layers of cells, deep layers are cuboidal to columnar, surface layers flat and scale-like.	Nonkeratinizing : Mouth, oesophagus, part of epiglottis, vagina and conjunctiva Keratinizing – Dry surface of skin.	Protection.
Stratified cuboidal : Two or more layers of cube-shaped cells.	Duct of adult sweat glands.	Protection.
Stratified columnar : Several layers of polyhedral cells, only superficial layer is columnar.	Male urethra (only part).	Protection and secretion.
Transitional : Resembles stratified squamous non-keratinizing tissue, except superficial cells are larger and more rounded.	Urinary bladder and ureters.	Permits distension.
Pseudostratified : Basically it is single layered, but few basal cells are present, smaller in size and do not reach upto free surface.	Trachea, bronchi, olfactory epithelium, eustachian tube.	Secretion and movement of mucus by ciliary action.

(ii) Types of Glands (Glandular epithelium)

Simple tubular glands : The secretory portion is straight and tubular, *e.g.*, Crypts of Liberkuhn.

Simple branched tubular glands : The secretory portion is branched and tubular, *e.g.* gastric and uterine glands.

Holocrine : Complete cell is filled with secretory products. The cell dies and discharge the contents. Discharged cell is replaced by new cells, *e.g.*, sebaceous gland.

Apocrine : Secretory products accumulate at the apical margin. It pinches off from rest of the cell. The cell repairs the lost part, *e.g.*, mammary glands.

Merocrine (Epicrine) : No damage to the cell. Secretion diffuses out through the cell surface. *e.g.*, pancreas, salivary glands and goblet cell.

Serous gland : Secretes watery fluid, *e.g.*, sweat gland.

Mucous gland : Produce mucus, *e.g.*, goblet cells.

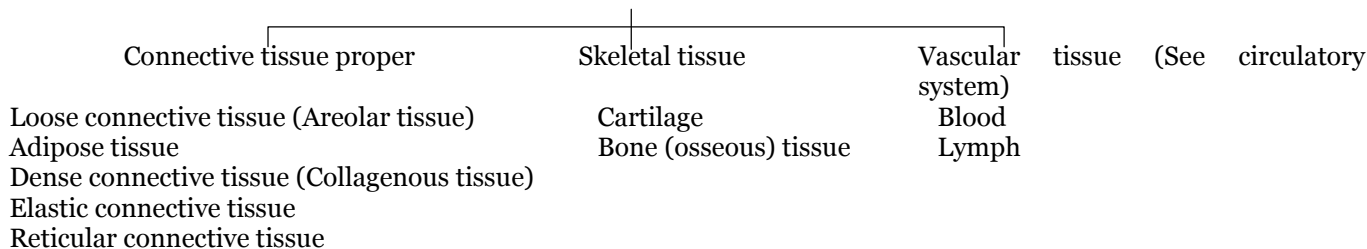
Mixed gland : Secretes both serous and mucous fluids, *e.g.* pancreas and gastric glands.

1.2 Connective tissue

Connective tissue is mesodermal in origin. Connective tissue is the most abundant body tissue. It has few cells, an extensive matrix and a rich blood supply. Two general types of connective tissue are : embryonic

connective tissue and adult connective tissue. Wharton's jelly present in the umbilical cord of foetus is a mucous connective tissue.

Adult connective tissue



(i) Connective tissue proper

(a) **Areolar tissue** : Areolar tissue contains fibroblasts, macrophages, mast cells, plasma cells, lymphocytes, adipose cells and fibres etc.

Fibroblasts : They are the principle cells which are irregular, flat with protoplasmic processes. Fibroblasts synthesise three kinds of proteins (collagen, elastin and reticulin) forming fibres.

Macrophages : They are large amoeboid cells which phagocytose and destroy microbes, dead cells, inert foreign particles, etc.

Mast cells : It is occur in connective tissue proper; these are modified basophils of blood. Mast cells are oval in shape and secrete **heparin** (anticoagulant), **histamine** (vasodilator) and **serotonin** (vasoconstrictor). **Histamine** is involved in allergic and inflammatory reactions.

Plasma cells : They are also known as '**cart wheel cells**' and produce antibodies.

Fibres : Three types of fibres are : Collagen fibres, Elastic fibres and Reticular fibres.

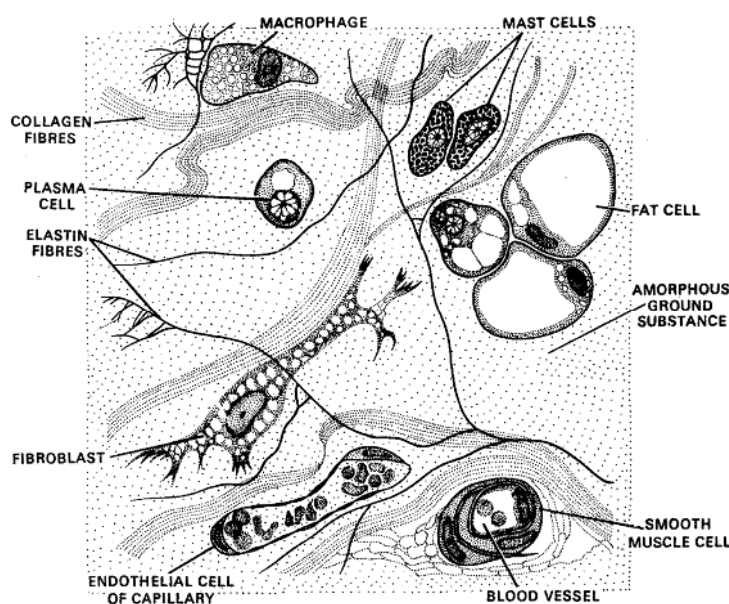
Collagen fibres : They are white, formed of a protein, **collagen**, occur in thick bundles.

Elastic fibres : The elastic fibres are yellow, formed of a protein **elastin**, occur singly.

Reticular fibres : These fibres are delicate, inelastic and formed of a protein **reticulin**.

(b) **Adipose tissue** : Adipose tissue is a specialized loose connective tissue in which the fibroblasts are modified for fat storage. Adipose tissue contains large, spherical or oval cells called fat cells or **adipocytes**. Prominent adipose tissue sites are : subcutaneous fat (**panniculus adiposus**), **blubber** of whales, hump of camel. In frog, adipose tissue forms the fat bodies. Two types of fat in adipose tissue are : white (yellow) fat and brown fat. **White fat** – It contains large adipose cells which are monolocular *i.e.* have a single large fat globule. **Brown fat** – Adipose cells of brown fat are multilocular *i.e.* have several small fat globules. Brown colour is due to iron containing cytochrome pigment in fat. On oxidation, brown fat yields about 20 times more energy than ordinary white fat.

(c) **Dense-connective tissue** : Fibrous connective tissue which connects bones is **ligament**. Sprain is caused by excessive pulling (stretching) of ligaments. Tendon and ligaments are connective tissues. This tissue is found at the joints between skull bones and make them immovable. Dense connective tissue is the principal component of **tendons** and **ligaments**.



Connective tissue

Tendon is a very dense, strong fibrous connective tissue made of collagen fibres. Tendon connects a skeletal muscle to a bone.

Ligaments consist of mainly collagen fibres and some elastic fibres. Ligaments connect bone together.

(d) **Elastic connective tissue** : Elastic connective tissue is a component of the cartilage of larynx, the walls of elastic arteries, the trachea, the bronchial tubes to the lungs and the lungs themselves. Yellow elastic ligaments form the **ligamenta flava** of the vertebrae (ligaments between successive vertebrae) and true vocal cords.

(e) **Reticular connective tissue** : Reticular connective tissue consists of interlacing reticular fibres. This tissue helps to form the framework or stroma of many organs including the liver, spleen and lymph nodes. Reticular connective tissue also helps to bind together the cells of smooth muscle tissue.

(ii) **Skeletal Tissue**

(a) **Cartilage** : Cartilage is surrounded by a sheath of dense connective tissue called **perichondrium**. The cells of mature cartilage, called **chondrocytes**, occur singly or in groups within spaces called **lacunae**.

Hyaline cartilage : There are no fibres and matrix is transparent. Hyaline cartilage is the most abundant kind of cartilage. Hyaline cartilage found upon articular surfaces at joints of long bones form articular cartilage. Hyaline cartilage forms the **costal cartilages** at the ventral ends of the ribs.

Fibrous cartilage < White fibro cartilage
Elastic cartilage

White fibro cartilage : White fibrocartilage is the **strongest** cartilage.

Elastic cartilage : Elastic cartilage provides strength and maintains the shape of certain organs. Elastic cartilage is found in the wall of larynx, ear pinna, epiglottis and eustachian tubes.

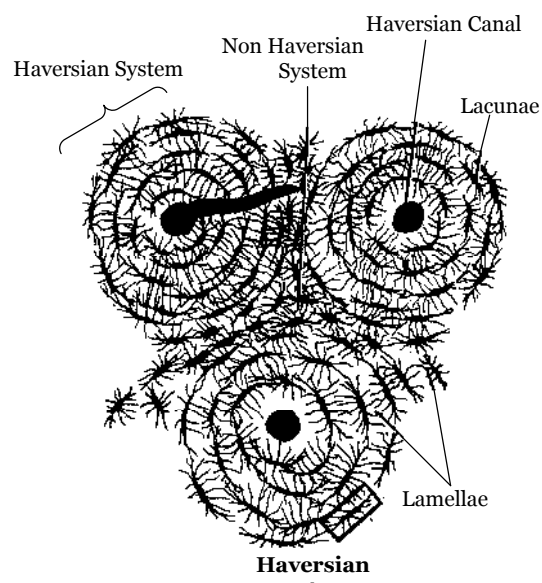
Calcified cartilage : It is formed by the calcification of hyaline cartilage. Calcified cartilage is hard and found in suprascapula of pectoral girdle and pubis of pelvic girdle in frog.

(b) **Bones** : The major component of vertebrate bone is calcium phosphate. Other components include calcium carbonate, magnesium phosphate and sodium chloride. Together these salts are referred to as hydroxyapatites. The mineral salts compose 67% of the weight of the bone, the organic phase comprising collagenous fibre make up the remaining 33%. If a bone is kept in dilute acid for few days, it becomes soft and flexible. This is called decalcification of the bone. A bone kept in *KOH* remains unaffected.

Periosteum is a tough sheath of white fibrous tissue which covers the bone externally. It contains blood vessels and active bone forming cells – the osteoblasts.

Endosteum lines the bone marrow cavity. Like periosteum, it is also composed of white fibrous tissue and contains blood vessels and bone forming cells.

Haversian system : Matrix between periosteum and endosteum is composed of a protein called ossein and is perforated by a series of fine channels called **Haversian canals**. Haversian system is found in long



bones of mammals to provide extra nutrition to living parts of matrix. Haversian system includes Haversian canal, surrounding lamellae, lacunae, osteocytes and canaliculi. Haversian canals are interconnected by transverse canals known as **Volkman's canals**.

Bone marrow : Inner to the endosteum, a cavity called bone marrow cavity is present in the long bones which is filled with fatty, neurovascular tissue termed bone marrow. It is composed of adipose tissue, blood vessels and haemopoietic tissue. A deficiency of vitamin *D* produces **rickets** in children and osteomalacia in adults. Paget's disease is characterized by irregular thickening and softening of bones. All the infectious diseases of bone is called **osteomyelitis**.

(iii) Types of bones

(a) **Spongy bone** : Contains red bone marrow and is without haversian systems, found at the ends of long bones.

(b) **Compact bone** : Contains yellow bone marrow and has haversian systems, found in the shaft of long bones.

(c) **Cartilaginous bones** : Develop from pre-existing cartilage and replace it. *e.g.* humerus, femur.

(d) **Dermal bones** : Develop in dermis of skin and sink to get attached over the original cartilaginous endoskeleton. *e.g.* frontal, nasals and parietals of skull.

(e) **Sesamoid bones** : Formed in the tendons at the joints. *e.g.* patella (knee-cap).

(f) **Visceral bones** : Formed in soft organs dissociated from the rest of the skeleton. *e.g.* os-cordis, os-clitoris, os-palpebrae.

1.3 Muscular tissue

It is mesodermal in origin except ciliary muscle of eye (ectodermal). The most specialized property of muscular tissue is contractility. The muscular tissue is responsible for the various movements in an animal. Muscular tissue stores glycogen as stored food. On the basis of structure, location and functions, the muscular tissue is classified into three types.

(i) **Striated muscle** : A striped muscle fibre has many nuclei and it is a syncytium (coenocyte). The entire muscle is usually wrapped with a fibrous connective tissue called **epimysium**. The plasma membrane covering the muscle fibre is called the **sarcolemma**. The major proteins present in muscles are actin, myosin, troponin, myoalbumin, myoglobin and myogen (20%). Skeletal muscle fibre shows transverse striations in the form of regular alternate dark **A (anisotropic)** and light **I (isotropic)** bands. At the centre of I band is a fine, dense **Z-line** or **Krause's membrane**. **Z-line** or **Krause's membrane** divides the myofibrils into functional units called **Sarcomeres**. Sarcomere is the area between two **Z-lines**. **H-zone** is found at the centre of **A** band, **M-line** or **Hensen's line** in the middle of **H** zone. Two types of protein filaments in muscle are **myosin** and **actin**.

(a) **Mechanism of contraction of striated muscle** : Sliding filament theory of muscle contraction was given by **H. E. Huxley** and **A.F.Huxley** (1953). The contraction of the muscle is brought about by a sliding movement of actin filaments over the myosin filaments. During muscle contraction, both I band and *H* zone progressively shorten and eventually disappear. Release of calcium ions from sarcoplasmic reticulum trigger the muscle contraction process. Calcium is an essential element for the contraction of muscles. In presence of calcium ions and energy from ATP, actin and myosin interact forming actomyosin. Contraction of a muscle is caused by actomyosin.

The energy for contraction of muscle is obtained from ATP. In a resting muscle, ATP combines anaerobically with creatine to form creatine phosphate. When muscle contracts creatine phosphate breaks down to produce ATP. During muscle contraction, conversion of pyruvic acid to lactic acid proceeds anaerobically.

When tension of a muscle remains constant but muscle shorten contraction is known as 'isotonic'. The contraction of muscles of shortest duration is seen in eye lids. During muscle contraction, chemical energy is changed into mechanical energy. The muscle fatigue occurs due to excessive activity resulting in the accumulation of lactic acid. Lactic acid is transported by blood to liver and there it is converted to glycogen through Cori's cycle.

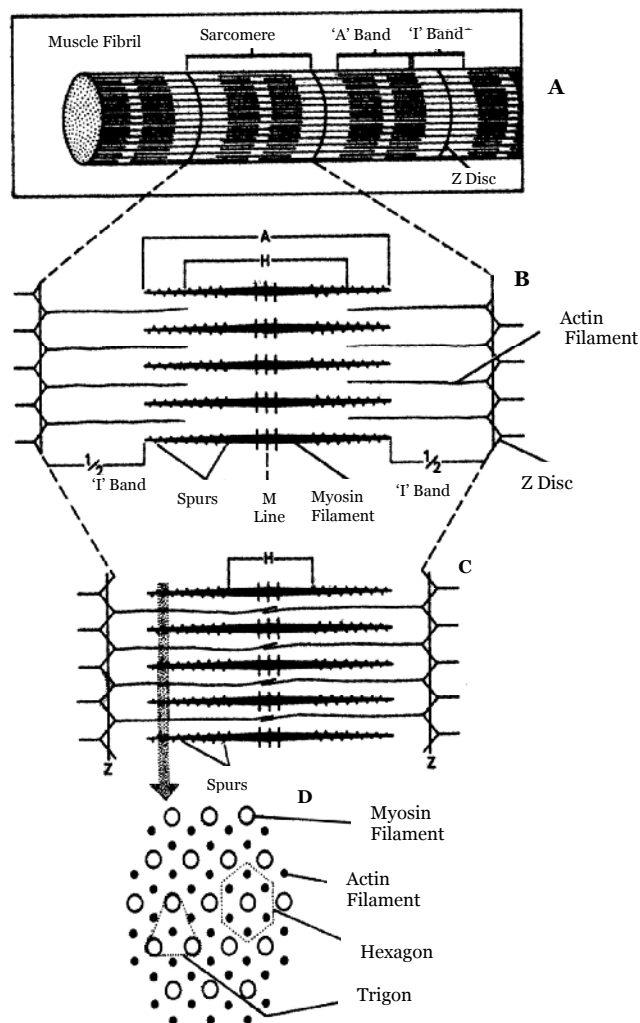
(ii) **Visceral muscle** : Functionally smooth muscles are of two types : single-unit smooth muscle and multi-unit smooth muscles.

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

(b) **Multi-unit smooth muscles** : They are composed of more independent muscle fibres, contract as separate units, *e.g.*, Hair root muscles and muscles on the wall of large blood vessels. Smooth muscles never connect with skeleton. Smooth muscles are located in viscera and also known as visceral, non-striated, plain nonskeletal or involuntary muscles. Smooth muscles are the most widely distributed muscles in the body, *e.g.*, Gastrointestinal tract, uterus, urinary bladder, iris ciliary body, blood vessels, etc.

(iii) **Cardiac muscle** : Cardiac muscles are the principal constituent of heart wall. Cardiac muscles have long cylindrical, branched and uninucleate cells divided at places by intercalated disc. Cardiac muscles are striated, involuntary contract quickly and do not get fatigued.

Cardiac muscles are striped muscles with fibre being nucleated and involuntary. Cardiac muscles have a mixture of properties of both striated and unstriated muscles. These muscles continue rhythmic contraction throughout life under the control of ANS.



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

1.4 Nervous tissue

It is mainly consist of four types of cells viz. neuroglia, neurons, ependymal cells and neurosecretory cells

(i) **Neuroglia** : Types of neuroglia cells in CNS

(a) **Astrocytes** : Star-shaped cells with numerous processes.

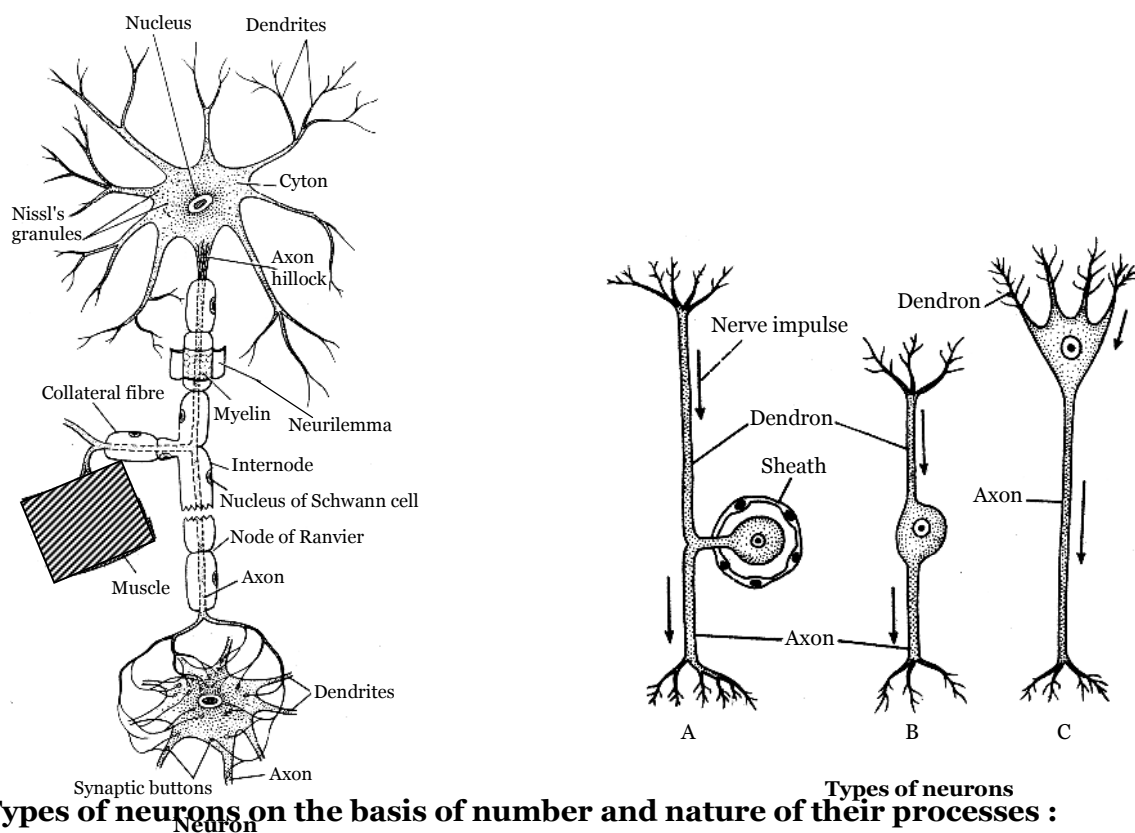
(b) **Oligodendrocytes** : Resemble astrocytes, but processes are fewer and smaller.

(c) **Microglia** : Small cells with few processes, phagocytic.

(ii) **Neurons** : It consists of cell body, dendrites and axon. The cell body of a neuron is called **cyton**, **perikaryon** or **soma**. It contains abundant granular cytoplasm and a large nucleus. Cyton of most **neurons** in our body occur in brain. The structures present in neuroplasm characteristic of neurons are **Nissl bodies** or **trigold granules**. Nissl granules are found to be rich in RNA and are concerned with protein synthesis. Nervous cells originate from embryonic **ectoderm**. Nervous system consists of two kinds of cells namely **neurons** and **neuroglia**. Neurons form the structural and functional unit of the nervous system. Neuroglia forms the connective tissue of nervous system which performs support and protection. Nissl bodies are absent in the axon and axon hillock. Axon is an efferent process because it conducts impulse away from cell body to another neuron or tissue. Longest cells in the human body may be nervous cells. Nerve cells do not divide. Least power of regeneration is found in nerve cells.

The myelinated or medullated or white fibre is surrounded by a phospholipid covering called myelin sheath. The myelin sheath is produced by flattened cells called **Schwann cell**. **Myelin sheath** is a layer covering the vertebrate nerve fibre. The unmyelinated gaps or constrictions in the axons are called **Nodes of Ranvier**. In the CNS, medullated nerve fibres form white matter.

Non – medullated or Non – myelinated nerve fibre lack medullary sheath and Nodes of Ranvier. In the CNS, these fibres form the grey matter.



(a) **Types of neurons on the basis of number and nature of their processes :**

Unipolar neurons are found in *Hydra*.

Unipolar neurons has only one process extending from the cell body as found in embryos and dorsal root ganglia of adult vertebrates.

Bipolar neurons have a single dendrite and axon at opposite poles of the cyton. These are found in the retina of eyes, olfactory epithelium and inner ear.

Multipolar neurons have several dendrites and one axon. Most neurons in the brain and spinal cord are of this type.

(b) Types of neurons on the basis of their function :

Sensory or Afferent Neurons : Bring sensory impulses from sense organs to CNS.

Motor or Efferent Neurons : Carry motor impulses from CNS to the effectors (muscles and glands).

Interneurons : Neither sensory nor motor. Present in CNS between sensory and motor neurons.

(iii) **Ependymal cells :** Arranged as an epithelial layer and possess one or more long processes towards opposite side which penetrate nervous tissue. Their free surface bear numerous microvilli and cilia.

(iv) **Neurosecretory cells :** Function as endocrine organs and release chemicals from their axons into the blood instead of synaptic cleft.

Important Tips

- ☞ Transitional epithelium also called plastic epithelium or **urothelium**. It lacks basement membrane
- ☞ 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.
- ☞ Some epithelial cells contain pigment such cells are present in the skin, retina and iris.
- ☞ The epithelial lining of brain ventricles and central canal of spinal cord is known as **ependyma**.
- ☞ Myoepithelium made up of fusiform or stellate cells capable of contraction.
- ☞ Basement membrane of epithelial tissue is non cellular.
- ☞ **Bartholins duct** is lined by Cuboidal Epithelium.
- ☞ Stereocilia present in Epididymis.
- ☞ The Cytoplasmic granules basophils contain histamine.
- ☞ Sprain – Excessive pulling of ligaments.
- ☞ Muroid 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, gluconic 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.
- ☞ The term "**blubber**" refers to a subcutaneous deposition of fat in whales.
- ☞ 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.
- ☞ **Ligamentum flava** – connects adjacent vertebrae and the ligaments between the phalanges, fingers and toes.
- ☞ **Ligamentum Nuchae** – Found in the neck of quadrupeds to bear the weight of head when grazing.
- ☞ The process of bone formation is known as osteogenesis or ossification.
- ☞ Marrow cavity is also called medullary cavity.

- ☞ Calcination – Process of burning of bone till it becomes white.
- ☞ Beside calcium phosphate the bones contain potassium, magnesium phosphate.
- ☞ **Wharton's Jelly** is a mucoid connective tissue present in umbilical cord.
- ☞ The triceps and biceps muscles are of antagonist type and these are voluntary in nature.
- ☞ Strongest muscles in human body are found in Jaws
- ☞ 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.
- ☞ Actin filaments contain mainly actin protein molecules though they also have troponin and tropomyosin (nearly 20%)
- ☞ Myoglobin protein is called as muscle haemoglobin.
- ☞ Deficiency of ATP in the muscles is called **rigor mortis**.
- ☞ Gastrocnemius (calf) muscle is found on post-axial side of shank of leg.
- ☞ **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**.
- ☞ 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
- ☞ Saltatory conduction occurs in only myelinated nerve fibres
- ☞ Synapse is a junction between dendrites and Axons ends